Concern for Europe's Tomorrow

Health and the Environment in the WHO European Region

WHO European Centre
for Environment and Health

WORLD HEALTH ORGANIZATION
EUROPE

WVG

Wissenschaftliche Verlagsgesellschaft mbH Stuttgart

Concern for Europe's Tomorrow
Health and the Environment in the WHO European Region

Concern for Europe's Tomorrow

Health and the Environment in the WHO European Region

WHO European Centre
for Environment and Health

EUROPE

Wissenschaftliche Verlagsgesellschaft mbH Stuttgart 1995

The Federal Minister for the Environment, Nature Conversation and Nuclear Safety (Federal Republic of Germany) provided financial support for, and undertook the printing of, this publication.

Die Deutsche Bibliothek – CIP-Einheitsaufnahme

Concern for Europe's tomorrow : health and the environment in the WHO European region / WHO European Centre for Environment and Health. [Publ. on behalf of the World Health Organization Regional Office for Europe]. – Stuttgart : Wiss. Verl.-Ges., 1995
ISBN 3-8047-1406-4
NE: European Centre for Environment and Health

Wissenschaftliche Verlagsgesellschaft mbH, Birkenwaldstraße 44, D-70191 Stuttgart, Germany.
Printed in Germany

Foreword

The remarkable political changes that have taken place within the European Region in the last five years have greatly enlarged the potential for international collaboration. The First European Conference on Environment and Health was held in Frankfurt in December 1989, when these dramatic changes were at their height. Ministers from 29 countries, and the European Commission, approved a Charter that set out the principles, strategy and priorities for achieving an effective approach to the many areas in which environmental conditions may significantly affect human health.

The Charter reflected the ministers' concern that the nature and extent of environmental health problems throughout the Region had not been adequately assessed. The WHO European Centre for Environment and Health, which was established as a direct result of the Conference's recommendations, was therefore given as its first major task the development of a comprehensive review of available data in such fields as water supply and sanitation, air and water pollution, radiation protection, food safety, occupational health, and housing and settlements. The project was entitled Concern for Europe's Tomorrow, and the Scientific Advisory Board of the European Centre decided that the final report should be available as the scientific basis for deliberations at the Second European Conference on Environment and Health in Helsinki in June 1994.

The time available for preparation was extremely limited. The fact that a summary of the final report was available in time for the Second European Conference reflects great credit on the many scientists (more than 270) and officially established national focal points in the Member States who have taken part in this major undertaking.

The report highlights a number of issues that demand urgent attention and has confirmed the existence of major differences in environmental conditions and the health status of populations between the western countries of the Region and the countries of central and eastern Europe and the newly independent states of the former USSR.

None of the countries of our Region, however, has room for complacency. As one example, substantial areas of many European cities provide a deteriorating environment for their citizens, owing to traffic noise, pollution and congestion, and social deprivation. Clearly, not all issues are of equal importance and it is hoped that the objective scientific nature of this report will help to allay unjustified public fears and to provide a more realistic perception of risk. Above all, the report is intended to be of assistance in rational decision-making, so that real priorities may be identified and limited resources efficiently utilized.

The process of developing this report has demonstrated the shortcomings of the available data, in both coverage and consistency. Nevertheless, the report is a major step forward. I am confident that the network of national focal points, which has now been firmly established, and the close collaboration between the WHO Regional Office for Europe and other international organizations, in particular the European Environment Agency, provide excellent prospects for considerable improvements in the quantity and quality of available information between now and the Third European Conference planned for 1999.

The present volume, which has been developed in very close cooperation with the Europe's Environment Task Force of the European Commission, represents a major step forward in collaboration among all 50 countries of the WHO European Region. It is hoped that it will be widely used, not only by government agencies but also by the very many nongovernmental organizations dealing with different aspects of the issues addressed by Concern for Europe's Tomorrow.

J.E. Asvall
WHO Regional Director for Europe

Table of Contents

Introduction

Part I Background

1 Economic Sectors

2 Environmental Health Management

3 Economics, the Environment and Health

4 State of Human Health

Part II
Environmental Exposure

5 Air Pollution

6 Water Supply and Quality

7 Wastewater and Surface Water

8 Solid Waste

9 Contamination of Food and Drink

10 Multimedia Exposure to Selected Chemicals

11 Nonionizing Radiation

12 Ionizing Radiation

13 Residential Noise

14 Housing and the Indoor and Urban Environments

15 Occupational Health

16 Accidents and Man-made Disasters

17 Environmental Health in the CCEE and NIS

Part III
Analysis, Discussion, Conclusions and Recommendations

18 Estimated Health Effects of Environmental Exposure and Role of Economic Sectors

19 Conclusions and Recommendations

Acknowledgements

The European Centre for Environment and Health of the WHO Regional Office for Europe prepared this volume through its divisions in Bilthoven and Rome, together with the coordination unit in Copenhagen. The assessment of the situation in the fields of health and the environment covering such a vast area as the WHO European Region would not have been possible without the active support and collective efforts of a great many contributing individuals and institutions. The Regional Office is grateful to all who participated in this effort, either as authors, as reviewers or in any other capacity. The extensive list of contributors is a measure of the size and complexity of the task.

The Organization is greatly indebted to all ministries of health and of the environment in the Region for their active support. The network of national focal points for Concern for Europe's Tomorrow (CET), acting as links between the national authorities and the Regional Office, provided invaluable help in data collection and evaluation. The Regional Office is especially grateful to the chairman and members of the Scientific Advisory Board of the European Centre for Environment and Health who, together with numerous individual reviewers, carried out a detailed scientific critique of the drafts and provided sound advice on their improvement. The close cooperation of other international bodies, especially the European Environment Agency Task Force of the European Commission, is appreciated.

The Regional Office wishes to record its special gratitude to Dr Barbara MacGibbon, who undertook the very difficult task of overall compilation and scientific editing of the whole report. Without her invaluable contribution, publication of this book would not have been possible within the very limited time available.

Contributors

National focal points for CET

Q. Kodra (Albania)
A. Hrair (Armenia)
G. Liebel (Austria)
Galina Kurganskaya (Belarus)
R. de Boeck (Belgium)
H. Mileva (Bulgaria)
M. Gunaric (Croatia)
K. Markvart (Czech Republic)
H. Balling (Denmark)
R. Silla (Estonia)
A. Nevalainen (Finland)
Y. Coquin (France)
H. Lange-Asschenfeldt (Germany)
G. Kamizoulis (Greece)
G. Dura (Hungary)
T. Ibsen (Iceland)
R. Ellard (Ireland)
R. Halperin (Israel)
G. A. Zapponi (Italy)
A. Zirnis (Latvia)
J. Ptashekas (Lithuania)

P. Huberty-Krau (Luxembourg)
A. Amato-Gauci (Malta)
R. Passeron (Monaco)
E. Lebret (Netherlands)
E. Dybing (Norway)
J.K. Ludwicki (Poland)
L. Delgado (Portugal)
M. Cucu (Romania)
N.F. Izmerov (Russian Federation)
M. Synek (Slovakia)
M. Macarol-Hiti (Slovenia)
A. Fresno Ruiz (Spain)
K. Victorin (Sweden)
B. Marti (Switzerland)
S. Yüksel (Turkey)
A.M. Serdiuk (Ukraine)
E. Smales (United Kingdom)

Other national contributors

J. Alexander (National Institute of Public Health, Oslo, Norway)
T. Anavi (Tel Aviv University, Tel Aviv, Israel)
E. Andronache (Institute of Hygiene and Public Health, Bucharest, Romania)
S.L. Avaliani (Sisin Institute of Community Hygiene, Moscow, Russian Federation)
A. Avni (Ministry of Health, Jerusalem, Israel)
W. Babisch (Institute for Water, Soil and Air Hygiene, Federal Health Office, Berlin, Federal Republic of Germany)
B. Bayar (Ministry of Health, Ankara, Turkey)
R. Becher (National Institute of Public Health, Oslo, Norway)
G. Bechu (Ministry of Health, France)
N.E. Billo (Federal Office of Public Health, Bern, Switzerland)
K. Binysh (Department of Health, London, United Kingdom)
G. Biro (National Institute of Food Hygiene and Nutrition, Budapest, Hungary)
C.-E. Boström (National Environmental Protection Board, Stockholm, Sweden)
G. Brunborg (National Institute of Public Health, Oslo, Norway)
J. Cachia (Department of Health, Valletta, Malta)
R. Cachia Zammit (Department of Environment, Valletta, Malta)
J. Carmes (Ministry of Health, France)
P. Caruna (Public Health Laboratory, Valletta, Malta)
F. Cicogna (Ministry of Health, Rome, Italy)
M. Csanady (National Institute of Public Health, Budapest, Hungary)
M. Dodic-Fikfak (University Institute for Medicine and Social Welfare, Ljubljana, Slovenia)
B. Drougge (National Environmental Protection Board, Stockholm, Sweden)
B. Duigu (Ministry of Reconstruction and Settlement, Ankara, Turkey)
S. Dumitrache (Institute of Hygiene and Public Health, Bucharest, Romania)
M. Eriksson (National Board of Health and Welfare, Stockholm, Sweden)
N. Essiz (State Planning Organization, Ankara, Turkey)
L. Ewetz (Institute of Environmental Medicine, Stockholm, Sweden)
W. Fonahn (National Institute of Public Health, Oslo, Norway)
E. Fröhlich (Federal Office of Public Health, Bern, Switzerland)
M. Gauci (Industrial Hygiene Unit, Valletta, Malta)
S. Gelberg (Ministry of Environmental Quality, Jerusalem, Israel)
M. Gerber (Ministry of Environmental Quality, Jerusalem, Israel)
Y. Gil (Ministry of Environmental Quality, Jerusalem, Israel)
A. Goren (Tel Aviv University, Tel Aviv, Israel)
F. Gösbebek (Turkish Atomic Energy Institute, Ankara, Turkey)
J. Gubernskiy (Sisin Institute of Community Hygiene, Moscow, Russian Federation)
S. Güven (State Statistics Institute, Ankara, Turkey)

J.-E. Haugen (National Institute of Public Health, Oslo, Norway)
F. Hirka (National Institute of Public Health, Budapest, Hungary)
A. de Hollander (RIVM, Bilthoven, Netherlands)
J. Hongslo (National Institute of Public Health, Oslo, Norway)
A. Horvath (National Institute of Hygiene, Budapest, Hungary)
M. Hristova (Institute of Radiobiology and Radioprotection, Sofia, Bulgaria)
H. Huitfeldt (National Institute of Public Health, Oslo, Norway)
J. Indulski (Institute of Occupational Medicine, Lodz, Poland)
H. Isnard (Ministry of Health, France)
L. Ivanovska (Ministry of Health, Skopje, The Former Yugoslav Republic of Macedonia)
M. Izrael (Institute of Radiobiology and Radioprotection, Sofia, Bulgaria)
V. Kalivoda, Federal Environmental Agency, Vienna, Austria)
K. Karlowski (National Institute of Hygiene, Warsaw, Poland)
N. Kehlkovskiy-Sergeev (Institute of Industrial Hygiene and Occupational Diseases, Moscow, Russian Federation)
M. Kertész (National Institute of Hygiene, Budapest, Hungary)
S. Khotimchenko (Institute of Nutrition of the Russian Academy of Medical Sciences, Moscow, Russian Federation)
B. Kihlström (National Institute of Public Health, Oslo, Norway)
E. Kivisäkk (National Radiation Protection Institute, Stockholm, Sweden)
V. Knizhnikov (Ministry of Health, Moscow, Russian Federation)
M. Köhalmi (Ministry of Welfare, Budapest, Hungary)
J. Korytkowsky (Ministry of Environmental Protection, Warsaw, Poland)
Z. Koszarny (National Institute of Hygiene, Warsaw, Poland)
D.I. Krammer, Federal Environmental Agency, Vienna, Austria)
N. Lazarus (Department of Health, London, United Kingdom)
L. Licari, (Department of Health,Valletta, Malta)
G. Lilleheil (National Institute of Public Health, Oslo, Norway)
T. Lindner (Federal Ministry of Health, Sport and Consumer Protection, Vienna, Austria)
D. Lupulescu (Institute of Hygiene and Public Health, Bucharest, Romania)
T. Majle (National Institute of Hygiene, Warsaw, Poland)
R. Maynard (Department of Health, London, United Kingdom)
S. Maziarka (National Institute of Hygiene, Warsaw, Poland)
T. Meredith (Department of Health, London, United Kingdom)
V. Metodiev, National Centre of Hygiene and Medical Ecology, Sofia, Bulgaria)
M. Micallef (Department of Health, Valletta, Malta)
I. Miller (Institute of Hygiene and Epidemiology, Prague, Czech Republic)
C. Milu (Institute of Hygiene and Public Health, Bucharest, Romania)
B. Montaville (General Directorate for Health, Paris, France)
C. Morawa (International Office of the Federal Environmental Agency, Berlin, Germany)
H.-G. Mücke (Institute for Water, Soil and Air Hygiene, Federal Health Office, Berlin, Germany)
E. Ne'eman (Tel Aviv University, Tel Aviv, Israel)
B. Nikiforov, National Centre for Hygiene and Medical Ecology, Sofia, Bulgaria)
K. Ormerod (National Institute of Public Health, Oslo, Norway)
O. Petursson, Office of Environmental Protection, Reykjavik, Iceland)
T. Popov (National Centre of Hygiene and Medical Ecology, Sofia, Bulgaria)
V. Radmilovic (Federal Secretariat for Labour, Health, Veterans' Affairs and Social Policy, Belgrade, Federal Republic of Yugoslavia (Serbia and Montenegro))
T. Radunsky (Federal Environmental Agency, Vienna, Austria)

J. Rakhmanin (Sisin Institute of Community Hygiene, Moscow, Russian Federation)
F. Ribarova (National Centre of Hygiene and Medical Ecology, Sofia, Bulgaria)
D. Ricochon (Ministry of Health, France)
D. Riechman (Ministry of Health, Jerusalem, Israel)
E. Rocco (Ministry of Health, Rome, Italy)
M. Rouge (Ministry of Health, France)
P. Rudnai (National Institute of Hygiene, Budapest, Hungary)
R. Skinner (Department of Health, London, United Kingdom)
S. Slorach (National Food Administration, Uppsala, Sweden)
T.-A. Stenström (National Bacteriological Laboratory, Stockholm, Sweden)
J.R. Sveinsson (State Housing Board, Reykjavik, Iceland)
N. Rusakov (Sisin Institute of Community Hygiene, Moscow, Russian Federation)
E. Rydén (National Board of Housing, Building and Planning, Karlskrona, Sweden)
E. Sabir (Ministry of Labour and Social Security, Ankara, Turkey)
M. Sammut (University of Malta, G'Mangia, Malta)
V. Scheftel (Ministry of Health, Jerusalem, Israel)
R. Schembri (Public Health Laboratory, Valletta, Malta)
E. Schneider (Zentrales Arbeitsinspektorat, Vienna, Austria)
T. Schossberger (Ministry of Health, Jerusalem, Israel)
C. Serrano Carcia (Institute of Hygiene at the Workplace, Madrid, Spain)
V. Shinev (Institute of Occupational Health, Moscow, Russian Federation)
A. Spassov (National Centre of Hygiene and Medical Ecology, Sofia, Bulgaria)
D.I. Stadler (Bundesministerium für Land- und Forstwirtschaft, Vienna, Austria)
F. Störmer (National Institute of Public Health, Oslo, Norway)
M. Sulcova (National Institute of Hygiene and Epidemiology, Bratislava, Slovakia)
L.B. Sztanyik (National Institute of Radiobiology and Radiohygiene, Budapest, Hungary)
N. Tarkan (Middle East Technical University, Ankara, Turkey)
M. Tchutchkova (National Centre of Hygiene and Medical Ecology, Sofia, Bulgaria)
S. Tekeli (Ministry of Trade and Industry, Ankara, Turkey)
G. Tezcan (Ministry of Energy and Natural Resources, Ankara, Turkey)
I. Thirouin (Ministry of Health, France)
S. Thorarinsson (Administration of Occupational Safety and Health, Reykjavik, Iceland)
I. Trettwer (Österreichisches Statistisches Zentralamt, Vienna, Austria)
B. Tichacek (National Institute of Public Health, Prague, Czech Republic)
E. Tacoronte (Ministry of Health and Consumer Affairs, Madrid, Spain)
M. Tat (Institute of Hygiene and Public Health, Bucharest, Romania)
H. Toksoy (Ministry of Agriculture and Village Affairs, Ankara, Turkey)
U. Torsmark (National Environmental Protection Board, Solna, Sweden)
D. Tricard (Ministry of Health, France)
R. Tulbure (Institute of Hygiene and Public Health, Bucharest, Romania)
G. Ungvary (National Institute of Occupational Heath, Budapest, Hungary)
L. Vella (Industrial Hygiene Unit, Valletta, Malta)
T. Ulgen (Ministry of Health, Ankara, Turkey)
L. Ursu (Institute of Hygiene and Public Health, Bucharest, Romania)
A. Vassallo (Department of Health, Valletta, Malta)
A. Wadge (Department of Health, London, United Kingdom)
K. Wahlberg (National Board of Occupational Safety and Health, Solna, Sweden)
H. Walker (Department of Health, London, United Kingdom)
M. Waring (Department of Health, London, United Kingdom)
S. Whitehead (Department of Health, London, United Kingdom)
R. Zechner (Federal Ministry of Health, Sport and Consumer Protection, Vienna, Austria).

Thematic contributors

U. Ackerman-Liebrich (University of Basle, Switzerland)
G. Andreottola (Istituto per l'Ambiente, Milan, Italy)
M.E. Apeldoorn (RIVM, Bilthoven, Netherlands)
J.H. Bernhardt (Institute of Radiation Hygiene, Neuherberg, Germany)
C. Corchia (University of Sassari, Italy)
R.B. Cundall (Medical Research Council, Chilton, United Kingdom)
H. Dovland (Institute for Air Research, Lilleström, Sweden)
K. Gerigk (Robert von Ostertag Institute, Berlin, Germany)
R.J. Gilbert (Central Public Health Laboratory, London, United Kingdom)
A. Henne (Medizinisches Institut für Umwelthygiene, Düsseldorf, Germany)
D. Hill (Environmental Resources Limited, London, United Kingdom)
G. Jukes (Institution of Environmental Health Officers, London, United Kingdom)
E.D. Kroese (RIVM, Bilthoven, Netherlands)
S. Lagorio (Istituto Superiore di Sanità, Rome, Italy)
F. Langeweg (RIVM, Bilthoven, Netherlands)
I. MacArthur (Institution of Environmental Health Officers, London, United Kingdom)
K. Martignoni (Institute of Radiation Hygiene, Neuherberg, Germany)
R. Mnatsakanian (Moscow, Russian Federation)
Eva Nielsen (National Food Agency, Søborg, Denmark)
R. Novick (Potomac, USA)
O. Juhl Pedersen (Technical University, Copenhagen, Denmark)
P. Peterson (MARC, London, United Kingdom)
J. Rantanen (Finnish Institute of Occupational Health, Helsinki, Finland)
J. Roberts (Adhealth Ltd, United Kingdom)
F. Sella (Apples, Switzerland)
R.M.C. Theelen (RIVM, Bilthoven, Netherlands)
P. Teufel (Robert von Ostertag Institute, Berlin, Germany)
B.T. Williams (University of Sheffield, United Kingdom)
E. Wirth (Institute of Radiation Hygiene, Neuherberg, Germany)
M. Wohlen (Gothenburg, Sweden).

Scientific reviewers

Scientific Advisory Board

Sir Donald Acheson (Chairman, London School of Hygiene, United Kingdom)
A.M. Kellerer (Institut für Strahlenbiologie, Germany)
M. Maroni (International Centre for Pesticide Safety, Italy)
G. Pershagen (National Institute of Environmental Medicine, Sweden)
J.K. Piotrowski (Institute of Environmental Research, Poland)
J. Rantanen (Institute of Occupational Health, Finland)
U. Schlottmann (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany)
V. Silano (Ministry of Health, Italy)
J. Weicherding (General Directorate of Health, France)
T.B. Zeltner (Federal Office of Public Health, Switzerland)
B.C.J. Zoeteman (Ministry of Housing, Physical Planning and Environment, Netherlands).

Individual scientific reviewers

T. Hancock (Public Health Consultant, Kleinburg, Ontario, Canada)
P. Kulling (National Poison Information Centre, Stockholm, Sweden)
M.D. Lebowitz (University of Arizona, Tucson, USA)
D. Larré (Director, Industry and Environment Office, UNEP, Paris, France)
J.L. Larsen (National Food Agency, Søborg, Denmark)
C.J. Macfarlane (Ontario International Corporation, Government of Ontario, Canada)
E. Morava (National Public Health and Medical Officer Service, Pécs, Hungary)
G. Salomon (Gentofte Hospital, University of Copenhagen, Denmark)
A. Parving (Department of Audiology, Bispebjerg Hospital, Denmark)
A. Pintér (National Institute of Hygiene, Budapest, Hungary)
R. Visser (OECD, Paris, France)
G. Winneke (Medizinisches Institut für Umwelthygiene, Düsseldorf, Germany).

Project Group of the *Europe's environment* report

J.-P. Ribaut (Council of Europe)
J. Benes, Jaroslav Mejzr (ex-Czechoslovakia)
T. Moth Iversen (Denmark)
G. Hilf (Eurostat)
L. Hopkins, Z. Karpowicz, T. Rajamets (IUCN)
K. van Egmond, R.M. van Aalst, Ad Minderhoud (Netherlands)
C. Avérous, C. Chung, P. Schreyer (OECD)
M. Leonor Gomes (Portugal)
A.M. Goudyma, D. Kolganov (Russian Federation)
T. Litscher (Switzerland)
J. Martin (United Kingdom)
A. Kahnert (UNECE)
A. Diamantidis, B. Ivanov, S. Jaakola (UNEP)
I. Waddington, J. Zakonyi, M. Krzyzanowski, B. Lübkert-Alcamo (WHO)
P. Bourdeau (Head of DG XI, EEA-Task Force)
D. Stanners (DG XI, EEA-Task Force, Project Manager of the *Europe's environment* report).

WHO Regional Office for Europe

(a) European Centre for Environment and Health

B. MacGibbon (Scientific Editor)

K. Baverstock, R. Bertollini, B. Fenger, K. van der Heijden, R. Kersauze, M. Krzyzanowski, B. Lübkert-Alcamo, P. Marchandise, R. Merineau, P. Rushbrook, R. Stern, S. Tarkowski, I. Vlachonikolis, I. Waddington, P. Weigert, M. Younes, J. Zakonyi (Project Officer for the CET report).

(b) X. Bonnefoy, M.S. Burgher, P. Charlton, O. Espinoza, E. Grandjean, D. Kello, F. La Ferla, A. Nanda, A. Nossikov, R. Prokhorskas, K. Runeberg, L. Saliba, M. Shabanah, M.J. Suess, F. Theakston.

WHO Headquarters

E. Giroult, T. Kjellström.

Introduction

The Setting

Many of the great advances in public health during the nineteenth and twentieth centuries resulted from the realization that unsatisfactory water supplies, sanitation, working conditions, housing, food and air quality were major contributors to disease and short lifespans. More recently, protection of the environment for its own sake and the maintenance of biodiversity for future generations have become important political issues throughout the world. The relationship of human health and wellbeing to environmental influences is an important dimension of these issues.

The relationship between environmental factors and health is complex. Many diseases have multifactorial causes and the influence of lifestyles and social and economic factors may be difficult to separate from environmental exposures.

Over recent decades, much of the WHO European Region has experienced rapid economic growth, but the benefits of increased overall prosperity have not always been accompanied by adequate measures to safeguard the quality of the environment. This has resulted in a wide range of direct threats to human health as well as potential indirect effects, including some that may occur in the future as a result of the unsustainable nature of much economic development.

The situation is far from uniform. Basic health statistics[a] show a general improvement in levels of health within the European member countries of the Organisation for Economic Co-operation and Development (OECD) as assessed by infant and total mortality rates, life expectancy and the incidence of certain diseases. By contrast, no improvement and in some aspects a deterioration in health status has occurred in the countries of central and eastern Europe (CCEE)[b] and the newly independent states (NIS) of the former USSR over the last two decades. In addition, considerable variations occur

[a] Health for all database of the WHO Regional Office for Europe.

[b] The CCEE comprise Albania, Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and the countries emerging from the former Yugoslavia.

among different social groups within individual countries of the Region, the poor everywhere suffering more ill-health than the better off. If appropriate and cost-effective action is to be taken to create a greater degree of equity in health throughout the Region, a better understanding must be reached of the role of the environment in influencing health, compared with social and economic inequalities, lifestyles and the quality of health care systems.

The definition of environmental health given in the European Charter on Environment and Health [1] should be borne in mind:

> Environmental health ... includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and wellbeing of the broad physical, psychological, social and aesthetic environment, which includes housing, urban development, land use and transport.

While public health policies are understandably mainly directed towards relieving society of disease and premature death, the environment should also be considered as a resource for enhancing health and wellbeing. People aspire to live in communities free of environmental hazards, with decent homes in which to raise their families, with opportunities for employment, education and culture, and with pleasant and harmonious surroundings that facilitate recreation and social contact and maintain a healthy and diverse ecosystem. Effective environmental protection, in its widest sense, provides a framework for many of these aspirations, as part of enlightened and sustainable socioeconomic development.

While these are desirable aims, already within the reach of many people in the Region, the far more basic needs of many others must also be recognized and dealt with as a matter of high priority. Many millions of people in the Region still lack at least one of the essential prerequisites of environmental health: safe water, clean air, sanitation and shelter. A substantial number are without the first and most fundamental prerequisite for health, namely peace. Rehabilitation of public services essential for environmental health and resettlement of large numbers of refugees will be major international tasks when hostilities have ceased.

The Genesis of Concern for Europe's Tomorrow

If countries are to improve the health of their people, they must know what environmental conditions prevail. Concern for Europe's Tomorrow was launched to assess the state of environmental health in the Region. To explain fully how this project came about, we must go back a little in time.

In 1980, the Member States of the WHO European Region adopted a common European strategy for attaining health for all [2]. This called for fundamental changes in approaches to health development. It focused on four areas of concern: lifestyles and health, the risk factors affecting health and the environment, the reorientation of the health care system, and the mobilization of political, managerial and technological support to bring about these changes. In 1984, the Member States of the Region approved 38 regional targets encompassing these areas. Their adoption proved to be a decisive event that gave a strong impetus to the wide political acceptance and implementation of the European health for all strategy. In many countries, the concepts, principles and strategies have already become reflected in national, regional and local policies. They have also provided a solid basis for health development in the CCEE and NIS, which has been greatly affected by political change in the last five years. While retaining their basic structure, the original targets were updated in 1991 [3]. As in 1984, nine targets are directly concerned with aspects of environmental health.

Target 11 – Accidents

By the year 2000, injury, disability and death arising from accidents should be reduced by at least 25 %.

Target 18 – Policy on environment and health
By the year 2000, all Member States should have developed, and be implementing, policies on the environment and health that ensure ecologically sustainable development, effective prevention and control of environmental health risks and equitable access to healthy environments.

Target 19 – Environmental health management
By the year 2000, there should be effective management systems and resources in all Member States for putting policies on environment and health into practice.

Target 20 – Water quality
By the year 2000, all people should have access to adequate supplies of safe drinking-water and the pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health.

Target 21 – Air quality
By the year 2000, air quality in all countries should be improved to a point at which recognized air pollutants do not pose a threat to public health.

Target 22 – Food quality and safety
By the year 2000, health risks due to microorganisms or their toxins, to chemicals and to radioactivity in food should have been significantly reduced in all Member States.

Target 23 – Waste management and soil pollution
By the year 2000, public health risks caused by solid and hazardous wastes and soil pollution should be effectively controlled in all Member States.

Target 24 – Human ecology and settlements
By the year 2000, cities, towns and rural communities throughout the Region should offer physical and social environments supportive to the health of their inhabitants.

Target 25 – Health of people at work
By the year 2000, the health of workers in all Member States should be improved by making work environments more healthy, reducing work-related disease and injury, and promoting the wellbeing of people at work.

The need to achieve a better understanding of the relationship between environmental factors and the health of individuals and communities, together with the clear need for the environment and health sectors at all levels of government to work closely together, was recognized by the first European Conference on Environment and Health, held in Frankfurt-am-Main, Federal Republic of Germany, in December 1989.

The Conference culminated in the adoption, by ministers of health and of the environment and other senior representatives from 29 European countries and by the Commission of the European Communities, of the European Charter on Environment and Health [1]. The Charter sets out a broad framework for action by all levels of government, by all sectors of society and at the international level.

Subsequently, the WHO Commission on Health and Environment was established and produced a report entitled *Our planet, our health* [4] in preparation for the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. This report analysed, within the global perspective, the various ways in which the environment interacts with health in the context of socioeconomic development, and provided a series of broad recommendations for action at international, national and local levels. The Rio Conference endorsed the so-called Agenda 21 [5], an action plan for the twenty-first century that sets a far-seeing course towards sustainable development. Its health component largely reflects the findings of the WHO Commission and acknowledges that, within the overall principle of sustainability, major changes in approach are required if health impairment due to environmental degradation is to be arrested and future adverse environmental impacts on health prevented.

In response to Agenda 21, a global strategy for health and the environment was endorsed by the World Health Assembly in May 1993 [6]. An environmental programme for Europe, including an Action Programme for Central and Eastern Europe [7], was approved by an intergovernmental conference on the European environment held in Lucerne, Switzerland, in April 1993. This action programme for the CCEE accepts that health impacts are an important part of the immense environmental problems facing these countries as they move towards parliamentary democracy and market economies, although in many areas concrete information on these health aspects is lacking.

Ministers at the First European Conference on Environment and Health had already acknowledged the inadequacy of the existing database and recognized that its strengthening was a prerequisite for national decision-making and the setting of priorities. As a direct consequence of the adoption of the European Charter, the WHO European Centre for Environment and Health was established as an integral part of the WHO Regional Office for Europe. Its priority mandate was collaboration with Member States on the development of an improved information system, covering all aspects of the relationships between environmental conditions and human health.

The Development of Concern for Europe's Tomorrow

At the first European Conference on Environment and Health in 1989 [1] it was agreed that:

> European Ministers of Health and the Environment should meet again within five years to evaluate national and international progress and to endorse specific action plans drawn up by WHO and other international organizations for eliminating the most significant environmental threats to health as rapidly as possible.

In preparation for this Second European Conference on Environment and Health, which was held in Helsinki in June 1994, the WHO European Centre for Environment and Health was asked to assess all aspects of environmental health in the countries of the Region, based on available national data and other information: the project known as Concern for Europe's Tomorrow.

Since this project was first planned in 1991, many political changes have taken place in the Region and the number of WHO Member States has increased from 31 to 50. While it was impractical to collect sufficiently detailed data from the NIS, the former Czechoslovakia and the former Yugoslavia for inclusion in the main text of the report, the special conditions that exist in these countries had to be reflected. A separate chapter in this report therefore summarizes the main environmental health issues in these countries.

From the outset, it was essential to work in harmony with other international bodies involved in assessing environmental conditions in the European Region, in particular the Commission of the European Communities (CEC). As a result of the United Nations Economic Commission for Europe (ECE) Ministerial Conference held at Dobris Castle in the former Czechoslovakia in June 1991, the development of a pan-European report on the state of the environment was begun. A close working relationship has been established between the CEC secretariat coordinating preparation of this report and the project office at the WHO Regional Office coordinating the development of this book. Further, joint use has been made of some of the data available for these two complementary projects.

The major sources of information have been individual countries, international organizations and internal WHO material. Member States were invited to nominate national focal points; they came together at a planning meeting in October 1991 and agreed on the project's general concept and main lines of development. From the outset it was accepted that, in view of the short time frame, only existing data should be utilized. It was hoped that the limitations that became evident during the progress of the work would indicate priority needs and stimulate the long-term development of an effective information system after the completion of the project.

Small task forces were convened to develop questionnaires on the various sectoral issues. Countries completed the questionnaires through the newly established network of national focal points. The replies, along with data and information obtained from other sources, were thereafter analysed by the chapter managers within the WHO European Centre for Environment and Health. The process of development of the project, and this report, involved two subsequent meetings of the national focal points, which greatly contributed to its successful completion.

The Scientific Advisory Board of the WHO European Centre for Environment and Health acted as an independent peer review body for the emerging document and reviewed progress in November 1992, September 1993 and January 1994. Peer review of separate chapters was carried out by appropriate specialists.

The Scope and Purpose of Concern for Europe's Tomorrow

The main aim of the project was to provide a balanced and objective overview of the principal environmental issues of present or potential concern for health in the WHO European Region. Of course, not all issues are of equal significance and priority in terms of human health. While this book does not provide a detailed comparative risk assessment, it is meant to help achieve a better understanding of the more important environmental factors that affect the health of the overall population or of potentially vulnerable groups. It is hoped that the gap between perceived risk and actual risk can thereby be narrowed by improving public information and facilitating informed debate. This will have the twofold result that, on the one hand, people's undue worries can be allayed and limited resources devoted to the most important tasks and, on the other, authorities and individuals can be persuaded to take action to prevent risks that they do not now take seriously enough.

It is axiomatic that prevention is better than cure. In terms of environmental protection, the anticipation and avoidance of potential harm not only benefit human health and wellbeing, but are almost always more cost-effective than later environmental clean-up and treatment of disease. Such preventive action involves many different areas of government, including agriculture, energy production, housing, industry, land use and urban planning, and transport. At present, the frequent absence of a multisectoral approach to environmental health management, and the lack of effective coordination of action, result in socioeconomic development having impacts on the environment that adversely affect the health and wellbeing of the population.

This book attempts to facilitate the reversal of these practices by presenting an overall picture of the effects on health of environmental conditions throughout the European Region, thus demonstrating the need for the various sectors of government and society to interact if improvements are to be made. In view of the many transfrontier environmental issues that have public health implications, the book also tries to demonstrate the need for countries to share information systems, as an objective basis for decision-making.

The European Charter emphasized that careful environmental stewardship could not only prevent adverse effects on health but also contribute towards wellbeing. It is easier to recognize wellbeing than to provide a rigorous, scientific definition of it, and there are no satisfactory measures of the benefits of an aesthetically pleasing environment in health terms. A mutually supportive community within a diverse and sustainable ecosystem, however, bestows benefits that go beyond the prevention of individual diseases. Epidemiology has not yet succeeded in dealing with these concepts, nor are there satisfactory indicators. This book tries to develop a perspective whereby enhancement is as important as prevention, although very little quantitative information is available on this difficult but important issue.

Limitations and Constraints

The project has shown the many shortcomings in the existing databases and systems for collection, collation, analysis and dissemination. On many topics, reliable data for assessing health impacts could not be assembled. Much information is fragmented, incomplete and of doubtful relevance and/or validity, and does not undergo proper quality control procedures. Much is collected and remains within separate administrations at central, regional and local levels. Much monitoring seems to lack clear objectives and does not appear to be used in decision-making or environmental health management. Many single studies have been carried out that have not or cannot be replicated. An ever present danger is that only the positive results of epidemiological studies are quoted, while the results of well conducted studies leading to negative results are not taken into account.

All those taking part in the development of the project, whether at country or international level, were aware of these constraints and difficulties. From the beginning, they realized that it would not be possible to make a comprehensive assessment of environmental health for all parts of the Region. They nevertheless considered that the objective was so important that they were fully justified in making the attempt.

Beyond Concern for Europe's Tomorrow

The investment that is being, and will be, committed to environmental management in the interests of human health and wellbeing is large, particularly in the context of the limited total resources available. Policies must therefore be based on sound data, and decisions on priorities for action should take the cost–benefit aspects into account. Better data will facilitate a proactive stance, whereby the potential effects on health of different forms of development may be predicted and prevented, rather than waiting until remedial action becomes necessary, which may be very costly even if practicable.

However good the information system, data are not always available to support a particular course of action. While acknowledging these shortcomings, one must sometimes resist the temptation to delay action while searching for the underlying causes of problems, or for data to define their precise nature. Society must sometimes act on intuition based on experience. Such justification can be found in the sanitary movement in Europe during the nineteenth century, when great advances were made in controlling communicable diseases many years before the etiological agents were identified and the problems precisely identified by epidemiological science.

To obtain better data, harmonized and comparable data collection and management are clearly needed throughout the Region, based on the use of core indicators of environmental health. The national focal points have stressed that, to achieve this objective, they require technical support from the WHO European Centre for Environment and Health. Such information systems cannot be the prerogative and responsibility of only one authority. They require careful planning and continuing collaboration among the various sectors at all levels. Further, such systems should be designed with clear objectives. Their relevance and effectiveness can be evaluated by their ultilization in the resolution of practical issues.

The national focal points have recommended that (*a*) lessons learned from the experience of Concern for Europe's Tomorrow be fully applied at national and international levels, and (b) the information collected be periodically updated and reviewed so as to provide a more accurate and comprehensive picture of the environment and health situation throughout the Region and, as far as possible, to predict trends.

References

[1] *Environment and health. The European Charter and commentary.* Copenhagen, WHO Regional Office for Europe, 1990 (WHO Regional Publications, European Series, No. 35).

[2] *The work of WHO in the European Region 1980.* Copenhagen, WHO Regional Office for Europe, 1981.

[3] *Health for all targets. The health policy for Europe.* Copenhagen, WHO Regional Office for Europe, 1991 (European Health for All Series No. 4).

[4] *Our planet, our health. Report of the WHO Commission on Health and Environment.* Geneva, World Health Organization, 1992.

[5] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3–14 June 1992.* New York, United Nations, 1992 (document A/Conf. 151/26 (Vol. 1)).

[6] *WHO Global Strategy for Health and Environment.* Geneva, World Health Organization, 1993 (document WHO/EHE/93.2).

[7] *Environment for Europe. Ministerial Conference, Lucerne, 28–30 April 1993. Conference report.* Berne, Federal Office for the Environment, 1993.

Part I

Background

Chapter 1
Economic Sectors

1.1 Introduction

This book provides a situation analysis of health and the environment in the Member States of the WHO European Region. Owing to the political changes of recent years, these countries have nearly doubled in number and their heterogeneity has become much more apparent. This chapter describes the basic economic circumstances that largely determine the conditions and chances for development in environmental health in most of these countries.

Further, this chapter briefly outlines some of the main patterns of economic activity in the Region whose growth is essential for human development. As both socioeconomic factors and the state of the environment influence health, information on overall economic development, the structure of economies and other basic data are essential to an understanding of the mutual relationships between health, the environment and economic sectors. The question as to whether the economic environment, production and consumption are able and willing to support sustainable development is one of the most important challenges for the future.

At the end of the twentieth century, the European Region faces major political, economic, social and environmental changes. Many Member States are in a transitional phase in their political systems and socioeconomic development, as they move from centrally planned to market economies. This creates special requirements, particular possibilities and considerable constraints. This chapter highlights some of these in relation to the environmental health situation.

1.2 The WHO European Region

1.2.1 Basic features and indicators

As of January 1994, the WHO European Region had 50 Member States. Of these, 12 are

Table 1.1: The central and eastern Member States of the WHO European Region

CCEE	NIS
Albania	Armenia
Bosnia and Herzegovina	Azerbaijan
Bulgaria	Belarus
Croatia	Estonia
Czech Republic	Georgia
Hungary	Kazakhstan
Poland	Kyrgyzstan
Romania	Latvia
Slovakia	Lithuania
Slovenia	Republic of Moldova
The Former Yugoslav Republic of Macedonia	Russian Federation
Yugoslavia[a]	Tajikistan
	Turkmenistan
	Ukraine
	Uzbekistan

[a] This is not the same entity as the Federal Republic of Yugoslavia (Serbia and Montenegro).

described as countries of central and eastern Europe (CCEE) and 15 constitute the newly independent states (NIS) of the former USSR. Together, these two groups are often called countries or economies in transition, in reference to the enormous political, economic and social changes currently taking place (Table 1.1). While the developed market economies of the Region vary, they are referred to as western countries when being compared with the CCEE and NIS.

Using gross national product (GNP) per head, the World Bank classified the countries of the world into four major groups according to the level of their economic output [1]. No country of the European Region was in the first group, the countries with low incomes, but 16 were found in the group with lower-middle incomes (a GNP per head of US $636–2555) in 1991. While 10 countries had upper-middle incomes (US $2556–7910), 19 belonged to the high income group with a GNP per head of more than US $7910 (Table 1.2).

The populations of countries in the WHO European Region range from some tens of thousands to approximately 150 million, and their areas from some tens of square kilometres to about 17 million. Their economic power is also extremely diverse: the gross domestic product (GDP) per year ranges from some hundreds of millions of US dollars to more than US $1500 billion.[a] Taking the GDP per head in the United States in 1991 as 100 %, the GDP per head, in purchasing power parity, in the countries of the Region was estimated to range from 10 % to nearly 99 % [1–3]. The countries differ much less in their scores on the human development index (Table 1.2), which combines three key components (income, knowledge and longevity) to arrive at an average deprivation index [4]. An index of 0.80 or more indicates high, 0–0.79 medium, and below 0.50 low human development.

In 1991, the countries in transition had a population of about 410 million, or nearly half of the Region's total population of 850 million. For 1991, the World Bank estimated the average GNP per head in the middle income countries of the Region as US $2670, with an average annual growth rate of 0.9 % in the period 1980–1991. The GNP per head

[a] 1 billion = 10^9.

Table 1.2: Economic and development indicators for countries of the WHO European Region

Countries	Population (millions) mid-1991	GNP per head (US $) 1991	GDP (millions US $) 1991	PPC[a] estimates of GDP per head (United States=100) 1987	1991	Score on human development index 1990
Lower-middle income countries						
Albania	3.1	–	–	–	–	0.699
Tajikistan	5.5	1 050	–	11.9	9.9	0.657
Uzbekistan	20.9	1 350	–	12.1	12.6	0.695
Romania	23.0	1 390	27 610	42.3	31.2	0.709
Kyrgyzstan	4.5	1 550	–	14.2	14.8	0.689
Georgia	5.5	1 640	–	24.7	16.6	0.829
Azerbaijan	7.1	1 670	–	20.2	16.6	0.770
Turkmenistan	3.8	1 700	–	17.3	16.0	0.746
Turkey	57.3	1 780	95 763	21.0	21.9	0.717
Poland	38.2	1 790	78 031	24.8	20.3	0.831
Bulgaria	9.0	1 840	7 909	31.1	22.5	0.854
Armenia	3.4	2 150	–	24.3	20.8	0.831
Republic of Moldova	4.4	2 170	24 000[b]	23.1	21.0	0.758
Ukraine	52.0	2 340	324 000[b]	25.7	23.4	0.844
Czechoslovakia	15.7	2 470	33 172	35.0	28.4	0.892
Kazakhstan	16.8	2 470	–	23.0	20.3	0.802
Upper-middle income countries						
Lithuania	3.7	2 710	28 000[b]	29.4	24.4	0.881
Hungary	10.3	2 720	30 795	31.9	27.5	0.887
Belarus	10.3	3 110	84 000[b]	29.7	31.0	0.861
Russian Federation	148.7	3 220	1 224 000[b]	35.2	31.3	0.862
Latvia	2.6	3 410	22 000[b]	37.2	34.1	0.868
Estonia	1.6	3 830	12 000[b]	45.8	36.6	0.872
Portugal	9.9	5 930	65 103	35.9	42.7	0.853
Greece	10.3	6 340	57 900	33.8	34.7	0.902
Malta	0.357	7 280	2 500[b]	–	–	0.855
Yugoslavia	23.9	–	82 317	28.4	–	0.893
High income countries						
Ireland	3.5	11 120	39 028	42.3	51.6	0.925
Israel	4.9	11 950	62 687	60.2	60.8	0.938
Spain	39.0	12 450	527 131	50.5	57.3	0.923
United Kingdom	57.6	16 550	876 758	73.0	73.8	0.964
Italy	57.8	18 520	1 150 516	71.4	77.0	0.924
Netherlands	15.1	18 780	290 725	70.0	76.0	0.970
Belgium	10.0	18 950	196 873	71.5	79.1	0.952
Austria	7.8	20 140	163 199	72.6	79.9	0.952
France	57.0	20 380	1 199 286	78.1	83.3	0.971
Iceland	0.258	23 170	5 800[c]	–	–	0.960
Germany[d]	63.2	23 650	1 574 316	80.5	89.3	0.957
Denmark	5.2	23 700	112 084	79.1	80.8	0.955
Finland	5.0	23 980	110 033	73.0	72.9	0.954
Norway	4.3	24 220	105 929	79.8	77.6	0.979
Sweden	8.6	25 110	206 411	80.3	79.0	0.977
San Marino	0.023	–	–	–	–	–
Luxembourg	0.385	–	10 100[c]	–	–	0.943
Monaco	0.068	31 780	–	–	–	–
Switzerland	6.8	33 610	232 000	95.6	98.4	0.978

[a] Purchasing power of currencies.
[b] Data for 1990 (*2*).
[c] Data refer to 1990 (*3*).
[d] National statistical sources; data refer to 1990 and do not cover the eastern *Länder*.
Sources: World Bank *(1)*; United Nations Development Programme *(4)*.

in the high income countries of the Region was about US $ 11 000–33 000, and the average annual growth rate of GNP in all the high income economies was 2.3 % in the period 1980–1991. The average annual growth rate of GNP for all countries of the world was 1.2 % for this period [1].

1.2.2 Development of economic activities

Economic growth, the main drive of socioeconomic development, represents the aggregation of activities in the various economic sectors. Worldwide it has shown unprecedented development this century. The global GDP, estimated at US $ 600 billion in 1900, grew to US $ 5000 billion in 1960 and about US $ 21 000 billion in 1991 [1,5].

Table 1.3 shows long-term trends in economic growth in the different regions of the world. The growth of the gross world product slowed in the 1980s. The decrease was slight in the developed market economies, but very significant in both the CCEE and the NIS, as well as in the developing countries. A fall of more than 50 % in economic growth in the 1980s and its overall consequences, along with other factors, contributed to the enormous changes in the CCEE and NIS at the end of the 1980s and the beginning of the 1990s.

Table 1.4 illustrates economic growth in 1989–1993. The annual growth of GDP has considerably decreased worldwide since 1989, with negative growth in 1991 and negative growth per head in 1991 and 1992 [6]. While GDP grew in the developing countries, economic growth in the developed market economies slowed considerably, resulting in growing unemployment and inflation. In addition, the new and disturbing phenomenon of "jobless growth" has become more visible [4] and the economies in transition showed an extremely sharp decline in output. These factors have had considerable consequences throughout the European Region, and they affect the medium-term economic outlook. The optimistic early expectations for the possibilities afforded by the political changes in the CCEE and NIS have been significantly modified.

Table 1.5 shows the distribution of GDP between the different sectors of the economy. The data clearly indicate an overall decrease in the share of agriculture, an increase in the role of industry in two groups of countries, and a decrease for industry and an increase for services in the third.

1.2.3 The CCEE and NIS

The domestic economies of the CCEE and the former USSR were characterized by a

Table 1.3: Economic growth 1971–1900

	Annual average growth in GDP (%)		GDP per head (US $)[a]		Share of world population, 1990 (%)
	1971–1980	1981–1990	1980	1990	
World	3.9	2.9	–	–	100.00
Developed market economies	3.1	2.6	10 200	12 500	15.6
CCEE and NIS[b]	5.2	2.5	3 200	3 800	7.8
Developing countries	5.6	3.2	760	850	76.7

[a] In 1980 prices.
[b] Figures are for the net material product.

Sources: World Bank *(1)*; United Nations *(5)*.

lack of market signals, inefficient production and distribution, lack of incentives to increase productivity, outdated technologies, the intensive use of natural and other resources, and a seriously degraded environment. The basic objectives of the historic changes that began in these countries in the late 1980s can be organized in three main groups: building a functioning democratic system, gaining the support of the population for the painful transition to market-based economic structures, and designing a proper strategy and tactics for transforming the economy [7].

The transformation processes have encompassed all aspects of the economies and societies concerned, although conditions, the pace of change, and its results and problems may differ considerably between countries. The broad objectives and direction of change are similar everywhere. The "shortage economy" characteristic of the previous decades will cease to exist: the buyer's market is to replace the seller's market and ex-

Table 1.4: Percentage annual change in gross domestic product, 1989–1993

	Percentage change				
	1989	1990	1991	1992[a]	1993[b]
World	3.3	1.7	–0.6	0.4	2.0
(per head)	(1.6)	(0.9)	(–2.3)	(–1.3)	(0.3)
Developed market economies	3.4	2.4[c]	0.7	1.5	2.0
CCEE and NIS	2.3	–5.0[c]	–16.0	–18.4	–3.5
Developing countries	3.5	3.4	3.4	4.5	5.0

[a] Preliminary estimate.
[b] Forecast.
[c] Discontinuity in the series arising from the unification of Germany.

Source: United Nations *(6)*.

Table 1.5: Distribution of gross domestic product between the agricultural, industrial and service sectors in the countries of the WHO European Region, 1970 and 1991

Groups of countries	Percentage of GDP					
	Agriculture		Industry		Services (plus unallocated items)	
	1970	1991	1970	1991	1970	1991
Lower-middle income [a]						
Lowest	30	7	27	34	43	33
Highest	–	19	–	56	–	49
Upper-middle income						
Lowest	18	12	31	34	37	32
Highest	18	20	45	48	50	56
High income						
Lowest	3	2	32	9	46	59
Highest	17	11	49	39	62	80

[a] Changes in the membership of this group between 1970 and 1991 greatly influence the figures given.

Source: World Bank *(1)*.

cess supply is to replace excess demand. The growing number of and choice between commodities are expected to help to create possibilities of a higher quality of life for the people in these countries.

Soon after the political changes, the CCEE and NIS started to act in many fields. The first measures included liberalizing prices, eliminating subsidies, strengthening governments' budgets, controlling the money supply, regulating wages, devaluating domestic currencies to stimulate exports, and opening economies to foreign competition. Later, more systematic measures could be observed. Great changes in ownership patterns and a basic restructuring of both economic sectors and institutions became necessary to deal with the inherited macroeconomic imbalances, distorted prices and poor behavioural patterns of managers, workers and consumers, and to speed up technological development.

The establishment of new legal frameworks for the structural transformation of the economy and society has proved to be a time-consuming, difficult task. The implementation of new laws related to accountancy, banking or bankruptcy, and many other economic and social issues, require changes not only in the theoretical approach but also in the behaviour of economic agents. Producers and consumers must make their decisions, actions and responses suitable for a market-driven environment.

The structural, organizational and ownership changes in the economy constitute the fundamental elements of the current transition process. Old, large state enterprises have been transformed into several smaller companies, and a larger number of new and in general small and medium-sized businesses have come into being. Private ownership has begun to play a decisive role. For example, the number of companies in Hungary that are legal entities rose from 15 000 at the end of 1989 to about 69 000 by the end of 1992 [8].

The impact of the instruments and institutions of the market economy, however, has revealed the inefficiency of the former conditions. Economic pressure has led to the fast reduction of low-efficiency production, but new and efficient replacements have not appeared equally quickly. The trade between the CCEE and the NIS collapsed, while trade with the developed market economies has only started to grow. The lack of competitiveness of the economies of the CCEE and NIS, coupled with restrictions on trade with western countries, made it impossible to offset the enormous losses that occurred. These problems, along with the contraction of domestic demand in most of the countries in transition, led to a very sharp decline in economic output; this decline is estimated to have been more than 30% from 1969 to 1993 [9].

In addition, employment has declined substantially. In December 1992, unemployment ranged from 2.6% in the Czech Republic to 15.9% in Bulgaria. In absolute figures, Poland had 2.5 million unemployed people, Romania 929 000 and Hungary 663 000 [9]. The losses of jobs in large enterprises was far too great to be absorbed by the smaller private businesses. High rates of inflation are also a major problem in the countries in transition, although their intensity varies. Unemployment and inflation are major contributors to falling standards of living and growing poverty in large segments of the population.

Economic and social trends in the CCEE and NIS have been less favourable than envisaged. The accumulated development needs in practically every economic and social area, and the high external debt burden of most of these countries, have created enormous and increasing needs for resources. Domestic sources can supply only part of these resources, so external financing is regarded as very important.

It is now widely recognized that, despite the differences between countries, the transition processes will stretch far into the future. In addition, the countries in transition will seek much more international assistance for a longer time than originally envisaged [10,11].

The transformation process offers possibilities to build environment and health needs into the overall adjustment programmes. All the CCEE and NIS have put the correction of the underlying causes of environmental degradation somewhere on the political agenda. The proper assignment of priorities is of enormous importance, particularly in view of the general lack of resources. Reducing the immediate threats to health and improving environmental health management, while supporting and influencing economic transformation, should be vital issues in these countries.

Making quantifiable improvements in environmental health in the CCEE and NIS is not an easy task. To counterbalance both the accumulated problems and recent negative experiences, the Environmental Action Programme for Central and Eastern Europe, adopted at the ministerial conference in Lucerne in April 1993, covers both the elimination of the most urgent environmental problems and the integration of environmental concerns into economic decision-making in the Region [12]. Box 1.1 summarizes the main messages of the plan.

1.3 An Outlook for the Future

1.3.1 Some trends

While making a reliable long-term forecast about economic trends in the Region is still very difficult, important tendencies suggest the basic path that economic progress may follow [14].

- The transition to a more complex and less predictable "world political and economic order" will continue and the leadership role of some countries and groups of countries will increase.
- Differences within and between countries and groups of countries will continue to be important factors in international politics and economics, requiring the introduction of special mechanisms to eliminate the most serious problems and reduce inequalities.
- The economy as such will play an even bigger role than at present, as military solutions for all kinds of problems become less feasible.

Box 1.1: Environmental Action Programme for Central and Eastern Europe

The Programme describes the necessary policy reforms and the short- as well as the longer-term investment priorities. It forecasts that in the long term, market reforms – especially industrial restructuring – together with appropriate environmental measures will take care of a large part of the emissions causing health and economic damage in the Region. Alternative sources of employment have to be found, however, for workers in inefficient and polluting industries, which need to be closed.

In the short term, strict sequencing and prioritization of tasks are necessary and investments should address the most serious health problems. Measures to deal with problems particular to different countries should be ensured, as should support to reinforce and accelerate environmental investments by enterprises in response to environmental policies, expenditures for the operation, maintenance, repair and rehabilitation of existing public environmental services, as well as for "win-win" types (both economically and environmentally beneficial) of investment and for institution building.

The Programme describes the main regional and global environmental concerns, the institutional prerequisites to support policies, and the suggested process, means and mechanisms for implementation.

Source: World Bank [13].

- The need for more sustainable development will be greater as resources become depleted, environments polluted and environmental consciousness enhanced. Such development requires substantial changes in production and consumption patterns, as well as measures to control and eliminate pollution.
- Rapid development in science and technology will continue to create possibilities for new solutions, and sometimes new concerns. Technological improvements will result in major shifts in the economy and the structure of employment.
- Energy consumption will increase further, and energy conservation and efficiency will play a much greater role than at present. Biotechnology will continue to develop and require extensive policy and legal responses. With the further development of microelectronics, the role of communication networks will be very important.
- There is little ground for assuming that the rate of economic growth in the Region will substantially increase in the short term; unemployment and growing social problems are expected to continue to be associated with development in the long term.
- The free movement of labour, goods, services and capital investments will be gradually established inside the European Union (EU); economic growth, unemployment and widening of the Union will be the main issues facing EU countries and institutions.
- Decentralization to the local level – with serious problems, however, in reorganizing political and economic power structures, as well as in creating local capacities – will continue and have an important impact on social policies.

1.3.2 Some scenarios

Various scenarios have been prepared for economic and environmental development. The most recent, which attempt to describe the main features of economic and environmental development in Europe from 1990 to 2010, come from the National Institute of Public Health and Environmental Protection (RIVM) in the Netherlands, and are entitled Globe I and Globe II [15]. They are based on a number of other forecasts, such as the "conventional wisdom" (used in Globe I) and the "high prices" scenarios (used in Globe II) of the Commission of the European Communities; the "overall economic projections" of the United Nations Economic Commission for Europe; and the "business as usual" (Globe I) and the "accelerated policies" (Globe II) scenarios of the Intergovernmental Panel on Climate Change. Other projections on long-term trends were taken into account; these included the implications of the different EU directives (Globe I), and the recent proposals for restructuring EU agriculture (Globe II), the Montreal Protocol on Substances that Deplete the Ozone Layer (Globe I) and its London amendments (Globe II), and others.

Globe I is based on more conservative views of future political and socioeconomic development, and simply extrapolates present trends. Globe II, while being fully feasible, assumes the implementation of the best policy options, the use of the best available technology and full international cooperation. Globe I predicts a 50% increase in GDP in all the CCEE and NIS and in Turkey between 1990 and 2010, while Globe II predicts a 90% increase. Both predict that GDP in western Europe will grow by 70% in this period. The GDP per head in the CCEE and NIS is predicted to grow from 3300 ECU to 4400 (Globe I) or 5600 ECU (Globe II). Both forecast growth in GDP per head from 6700 to 10 800 ECU.

1.4 Energy

Energy production, transport, transformation and use are important contributors to socioeconomic development and thus

Table 1.6: Ranking of WHO European Member States among the 40 greatest producers and consumers of energy in the world, 1989

Country	Rank		Production (thousands of tonnes coal equivalent)	Consumption (thousands of tonnes coal equivalent)
	Producer	Consumer		
USSR	1	2	2 356 765	1 875 232
United Kingdom	6	6	280 175	288 155
Poland	13	11	167 634	173 118
Norway	14	40	166 285	30 175
Federal Republic of Germany	16	5	148 457	329 470
German Democratic Republic	22	13	94 613	124 479
Netherlands	24	18	83 240	98 622
Romania	26	17	78 742	103 902
France	28	9	66 578	220 897
Czechoslovakia	30	20	63 841	93 134
Yugoslavia	37	25	36 104	60 432
Italy	39	10	32 013	217 760
Spain	40	19	29 130	97 106
Belgium	–	27	–	57 219
Turkey	–	29	–	52 477
Bulgaria	–	31	–	44 033
Sweden	–	32	–	42 720
Hungary	–	33	–	38 760
Greece	–	37	–	31 309
Austria	–	39	–	30 452

Source: The Economist Books *(3)*.

to health, although they may also result in the depletion of natural resources, environmental degradation and health impairment. The environmental and health effects of the energy sector may be exacerbated in the future, as energy demand is rising, but concomitant improvements in energy conservation and efficiency may slow this trend.

1.4.1 Indicators and trends

Table 1.6 shows that the 40 greatest producers of energy in 1989 included 13 countries of the WHO European Region, while the 40 greatest energy consumers included 20 European countries. In addition, European Member States comprise half of the 30 countries with the greatest energy consumption per head of population [3].

In the period 1980–1991, the annual average growth rate in global energy consumption was 3.8 % in the countries with middle incomes, but only 1.5 % in the high income countries. Table 1.7 shows the annual average growth rates for some European countries between 1980 and 1991. Many of the industrialized countries of the world reduced the energy intensity per unit of economic output. In the Federal Republic of Germany, for example, GNP increased by 60 % between 1970 and 1990, while primary energy consumption grew by only 16 % and emissions of most air pollutants declined (Fig. 1.1).

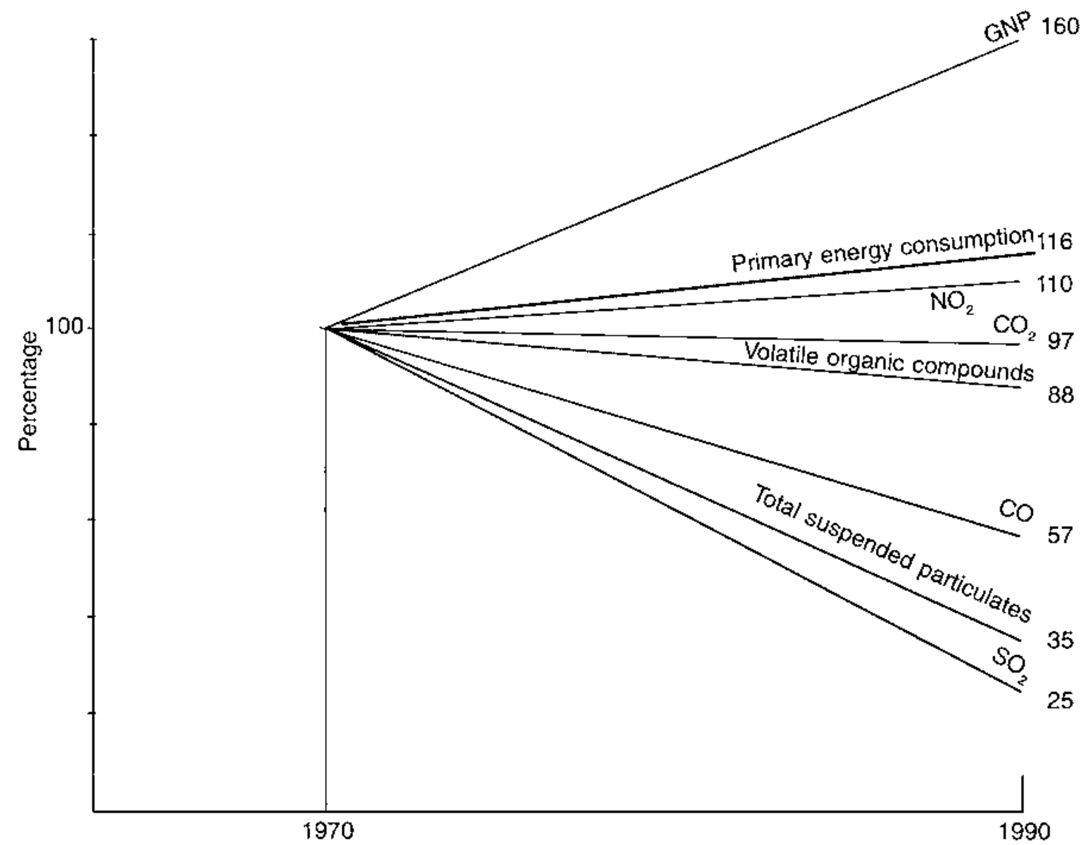
Energy balances and indicators of energy production and consumption in the EU, CCEE and NIS suggest significant differences. Fig. 1.2 shows the actual and projected changes in final energy consumption (that is, consumption of primary and secondary energy by end-use sectors: industry, households, transport, services and agriculture) in these three groups of countries between 1985 and 2005. The trends in the CCEE and NIS, however, depend on the pace of economic recovery and the nature of development. Fig. 1.3 shows the actual and projected changes in energy production.

The major energy sources currently used in western Europe and the CCEE are oil and

Table 1.7: Energy production and consumption in some countries of the WHO European Region

Country	Annual average growth rate, 1980–1991 (%)		Consumption per head (kg of oil equivalent)		Energy imports as a percentage of merchandise exports, 1991
	Production	Consumption	1970	1991	
Bulgaria	2.3	0.8	2657	3540	–
Denmark	34.0	0.0	4176	3747	5.0
France	6.3	1.2	3182	3854	10.0
Federal Republic of Germany	0.0	0.4	3077	3463	8.0
Greece	5.9	2.8	976	2110	24.0
Hungary	0.2	0.7	2053	2830	17.0
Israel	–7.4	2.3	1876	1931	11.0
Italy	1.0	0.9	2334	2756	10.0
Switzerland	1.0	1.4	3186	3943	5.0
Turkey	7.7	6.5	362	809	32.0

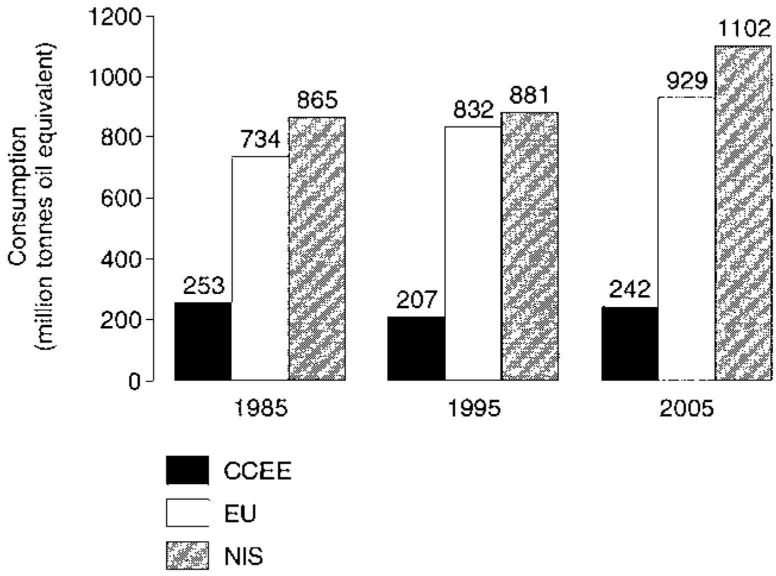
Source: World Bank *(1)*.



Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety *(16)*.

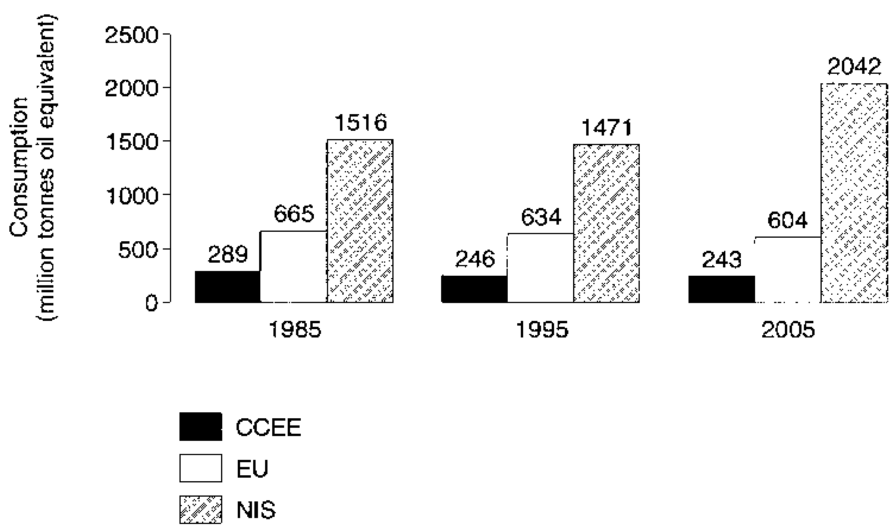
Fig. 1.1: Trends in economic growth, primary energy consumption and emissions in the Federal Republic of Germany, 1970–1990

coal, respectively; the main fuels in the NIS are oil and gas. The NIS have large resources of natural gas, oil and coal. For example, the known resources of natural gas in the Russian Federation will last about 60 years at current rates of production. The greatest increase in consumption in the NIS is predicted to be in gas [18]. Coal consumption is predicted to decrease in western Europe, with increases in the use of other fuels. In-



Source: Commission of the European Communities *(17)*.

Fig. 1.2: Actual and projected changes in total final energy consumption in the CCEE, EU and NIS, 1985–2005

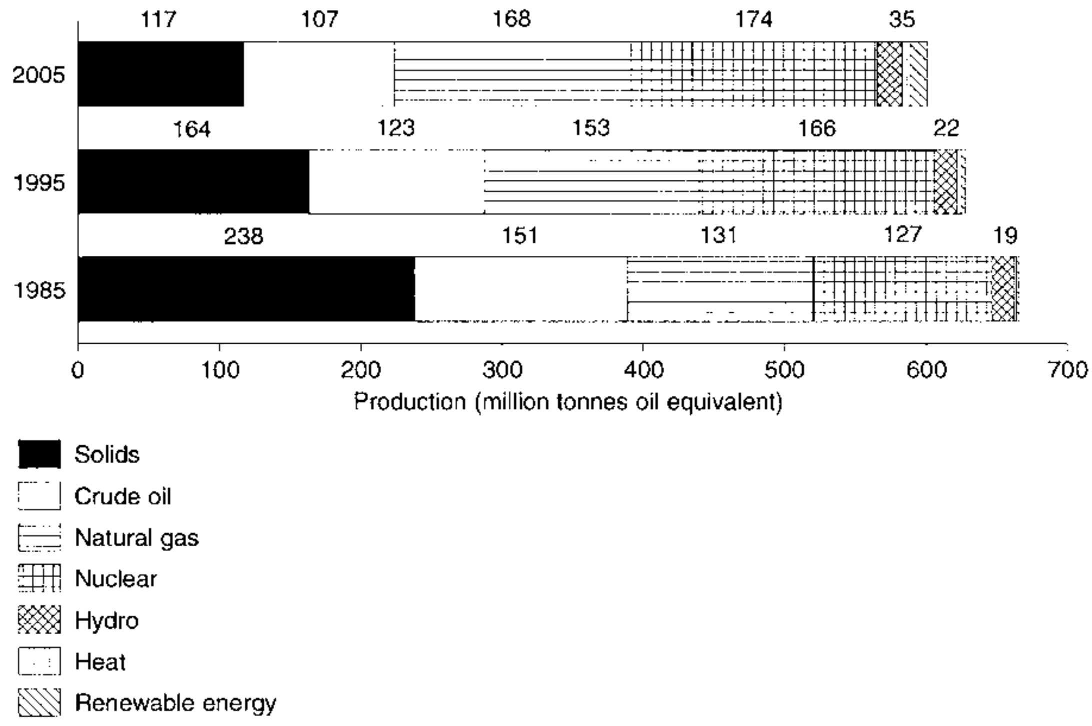


Source: Commission of the European Communities *(17)*.

Fig. 1.3: Actual and projected changes in energy production in the CCEE, EU and NIS, 1985–2005

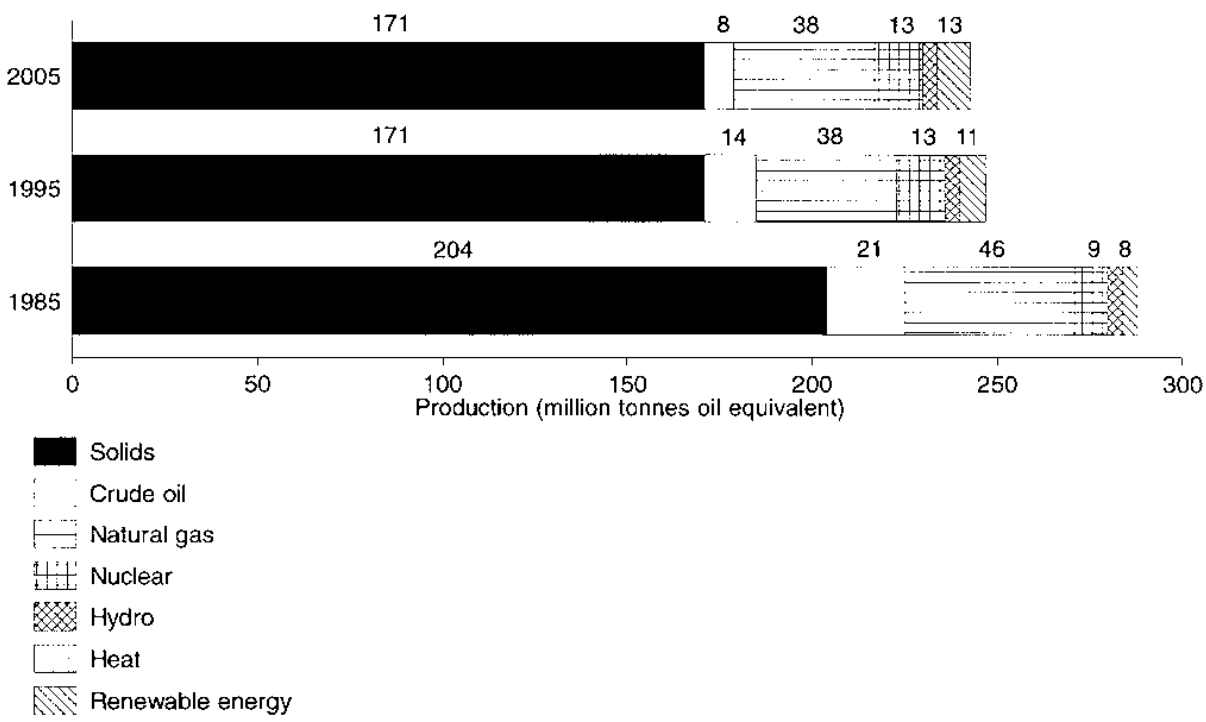
digenous coal is unlikely to be displaced as the major source of energy in the CCEE. Fig. 1.4–1.9 inclusive show the actual and projected structures of energy production and consumption in the EU, CCEE and former USSR.

The rises in the price of oil in 1973 and 1979 profoundly affected energy demand in western European countries. These countries responded with structural changes in their energy sectors, primarily increasing energy efficiency and reducing dependence on imported oil [19]. Nuclear power is now on the decline in western Europe, owing to concerns about capital costs, the risks of accidents and the problems of the disposal of high-level radioactive waste. The share of renewable energy (from sources such as the sun, wind and biomass) has increased, particularly in Scandinavia.



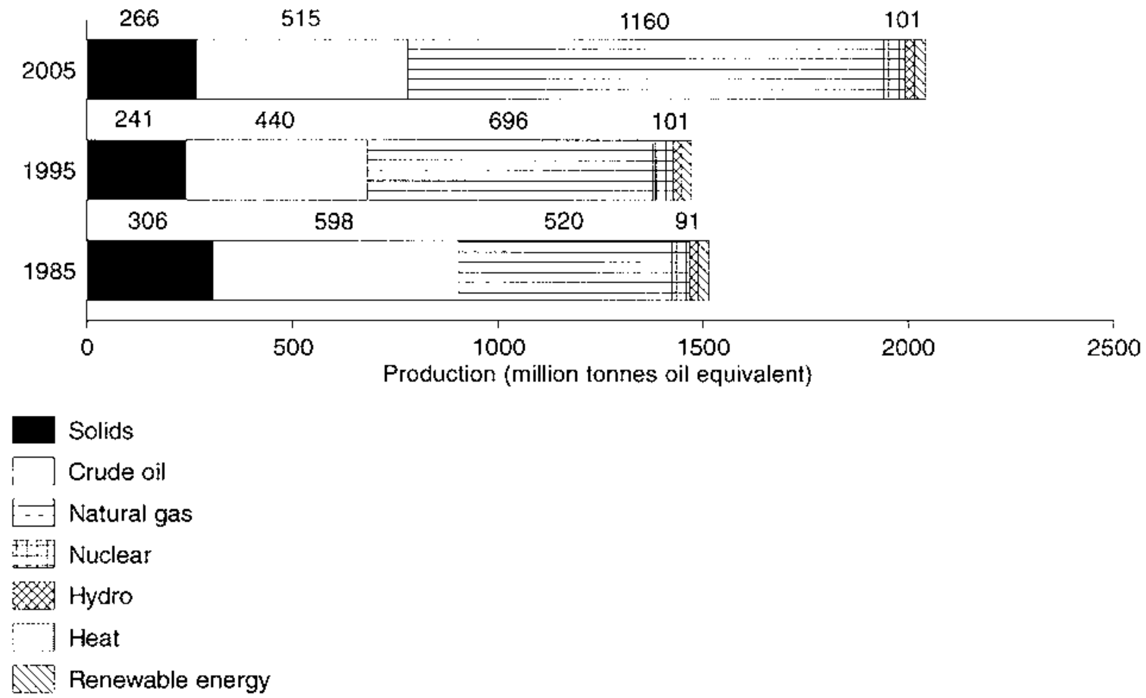
Source: Commission of the European Communities *(17)*.

Fig. 1.4: Actual and projected structure of energy production in the EU, 1985–2005



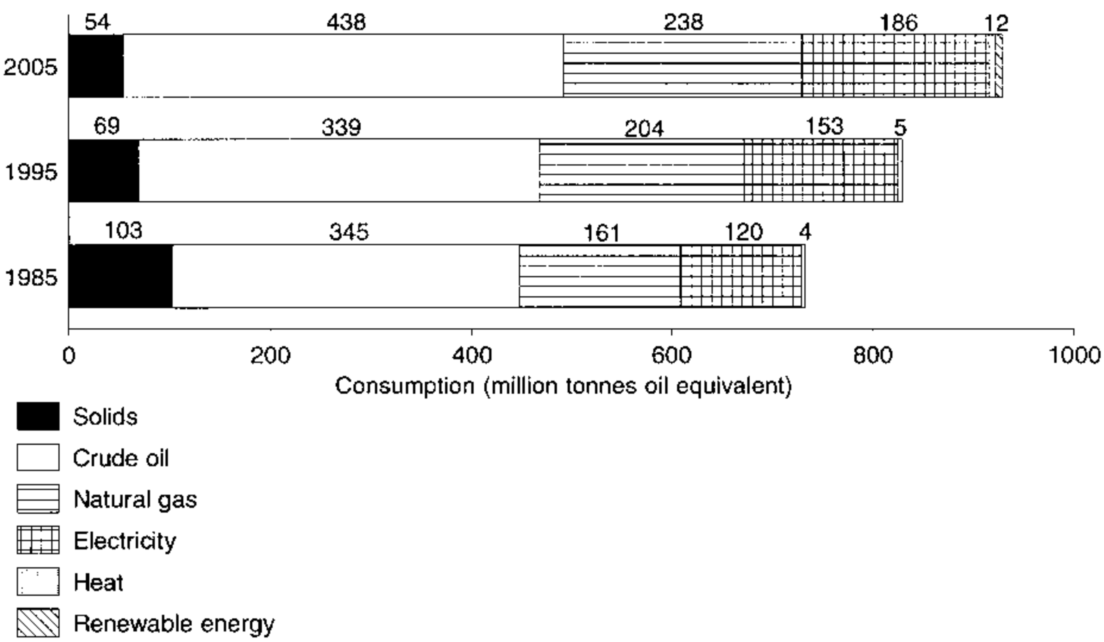
Source: Commission of the European Communities *(17)*.

Fig. 1.5: Actual and projected structure of energy production in the CCEE, 1985–2005



Source: Commission of the European Communities *(17)*.

Fig. 1.6: Actual and projected structure of energy production in the former USSR, 1985–2005



Source: Commission of the European Communities *(17)*.

Fig. 1.7: Actual and projected structure of final energy consumption in the EU, 1985–2005

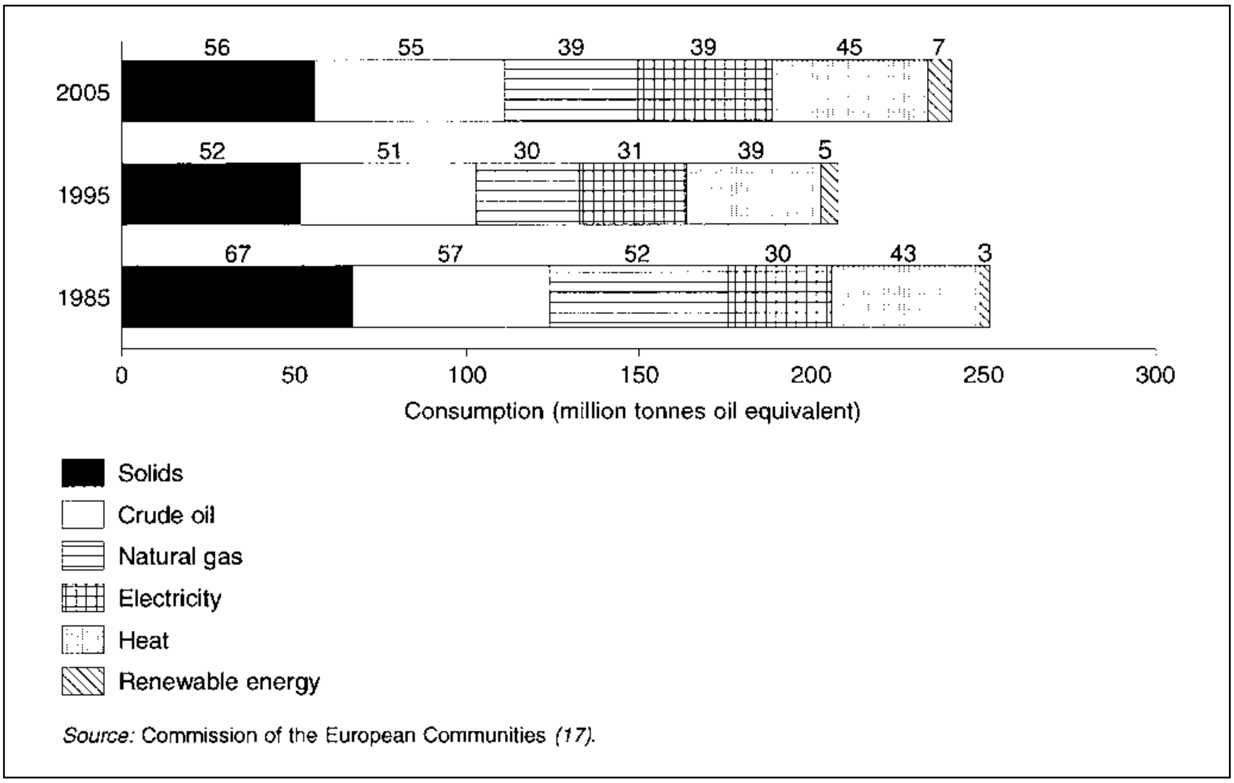


Fig. 1.8: Actual and projected structure of final energy consumption in the CCEE, 1985–2005

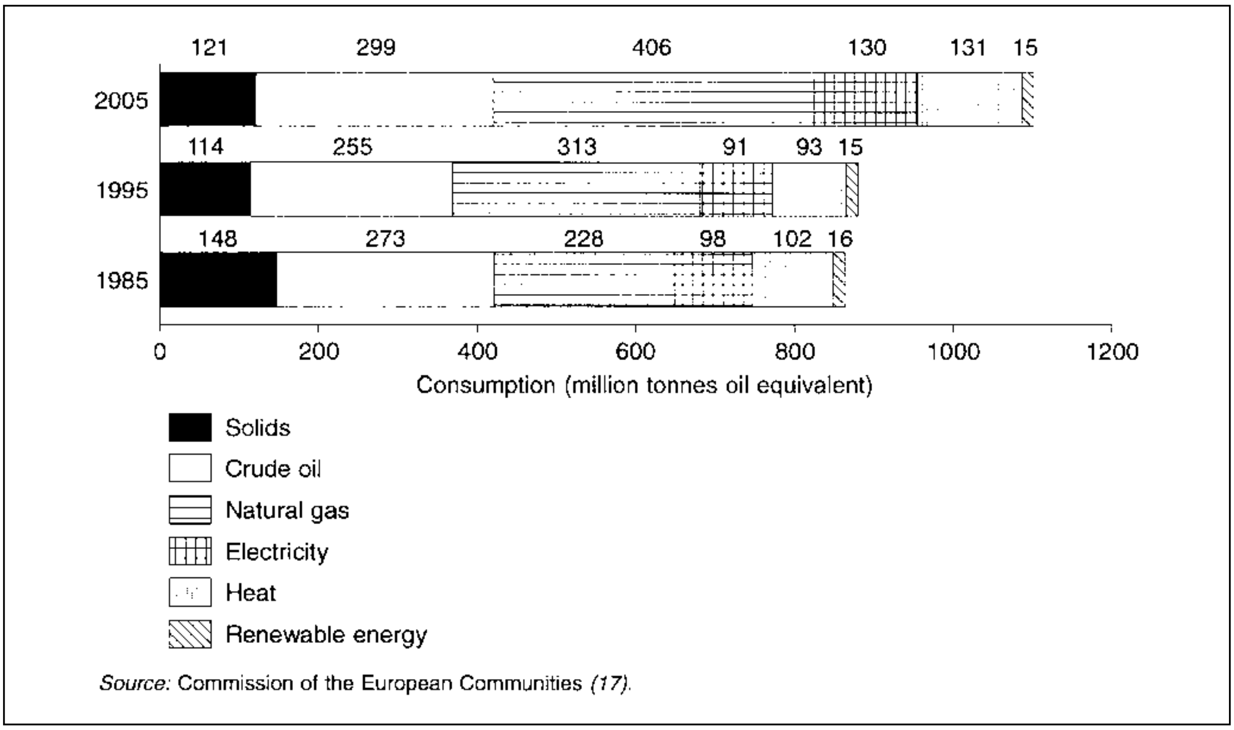


Fig. 1.9: Actual and projected structure of final energy consumption in the former USSR, 1985–2005

In the 1990s, the trend towards improving energy efficiency in conversion and in industrial and domestic use is likely to continue. In addition, many countries in the Region are beginning to adjust their energy policies to discourage the use of fuels that emit greenhouse gases. For instance, Germany has undertaken to cut carbon dioxide emissions by 25 % by the year 2005, and many other countries will cut emissions or stabilize them at 1990 levels [20]. These policies are likely to lead to an increased use of natural gas and renewable sources.

Belgium, France and Switzerland produce over 60% of their electricity from nuclear power, but in other western European countries where nuclear energy is used its share is much smaller. Hydropower currently accounts for some 12% of total EU electricity production, and this percentage share is likely to be maintained [21]. The contribution of renewable sources is small, although the economics of these sources is increasingly favourable. Their unit costs will undercut those of other fuels and thus make them competitive only in the long term.

Until the late 1980s, Soviet-produced fuels dominated energy supply and demand in the CCEE. Since then, however, these countries have had to pay hard currency for their energy imports. The countries rely heavily on domestically produced (sulfur-rich) coal. This is the most important energy source in Bulgaria, the Czech Republic, Poland and Slovakia. The share of coal in the CCEE is more than three times that in western European countries [17].

The former USSR did not really feel the shocks of the rises in oil prices in the 1970s because of its self-sufficiency in energy; it was the world's largest producer of oil and gas. Consequently, energy consumption patterns continued almost unchanged until the late 1980s.

Soviet energy policy focused on coal production until the late 1970s, when it shifted to oil, and then moved towards gas when oil production levelled off in the 1980s [22]. Coal accounts for nearly half of the domestic consumption in the CCEE, while indigenous supplies of natural gas account for 52% of domestic energy consumption in the NIS [23].

Among the most important predicted trends in the European Region is the increase in the use of gas, particularly in western countries and the NIS. These countries are shifting to gas from coal as part of an attempt to meet targets for emissions of greenhouse gases, and to diversify supplies of energy. The NIS have vast natural reserves of gas to exploit. The CCEE, however, have neither the economic nor the natural resources to be able to diversify energy supply. Although expected to use more gas, the CCEE will not do so to the same extent as western Europe and the NIS.

The amount of energy needed to produce a unit of economic output (energy intensity) is changing. In most countries belonging to the Organisation for Economic Co-operation and Development (OECD) the ratio of fuel use to GNP (or GDP) fell by about one quarter in the past decade. This has been interpreted as indicating an increase in the energy efficiency of the economic systems. It has been suggested that much greater increases can be secured, so that a sustainable energy supply can be achieved without any basic changes in lifestyle or population, for example. It seems more likely, however, that a change in behaviour towards more careful use of energy will also be required; energy conservation will be needed, as well as energy efficiency.

Conserving energy and increasing energy efficiency are crucial economic and environmental health issues in all countries of the Region, but particularly in the economies in transition. Incentives for improved energy efficiency are needed, as is investment in efficient production. More efficient technology and more strictly enforced standards, as well as incentives, are essential for success. The establishment of international infrastructures (such as pipelines and power lines) will help to encourage fuel competition, allow the export and import of energy, and facilitate the use of available productive capacities during peak periods or emergencies.

According to the Globe I scenario, the use of energy in Europe will increase by 44% between 1990 and 2010 [15]. The increase is to be lower (25%) in the western countries and higher (55%) in eastern ones. Considerable growth in the use of fossil fuels is predicted. The share of other fuels is predicted to increase slowly from 14% in 1990 to 16% in 2010. The use of nuclear energy is estimated to increase by about 45%. As 29 of the 36

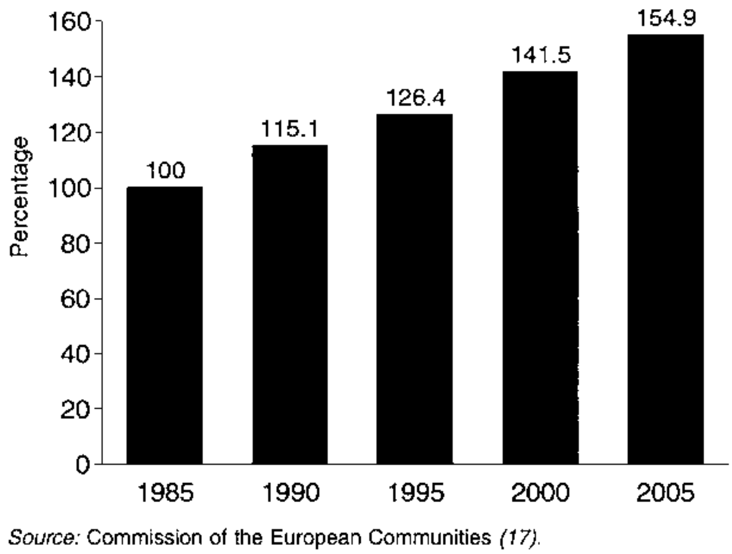


Fig. 1.10: Actual and projected growth of industrial production in the EU, 1985–2005

nuclear power plants under construction in Europe in 1991 were in the CCEE and NIS, these countries will account for most of the increase. Energy intensities in various parts of Europe will continue to differ substantially. According to Globe I, the use of energy per unit of GDP will be more than twice as high in the eastern than in the western countries of the WHO European Region.

According to the Globe II scenario, only a slight increase in total energy use (4 %) is expected [15]. Much attention will be paid to energy conservation, and to the use of energy-efficient installations in all sectors. The overall use of fossil energy in Europe will decrease by 10 %. This will result from growth in the use of renewable energy sources such as the sun, wind, water and biomass.

1.5 Industry

Industrialization is a major component of economic development and related improvements in the quality of life, but it carries the potential for environmental degradation. Many decisions in the industrial sector affect environmental health. Inappropriate choices can lead to environmental consequences that may offset many of the benefits of industrialization.

1.5.1 Indicators and trends

Member States of the WHO European Region comprised 21 of the 40 countries with the largest industrial output in the world in 1989, and about half of the 20 countries with the largest output of chemicals, machinery and transport equipment, and processed food in 1990 (Table 1.8). Between 1980 and 1991, the average rate of annual industrial growth in the Region ranged from –1.6 % in Hungary to 6.0 % in Turkey [1]. From 1965 to 1989, Turkey was the only European Member State among the 20 countries of the world with the highest average annual industrial growth, and the Federal Republic of Germany and the Netherlands were among the 20 countries with the lowest growth [3].

Industrial production in the EU has been projected to grow by nearly 55 % from 1985 to 2005, but by only about 35 % from 1990 to 2005 (Fig. 1.10). The annual average percentage change was 2.9 % in 1986–1990, and is projected at 1.9 % in 1991–1995, 2.3 % in 1996–2000 and 1.8 % in 2001–2005. These trends indicate rather moderate industrial growth [17].

Table 1.8: Ranking of WHO European Member States among the 40 countries of the world with the largest industrial output in 1989,and among the 20 countries with the largest output of chemicals, machinery and transport equipment and processed food in 1990

Industrial output			Chemical output			Machinery and transport equipment output			Processed food output		
Country	Rank	Output (billions US $)	Country	Rank	Output (billions US $)	Country	Rank	Output (billions US $)	Country	Rank	Output (billions US $)
Federal Republic of Germany	3	495	Federal Republic of Germany	3	49.03	Federal Republic of Germany	3	154.64	Federal Republic of Germany	3	33.95
USSR	4	485	Italy	4	19.29	Italy	4	61.72	France	4	26.39
Italy	5	303	France	5	18.25	France	5	60.82	United Kingdom	5	18.31
France	6	277	United Kingdom	6	16.91	United Kingdom	6	45.08	Italy	7	15.43
United Kingdom	7	266	Netherlands	11	6.33	Sweden	10	13.17	Netherlands	10	8.60
Netherlands	13	69	Belgium	13	4.73	Netherlands	12	11.31	Belgium	12	6.76
Switzerland	17	61	Sweden	14	3.49	Austria	13	8.77	Denmark	20	3.98
Sweden	18	57	Austria	16	2.36	Belgium	15	7.78			
Belgium	19	49	Turkey	19	1.85	Finland	17	5.15			
Austria	20	47	Denmark	20	1.81	Denmark	18	4.16			
Finland	21	36									
Spain	25	34									
Norway	26	32									
Yugoslavia	27	30									
Czechoslovakia	28	29									
Denmark	29	26									
Turkey	31	25									
Israel	32	23									
Poland	34	22									
Romania	36	18									
Portugal	39	17									

Source: The Economist Books *(3)*.

Table 1.9: Percentage annual change in the net material product and in industrial production in some of the CCEE and NIS, 1990–1992

Country	Percentage change: Net material product 1990	1991	1992	Gross industrial output 1990	1991	1992
Bulgaria	−17.5	−25.7	−22.0[a]	−12.6	−23.3	−22.0
Czech Republic	−0.8	−19.0	−7.1[b]	−3.3	−24.4	−10.6
Slovakia	−3.8	−19.3	−6.0[b]	−4.0	−25.4	−12.5[c]
Hungary	−3.3	−11.9	−(4–6)	−4.5	−19.1	−9.8
Romania	−7.4	−13.7	−15.4	−17.8	−19.6	−22.1
Croatia[d]	−8.5	–	−24.3	−11.0	−28.5	−14.6
Slovenia	−3.4	−9.3	−6.5	−10.5	−12.4	−13.2
Armenia	−8.2	−11.4	−42.6	−7.5	−7.7	−52.5
Russian Federation	−4.0	−11.0	−20.0	−0.1	−8.0	−18.8
Ukraine	−3.6	−11.2	−15.0	−0.1	−4.8	−9.0
Lithuania	−6.0	−6.7	−35.0[e]	−2.8	−4.9	−51.2

[a] Sales, excluding agriculture and the private sector.
[b] Gross domestic product.
[c] Covering enterprises with 25 or more employees.
[d] Gross material product.
[e] January–September 1992.

Source: United Nations Economic Commission for Europe *(9)*.

Table 1.10: Changes and structure of industrial output (at comparable prices) in Hungary, 1991/1992

Decline in output	1992 output as a percentage of 1991 output	Percentage share of industrial output 1991	1992
Above average			
Metallurgy	73.7	7.4	6.6
Engineering industry	73.2	19.2	17.0
Chemical industry (excluding products for energy purposes)	80.5	12.1	11.7
Mining	80.9	3.1	3.0
Around average			
Light industry	83.5	11.2	11.3
Below average			
Electricity industry	88.5	8.0	8.5
Building materials industry	86.4	3.1	3.2
Chemical products for energy purposes	81.9	13.0	14.4
Food industry	87.4	22.6	23.8

Source: National Bank of Hungary *(24)*.

The period 1989–1992 saw not only recession in most of the Region's countries but also a drastic decrease in the economic output of the countries in transition. Table 1.9 shows the decline in net material product and industrial output in some of the CCEE and NIS in 1990–1992. The CCEE as a whole showed decreases in net material product of 9.9%, 14.4% and 10% in 1990, 1991 and 1992, respectively. The decreases in industrial output were even greater: 15.2%, 19.6% and 11.8%. In the CCEE as a whole, industrial output fell over 40% from 1989 to 1992; some countries had a lower industrial output in 1992 than in 1975 [9].

As Table 1.9 shows, trends in the NIS are similar, although showing some delays.

Metallurgy, mining and engineering have been affected most, with light industry and some food processing industries also heavily depressed. Construction output has fallen less than that of industry. Table 1.10 indicates these processes, using the example of Hungary.

The structure of industry is an important indicator of both the stage of development and of environmental impact. The structures of industry in the western countries of the Region and the CCEE and NIS differ widely. After the Second World War large, energy- and resource-intensive sectors such as metallurgy, coal mining, construction materials and power production dominated the industrial development of the CCEE and NIS. The types of fuel and the mostly outdated, ineffective technologies used led to considerable environmental pollution and serious threats to human health. The western economic pattern, however, changed considerably in recent decades, relying increasingly on cleaner sectors and service-type industries.

An important feature of the current structural changes in the CCEE and NIS is the growing share of small economic entities. The share of those employing fewer than 50 people has increased in all the countries. In 1992, for example, small organizations in Hungary doubled their 1991 industrial output and more than doubled their share in total industrial output (from 6.4% in 1991 to 14% in 1992). In 1992, however, 20% of industrial organizations with more than 50 staff employed about 86% of industrial workers and produced 86% of the industrial output and 93% of exports [24].

Light, labour-intensive industries (such as textiles, clothing and footwear) are expected to remain highly important in the European Region. They contribute nearly 4% of the GDP and provide some 2.5 million jobs in the EU [25]. These sectors have special importance in the southern countries of the Region, and the low cost of labour and factories in the CCEE and NIS provide good chances for their development as well.

The high-technology sectors are growing in the more developed parts of the Region. The electronics and information technology industry contributes about 5% of the GDP of the EU. Its growth rate was high in the 1980s and this trend is expected to continue. By the end of the 1990s, this industry doubled its share of the GDP and thus is expected to outstrip such major industries as chemicals and cars [25]. The chemical industry, however, remains a major, prosperous industry in the Region, mostly in the more developed countries. The iron and steel industry will be increasingly influenced by resource economy efforts, that is, more efficient use of its products. Major restructuring and partial reconstruction of these industries is expected in the CCEE and NIS in the long term.

In recent years, industrial decision-makers have strongly shifted their policy towards the protection of the environment. They no longer see this goal solely as a hindrance to the growth of production. The most noticeable developments are taking place in the western countries of the Region, with an increased focus on environmental management and auditing, instigated both by regulations and by commercial competition for consumers with a greater awareness of environmental issues.

1.6 Agriculture

The ways in which agriculture meets the population's demand for food have changed greatly over the last few decades, and change continues. The difficulties in providing sufficient food in Europe in the period following the end of the Second World War led to profound changes in countries' agricultural pol-

Table 1.11: Characteristics of and changes in agriculture in groups of countries in the WHO European Region, 1977–1990

Group of countries	Cropland		Share of irrigated cropland (%)		Index of agricultural production (1979–1981 = 100)				Cereals			Average annual fertilizer use (kg/ha)		Average annual pesticide use (kt)	
					Total production		Production per head		Average increase in production between 1978–1980 and 1988–1990 (%)	Average yield (kg/ha)					
	kha 1989	ha per head 1990	1977–1979	1987–1989	1979–1980	1989–1990	1978–1980	1988–1990		1988–1990	Increase since 1978–1980 (%)	1977–1979	1987–1989	1977–1979	1987–1989
CCEE	6629	0.4	14.1	17.1	99.0	106.9	102.0	104.5	10.9	3867.0	13.8	220.4	218.5	19.6	21.7
USSR	230 630	0.8	7.0	9.0	104.0	119.0	105.0	110.0	5.0	1925.0	20.0	78.0	114.0	348.8	535.4
Western countries	4 823	0.2	11.0	13.0	99.4	108.1	101.6	106.9	16.1	4708.2	24.4	493.3	434.2	20.6	24.2

Source: World Resources Institute *(19)*.

icies. Farmers were encouraged to adopt different practices that would raise food production. In the western countries, this had impressive results. Farm output increased rapidly and clear signs that supply was outstripping demand appeared by the late 1960s. Countries then adopted different measures to limit production. For example, milk quota restrictions were introduced in Finland; in 1968, the European Community Mansholt plan proposed a range of measures aimed at checking farm output. In contrast, food production in most of the eastern countries of the Region remained in deficit.

1.6.1 Indicators and trends

Between 1980 and 1991, the average annual rate of agricultural growth in the Region ranged from −2.5% in Bulgaria to 3.71% in the Netherlands, with a world average of 2.6%. In 1991, the share of agriculture in the GDP ranged from 1–2% in Belgium and Germany (excluding the eastern *Länder)* to 20% in Latvia and Lithuania [1]. With the exception of a few countries, this share has significantly decreased worldwide in the last 20 years.

Of all the economic sectors in the European Region, agriculture is one of the most heterogeneous. For example, farms vary widely in size. The EU (excluding the former German Democratic Republic) had about 8.2 million farms in 1989–1990; 7% were larger than 50 ha and 60% were smaller than 5 ha. The average farm size was 4.0 ha in Greece and 68.0 ha in the United Kingdom; there are few data for the eastern countries of the Region [26].

Table 1.11 summarizes some of the important characteristics of and changes in agriculture in the CCEE, the former USSR and the other countries of the Region during 1977–1990. The former USSR had by far the most agricultural land both in absolute terms and per head of population, and the CCEE the highest percentage of irrigated land [19].

Between 1978 and 1990, total agricultural production increased by about 15% in the USSR, 9% in the western countries of the Region and 8% in the CCEE. Agricultural production per head in this period increased by just over 5.3% in the western countries, 5.0% in the USSR and 2.5% in the CCEE [19]. This is due in part to increasing yields from intensive farming techniques and increased fertilizer use, and partly to slower population growth.

The much greater use of agrochemicals, particularly fertilizers and pesticides, has been one of the most important factors in increasing food production in the Region. Nitrogenous fertilizer use has increased by an average of 68% over the last 20 years, while the use of phosphate fertilizers has remained fairly constant at an average of 22 kg/ha [19]. The use of fertilizer in the Region rose steadily up to 1970 but began to level off towards the end of the 1980s, except in the NIS. Pesticide use has also been critical to the success of raising the yields of European agriculture. Pesticides have been developed and used largely within the last 30–40 years, and the industry has introduced a succession of more sophisticated and effective products [19].

The demands on the agricultural sector are likely to continue to increase, particularly in some of the CCEE and NIS. Attitudes towards agriculture are changing profoundly, as criticism of both its costs and its environmental impact increases. Such criticism applies to animal husbandry, as well as the use of agrochemicals and other practices.

According to the Globe I scenario, the land devoted to agriculture will decrease by 1% in the CCEE and NIS and by 8% in the rest of the Region between 1990 and 2010, while pesticide use will remain constant. The number of livestock will rise by 28% in the Region, and the amount of nitrogenous manure will increase by 2% in the CCEE and NIS and by 5% in the other countries. The use of nitrogenous fertilizer is predicted to increase sharply: by 45% in the CCEE and NIS and by 19% in the other countries [15].

The Globe II scenario paints a rather different picture, predicting a decrease of 15% in agricultural land in the western half of the Region and the doubling of pesticide use in the Region as a whole. It indicates a smaller increase in livestock (15%) than the Globe I scenario and a 15% decrease in manure. While a 5% increase in nitrogenous fertilizer use is predicted for the CCEE and NIS, the rest of the Region will reduce its use of fertilizers by 10% [15].

1.7 Transport

The transport of freight and passengers is a vital and rapidly growing component of a country's economy. The state of development of this sector reflects the level of economic activity, and its volume and structure. Different modes of transport are used to satisfy different demands and market needs. Their services and costs, together with their unique range of environmental health effects, constitute a major issue in government policies aiming at sustainable development.

1.7.1 Indicators and trends

The 30 countries of the world with the most crowded roads in 1988–1990 included 17 European Member States (Table 1.12). Seven Member States are found among the 20 countries worldwide with the largest numbers of people injured in traffic accidents (Table 1.13).

Roads have increasingly become the most important traffic medium in the Region; on the whole, the use of the railway network is decreasing, despite the addition of new routes. The number of cars in the Region increased by 20–30% between 1980 and 1988. In 1980, there was about one car for every four people in the European Community; in 1988, the ratio was closer to one for every three. In general, cars in the CCEE and NIS are old and poorly maintained; many have highly polluting two-stroke engines [18,27]. The share of road transport is, however, lower than in the west.

The people or goods transported every year by various means are estimated in passenger-km or tonne-km. Public transport shows significantly lower emission levels per passenger-km than private cars. In addition, the increased use of rail transport would lead to even lower emissions.

Transport, particularly road transport, is one of the fastest growing markets for energy use in the European Region [17]. In 1989, transport's share of total energy consumption was 22% for the Region as a whole: nearly 32% in European Community countries and 12.6% in the CCEE [18]. Oilproducts account for 98% of all transport energy needs, and road transport is responsible for 80% of this amount. In the European Community in 1990, fuel consumption by the transport sector was roughly split between passenger transport (40%) and goods transport (60%) [28].

Bottlenecks have been predicted in the major European traffic corridors by the year 2000 if road traffic increases by more than 1.1–1.3% per year. At present, road traffic is increasing much faster; the annual rate of growth could reach 2.8% for goods and 2.9% for passengers between 1985 and 2000 [29]. Benefits from increased fuel efficiency and reduced pollutant emissions have to be assessed in the context of increasing numbers of vehicles.

The number of cars is growing faster than the population. A sharp rise in vehicular traffic and in the long-range transport of goods is predicted for many countries. Between 1991 and 2010, individual vehicular transport will rise by more than 10% in western Germany, and nearly double in eastern Germany. Long-distance goods transport by road is predicted to grow by some 70% in Germany as a whole, with around 40% growth in the western *Länder* and nearly fivefold growth in the eastern *Länder* [16].

Estimates of the future numbers and use of cars and lorries have been based on current relationships with GDP and population. Global scenarios predict a considerable in-

Table 1.12: Ranking of WHO European Member States among the 30 countries with the most crowded and the most used road networks, 1988–1990

Country	Crowding of network: Rank	Crowding of network: Number of vehicles per km of road network	Use of network: Rank	Use of network: Vehicle-km per year per km of road network (thousands)
Italy	5	90	5	972.9
Federal Republic of Germany	6	63	6	838.6
United Kingdom	6	63	3	1736.2
Netherlands	9	49	7	775.0
Switzerland	10	46	–	–
Spain	11	44	22	291.9
Luxembourg	12	38	10	645.1
France	13	35	–	–
Austria	16	30	16	464.9
Belgium	16	30	20	411.3
Portugal	16	30	–	–
Finland	20	29	13	520.2
Sweden	20	29	18	441.4
Yugoslavia	20	29	23	290.8
Denmark	24	27	14	516.4
Romania	29	23	–	–
Norway	30	21	–	–
Bulgaria	–	–	21	404.8
Ireland	–	–	24	262.2
Poland	–	–	30	164.2

Source: The Economist Books *(3)*.

Table 1.13: Ranking of WHO European Member States among the 20 countries with the largest numbers of people injured in road traffic accidents, 1988–1990

Country	Rank	Number of people injured per 100 million vehicle-km
Turkey	3	324
Belgium	10	165[a]
Spain	11	155
Portugal	12	147[b]
United Kingdom	16	109
Federal Republic of Germany	18	102
Italy	20	69

[a] Data from 1987.
[b] Data from 1986.

Source: The Economist Books *(3)*.

crease in the use of cars and lorries in the European Region for the period 1990–2010. The number of passenger cars is forecast to increase by 54% (from about 191 million in 1990 to about 294 million in 2010) and passenger-km by 55%. For lorries, an increase of 41% in tonne-km is expected over this period. The use of other means of transport is also predicted to increase: rail freight by 29% and the number of air passengers by 77% [15].

Tables 1.14 and 1.15 compare the passenger traffic and goods transport patterns in western and eastern Germany in 1990. The differences point to the possible scenarios for the future development of transport in

Table 1.14: Passenger traffic in western and eastern Germany, 1990

Mode of transport	Western Germany		Eastern Germany	
	Passenger-km (billions)	Share (%)	Passenger-km (billions)	Share (%)
Privately owned vehicles	593.8	82.0	90.0	67.5
Local public transport	65.2	9.0	24.8	18.6
Train	44.6	6.2	18.0	13.5
Air transport	18.4	2.5	0.3	0.2
Taxis and rented cars	2.5	0.3	0.3	0.2
Total	724.5	100.0	133.4	100.0

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety *(16)*.

Table 1.15: Transport of goods in western and eastern Germany, 1990

Mode of transport	Western Germany		Eastern Germany	
	Tonne-km (billions)	Share (%)	Tonne-km (billions)	Share (%)
Road				
Long-distance transport	120.4	40.1	6.2	10.5
Short-distance transport	49.4	16.5	6.8	11.5
Train	61.8	20.6	40.9	69.2
Waterways	54.8	18.3	1.9	3.2
Long-distance pipelines	13.3	4.4	3.3	5.6
Air transport	0.4	0.1	–	0.0
Total	300.1	100.0	59.1	100.0

Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety *(16)*.

the CCEE and NIS, and present a major challenge for transport policies in eastern European countries. To follow the typical pattern of western countries, with predominance of road and private transportation, would have an enormous adverse impact on the environment; reducing road transport intensity and maintaining (or even increasing) present shares of public road transportation and the railways could benefit environment and health.

1.8 Tourism

Tourism has become one of the most important economic sectors in the European Region, both for employment and contribution to GDP, and as a major item of consumer demand. More than any other industry, tourism depends for its success on the quality of the natural and built environment. Tourism can bring economic benefits; in many areas it is the greatest economic activity and source of employment. By its very nature, however, it may also have adverse effects on the environment and so jeopardize its own future development.

1.8.1 Indicators and trends

Worldwide, tourism almost tripled between 1970 and 1990, growing at nearly 5% per year. It is the third most important item in world trade, surpassed only by oil and motor vehicles. The number of tourist arrivals in Europe increased from 190 million in 1980

Table 1.16: Actual and projected international tourist arrivals in Europe, excluding the NIS, 1990–2000

Year	Arrivals		Receipts	
	Number (millions)	Percentage of world total	Amount (billions US $)	Percentage of world total
1990	271.2	63.8	–	–
1995	293.9	61.1	152	44.3
2000	380.5	60.1	206	39.0

Source: Euromonitor Corporate Publisher *(31)*.

to 288 million in 1992, with an average annual growth rate of over 3.5 % and accounting for some 60 % of the total worldwide [26,30]. Countries of the WHO European Region comprise 20 of the 40 in the world with the most tourist arrivals [3]. Table 1.16 shows the actual and projected international tourist arrivals in Europe.

Most of the northern and western European countries are net spenders on tourism; others, including a number of Mediterranean countries, Austria, Ireland and Switzerland, are net earners from tourism. Tourism makes a major contribution to GDP (between 3.1 % and 7.3 % in 1990) in Austria, Greece, Portugal, Spain, Switzerland and Turkey. In countries such as France and Italy the contribution is below 3 % of GDP.

Few data are available on the contribution of tourism to economies in the CCEE; it has so far been geared to low-budget mass tourism from within this group of countries and has accounted for less than 1 % of GDP. In Hungary, however, tourism accounts for some 3 % of GDP; in 1992, it produced a surplus of US $590 million from a revenue of more than US $1.2 billion. This considerably contributed to the surplus in the current account of the country [24].

The vast majority of tourism in the EU still focuses on the coast of the Mediterranean Sea; this accounts for 35 % of total international tourism and is the most important tourist destination in the world. The number of tourists to the Mediterranean tripled from 54 million to 157 million between 1970 and 1990, and grew sixfold in some countries such as Greece [26]. The major destinations are the coasts of Spain, the Balearic Islands, southern France, Liguria and the northern part of the Italian Adriatic coast and Sicily. Other popular areas include Cyprus, Israel, Malta and Turkey, and account for most of the remaining tourist arrivals. In northern Europe, parts of the French and Belgian Atlantic seaboard and resorts in the Netherlands and the United Kingdom attract large numbers of tourists [31].

In addition, sporting holidays of all types have grown, but the most popular activities are skiing and winter sports. The majority of ski tourism concentrates in the Alps, which also receive about an equal number of summer tourists.

A number of factors will determine the future demand for tourism; national and regional economic trends are probably the most important of these. Tourism growth rates are predicted to increase in the mid-1990s as a result of the end of the Cold War, the addition of CCEE tourism, and the effect of the single European market [31]. Once the recession that began in the early 1990s is over, consumer purchasing power is expected to increase and tourism expenditure to account for an increasing proportion of discretionary spending. The World Tourism Organization, OECD and other organizations expect that current tourism growth rates will continue, averaging about 3.4 % per year in the 1990s and reaching 380 million arrivals per year in Europe by 2000. Annual average growth rates are expected to be over 6 % per year between 1995 and 2000 [26,31].

In the CCEE, growth rates may be higher still, as well managed tourism is seen as a major focus of economic recovery. Tourism is undoubtedly one of the sectors likely to see substantial development in these countries. If well planned, it can bring substantial income to local populations, while preserving the beauty and diversity of the environment.

It has been predicted that the number of tourists visiting the Mediterranean coast will double to between 260 and 320 million by 2000 [30,32]. This is expected to be accompanied by a doubling of resident populations in Mediterranean cities, partly as a result of the building of retirement and second homes. While some 90 % of all this growth is expected to be in EU countries, some evidence suggests a trend away from passive “sun and sea” holidays in Europe, with an increase in longer, more active holidays in distant countries [30,32]. In addition, factors such as the poor environmental state of part of the Mediterranean coast, rising prices and the recession suggest that the predicted growth rates may not be achieved.

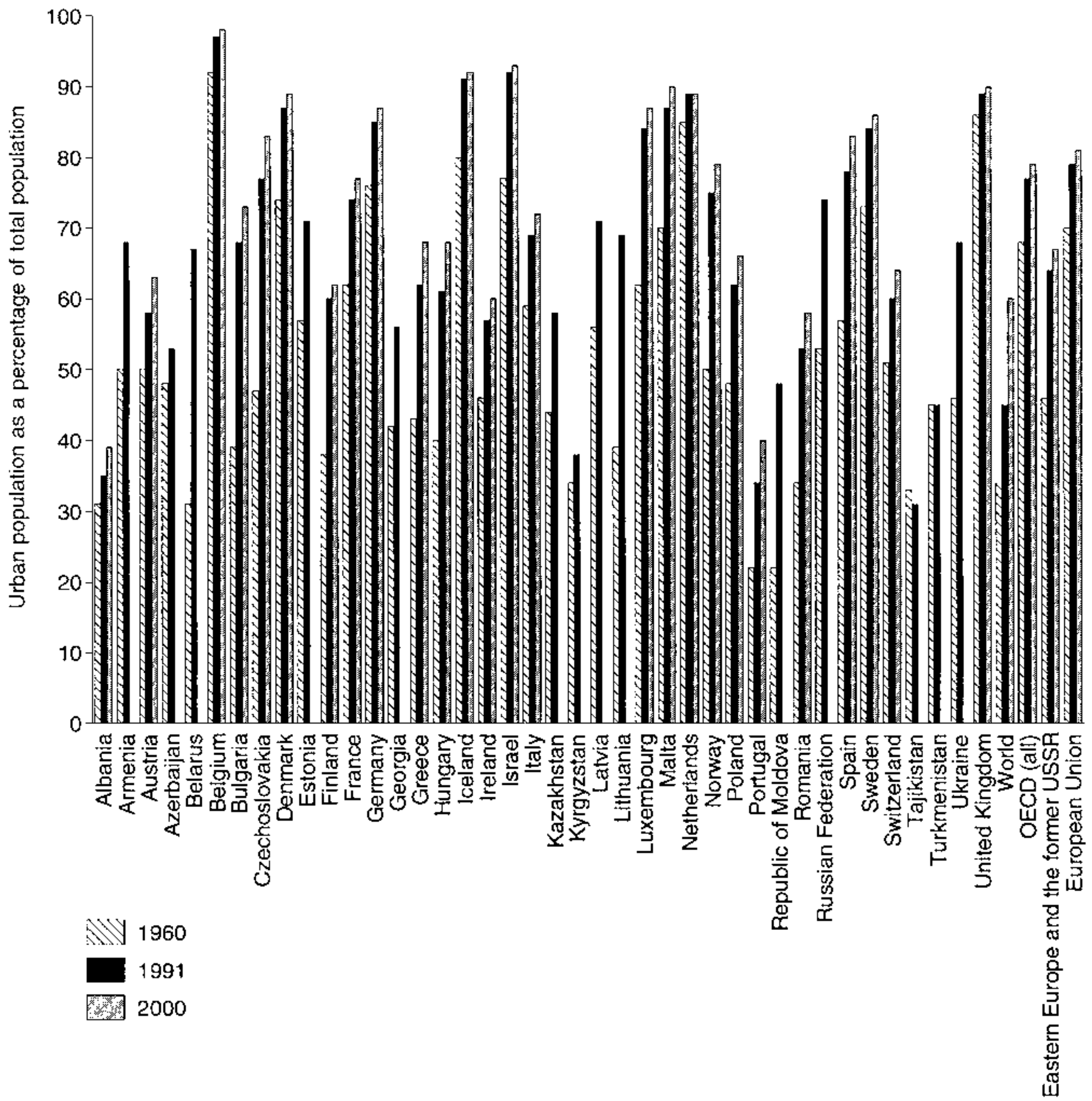
Other major factors are expected to contribute to increased tourism in all the countries of the European Region. The first of these is increased leisure time. Although annual leave entitlement is unlikely to increase in Europe, or in Japan or the United States (which supply the two major non-European tourist populations), the length of the working week is expected to decrease; this will lead to more short breaks and domestic tourism. The second is demographic change, particularly the increasing number of retired people with an acquired taste for travel, better health and higher pensions than in the past (at least in western Europe). Social factors are also relevant; for example higher female work participation rates and trends towards later marriage mean that many young couples have higher disposable incomes. An increasing interest in education, the environment and different cultures is leading to a growing interest in more environmentally sensitive types of tourism. Finally, reductions in the cost of travel, improved continental transport links and increased access to private transport, particularly in the CCEE and southern European countries, are leading to more European travel. Large numbers of people from the CCEE already visit the Mediterranean, and many western Europeans visit the historic cities of the eastern countries of the Region.

More than any other industry, tourism depends on the quality of the human and natural environment and resources for its continued success. The paradox of tourism is that, as countries or particular resort areas attract mass tourism, the resulting adverse impact on the environment may undermine future earnings from that source unless careful planning and management of resources makes development of tourism sustainable.

1.9 Urban Development

Planned urbanization involves the provision of housing, water, sanitation, transport, energy for heat and light, and waste collection and disposal facilities. In addition, a range of cultural and commercial services and facilities, such as hospitals, schools, retail centres, offices and urban industries, is required.

Between 1960 and 1991, urban population levels grew by 0.9 % per year in the European Community, by 1.2 % in the Nordic countries and by 2.0 % in the CCEE and the former USSR. As a result, the proportion of the population living in urban areas rose in this period from 70 % to 79 % in the Community, from 61 % to 78 % in the Nordic countries and from 46 % to 64 % in the CCEE and the former USSR [4]. The environmental, social and health effects of this trend can be enormous. The major problem is that the level of urban growth in many places has outstripped the capacity of municipal authorities to provide the necessary utilities and facilities. This problem is particularly severe in areas of the Region suffering from war or civil unrest;



Source: United Nations Development Programme *(4)*.

Fig. 1.11: Percentage of urban population in selected countries of the WHO European Region in 1960 and in 1991 and its forecast in the year 2000

thousands of refugees from conflict are seeking shelter in towns that now lack basic utilities and facilities.

1.9.1 Indicators and trends

In 1990, 45 % of the world's population (2.4 billion people) lived in urban areas [5]. Rapid urbanization is particularly important in developing countries, but urban settlements can also be expected to grow in some parts of the European Region, and the number of large towns will continue to rise. In addition, international migration has recently become widespread, and concern about illegal migration has grown considerably.

The populations of the European OECD countries, the CCEE and the NIS have more than doubled in the last 100 years, from around 500 million to over 1.2 billion. The urban population of these countries rose from around 120 million to 1 billion. All countries have, therefore, undergone a fundamental urbanization; the changes in most OECD countries, however, took place outside the major cities [33,34].

In 1950, with the exception of the German Democratic Republic, all the central and eastern countries in the Region were predominantly rural nations. By 1980, all but Albania, Portugal, Turkey and the former Yugoslavia had almost half of their populations in urban centres [33,34]. (See also Chapter 14.) Fig. 1.11 shows the growth of urban populations in the Region. In Belgium, Iceland, Israel, the Netherlands and the United Kingdom, around 90 % of the population live in urban areas. In 1991, the figure for the world as a whole was 44 %, and western European populations were more urbanized than those in the eastern part of the Region; the average figures for the European OECD countries and the European Community were 77 % and 79 %, respectively, in contrast to 64 % for the CCEE and USSR. The urban population in the CCEE and NIS is expected to grow to 67 % by the year 2000 [4].

The urban population is expected to continue to increase worldwide. The trend towards urbanization will be stronger in the less developed parts of the world than in the more developed, with rather large differences between more developed areas and countries [5]. The trend towards urbanization affects the trends in the economic sectors already described. As urbanization increases, so do the pressures on agriculture, energy, industry, transport and the environment.

1.10 Conclusions

The WHO European Region is extremely heterogeneous. The number of Member States has increased substantially in recent years, and their differences have become more visible with the political and economic changes they are undergoing.

Economic growth has considerably slowed down in recent years in the developed market economies, and an extremely sharp decline in output has occurred in the economies in transition. The more optimistic, early expectations of the possibilities afforded by the political changes in the CCEE and the former USSR have had to be significantly modified. It is now recognized that transition is going to be a slower process, and that international assistance must be sought over a longer period and on a much larger scale than originally envisaged.

To achieve quantifiable environmental health improvements in the general circumstances of a transition, which is in many respects aggressively profit motivated and often on a short-term basis, is not an easy task. Proper sequencing is of enormous importance, especially with the present general lack of resources. Reducing the immediate threats to health – while at the same time supporting and influencing economic transformation by building environment and health needs into development programmes and improving management – should be high on the national agenda and on those of all relevant international organizations.

As economic growth is essential to human development, the question as to whether the economic sectors are able and willing to support a sustainable pattern of development has become one of the most important in the European Region.

The targets set by the United Nations Conference on Environment and Development require, in practice, a balanced use of fuels with a decrease in the use of coal and an increase in the use of gas. Factors that have to be considered in a country's efforts to reach these targets include: the natural energy resources, the need to avoid too great a dependence on imported oil, and public concern in some countries about nuclear power. Against this background, different scenarios are developing in the different parts of the European Region. Common requirements for sustainable development in the Region, however, are substantial changes in production and consumption patterns. Conserving energy and increasing energy efficiency are crucial economic and environmental health issues in all Member States, but particularly those with economies in transition.

During the present period of recession and transition from planned to market economies, it cannot yet be predicted to what extent the CCEE and NIS will follow the pattern of the other industrialized countries of the Region and move from traditional to service industries. The pattern and scale of industrial activity are unlikely to change greatly in western Europe in the next decade. Smaller private economic entities, often with foreign capital, are regarded as important long-term elements of the economic structures in the Region.

Although agriculture is, in general, a smaller economic sector in western Europe, productivity is greater in these countries than in the CCEE and NIS. Food shortages in some of the CCEE and NIS mean that demands on the agricultural sector are likely to increase, and to be accompanied by the use of more intensive farming practices.

The number of cars in the Region continues to rise (despite considerable population stability) and a rapid increase will presumably take place in the CCEE and NIS when the economic situation improves. Environmental effects associated with road transport are therefore likely to become more widely prevalent in the European Region. The vehicle stock in the CCEE and NIS requires considerable improvement.

Tourism is expected to increase throughout the Region, particularly in established tourist areas such as the Mediterranean coast and the Alps. Unfortunately, these areas already show inadequacies in meeting requirements for safe sewage disposal and drinking-water supplies. In the CCEE, tourism is undoubtedly one of the sectors likely to see substantial development and is thus a major focus of economic recovery.

The CCEE and NIS still show increasing urbanization, whereas the trend seems to have peaked in western Europe. Current economic conditions encourage the flow to towns of people searching for work, while making it more difficult for municipalities to provide the necessary housing and public health services.

References

[1] World Bank. *World development report 1993. Investing in health.* New York, Oxford University Press, 1993.

[2] *Atlas of the new Europe.* London, The Economist Books, 1992.

[3] *Pocket world in figures.* London, The Economist Books, 1992.

[4] United Nations Development Programme. *Human development report 1993.* New York, Oxford University Press, 1993.

[5] *The relationship between demographic trends, economic growth, unsustainable consumption patterns and environmental degradation.* Geneva, United Nations, 1991 (document A/CONF. 151/PC/46).

[6] *The world economy at the end of 1992. Background for an international policy agenda.* New York, United Nations Economic and Social Council, 1993 (document E/1993/INF/1).

[7] *Impact of the evolution of east-west relations on global growth and development.* New York, United Nations, 1993 (document A/47/4O3).

[8] Portes, R., ed. *Economic transformation in central Europe. A progress report.* Luxembourg, Office for Official Publications of the European Communities, 1993.

[9] *Economic survey of Europe in 1992-1993.* Geneva, United Nations Economic Commission for Europe, 1993.

[10] *Economic survey of Europe in 1990-1991.* Geneva, United Nations Economic Commission for Europe, 1991.

[11] *Economic survey of Europe in 1991-1992.* Geneva, United Nations Economic Commission for Europe, 1992.

[12] *Environment for Europe. Ministerial Conference, Lucerne, 28-30 April 1993. Conference report.* Berne, Federal Office for the Environment, 1993.

[13] *Environmental Action Programme for Central and Eastern Europe*. Washington, DC, World Bank, 1993.

[14] *Future trends in society and the European health for all strategy.* Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/HSC 013(B)).

[15] *The environment in Europe: a global perspective.* Bilthoven, National Institute of Public Health and Environmental Protection, 1992.

[16] *Environmental policy: climate protection in Germany.* Bonn, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 1993.

[17] *Energy in Europe: a view to the future.* Brussels, Commission of the European Communities, 1992.

[18] *Energy yearly statistics 1991.* Luxembourg, Office for Official Publications of the European Communities, 1992.

[19] WORLD RESOURCES INSTITUTE. *World resources 1992–93: towards sustainable development.* Oxford, Oxford University Press, 1992.

[20] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. *Climate change: the IPCC response strategies.* Geneva, World Meteorological Organization and United Nations Environment Programme, 1990.

[21] Energy for a new century: the European perspective. *Energy in Europe,* June 1990.

[22] COOPER, R.C. & SCHIPPER, L. *Energy use and conservation in the USSR: patterns, prospects and problems.* Berkeley, CA, Lawrence Berkeley Laboratory, 1992 (document LBL 2983O).

[23] *Energy balances of OECD countries.* Paris, Organisation for Economic Co-operation and Development, 1992.

[24] *Annual report.* Budapest, National Bank of Hungary, 1992.

[25] *Europe 2000. Outlook for the development of the Community's territory.* Luxembourg, Office for Official Publications of the European Communities, 1991.

[26] *The environment in Europe and North America: annotated statistics 1992.* New York, United Nations, 1992 (Statistical Standards and Studies No. 42).

[27] GEMS MONITORING AND ASSESSMENT RESEARCH CENTRE. *Environmental data report.* Oxford, Blackwell, 1989.

[28] *Effects of best available technologies for vehicle fuels.* Starnberg, Regio-Tech GmbH, 1991.

[29] *The state of the environment in the European Community. Overview. Vol. III.* Luxembourg, Office for Official Publications of the European Communities, 1992 (document COM(92) 23. final).

[30] BEEKHUIS, J. *Travel and leisure: world travel overview.* New York, American Express Publishing Corporation, 1989.

[31] *European tourism 1992.* London, Euromonitor Corporate Publisher, 1992.

[32] *Lifestyles, environment and development. A European perspective.* Nairobi, United Nations Environment Programme, 1992 (UNEP Reports and Proceedings Series No. 4).

[33] O*ur planet, our health. Report of the WHO Commission on Health and Environment.* Geneva, World Health Organization, 1992.

[34] WHO COMMISSION ON HEALTH AND ENVIRONMENT. *Report of the panel on urbanization.* Geneva, World Health Organization, 1992.

Chapter 2
Environmental Health Management

2.1 Introduction

The countries of the WHO European Region vary widely, not only in geography and culture but also, and more importantly, in their current social and economic conditions. As a result, the countries also vary widely in their perspective on environmental health issues and in their environmental health services. Some countries have well established services that can trace their origins back 100 years or more, while others are only now developing services for environmental health work.

Since the demise of the USSR, the international community has largely focused on the environmental damage that the former administrations bequeathed to the countries of central and eastern Europe (CCEE) and the newly independent states (NIS) of the former USSR. Efforts have concentrated mainly on assessing the problems in the physical environment and setting priorities for direct capital investment.

The breakdown of formerly strong economic alliances has affected environmental conditions in the whole of the eastern part of the Region. Without the aid of heavy subsidies and with the loss of previously reliable trading partners, industrial production has fallen, leading to the reduction of some emissions of pollutants. This short-term reduction, however, will not necessarily continue when market forces are in operation. Positive action is required to ensure that lower levels of environmental contamination are maintained. This can take the form of laws and regulations, and may involve incentive or disincentive policies.

Economic reforms will directly affect the environment. The transition to a market economy from one of centrally controlled planning will lead to a broad change of attitude and will give the CCEE the opportunity to begin to reform business practices. The waste of natural resources that has been commonplace will, it is hoped, now be heavily resisted; the removal of subsidies on various commodities should provide a sufficiently large incentive for the introduction of more economical practices.

Again, however, the creation of a market economy cannot, on its own, be assumed to ensure improvement of the environment; a mix of economic, social and regulatory reforms is required to create a comprehensive strategy for control. Such a strategy can be balanced, be adapted to changing circumstances, and recognize the important needs of economic growth while effectively controlling environmental health problems. Developing these strategies requires investment in areas other than the direct financing of capital programmes. Investment will also be needed in education and in building institutions. Environmental health policies and strategies are of no value unless they can be implemented and monitored by suitably qualified and motivated personnel, situated in appropriate institutions with the necessary capabilities.

The policy of the WHO Regional Office for Europe includes supporting the development of environmental health services. To this end, a survey was carried out during 1993 to assess the current level of provision and to identify areas for development and improvement. This work complements the calls made through Agenda 21 [1], the Lucerne Declaration [2] and *Towards sustainability* [3] to improve institutional development in environmental health.

In general, western European countries have well established environmental health policies and the appropriate institutions to implement them. The eastern part of the Region may learn much from the other countries' experience in this area, their successes and failures and the means by which environmental health policies and services can be developed. Indeed, some of the southern countries of the Region that are still developing environmental health services could provide invaluable examples for these countries at the beginning of the process.

2.2 Environmental Health Services

In 1989, WHO defined environmental health as comprising those aspects of human health and disease that are determined by factors in the environment [4]. It also refers to the theory and practice of assessing and controlling environmental factors that have the potential to affect health. This is a far-reaching definition. To establish "environmental health" in a country or region, governments must set and then implement policies to control environmental factors. The services needed to implement such policies can be developed in a variety of ways, depending on a number of social, economic and cultural factors. This chapter describes how environmental health services are provided in the European Region, and the essential components of their development.[a]

The policy that a country adopts to deal with environmental health issues will reflect its social and economic situation. All policies, however, require implementation and monitoring, in which environmental health services are a vital element. The services act as the interface between the policy-makers and the economic sectors that are subject to control by the policy. They also have a direct relationship with the general public, in dealing with complaints and concerns relating to environmental health issues. Services must therefore be appropriately targeted and responsive to public needs while representing the views of the controlling authority, whether at the local, regional or national level.

Environmental health services are the cornerstone of any policy dealing with environmental or public health protection. They are intended to carry out duties that facilitate the implementation and monitoring of the policy, and to ensure its effectiveness. More specifically, they may be called upon to advise and educate members of the public and the business community on compliance with laws and standards on environmental health, to enforce such laws and standards, and to administer and monitor other services related to public or environmental health.

The range of subject areas covered under the title of environmental health vary between countries; they are so diverse that no single profession or institution can deal with them all. Some professions or agencies may

[a] The information presented was gathered during a series of WHO missions to countries.

Box 2.1: Coastal protection in Greece

Greece has a coastline of about 16 000 km, the longest in the European Union and one of the longest national coastlines in the world. No part of the country is more than 100–120 km from the sea, even at the northern borders.

The primary responsibility for the protection of the Greek environment, including the coastal marine environment, lies with the Ministry of the Environment, Town Planning and Public Works. The Ministry of the Merchant Marine, however, is responsible for dealing with pollution incidents from ships or coastal industries, and for settlements discharging sewage directly to the sea. These problems are therefore the concern of the port authorities or coastguard, a body with a status intermediate to that of the merchant marine and the police, with the power to impose fines and prosecute polluters of coastal waters.

This divided responsibility and the lack of integration between the environmental and merchant marine inspectorates lead to difficulties in implementing any national pollution control strategy, while the length of the coastline makes it difficult to impose proper monitoring and controls. Without the appropriate implementation of existing legislation, illegal practices almost certainly occur. The lack of appropriately trained and qualified enforcement officers in the merchant marine inspectorates ensures the continuation of this situation.

deal with many aspects of environmental health and yet seek technical advice elsewhere; or they may deal primarily with one dimension of environmental health control, such as the enforcement of laws, rather than the direct provision of services to the public or industry (Box 2.1).

Police officers are used to enforce environmental health law on, for example, noise and retail food sales in some countries of the Region. Their general knowledge of and experience in law enforcement can add to the authority of technically trained inspectors, but their lack of technical knowledge can reduce their credibility when collecting evidence or giving evidence in court. Separating the advisory and enforcement functions can have the added advantage of creating effective working relations between the environmental health services inspector, acting as an adviser, and an enterprise.

The example given above demonstrates how environmental health services address more than just a technical subject, such as the control of air pollution or food. They must deal with different aspects of the overall environmental health control strategy. Some countries rely heavily on the services of a single professional group, such as the environmental health officers in the United Kingdom; they can be responsible for a great many aspects of control enforcement, education and other forms of policy administration. No country in the European Region can claim to operate a service that is totally comprehensive and independent. The comprehensiveness of services obviously varies, according to the traditions and evolution of services in each country. In all cases, however, ensuring a comprehensive service requires the development of strong intersectoral links between the various instruments and institutions involved in formulating and implementing policy.

2.3 Intersectorality

The range and diversity of subject areas that comprise the topic of environmental health lead many people to advocate a multidisciplinary approach to policy formulation and the delivery of environmental health services. Such an approach can ensure that a coherent view is used to set priorities that will not conflict with those of other social and economic

Box 2.2: Cooperation of ministries in Bulgaria

In Bulgaria, work on environmental health is changing greatly. Under the previous centrally controlled administration, the ministries of health and of the environment viewed their roles as separate and distinct. The Ministry of the Environment concentrated on environmental damage, without necessarily referring to health, while the Ministry of Health concentrated on primary health care and various aspects of public health. Obviously, in dealing with such closely related fields, the work of the two ministries sometimes overlapped. It was therefore wasteful of resources and sometimes counterproductive.

In recognition of the pitfalls of such a system, the Ministry of the Environment has established a new institutional framework to deal more effectively with policy formulation and environmental health service delivery. First, the Ministry has created a new policy forum: an Interministerial Council with representatives from all the relevant ministries in the Bulgarian Government. This intersectoral Council will advise on the best way forward on environmental health issues, while keeping in mind the other social and economic needs and policies of the country. Such an approach allows a realistic view of important problems by examining issues as a whole rather than in isolation, and permitting strategic preparatory planning instead of ad hoc responses to crises. To support the Council, and to further develop an intersectoral approach to environmental health services, the Ministry of the Environment has established a unit dealing with ecological risk assessment. It is to be headed by a medical doctor or a toxicologist, and will complement the unit in the Ministry of Health that deals with health risk assessment.

With the Ministry of the Environment, the Ministry of Health has carried out environmental monitoring since 1975. Both ministries have agreed to exchange information on their regulatory activities related to environmental health. At present, most environmental health problems are addressed jointly by the two ministries.

policies. In particular, the liaison between environment and health ministries needs to be strong when an environmental health service is developed. Each ministry will undoubtedly have its own traditional role in related subject areas. To prevent the duplication of effort or the formulation of contradictory policies, however, many countries have realized that both ministries must work closely at the national and local levels to develop an intersectoral approach to environmental health (Box 2.2).

Other countries have different mechanisms for liaison and communication between ministries. These may be formal or may rely on good will and personal contacts. Obviously an informal mechanism is more likely to fail as a result of personnel changes or departmental restructuring. In many smaller countries, however, informal links between departments and sectors are widely used and accepted.

2.4 Involvement at the Local and Regional Levels

Environmental health services are normally delivered at the local or regional level, in response to local or regional demands. In the European Region, however, there are several different systems of controlling the delivery of services. While many countries have a tradition of control through central planning, the trend in the Region is to shift decision-making power to regional and local administrations. Many countries are attempting such a transfer, but in several cases the necessary infrastructures are not yet in place. The desire for quick reform has sometimes meant that power has been devolved to the local level without the necessary means or mechanisms to implement policies. This can lead to frustration and disillusionment

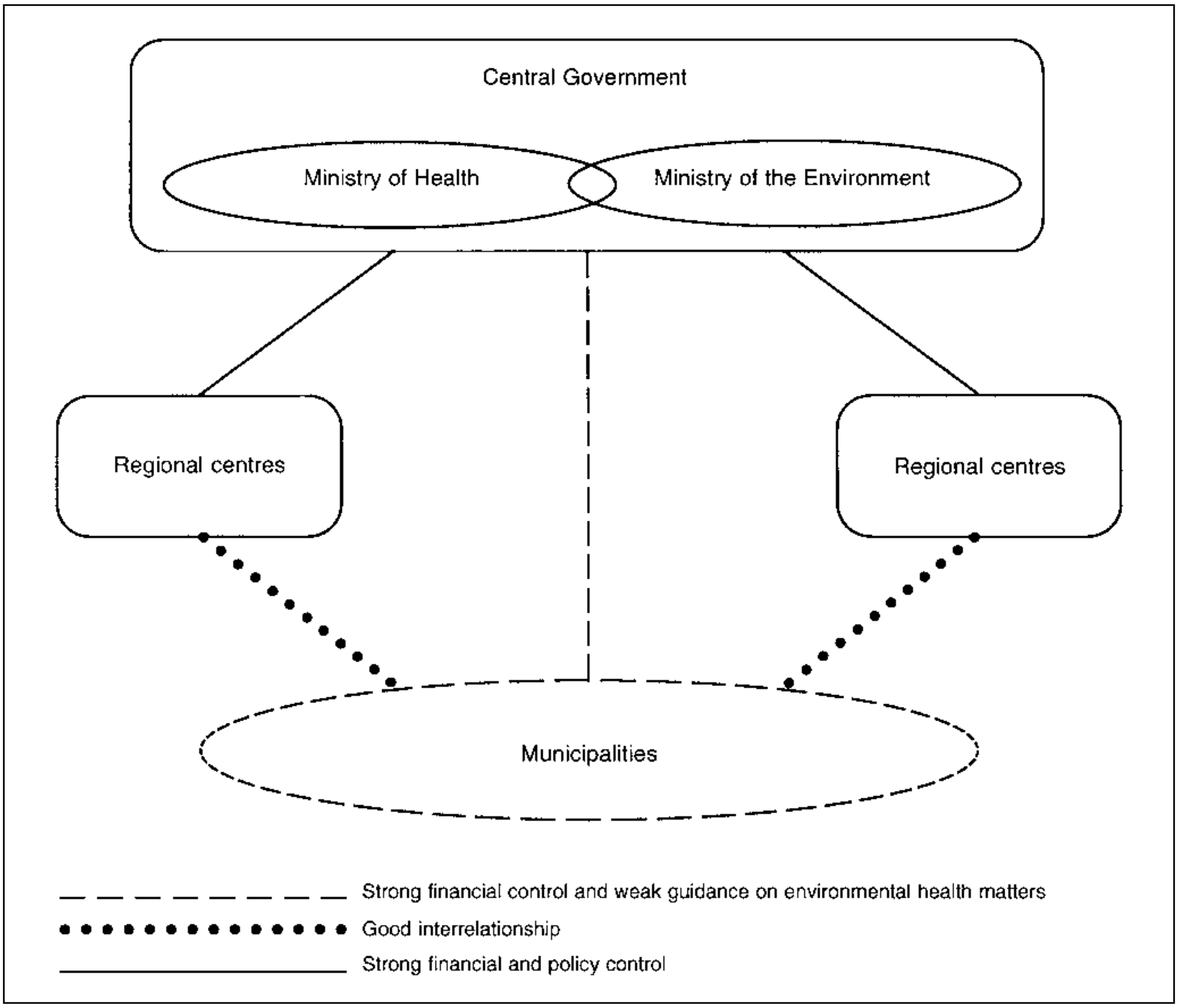


Fig. 2.1: Environmental health services in Bulgaria

in the local administration, and mistrust and resentment in the population that the administration tries to serve.

In the CCEE and NIS the central administration still controls many local services, and vertical or "top down" controls are applied to regional offices of the central ministries (Fig. 2.1). Although these units are geared to deliver services at the local level, they cannot easily respond to particular local needs, and they may not necessarily offer the service that the local population wants or requires.

In this respect, municipalities can contribute significantly to the appropriate provision of environmental health services. Municipalities, controlled democratically by locally elected representatives, can give the local population a sense of control and ownership of the services provided. A centrally formulated policy is obviously needed as a framework for the efforts of municipalities. This can ensure a consistency of approach, with local commitment to national policies. Within the framework, however, municipalities should be permitted to adapt and develop their priorities, and to obtain the means of financing their activities. Further, the provision of environmental health services by a municipality allows an intersectoral approach, linking environmental protection with public health functions. It also means that considerations of environmental health can be built into local decision-making and fiscal processes. Services provided at the regional level by satellite offices of central ministries do not always offer the same opportunities for intersectoral collaboration (Box 2.3).

Box 2.3: Regional and local administration in Estonia

In Estonia, the Health Protection Inspection Department in the Ministry of Health operates 21 regional offices of the Health Protection Service in the 15 administrative districts, in 4 major towns and at border control points. The highly centralized organization and detailed regulations of the Service mean that local influence on the setting of priorities is very limited.

The main tasks of the Service are inspection, control, monitoring and the collection of data. It is involved in local planning and environmental impact assessment as far as health issues are concerned. It can impose various sanctions for non-compliance with requirements.

The local offices are not subject to control by municipalities, which has both advantages and disadvantages. The current system allows these offices to be independent of local politics and financial constraints and to make unbiased, considered decisions. They cannot, however, develop environmental health services beyond the centrally controlled priorities, and they are not accepted by the local public.

In 1990, Local Nature Protection Departments were founded in 4 major towns and the 15 districts. They are responsible for setting tax rates to protect natural resources and to control pollution, for issuing permission for the use of natural resources, for determining limits in natural resource management, and for carrying out environmental impact assessments at the local level. The departments are subordinate in terms of organization to the local district authorities, but the Ministry of the Environment supplies coordination, general standards and policies.

The representatives of the Nature Protection Departments in neighbouring districts meet regularly. These departments and the Health Protection Service cooperate because they carry out similar or overlapping activities, but each type of unit distrusts the abilities and intentions of the other. The Health Protection Service accuses the Nature Protection Departments of being interested only in technical problems and collecting pollution taxes, not in the health problems of the local population. The Departments, considering themselves a new type of institution, accuse the Service of being unwilling to cooperate, closely bound to former modes of thought and action, and unable to use modern methods and technologies.

In addition, a two- or three-tier system can provide environmental health services at different levels. Such systems are commonly found in western Europe, where central government authorities and services take responsibility for matters of strategic and national importance, while municipalities provide services at the local level.

In summary, the powers and responsibilities of services at the local level are quite unclear and continuously developing. Highly centralized and highly decentralized structures work in parallel and sometimes in opposition. The central authorities alone set standards and regulations, but they are continually hindered in this work by political decisions to decentralize. A compromise – local decision-making within a strong national framework – is required for the effective delivery of services.

Whatever the structure adopted to provide environmental health services at the local level, the services must be adequately financed. The local unit’s ability to pay will determine its ability to carry out any planned programmes. Centrally controlled units are normally centrally funded, with little ability to develop new ways of obtaining resources. Municipalities can usually raise tax revenue from the local population and businesses to supplement central funding, but municipalities throughout the Region complain that

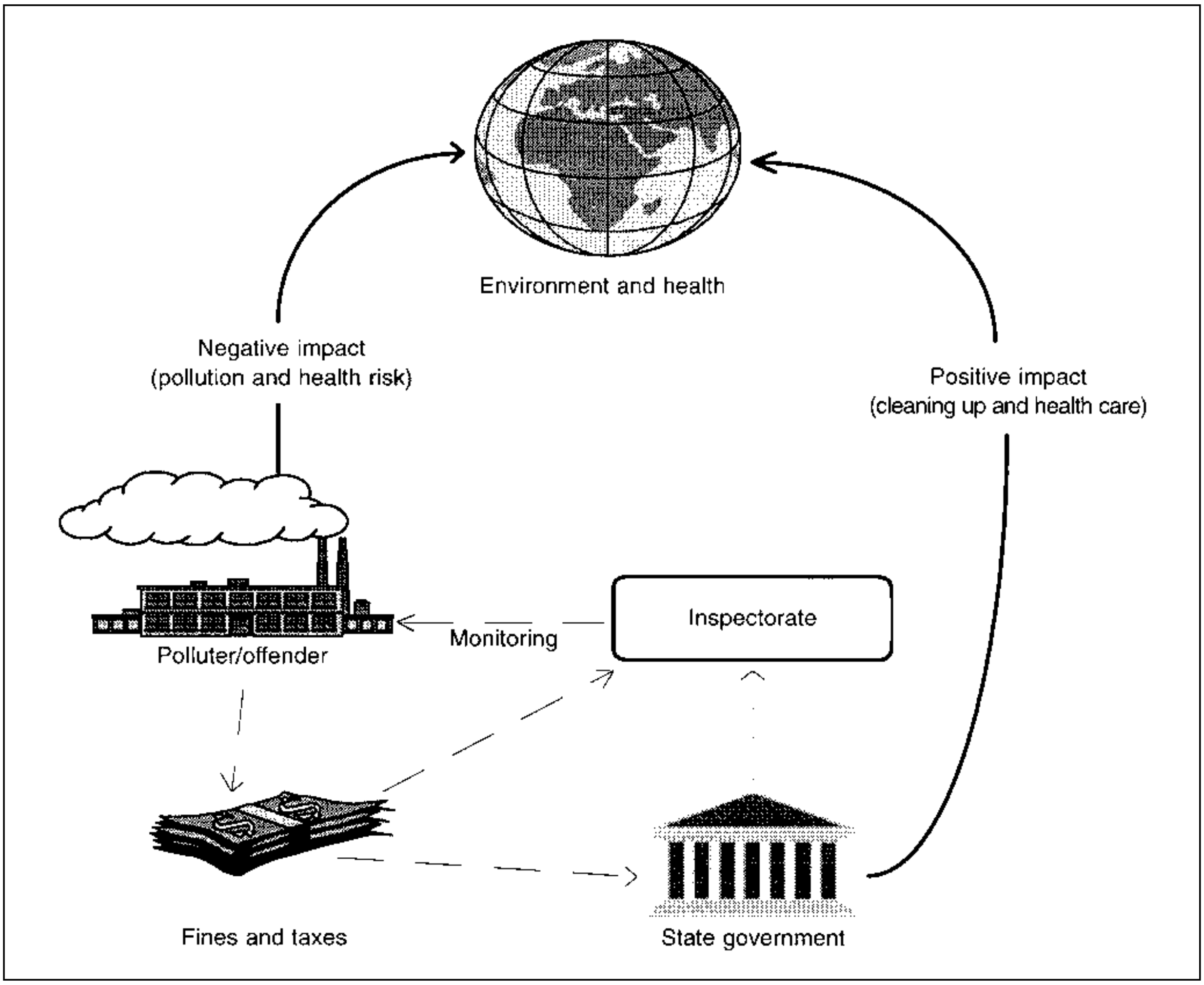


Fig. 2.2: Former systems of environmental health control in the CCEE and NIS

central administrations give them responsibilities without sufficient resources to carry out the work required.

The funds for certain responsibilities can be assigned "ringfenced", or reserved solely for these tasks, to ensure that the required service is actually carried out. Local environmental health services can be financed in many other ways, from charges for inspections to pollution taxes. Whatever the financing system adopted, however, it is extremely important to ensure that it is geared towards improving environmental health conditions, not perpetuating the status quo.

Fig. 2.2 illustrates the cyclical system of control that remains typical of the approach to many environmental health problems in the CCEE and NIS. The system is self-perpetuating, ensuring continuous monitoring without the necessary action. The weaknesses in this system are apparent, and now that they are recognized efforts are being made to create more appropriate systems of control.

2.5 Intervention and Control

The main task of environmental health services is to improve environmental conditions through the application of legal requirements. The effectiveness of these provisions varies, and a well balanced service should develop a range of interventions for application to particular circumstances and problems.

Many countries have developed fiscal policies with punishments or rewards to encourage commerce and industry to comply with regulations and norms. Fines, however, must be of a size that not only reflects the community's concern about the issues but also deters the repetition of offences. This is a problem in the CCEE and NIS, where rates of inflation are so high that paying the fines imposed by the environmental health services may be more cost-effective for an enterprise than making the investment required to prevent the repetition of an offence. Such problems urgently need to be addressed. Several countries in the Region threaten imprisonment for environmental health offences, but rarely use this mechanism.

Many countries in the Region use permissions, authorizations and licences to control various activities with potential impact on environmental health; these are very effective. Licences can go further than set regulations, and the licensing authority can impose its own local conditions and requirements. The threat of losing a licence to trade or operate ensures that licensees respond positively to requests and advice from environmental health personnel. Through such mechanisms, the environmental health services can take preventive measures; newly established premises or practices can be vetted for compliance with requirements before going into operation. Fees are often charged for the granting of licences, and can supplement the local administration's funds.

While the principle that the polluter pays has been incorporated into new legislation throughout the European Region, its interpretation varies. There are differences in the way the sum to be paid is calculated, but the essential difference between countries is the final destination of the payment. Several countries have established "environment funds" that are fed by revenue from pollution taxes. These funds fuel government programmes and policies devoted to improving the environment. The funds need not necessarily be spent on the area from which they were obtained, but can be distributed through national networks to other areas that require support. Some environmental taxes that are collected and retained at the local level work in a similar way; the money is spent on the community, although not necessarily on environmental improvements. Care is needed when establishing such funds to ensure that the money collected is not viewed as a main source of community income, paid as compensation for the environmental damage caused. The money should be used to reduce pollution at source, or at least repair the damage that has already occurred. If the pollution tax is viewed as a source of income, environmental improvements may be resisted in order to sustain that income. Through positive intervention, environmental health services should try to reduce the amount of tax revenue collected; it should not be seen as a potential means of financing more monitoring so as to enable further taxation (see Fig. 2.2).

Financial intervention need not always take the form of penalties and fines. Monetary incentives and benefits can be offered through environmental health services. Some countries, for example, provide grants and financial incentives to enterprises to use cleaner technology or reduce and recycle waste. Some environmental health services offer grants for the improvement of housing that falls below minimum national standards. National programmes for environmental health improvement provide many other financial incentives (Box 2.4).

The example given in Box 2.4 was based on a non-statutory intervention policy, which was very successful in that particular situation. Environmental health services cannot operate effectively, however, without a strong legal basis for intervening and working for improvements. In many of the CCEE and NIS, legislative reforms are being undertaken to create environmental health requirements that are in line with countries' needs and capabilities.

2.6 Public Participation

Environmental health services have the primary function of acting to protect the health of the general public. They usually have direct contact with the population at the local

Box 2.4: Money for rubbish in Copenhagen

Along with the City of Copenhagen municipality, Wonderful Copenhagen, an association of city centre traders and tourism authorities, decided to tackle the problem of street litter. In 1987, there were excessive amounts of litter in the streets of Copenhagen, and improving the situation was considered to require changes in people's attitudes. First, a campaign of education was undertaken. This was not an ordinary poster campaign, however. Instead of cleaning the streets at night, when no one would see them, street cleaners in conspicuous white uniforms worked during the day, when their presence served as a visual reminder of the need to collect refuse.

Second, the association and the municipality looked at how other countries attempted to control street litter. They learned that people were penalized in some way when caught dropping litter. The Wonderful Copenhagen office decided to turn this policy around. Instead of fining transgressors, the association decided to reward the people who used the litter bins provided. When an observer spotted someone using a bin, that person was given 100 Danish kroner. Later, lottery tickets were given instead of cash. The mass media gave this project great coverage and the level of street litter was considerably reduced.

level, and public participation in operating and setting priorities for the services is encouraged.

In the CCEE and NIS, a major focus of the sweeping changes of the late 1980s and early 1990s was the environmental or "green" movement. Ecoglasnost, a leading nongovernmental organization (NGO), led many public demonstrations and campaigns against the exploitation of national environments and was, to a large extent, the catalyst for change in the entire political system. Largely because of the harsh results of the economic changes in these countries, public interest in environmental protection has waned since then. Nevertheless, environmental NGOs are still heavily involved in policy formulation at both the national and local levels, and some countries' legislation names national organizations as bodies that must be consulted during the creation of regulations or standards. Their involvement functions as a "reality check" of the feasibility of the implementation of particular proposals, and directly reflects the priorities and concerns of the general public. In this respect, some governments in the Region actively encourage and support the work of NGOs by providing grants. These organizations are very numerous and some consolidation is required to achieve effective representation. In 1991, for example, 1300 NGOs in the Russian Federation were registered as having environmental interests.

Nongovernmental organizations can bring together the environmental interests of a very wide range of professions. The building of multidisciplinary teams with common aims, not tied to political motives, is an important feature in the creation of a balanced environmental health policy and services. Several enlightened governments have realized the value of such organizations and have used their resources and expertise for research and information activities and, sometimes, guidance on policy.

Information is essential for the formulation of environmental health services and effective public participation. Information can be held at both the central and local levels, depending on the issue. Information obviously needs to be held centrally to aid national governments in making policies for action by environmental health services, but it must also be available to the services at the regional and local levels and to the general public (Box 2.5). This will aid local policy formulation and help people in isolated areas to gain information on subjects on which they may lack specialist knowledge. In addition, local information for particular areas will assist the effective operation of en-

Box 2.5: Professional information exchange in the United Kingdom

In the United Kingdom, about 230 environmental health departments exchange information through electronic mail. This enables environmental health officers to discuss issues, request assistance from other departments, and liaise comprehensively on issues of national importance. The Department of Health has access to this confidential service, which it can use to collect and disseminate information on hazards or events that require immediate action. This form of communication and information exchange creates a forum for open discussion and a vast database of knowledge.

vironmental health services. If members of a community have free access to information on the state of the environment and public health in their area and on the related activities of the environmental health services, they will give the services greater trust and cooperation.

2.7 Environmental Health Professionals

Once environmental health policy has been set, and existing services adapted or new institutions created, suitably qualified personnel have to be employed to do the work. Qualified environmental health professionals are relatively few in the European Region. In most countries, environmental health workers fall into one of three categories: medical doctors, environmental engineers and environmental/public health technicians. Even within these broad categories there is a great deal of specialization.

Some western European countries, most notably Ireland and the United Kingdom, have a holistic professional group: environmental health officers. Educated to degree level, these professionals receive broad training in technical knowledge, social policy, management and communication skills in environment and health. Their perspective gives them an overview of environmental health factors and their interrelationships. This allows these personnel to play a variety of roles as advisers, enforcers and educators. Individual specialist knowledge is likely to be developed in a particular field, but other specialists, doctors and engineers will be involved to facilitate a multidisciplinary approach to solving problems. With an understanding of the broad basis of environmental health, environmental health officers can take on a managerial role in the delivery of environmental health services.

The management and decision-making skills of environmental health professionals in the CCEE and NIS require improvement if services are to be more effective. Long reliance on central direction has stunted the ability of local directors of environmental health services to develop new and independent strategies. Personnel management skills are also needed.

While the development of professional environmental health staff will undoubtedly take a long time, investments should be made now. In many countries in the Region, the low and narrow salary scales of staff provide minimal incentives for a career in environmental health services. Skilled professionals are at a premium in certain areas of private industry and consultancy. If public services cannot offer suitably attractive career development structures with appropriate rewards, the industrial sector will always be in a far stronger position to bid for such people.

Many colleges and universities throughout the Region are developing new concepts in environmental health training to give a more broadly based education through numerous exchange schemes. These changes will generate a new breed of environmental health pro-

Box 2.6: Continuing professional development in the United Kingdom

The Institution of Environmental Health Officers (IEHO) is a nongovernmental organization responsible for the training and professional development of over 8000 environmental health officers working in the United Kingdom. Its primary function is to promote environmental health and to spread knowledge of environmental health issues. IEHO presents the views of its members on environmental and public health issues and is independent of both central and local government.

As part of its professional education activities, IEHO runs a scheme of continuing professional development. Each member must undertake 20 hours of appropriate development activity each calendar year, or an aggregate of 60 hours in any three consecutive years. Participation in the scheme is voluntary at present, but is planned to become a requirement for continuing membership of IEHO. To aid this process, IEHO runs many short courses and seminars on environmental health subjects.

fessional, who can exert a greater influence on the environmental health services provided.

The staff of environmental health services need to continue their professional development to ensure that they keep up to date. Box 2.6 gives an example of how this can be achieved.

2.8 Conclusions

Environmental health services are still developing in many countries of the European Region, not only the CCEE and NIS. The links between activities in environmental protection and public health need to be strengthened, managerial institutions need to be established and personnel trained, and public participation at the local and regional levels needs to increase.

Many of the existing structures for the delivery of environmental health services need radical reform. Achieving more responsive and effective services will require a sustained and concerted effort.

Countries at the beginning of this process need to consider three main areas of action. First, environmental health policy needs to be developed through strong intersectoral cooperation; government can then give policy a solid and effective legal basis for implementation. Second, the institutional structures to carry out these policies through environmental health services will have to be developed. Central administrations should not only provide these services with suitable support and guidance, but allow them the opportunity and flexibility to respond to local needs. Finally, trained environmental health professionals and managers are required to deliver these services through the appropriate institutions. Effective intersectoral cooperation is essential at all stages in the development and operation of environmental health services.

Countries should develop environmental health services that not only reflect their culture and traditions but can also respond to urgent needs for action. The development of environmental health services and the various transitional stages involved require careful and considered planning now, to ensure appropriate and effective services for the future.

References

[1] *Earth Summit '92. The United Nations Conference on Environment and Development, Rio de Janeiro, 1992.* London, Regency Press, 1992.

[2] *Environment for Europe. Ministerial Conference, Lucerne, 28–30 April 1993. Conference report.* Berne, Federal Office for the Environment, 1993.

[3] *Towards sustainability. A European Community programme of policy and action in relation to the environment and sustainable development.* Brussels, Commission of the European Communities, 1992.

[4] *Environment and health. The European Charter and commentary.* Copenhagen, WHO Regional Office for Europe, 1990 (WHO Regional Publications, European Series, No. 35).

Chapter 3
Economics, the Environment and Health

3.1 Introduction

3.1.1 Links

The economy of any country, the state of the physical environment and the health of its people are intimately interconnected [1]. Economic activity affects the natural resources of a country for good or ill; both affect health.

The link between economic growth and increasing environmental damage from pollution can be broken. Action taken by countries belonging to the Organisation for Economic Co-operation and Development has demonstrated that the hazards to health posed by environmental factors can be controlled and that action can lead to better health and more efficient use of natural and other resources [2]. Control measures that have been taken include laws and regulations, and market instruments such as taxes. Future control measures for use in the WHO European Region need to be chosen with careful consideration of the relationship between costs and effectiveness, since spending on environmental control is reflected in the cost of other goods and services that people want. For example, if a company producing soap has to increase its costs to comply with new regulations on wastewater treatment, it is likely to pass on the costs of those improvements in the price of the soap; the “polluter pays” principle is not as simple as it may seem. In particular, consideration should be given to how much an improved environment can benefit human health and how much people are willing to pay for such benefits before deciding that introducing new controls is justifiable in the face of their costs.

For example, improving water supplies requires an evaluation of the cost and impact of improvements, whether the controls are on the water at the source (preventing pollution) or introduced at any stage of water treatment (controlling pollution). Costs can rise steeply as different treatment processes are added to improve the quality of water [3]. Careful assessment is needed to ensure that each additional measure gives value for money in its impact on health. Several factors affect such an assessment: the level of pollution and the difficulties of controlling it, the numbers of people exposed, and the level of risk to health. The additional costs of installing biological treatment to reduce phosphorus and nitrogen concentrations in water can be twice those of mechanical and chemical treatment to reduce by 80–90 % the problems of the biological oxygen demand from microorganisms and suspended solids [3].

Taking countries as a whole, improved general health and reduced premature mortality can lead directly to economic growth through higher productivity. Economic growth can give rise to changes in health through better housing, education and health services. It can also, however, damage health by increasing inequality in the distribution of wealth through the creation of poverty among people whose lives are disrupted by the socioeconomic changes that accompany economic growth. These changes can include the restructuring of major industries and sectors and the redeployment and migration of large sections of the population, with intermittent or permanent unemployment. Riches and poverty, and good and ill health, may live side by side [1,2].

3.1.2 Environmental epidemiology and environmental health economics

The impact of the environment on health is the subject of environmental epidemiology; the valuation of differences in health status is the subject of health economics. Health is defined by WHO as that part of human welfare that embraces physical, mental and social wellbeing. Health economics is thus essentially anthropocentric, and concerned with ecological issues only in so far as they are critical to human survival and health.

The relationship between the environment and the general state of the economy is the subject of environmental economics, which is also concerned with the investment required to improve environmental conditions and to conserve and protect natural resources and amenities, which people value either for the use they make of them or merely for their continued presence (Fig. 3.1).

The goal of sustainable development means that economic activity to achieve greater welfare for people today should not be increased, if the welfare of future generations is compromised as a result [4].

3.2 The Productive Economy and the Environment

Not all improvements in the quality of the environment lead to improvements in health. Moreover, some countries may not be able to afford or be willing to pay for certain environmental improvements, even when they can lead to improvements in health. Economists have a role in helping to show more clearly the relationship between the costs and benefits of environmental improvements and how far people are willing to pay for the required changes.

The provisions of the Treaty on European Union, also known as the Maastricht Treaty, require the policy of the European Union (EU) on the environment to help to protect human health, to encourage the prudent and rational use of natural resources, and to take account of the potential benefits and costs of action or inaction. This will allow the assessment of all aspects of EU action for their impact on the environment and health, and cost–benefit review of investment, taking an

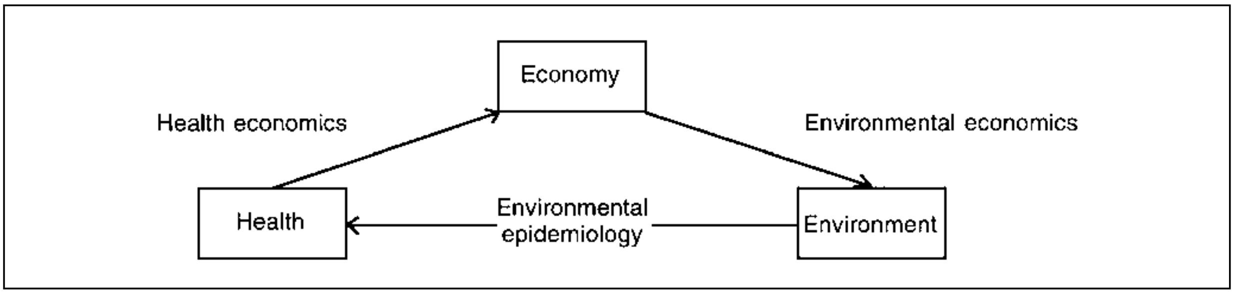


Fig. 3.1: The basic model for the economic approach to the links between the economy, the environment and health

integrated view of the many factors that, for example, affect pollution control using the best available technology not entailing excessive cost.

3.2.1 Response of industry to environmental concerns

The extensive development of the reuse of industrial materials and the recycling of products and product components in the European Region illustrates the relationship between the environmental impact and the economics of control activity. Differences in the market price of components and industrial and consumer participation, and the political value of these schemes, have affected their viability [5–7]. Reuse and recycling schemes are not in themselves justifiable in environmental, health or economic terms; they require continual and individual judgement on their merits.

Commercial organizations are now introducing environmental labelling of products in response to the EU requirements for packaging, which must be implemented in national laws by 1997. Environmental accounting is being developed to demonstrate how companies are monitoring and reducing the adverse environmental impact of their activities [8,9]. While both of these are steps towards accountability to shareholders and consumers, they fall short of the information required to reveal the cost–effectiveness of investments to protect the environment and human health (Perriman, R.J., personal communication).

The life cycle assessment approach is being adopted as an analytical process in certain multinational commercial companies [10,11]. An environmental balance sheet is established for each product to identify its impact on the environment and opportunities for reducing that impact, including the reuse of all or certain parts of it and the recycling of its constituent materials for similar or other purposes. These tasks can be handled within the company or on contract by the growing number of specialist companies in this field. As the volume of waste has kept pace with economic growth [5], developing waste disposal methods that give the greatest added value has become an opportunity for investment [12].

By increasing capital investment in environmental protection by 300 % and revenue investment by 50 % in four years, a multinational company has been able to reduce measured hazardous waste by nearly 50 % and non-hazardous waste by more than 10 %. It has saved energy, reducing the energy/volume of production index by 50 % since 1971, reducing carbon dioxide emissions per unit volume of production by 60 % in that period, and substantially reducing the number of fines and prosecutions for breach of national and international laws and regulations on environmental protection [11]. The company has not, however, been able to calculate the costs and benefits more precisely; that, in the end, is a policy judgement. The fact that the company continues to invest in improvements implies that it considers the results justify the present level of investment.

3.3 Investment in Environment and Health

Investment in the environment and health should be judged by its costs and health benefits compared with those of other investments made to promote and improve health. Such assessments should consider the relative value, for meeting these objectives, of investment in improvements in health education, in health care, and in those improvements in economic growth and the relief of poverty that directly and indirectly benefit health. Weighing the value, relative to costs, of different measures to prevent ill health – such as health education, relief of poverty and the mitigation of environmental effects – is relatively straightforward, but a similar consideration of the relative value of prevention and cure in health raises important ethical issues. It may be more costly, for example, to prevent environmental effects on health than to treat the resulting illness, but the benefits of prevention, both to individuals and to society, need to be taken into account.

As Fig. 3.2 shows, there appears to be a positive relationship between real gross domestic product (GDP) per head (calculated in accordance with the techniques of purchasing power parity) and life expectancy at birth [1]. A rise of real GDP from US $ 1000 to US $ 5000 appears to have a larger impact on life expectancy than increases beyond that point. Most of the CCEE and NIS have a GDP below US $ 7000 per head, and over one third below US $ 5000 per head. Life expectancy shows a gap of some 5–10 years between people living in the CCEE and NIS and those in western European countries. Socioeconomic and lifestyle differences explain much of this gap. There is also a gap of 5–10 years between the lowest and highest levels of life expectancy in the CCEE and NIS, and there is sufficient variation in life expectancy between countries with similar levels of economic wealth to suggest that prudent investment in health education and development policies could achieve health gain without economic growth. Improvements in water supplies, sanitation, food hygiene and housing, and controls on air and water pollution are the most likely environmental investments to yield substantial health gain [13]. Judicious investment becomes even more important in countries experiencing economic recession and inflation. The questions that need to be addressed include: the costs of improvements in health through environmental intervention, the time scales over which health gains can be realized, and whether these investments are more cost-effective than others that could be made in sectors such as education and health care. It must be recognized that the main causes of premature mortality (see Chapters 4 and 18) are more likely to be attributable to lifestyle factors, particularly smoking, than to environmental agents.

Damage to the environment in the CCEE and NIS and its impact on health can be clearly seen in the level of emissions from the use of fossil fuels in production processes. Most factories in these countries use production systems that are obsolete, energy intensive and highly polluting in comparison with those in western countries. Industrial energy intensity is five times higher in Poland, for example, than in the United States; similar differences are found between Germany and Hungary [14–16]. The use of fossil fuel and the intensity of emissions are inversely related to price [14] and adverse health effects are directly related to the resulting air pollution [16–18].

One flaw in using GDP to assess the economic capacity of a country is that the standard measure of GDP ignores the depletion and degradation of natural resources and their effects on health. Indeed, in so far as environmental damage creates treatable illness and a cost to the health services, that cost creates employment and paradoxically appears as a positive contribution to GDP. This is clearly misleading. Many countries, however, are adjusting their measure of GDP to take account of adverse environmental effects and the depletion of natural resources.

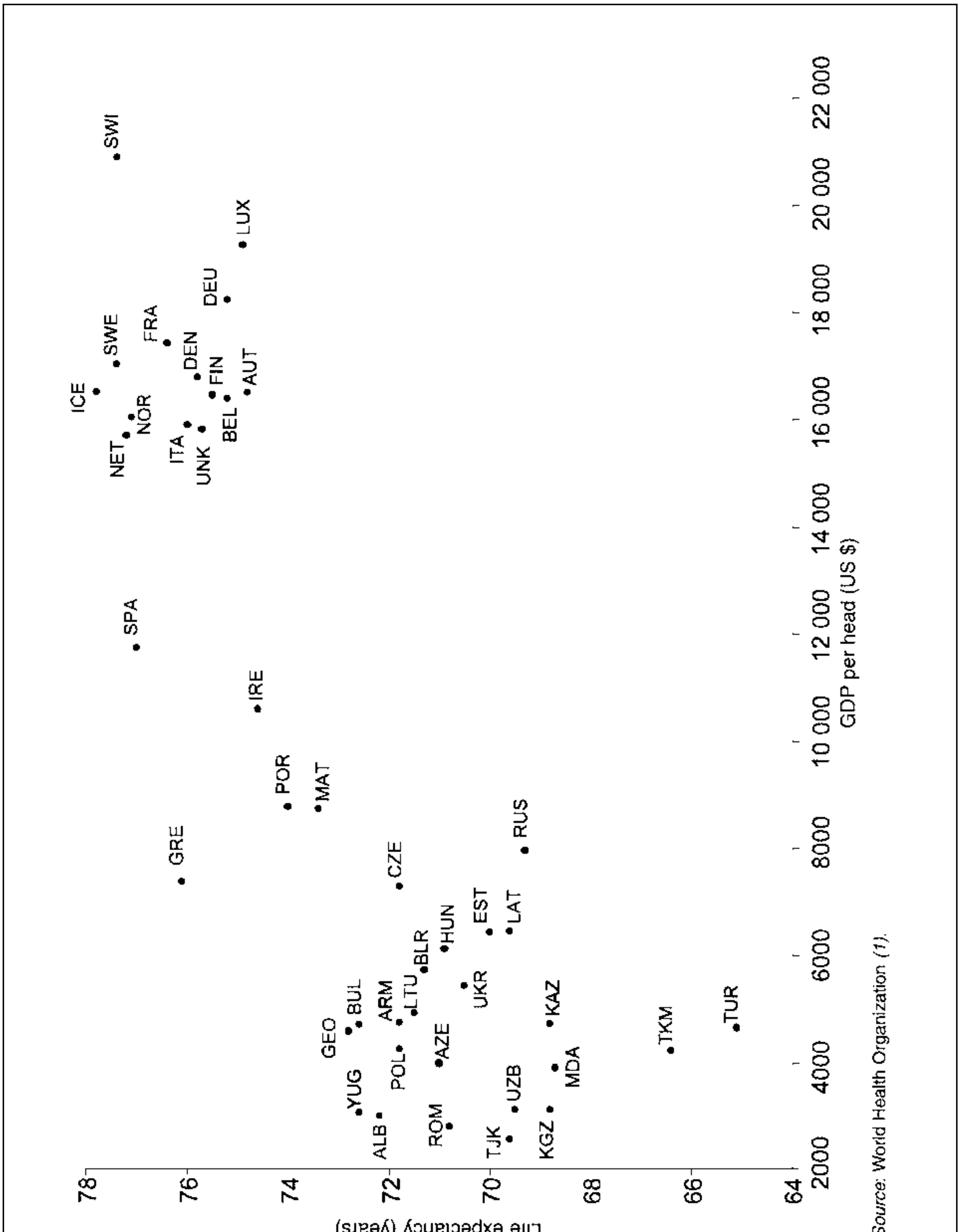


Fig 3.2: Health and wealth: the correlation between real GDP per head (purchasing power parities) and life expectancy in the WHO European Region, 1990

Businesses are attempting similar developments in environmental accounting, and major industries are producing accounts that show more clearly to shareholders and the public the damage that their activities do to the environment and the extent of investments to counteract these problems [2,19–21]. These new forms of environmental accounting give a more complete picture of real change in national and corporate wealth and its relationship to environmental status in the community. Further developments in this accounting process should consider adverse effects on health.

In its strategy for health for all [22] WHO named decent housing, safe food, water and sanitation, adequate income and employment as prerequisites for health, and these factors were part of the McKeown hypothesis of health development [23]. They also offer some explanation for differences between countries in life expectancy. Further work is required in the Region to determine the exact impact of these factors and their importance in comparison with, for example, environmental pollution or individual lifestyles.

While the environmental sector is important, it competes with health care for investments to improve health in the Region. A key issue in health care in the Region in general, and in the CCEE and NIS in particular, is the extent to which greater efficiency and perhaps greater investment in health care could reduce avoidable disease and mortality [24].

Avoidable mortality generally attributable to inadequate health care includes deaths from tuberculosis, cancer of the cervix, diabetes, chronic rheumatic heart disease, certain other types of circulatory disease and appendicitis; deaths principally related to environmental conditions and lifestyle are excluded. Rates of avoidable mortality are substantial, but are declining in most western countries of the Region while remaining constant or increasing in certain of the CCEE and NIS [24]. Some of the CCEE and NIS have rates of avoidable mortality, in both males and females, 2–4 times greater than those in most western countries [24].

While political pressure is increasing to raise the level of national and international investment in environmental improvements with the aim of improving health, these investments may not be high on the list of the "best buys" for health [13].

Environmental improvement can lead to improved health by, for example, eliminating or reducing specific threats to health and creating the conditions that promote healthier lifestyles and better living conditions. It has been estimated that an extra investment of 2–3 % of GDP globally is necessary by the end of the decade to stabilize soil conditions, protect forests, improve air quality, and provide universal access to sanitation and clean water [2].

Further environmental improvements would require extra investment. Some policies can, however, promote economic growth, alleviate poverty and create direct environmental improvements. For example, the removal of subsidies that at present encourage the excessive use of fossil fuels and pesticides and the reduction of forests would promote greater efficiency in the use of resources, thus contributing both to economic growth and to environmental improvement [2]. Clarifying property rights on land, forests and fisheries would encourage reinvestment and the removal of past pollution [14]. Accelerating the provision of basic services such as sanitation, clean water, education and housing throughout the European Region would also contribute to economic growth and human welfare by unlocking further human capital, and directly and indirectly improve health [23].

Three types of better investment in environmental improvement can lead to health benefits. The first comprises policies, such as energy price reform, that are both economically efficient and environmentally beneficial. Once provision has been made to secure the welfare of the poorest, whose survival depends on heating and power, such policies can lead to net health gain from reduced pollution. Second, regulatory policies and taxes can be used to internalize the costs of environmental damage; these either require polluters to bear the costs of reducing emissions or to pay a charge that reflects the damage done by the pollution. Third, public investment in or the reduction of subsidies for public utilities (especially gas) in particular, but also for some other publicly owned enterprises, can be used to reduce emissions.

Since 1987, the EU has committed about 5 billion[a] ECU to environmental improvement [3] but current investment in countries

[a] 1 billion = 10^9.

varies widely between the key areas of concern. For example, while 22 % of investment in the EU is on reducing air pollution, the percentages for Portugal and Spain are only 2 % and 1 %, respectively. Portugal devotes only 14 % of its declared environmental investment to improving waste disposal, in contrast to an overall figure for the EU of 29 %. Portugal allocates three quarters of its investment in environmental improvements to water, while Spain devotes less than half that proportion to the purpose [25]. This pattern of expenditure needs further review, because investment in environmental improvement needs to be carefully targeted according to national priorities to produce the greatest health benefits. Reports of returns on investment should make transparent the nature and volume of the benefits to human health and other goals.

3.4 Failure of Economic Systems

The level of investment in environmental improvements in Europe seems low by comparison with the likely benefits; its growth is poor and its targeting inexplicable [25]. What factors explain this?

In the past, both market-led and centrally planned economies inadequately protected health from the adverse environmental effects of economic development [26]. Some control proved possible in improving water supplies, but the record on air and soil pollution is indifferent. On average, the control of concentrations of particulate matter, seen as smoke from chimneys and other sources, has been better in richer than in poorer countries [2]. The large variation in urban pollution control in countries of similar income level, however, suggests that much can be done to improve the efficiency of control through better management and education, without new technology and building on the example of the best practice in each country.

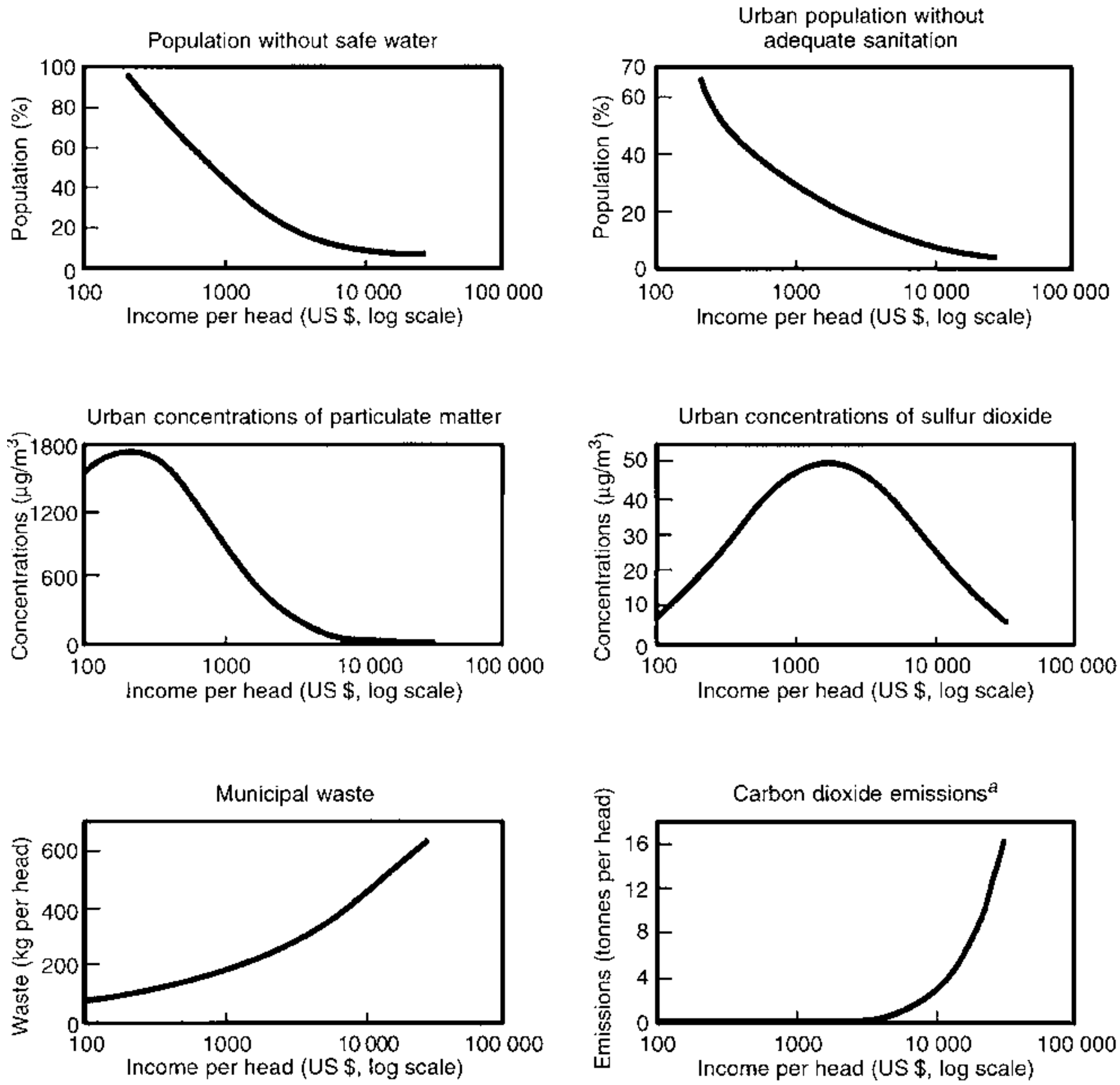
Industrial growth and economic development do not necessarily mean more pollution (Fig. 3.3). Indeed, if pollution kept pace with economic growth, pollution in countries with income rising at 5 % would quadruple in 30 years. Breaking the link between growth and pollution is vital. Theory and practice can go together, but this is not inevitable. Progress depends upon judicious policy and management and careful evaluation of the results (Fig. 3.3).

Since 1970, western economies have grown by 60 % but their emissions of carbon dioxide and nitrous oxide have remained constant as a result of improved energy efficiency. Emissions of sulfur oxides have decreased by 40 % as a result of both energy efficiency and active abatement programmes [2].

3.5 Issues for the CCEE and NIS

A global review of environmental improvements concluded that the costs of implementing a global strategy are modest compared with the gains from improved efficiency and economic growth [2], and the EU has demonstrated that much of the change in industrial practice is commercially beneficial [25]. Many of the necessary investments will pay for themselves, but industries and people with long practice in neglecting environmental problems caused by their behaviour resist change. The process of change can be long in countries that are not used to technical and cultural development of this kind, and the management of change requires special skills and experience. Some of the early results, however, give hope for the future.

The key is to concentrate on the practicable changes with the highest net returns. Some of the industries that have created the biggest environmental problems in the CCEE and NIS are closing down for economic reasons. The transformation of economies offers the opportunity to make environmental protection a condition of privatization. Aid from the main international agen-



[a] Emissions are from fossil fuels.

Note. Estimates are based on cross-country regression analysis of data from the 1980s.

Source: World Bank *(2)*.

Fig. 3.3: Environmental indicators at different levels of country income

cies includes environmental impact assessment as a basic condition; this should become a more general principle for industrial policy in the CCEE and NIS.

Less than 1% of GDP over the next decade is probably a sufficient investment to achieve substantial improvement in the living and working environments in the CCEE and NIS, and convergence towards western standards. This should allow the control of particulate matter, reduction in the levels of acid deposition and effluent wastes, the raising of water and sanitation standards, soil conservation and more replanting of forests, and more environmental research [2]. Within the European Region, immediate priorities that offer good returns on investment include dust containment, a shift from coal to gas or smokeless fuel, the treatment of contaminated wastewater by carefully assessed multistage improvements, the selective installation of septic tanks for domestic wastewater and for livestock operations with high nitrate production, and the control of hazardous waste, including radioactivity from nuclear installations. The tools required for these immediate needs and those for medium-term and long-term improvements include improvements in the efficiency of existing controls on adverse environmental effects; technical improvements in selected high-priority production systems such as aluminium plants, tanning, electroplating and other metal work; controls at the end of the pipeline; and systematic industry-by-industry assessment of opportunities for improvement. In such assessments, economic incentives may have their most important role in stimulating local managers and consumers to take responsibility for changing present practice. This will be greatly assisted by improved information [25].

Most of the CCEE and NIS are in severe economic recession and their income per head is between 5 and 10 times less than that of western countries, and there is a widening gap in health status between the CCEE and NIS and the other Member States of the Region. This increases the importance of ensuring that the use of scarce resources on environmental improvement is based on a solid assessment of the relative costs and benefits. Where the choice is clear, strategic decisions are needed to ensure that vital environmental improvements can be made with local and international funding, and are not critically affected by the recession. Poland has shown what is possible by creating a National Environment Fund and enforcing a tenfold real increase in pollution charges, to fuel investment in environmental improvements on the "polluter pays" principle [3].

It has been estimated that reducing and finally eliminating the existing energy subsidies in the CCEE and NIS could result in a 24% reduction in carbon emissions in the European Region [2]. The effects of such a measure need to be carefully assessed, as the structural collapse of noneconomic industries is creating severe problems of unemployment and poverty, which themselves impair health. Furthermore, removal of the heating subsidy is likely to have adverse effects on the health of vulnerable groups of the population.

3.6 Funding and Management of Environmental Improvement

More specific costing is necessary to determine the relative contributions of different aspects of environmental management. For example, what is the relative return on investment in the improvements that "good housekeeping" can achieve in industries with previously inefficient environmental control, in the introduction of established western technical solutions to environmental problems, and in the use of controls at the end of the pipeline [3]? There is a strong case for the development of controls in stages. The criteria that should be used in choosing an area for investment should include cost, feasibility, effectiveness, acceptability, the size of the health hazard, the expected health gain, the capacity to enforce the change and the likely macroeconomic impact.

The transition towards the cost-effective control of environmental hazards to health and environmental improvements predicated on a health goal should include the implementation of a policy based on economics. This should include three stages:

- the introduction of fees or fines, the revenue from which will establish a development fund to provide capital and revenue for subsequent improvements;
- an increase in the fees or fines to accelerate progress in improvement, shortening the projected time scale; and
- the setting of charges and fines to cover the full external economic and social costs of environmental and health damage, which will result in the closure of firms that fail to survive the internalization of the environmental costs with which they currently burden the community.

This three-stage implementation of policy is even more important in the CCEE and NIS, where the current difficulties of economic and social transition are putting much of the economy at risk.

It is as yet uncertain how far debt-for-nature and debt-for-health swaps can play a significant part in development in the CCEE and NIS; experience from Latin America and elsewhere with these swaps (by which a lender cancels a debt in return for work on an environmental or health problem) may be useful to policy-makers [2].

Recent WHO reviews of health policy suggest that simple improvements in waste management can yield considerable advantages; this is a neglected field of public health in the CCEE and NIS. In addition, opportunities for the development of the WHO Healthy Cities project in these countries are being pursued to give a sharper focus to participatory action in lifestyle and environmental health issues. Involvement in the project's international network offers access to technical assistance from the EU and other countries in the Region.

3.7 Economic Instruments

While all interventions to promote environmental and health gain can be subject to economic assessment, advocacy of so-called economic instruments and financial mechanisms for control seems to be growing, although they are not necessarily more efficient or effective than others. On the contrary, legally enforceable standards or agreed guidelines may be more economic if they promote a change in technology that results in environmental and health improvements at less cost and at a faster pace than economic instruments can achieve. The promotion or enforcement of environmental standards can result in the use of new raw materials, alternative energy sources, the recycling of finished products or residuals, or new additional products that use residuals in an environmentally friendly way.

There is no reason why the stimulus for economic change and the evolution of industrial or agricultural production cannot come from companies or state industries responding to agreed standards imposed with legally enforceable (including financial) penalties. The environmental problems of the CCEE and NIS did not arise from a lack of economic instruments or standards to apply to environmental problems, but from the failure of industry and agriculture to meet the standards and the failure of authorities to enforce them or to set the penalties at a level equal to or greater than the commercial benefits of evasion [3]. It is vital in these countries to introduce and strengthen, as soon as possible, the staged implementation of environmental controls with market-based components.

Economic instruments can take a variety of forms. These include fiscal policies such as taxes and subsidies, and direct investment in environmental protection and education services [21,27–29]. Some of these measures are used not to achieve environmental objectives but purely to raise government revenue, which may not be spent on the environment. This practice complicates the assessment of the impact of such instruments.

Nevertheless, environmental charges have been levied against polluters of water supplies in France, Germany and the Netherlands. They have been used to reduce air pollution in Sweden, to reduce noise from aircraft in the Netherlands and Switzerland, and to control waste disposal in the Netherlands.

Some countries levy a charge not on the act of pollution but on products that can pollute. This approach has been applied to fertilizers and pesticides in Norway and Sweden, lubricant oils in Finland and Germany, the sulfur content of fuel in France, and motor vehicle fuels in Finland and Sweden. Differential taxes on leaded and unleaded petrol have been used in France, Germany, Norway and the United Kingdom. To promote container recycling, charges have been used on containers for beverages in Finland, plastic bags in Italy and containers for lubricating oils in France and Germany. Deposit refund systems have been used for cars in Norway and Sweden for similar reasons.

In addition, marketable permits have been used to control water and air pollution. Such schemes exist in Australia, Canada, Germany and the United States [30]. They provide permits that can be purchased to allow a company to exceed a specified level of pollution. The price acts as a pollution tax and is itself a disincentive to pollute. In addition, companies that have purchased permits and then achieve the specified levels of pollution control can then sell on their permits to others who have yet to achieve the required level of control. The aim of this is to create a market that will deliver the greatest amount of reduction in pollution for a given level of investment. Experience so far with such pollution trading permits has been limited and mixed [30].

Other instruments are also available, including incentive payments and subsidies, methods of raising funds for environmental investment, and special support to small and medium-size businesses to promote environmentally sensitive investment [31]. More information on their effectiveness would be useful. A review of the value of these instruments needs to take account of a number of the factors discussed above, including the phasing of their introduction. Successful implementation is not easy, and proper management is essential if they are to have more than a transient, cosmetic political advantage in appeasing the growing environmental lobby [5].

Implementation depends on a clear framework of operation, a simple mode of introduction, the availability of resources for promotion, design and management, conformity with local principles of trade and, possibly, national or international agreements. New forms of environmental management are required. Above all, such developments need careful economic and social appraisal, adaptation to local circumstances and careful testing before they are likely to be cost-effective. Economic instruments are not necessarily superior to other methods of controlling environmental problems, and are likely to work best as part of an integrated policy for environmental improvement and health in which both costs and benefits are considered [20,32]. Economists concerned with the environment are taking increasing interest in the technical issues (such as intergenerational cost–benefit analysis) involved in the economics of development, seeing health as a key component in their analyses. Health economists, who have largely focused on health services, are extending their interest to prevention and intersectoral issues. This is resulting in the refinement of economic methods applied to the health aspects of sustainable development and a call for greater application of the existing methodology of cost–benefit and cost–effectiveness studies to a wider range of interventions intended to achieve health gain [20,33,34]. This is an approach now endorsed in the policy developments following the passage of the Maastricht Treaty and the application of its provision for health assessment as part of environmental impact assessment [32].

3.8 Information

Better information is an essential requirement for improving the effectiveness and efficiency of environmental control to achieve health gain. Investment in environmental control can be expensive, and it is but one way to invest resources to achieve health objectives.

Information from nine areas is needed to implement a strategy on economics, the environment and health.

Willingness and ability to pay

How much are people, companies and governments willing and able to pay for improvements in different aspects of the environment that are known to affect health? Over what period should the investment in improvement be stretched to avoid the harmful macroeconomic effects of too rapid reform? More studies on this topic are needed to sustain political commitment, to focus priorities and to sharpen the timing of change.

Value of health benefits and opportunity costs
How much better value in health gain can be obtained from environmental improvements, bearing in mind the opportunity costs with respect to other investments for health? Do all countries have effective financial mechanisms to switch investments to get the best value for money? Are there cases in which such analysis has resulted in the reallocation of resources? Do conditions in a country permit the operation of an "environmental improvements market" so that people and companies can pay for what they want?

Rising costs of improvements and economies of scale
In each country, how variable are the resource costs and health benefits for what can be achieved now in terms of environmental health improvements? Who is responsible for collecting such data and what resources are available to them for the task?

Best buys for each country
How responsive have the economies of different countries been to the main types of intervention applied to key environmental problems? What examples can be shown of cost-effective environmental improvements that may lead to increases in productivity and more efficient use of natural resources as a result of the use of:

- market forces (such as consumer demand for "green" products, employee demand for cleaner processes, and improvements by companies seeking new "green" customers);
- legally enforceable standards and regulations; and
- economic instruments, such as environmental taxes, charges and marketable permits.

New ideas for action
What are other examples of economic mechanisms being used? These may include:

- incentive payments through government grants, tax reductions, accelerated concessionary leasing, export premiums and subsidies for environmental research;
- support for small and medium-size businesses in applying new environmental technology, such as risk insurance measures and government procurement advantages;
- revenue raising schemes to fund environmental improvements through, for example, earmarking funds, progressively shifting the tax burden from labour and man-made capital towards the use of natural resources, debt-for-nature swaps, and international collective funding agreements for environmental projects.

What have been the results of using these measures? How acceptable, efficient and equitable are they? What are the major problems that their use entails and how can these be overcome?

Learning from experience
What examples of problems in the finance and economics of environmental management can be highlighted to avoid future mistakes?

Environmental accounting
What experience have countries gained in the use of environmental accounting at the national, regional and local levels and in companies? What is the cost, and does it provide value for money?

What experience has been gained with environmental accounting in the health services? How can this be linked to environmental audit so that patients, other citizens and policy-makers can all see the issues and the choices that can be made?

Training and education
To what extent is economics included in training in new environmental management and in addressing the issue of the cost–effectiveness of intervention? How far is it included in public education programmes and the training of teachers of environmental studies in schools?

Lifestyle
What is being done to explore more thoroughly the impact of environment on lifestyle in the countries with a diminishing health return from investment in lifestyle programmes? What is being done to explore the value of greater investment in environmental improvement programmes as an indirect means of reducing health-damaging behaviour, such as the misuse of alcohol and the use of addictive drugs and tobacco?

3.9 Conclusions

Considerations of the environment and health are inescapable elements of economic and social development in the European Region. Market forces may help to ensure this. Industries that do not take on the dual challenges of promoting environmental improvement and health gain may become less viable in a competitive world; the internalization of health and environmental impact costs in industry and agriculture can create a self-correcting mechanism driving economies to support sustainable development. Careful monitoring is required, however, along with stimulation to establish the circumstances in which these factors operate in favour of improvements in the environment and health and the extent to which overt planned intervention is necessary, efficient and effective.

3.9.1 Economic strategy

The core of the economic strategy to promote improvements in the environment and health is likely to contain a number of elements, including support for market mechanisms linked to general economic growth, measured in a way that takes account of the state of environmental capital and the health of the population. Health measurement should cover physical, mental and social wellbeing. This should be supplemented by the use of intervention methods shown to be valuable in terms of return on investment, whether they are laws, regulations or economic instruments. When the principles that the polluter pays and the user of natural resources pays prove to be efficient mechanisms, they should be integrated in economic investment decisions. Further, citizen participation in decisions on the environment should be developed as an economic and social instrument to promote efficiency.

The most likely areas for cost-effective investment, especially for the CCEE and NIS, are probably energy (including nuclear power), agriculture, pollution control, water resources and sanitation, transport, and the working and living environments. In addition, the development of the environment for tourism will help to increase international pressure and support for change. Action should be taken in each of these areas when the particular problems have been identified and where feasible, acceptable and effective strategies for control, in which people are willing to invest, are available.

Key points for successful implementation are the formulation and negotiation of and consultation on policy, the creation of new forms of institution for environmental management, and the commitment of the private sector to environmental improvement in the transition to a mixed economy. Within this general strategy, economic analysis and environmental accounting are essential ingredients. They are proving their value in countries and will be in increasing demand in the CCEE and NIS.

Finally, environmental control technology for industry and monitoring should be developed in each country, as it can be expensive if imported. Technology transfer should be an essential feature of aid.

3.9.2 Information

Improved information on the environment, economics and health should be a vital part of any strategy. It is a prerequisite for efficient investment by individuals, businesses and governments; it is a requirement for operating an efficient market-led or planned economy.

Only by gathering such information as investments are made, and including information collection in the design of interventions, can future policies and programmes for environmental health be defended against the competing demands of other sectors. Existing sources of national and international information are being reviewed with this in mind [2,5,13] but it is not yet possible to put together a rational investment policy for improving health by improving the environment in the European Region.

References

[1] *Our planet, our health. Report of the WHO Commission on Health and Environment.* Geneva, World Health Organization, 1992.

[2] World Bank. *World development report 1992. Development and the environment.* New York, Oxford University Press, 1992.

[3] *Environmental Action Programme for CCEE. Document submitted to the Ministerial Conference, Lucerne, April 28-30, 1993.* Berne, Federal Office for the Environment, 1993.

[4] *The global partnership for environment and development. A guide to Agenda 21.* Geneva, United Nations, 1992.

[5] GEMS Monitoring and Assessment Research Centre. *Environmental data report.* Oxford, Blackwell, 1991.

[6] Department of the Environment. *Environmental waste.* London, H.M. Stationery Office, 1991 (Management Paper No. 28).

[7] Steeg, H. *Guidelines for the economic analysis of renewable energy technology applications.* Paris, International Energy Agency, 1991.

[8] Requirements for reusable, recoverable and recycled packaging. *Official journal of the European Communities*, **C263**: 8 (1992).

[9] Macve, R. *Business, accountancy and the environment. A policy and research agenda.* London, Institute of Chartered Accountants in England and Wales, 1992.

[10] *Progress towards environmental objectives.* London, Imperial Chemical Industries, 1991.

[11] *Improvement by design. Environmental report. Progress 1992.* London, Imperial Chemical Industries, 1992.

[12] Yakowitz, H. What trade in recoverable wastes? *OECD observer,* **180**: 26–28 (1993).

[13] World Bank. *World development report 1993. Investing in health.* New York, Oxford University Press, 1993.

[14] *The economic costs of reducing carbon dioxide emissions.* Paris, Organisation for Economic Co-operation and Development, 1992 (OECD Economic Studies No. 19).

[15] *Conference on Energy and Environment in European Economies in Transition. Priorities for co-operation and integration. Proceedings.* Paris, International Energy Agency, 1992.

[16] Juhasz, F. & Ragno, A. The environment in eastern Europe: from red to green? *OECD observer,* **181:** 33–36 (1993).

[17] Moskowitz, P.D. & Morris, S.C. *Energy, pollution, environment and health.* Nairobi, United Nations Environment Programme, 1989.

[18] *Acute effects on health of smog episodes.* Copenhagen, WHO Regional Office for Europe, 1990 (WHO Regional Publications, European Series, No. 43).

[19] Bartelmus, P. et al. *Integrated environmental accounting. A case study for Papua New Guinea.* Washington, DC, World Bank, 1992.

[20] Peskin, H.M. *Accounting for natural resource depletion and degradation in developing countries.* Washington, DC, World Bank, 1989.

[21] Pearce, D.W. & Warford, J.J. *World without end. Economics, environment and sustainable development.* Oxford, Oxford University Press, 1993.

[22] *Health for all targets. The health policy for Europe.* Copenhagen, WHO Regional Office for Europe, 1993 (European Health for All Series No. 4).

[23] McKeown, T. The road to health. *World health forum,* **10:** 408–416 (1989).

[24] Bojan, F. et al. Regional variations in avoidable mortality in Europe. *In*: Normand, C.E.M. & Vaughan, J.P., ed. *Europe without frontiers, the implications for health.* London, John Wiley & Sons, 1993.

[25] *The state of the environment in the European Community. Overview. Volume III.* Luxembourg, Office for Official Publications of the European Communities, 1992 (document COM(92)23).

[26] Ashton, J., ed. *Healthy cities.* London, Open University Press, 1992.

[27] *Environmental policy. How to apply economic instruments*. Paris, Organisation for Economic Co-operation and Development, 1991.

[28] Walker, T. Tardy Europe set to follow Clinton lead on energy tax. *The Times (London)*, 10 March 1993, p. 27.

[29] Linde, V. et al. *Environmental education: experiences and suggestions*. Stockholm, Swedish International Development Agency, 1993.

[30] Opschoor, J.B. et al. *Managing the environment. The role of economic instruments*. Paris, Organisation for Economic Co-operation and Development, 1994.

[31] *Implications of the outcome of the United Nations Conference on Environment and Development, in the field of environment and economics*. New York, United Nations Economic and Social Council, 1992 (document ENVWA/WG.2/R14: EC.AD/WG1/R14:6).

[32] *Integrated pollution prevention and control. Background report to the introduction of a directive.* Luxembourg, Office for Official Publications of the European Communities, 1993 (document COM(93)423).

[33] Phillips, D.R. & Vehasselt, Y. *Health and development*. London, Routledge & Kegan Paul, 1994.

[34] Godfrey, C. Is prevention better than cure? *In:* Drummond, M.F. & Maynard, A., ed. *Purchasing and providing cost effective health care*. London, Churchill Livingstone, pp. 183–197 (1993).

Chapter 4
State of Human Health

4.1 Introduction

The WHO Constitution defines health as "a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity". Measuring health as so defined in a population is not a simple task. Some studies use self-assessment of health status, with the meaning of health depending on the subjective perception of the individual. This meaning is probably close to the WHO definition, but it may vary between different populations and countries. Other indicators of positive health have yet to be developed. Evaluations of the health status of populations are therefore based on the more readily ascertainable negative indicators, such as mortality or morbidity rates. Populations with lower prevalence rates for a disease are assumed to be in better health. This approach has many limitations. Disease reporting is usually confined to specific, clinically defined conditions. Special studies are necessary to obtain information about less severe disorders, such as early symptoms of a disease, physiological changes indicative of the functional impairment of particular organs, or small psychological or behavioural changes. The lack of appropriate methods for assessing positive aspects of health is particularly obvious when potential environmental effects are considered: where degradation of the environment has little obvious effect on physical health, it may nevertheless seriously compromise the population's sense of wellbeing.

This chapter identifies the main health issues in various parts of the WHO European Region. The current health status of the Region's population is described, and an analysis presented of trends in available health indicators over the last few decades. The inequalities in health status between population groups are discussed at the end of the chapter. The issue of causality, however, and the extent of the impact of environmental factors, particularly on these inequalities, is evaluated in Chapter 18.

The description of health largely deals with the Member States of the Region in three groups: the CCEE, the NIS and the other countries; for the sake of convenience, the last of these are referred to as western countries.[a]

Since the size and demographic structure of populations, as well as socioeconomic factors and lifestyle characteristics, are major determinants of health, such background data for the Region's population are presented first.

4.2 Demographic, Socioeconomic and Lifestyle Data

4.2.1 Population size and age structure

The WHO European Region encompasses the European continent (i.e. that lying west of the Ural Mountains), the central Asian republics of the NIS, Israel and Turkey. In 1991, the Region had a population of 852 million [1], about 51 % of whom lived in western countries (including 7 % in Turkey and Israel), 34 % in the NIS and 15 % in the CCEE .

Over the last two decades, the Region's population has grown continuously, with a 15 % increase between 1970 and 1991. The rate of population growth, however, has varied considerably. Between 1960 and 1975, the eastern countries witnessed a steep decline in the rates of population increase, which has levelled off over the past few years. In contrast, western European rates of increase remained stable at around 0.8 % between 1950 and 1970, but then fell to 0.1–0.3 %. At the end of the 1980s, a net natural population increase was observed in most countries. It exceeded 1 % in a few (Albania, Israel and Turkey); for several others the increase was close to zero. In Austria, Denmark, the Federal Republic of Germany, Hungary and Italy a negative change was observed (down to a decrease of 0.2 % in Hungary).

These natural changes resulted from the differences between birth and death rates. The crude birth rate was 11–18 per 1000 population in most of the Region, with higher rates (22–29 per 1000) in Albania, Israel and Turkey. The crude death rate varied from 9 to 12 per 1000 population in most countries, with lower rates (6–8 per 1000) in Albania, Iceland, Israel and Turkey and a higher one (13.4 per 1000) in Hungary. Based on the trends in birth rates, death rates and other demographic factors such as migration, the population of the Region is projected to grow by some 16 % in the next 35 years, reaching 990 million in 2025. Only about a quarter of this increase, however, is expected to occur in the western countries [2].

In 1990, children under 15 years of age comprised some 20 % of the European Region's population, the proportion ranging from 17 % to 25 % in most countries and reaching 35 % in Turkey. People aged 65 years and over represented 13 % overall (10–18 % in most countries; 4–5 % in Albania and Turkey). Thus, age distribution varies substantially between countries. Owing to the declining birth rates and the growth of the population aged 65 years and over, the age composition of the Region's population is changing. By the year 2025, the proportion of children is expected to decline to 16 %, and that of people 65 years and older to increase to 20 % [3]. The median age rose from 32.2 years in 1970 to 34.0 in 1990, and is expected to be 42.9 in 2025.

[a] Many of the data sources used in this chapter (and particularly for the tables and figures) refer to "European OECD countries" instead. These data do not include those on Israel, Malta, Monaco or San Marino.

4.2.2 Population distribution

With a total area of almost 28 million km^2, the average population density in the WHO European Region is about 30 per km^2. Five countries (Belgium, Malta, Monaco, the Netherlands and San Marino) have a population density of more than 300 per km^2, but many more (Austria, Bulgaria, Croatia, Finland, Greece, Iceland, Ireland, Norway, Romania, Slovenia, Spain, Sweden, Turkey, the former Yugoslavia, and all the NIS except the Republic of Moldova) have an average population density of less than 100 per km^2. Chapter 5 (Fig. 5.1) discusses population density in the parts of the Region west of the Ural mountains.

The distribution of the Region's population has changed significantly, and migratory pressures are likely to increase in the 1990s. Population redistribution has shown four major trends since 1950:

- continued movement from rural to urban areas;
- movement from large urban areas to the suburbs and to medium-size and smaller peripheral towns;
- recent movement from urban and suburban areas to small towns and villages in rural districts in several countries; and
- movement between countries.

Various factors have influenced these movements, including changes in national economies (with concomitant effects on the economic fortunes of towns, cities and regions); increasing levels of real income, education and car ownership; improvements in public transport; and significant changes in preferred lifestyles.

The urban population of the Region is estimated to have increased by some 75% between the 1950s and 1980s, although countries and groups of countries show substantial differences in the rate of increase (see also Chapter 1). From 1950 to 1970, growth rates in urban areas of eastern Europe and the USSR first declined and then stabilized. In northern, western and southern countries of the Region, urban population growth reached a peak in the 1960s and then declined, but at very different rates. In 1985, people living in urban areas comprised 75% of the population in the western countries of the WHO European Region, 58% in central and eastern countries and 65% in the USSR. The definitions of urban areas vary between countries: in some, administrative or historical considerations classify a settlement as urban or rural. For this report, urban areas in the European continent with populations over 50 000 are classified as cities. Out of 700 million people in this area with relatively complete population data, 314 million (44.9%) lived in such cities at the end of the 1980s.

In the European Community, migration between countries virtually stood still in the 1970s and early 1980s. With the exception of Ireland, net migration from weaker economic regions was close to zero, and even slightly negative in some cases in the second half of the 1980s. In contrast, the eastern parts of the Region experienced considerable migration after the Second World War. Until 1989, the Latvian SSR had the highest population growth in the Region, owing to immigration from the RSFSR,[a] the Byelorussian SSR and the Ukraine.

With rates of natural increase declining, net immigration became an important source of population growth. As a result of net immigration in the late 1970s, the population of the western countries grew nearly three times faster than it would have by natural increase alone. In countries such as the Federal Republic of Germany, with a negative natural population growth rate, an increase in net immigration resulted in overall population growth.

4.2.3 Socioeconomic factors

Socioeconomic status is an important determinant of health. It is measured by a variety

[a] The Russian Soviet Federal Socialist Republic, now the Russian Federation.

of indicators such as level of education, occupational category and income. These are indirect measures of a complex interaction between external factors such as living conditions or the accessibility of adequate health services, and personal characteristics such as choice of lifestyles or attitudes to disease prevention and health care.

Data from several western European countries have suggested that the relative level of income within a country or over time is a more important determinant of health than the mean absolute level [4].

Poverty and ill health are strongly and obviously associated. On a global scale, poverty is a less severe problem in the European Region than in some other parts of the world [5]. Nevertheless, a considerable proportion of people live close to or even below the official minimum income level in many countries of the Region. Such circumstances are likely to be associated with restricted access to adequate food and health services, poor housing, urban pollution and a lower level of education (which, as well as economic factors, may influence choice of lifestyle); educational attainment also affects understanding of hygiene and how to make the best use of available health care services.

4.2.4 Lifestyle indicators

According to the estimates collected by the WHO Regional Office for Europe from population studies conducted in several countries at the end of the 1980s, 20–45 % of the total population smoked cigarettes (Fig. 4.1). In most of the countries, more men than women smoked; the greatest contrasts were reported in Greece, Hungary and Portugal, and in studies conducted in Moscow and Tashkent. In other countries, the differences are smaller, however, and the opposite pattern is observed in some. According to data from several western countries of the Region, the decreasing differences in smoking between the sexes are particularly clear in young people [6]. According to the estimates of the Food and Agriculture Organization of the United Nations (FAO) the consumption of tobacco per head is declining in the western and northern countries of the Region [7]; this decline is expected to continue. Consumption is stable or rising in the eastern and southern countries. Some of the CCEE, such as Bulgaria, Hungary and Poland, show alarming levels and trends.

Registered annual alcohol consumption in the Region, expressed as litres of pure alcohol per head, varied in 1990 from less than 1 litre per head in Israel and Turkey to over 12 in France and Luxembourg. Average consumption in the Region rose until 1980 and then a slow decline was observed, which accelerated in the late 1980s to a level that was 20 % lower in 1990 than that at the beginning of the 1980s (Fig. 4.2). That acceleration was mainly related to a 40 % drop in registered alcohol consumption in the USSR in the period 1985–1987; there was also an average decrease of 13–15 % in consumption in other parts of the Region, except the Nordic countries. The available figures do not reflect unregistered consumption, the extent of which may vary between countries. For example, the estimates for Norway indicate that unregistered consumption amounts to 50 % of that registered [8].

4.3 Availability and Interpretation of Health Data

Much of the analysis presented below is based on mortality data. Systems to collect such data are the best developed and standardized, and broadly comparable data for at least 20 years are available in almost all countries of the Region. The national mortality data used in this report were collected by WHO headquarters. Causes of death are coded according to the eighth or ninth revisions of the International Classification of Diseases (ICD8 and ICD9) and tabulated in the defined groups of the ICD9 basic tabulation list [9]. Rates were calculated for

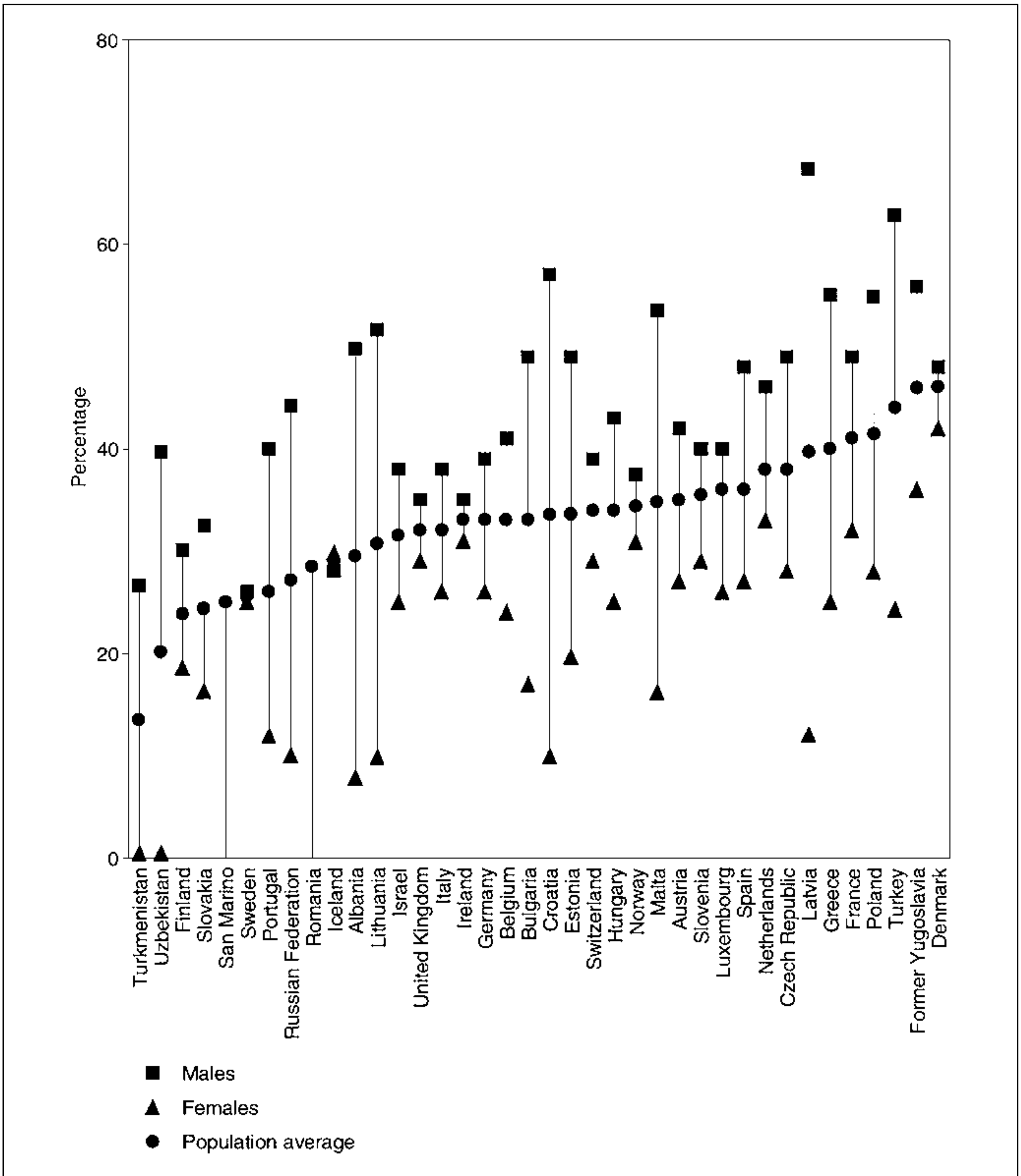


Fig. 4.1: Smoking prevalence in the WHO European Region in the early 1990s

three groups of countries in the Region: the CCEE, the former USSR and the western countries. The relative similarity of the data patterns in countries suggested this grouping, although the national data were used to detect possible major deviations from group levels and trends. Data on mortality at the subnational level were collected from national statistical publications and/or the database of EUROSTAT.[a] The national figures for life expectancy were retrieved from the health for all database of the WHO Regional Office for Europe [8] and other WHO sources [1].

Whenever data are available, an evaluation of disease incidence or prevalence

[a] Statistical Office of the European Communities.

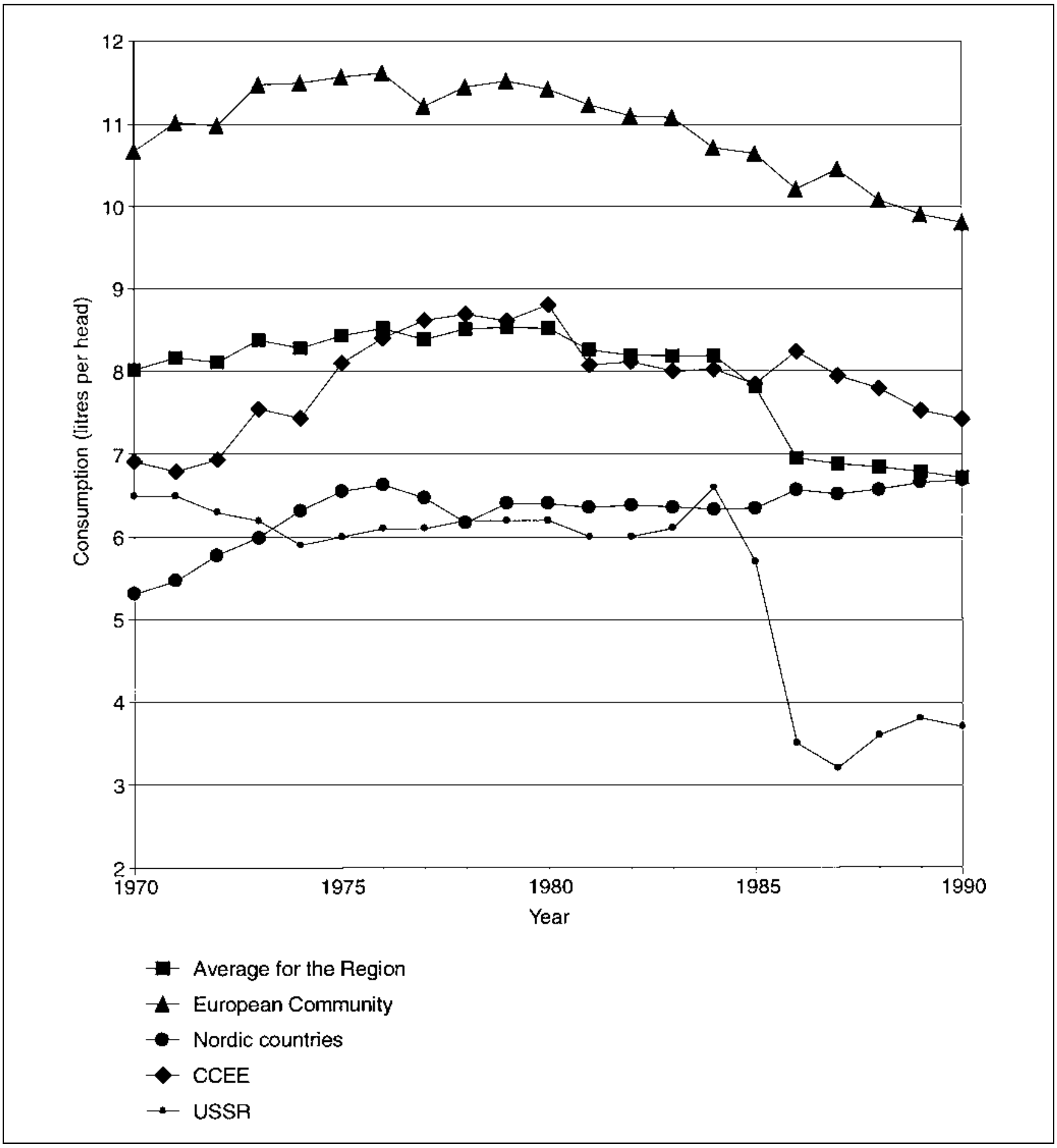


Fig. 4.2: Registered annual consumption of pure alcohol in the WHO European Region, 1970–1990

supplements the analysis of mortality. Data on cancer incidence are based on publications of the International Agency for Research on Cancer (IARC). To analyse the occurrence of congenital malformations, data are used from both the International Clearinghouse for Birth Defects Monitoring Systems and a EUROCAT[a] report. In the analysis, some indicators reported to the Regional Office by Member States in the context of monitoring progress towards health for all are also used. Information on communicable diseases and on mental disorders was supplied by the units of the Regional Office that deal with these issues. In addition, data published in peer-reviewed scientific journals and in national statistical publications were used. Some of these are based on studies conducted in selected populations, and therefore cover only a part of the Region's population. As the methodology of such

[a] European Registration of Congenital Anomalies and Twins.

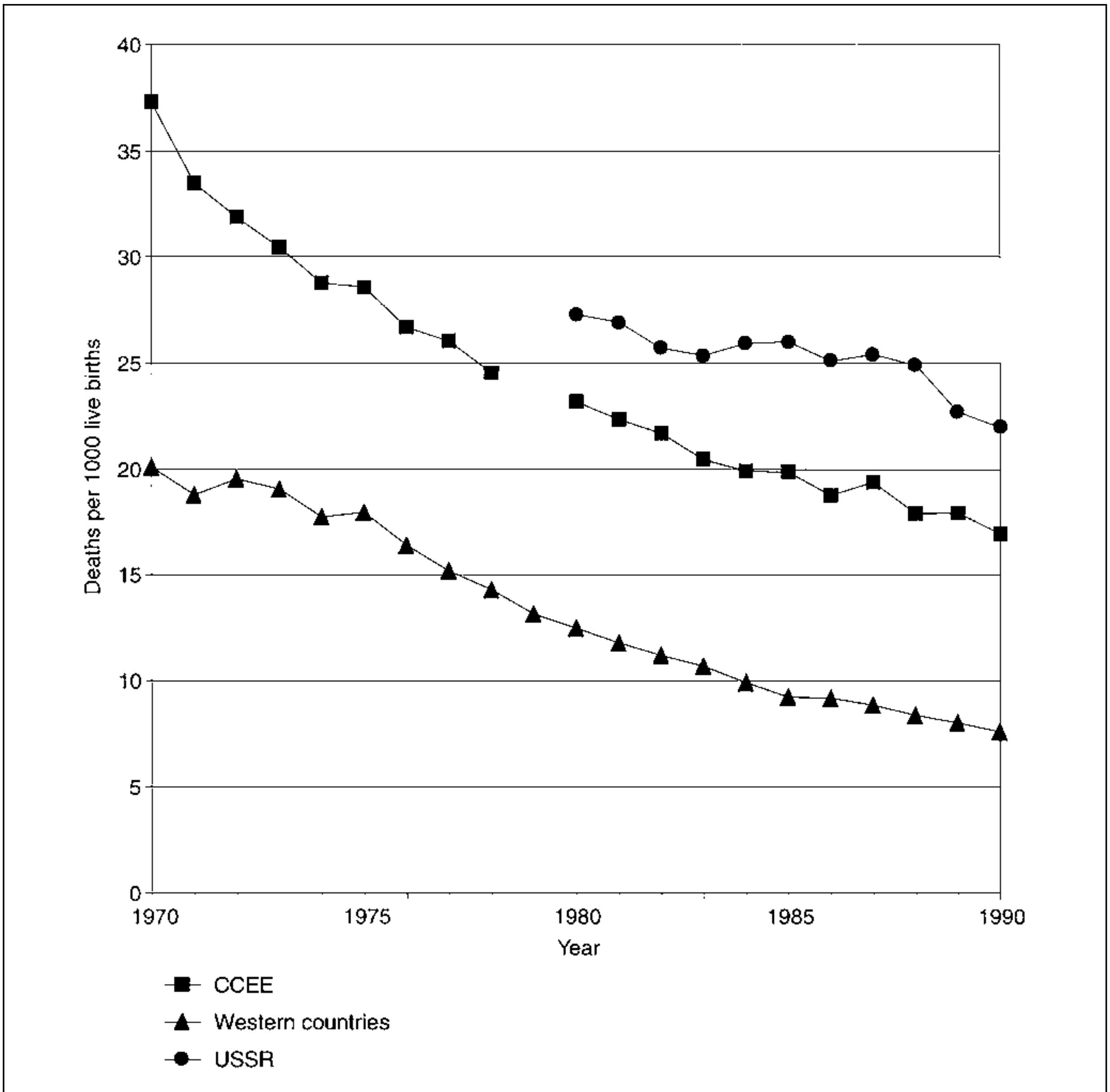


Fig. 4.3: Infant mortality in the WHO European Region by groups of countries, 1970–1990

studies differs and the results are difficult to compare, these data have limited usefulness for a comprehensive assessment of health in the Region.

4.4 Infant Mortality

Infant mortality is traditionally considered an indicator of the state of health of a population [10]. Infant mortality has consistently decreased in the European Region in the past 20 years. The average rate was 26.1 deaths per 1000 live births in 1970, 16.0 in 1980 and 10.0 in 1991, a decrease of 62%.

This trend was present in all European countries but with distinct and stable differences in infant mortality rates in different parts of the Region (Fig. 4.3). In 1990 infant mortality rates were 7.5 per 1000 in the western countries, 16.9 per 1000 in the CCEE and 22.0 in the USSR. The relative risk of dying within the first year of life was 2.3 and 2.9 for infants born in the CCEE and USSR, respectively, in comparison with those born in western countries.

During the period 1986–1990, infant mortality rates were 8.1 per 1000 live births in

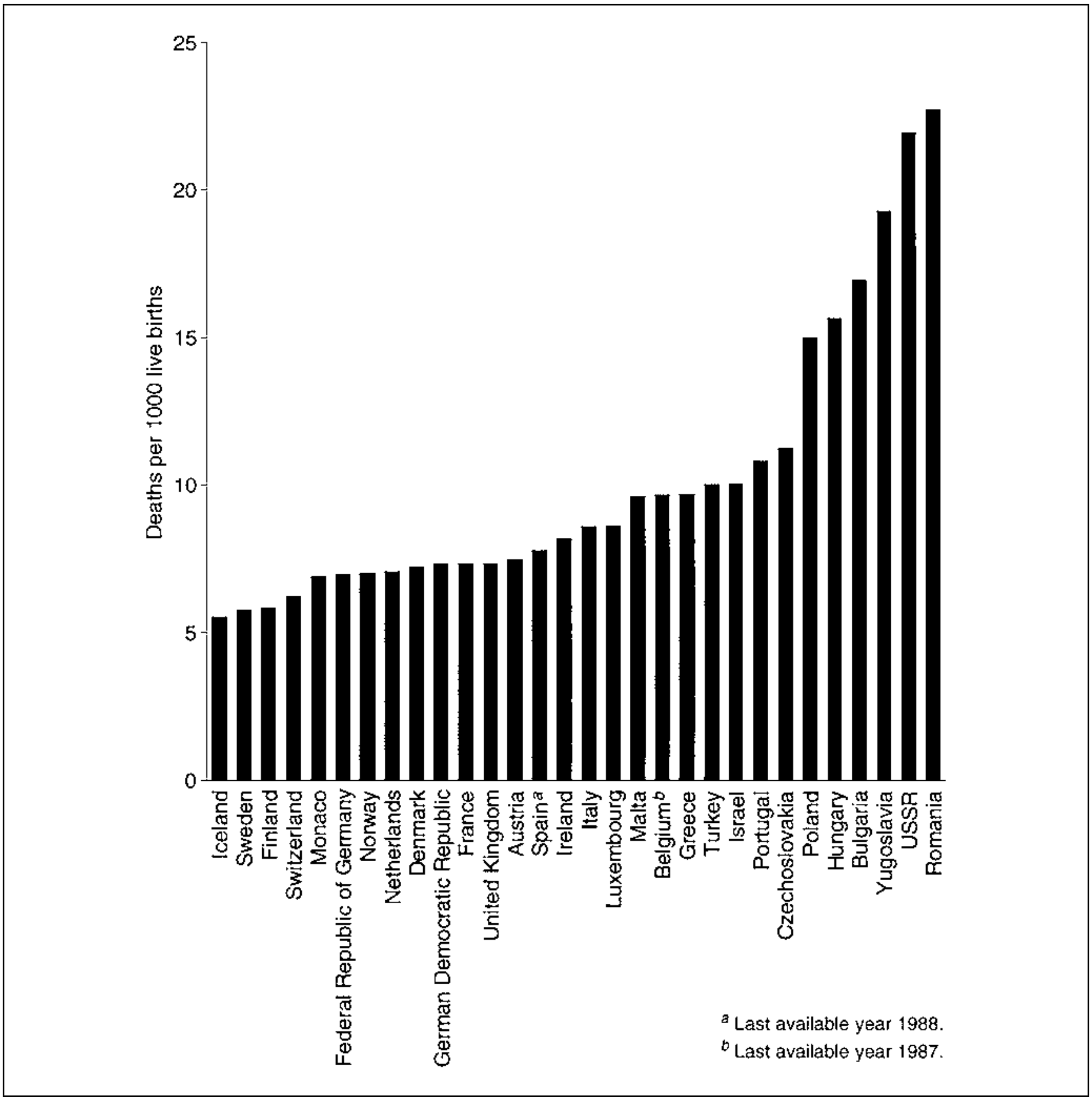


Fig. 4.4: Infant mortality in the WHO European Region by country, last available year (1989–1991)

the western countries, 18.8 in the CCEE and 22.0 in the USSR. When data for the last available year (1989–1991) were analysed by country (Fig. 4.4) the highest rates were found in Romania (22.73 per 1000), the USSR (21.96 per 1000) and Yugoslavia (19.27 per 1000). The present position, in terms of the new targets for reduction of infant mortality in the European Region [11] is as follows: 52 % of children (6.0 million infants) are born in countries in which the infant mortality rate exceeds the target level of 15 per 1000, 8.6 % (1.0 million) in countries in which the target of 10 per 1000 has not yet been met, and 39.4 % (4.5 million) where the target of 10 per 1000 has already been reached.

The main causes of infant mortality differ markedly between groups of countries (Fig. 4.5). The most common causes of infant death in the western countries and the CCEE were asphyxia and immaturity, responsible for 41 % and 39 %. In the USSR, these causes were responsible for 34 % of infant deaths, with deaths due to infectious diseases being the most common. For almost

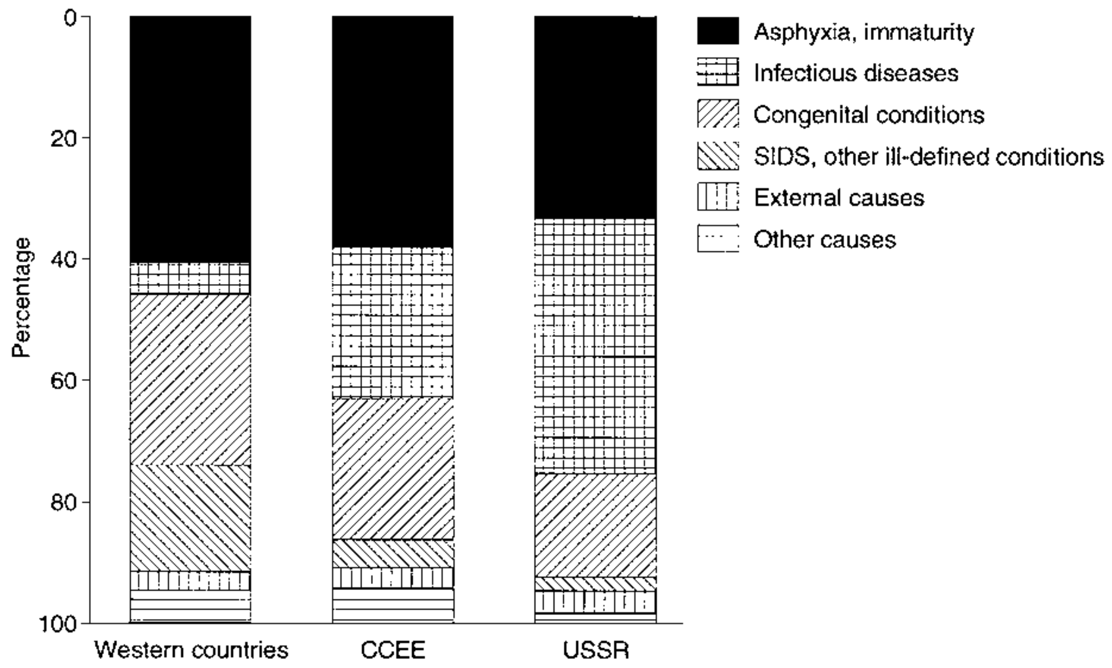


Fig. 4.5: Main causes of infant mortality in the WHO European Region, 1986–1990

all main causes, the rates were higher in the CCEE and the USSR than in the western countries with the exception of the sudden infant death syndrome and other ill-defined conditions, which were responsible for 1.4 deaths per 1000 in the western countries, 0.9 in the CCEE and 0.5 in the USSR. Rates differed most strikingly for deaths caused by infectious diseases, which ranged from 0.4 per 1000 live births in the western countries, through 4.7 in the CCEE, to 9.2 in the USSR. These differences clearly indicate that infectious disease is the priority area for intervention to reduce infant mortality in the CCEE and NIS.

4.5 Life Expectancy and Total Mortality

4.5.1 Life expectancy

Life expectancy is a widely available indicator of the state of health of a population, calculated from registered data on age-specific mortality and age structure.

Taken overall, life expectancy has increased in the European Region. Trends differ between groups of countries and age groups. Fig. 4.6 gives weighted mean life expectancy figures by age for the three groups of countries. Life expectancy at birth increased in the 1970s and 1980s, by 4.5 years to 76.5 years in the western countries and by 1.9 years to 71.23 years in the CCEE. An increase was also seen in the USSR in the 1980s but, after a marked increase to 69.8 years in 1986, life expectancy at birth stagnated or even declined at the end of the decade. In the western countries, life expectancy increased at all ages after infancy. This was not the case in the CCEE, where no improvement was seen at ages 1, 15 and 45 years; only at 65 years did life expectancy increase (by 1 year, in contrast to a rise of 2.1 years in the western countries). The figures for the USSR, available for the years 1981–1990 only, indicate a decrease in life expectancy for all ages at the end of the decade.

Time trends for life expectancy at 15 and 45 years were further studied by sex and

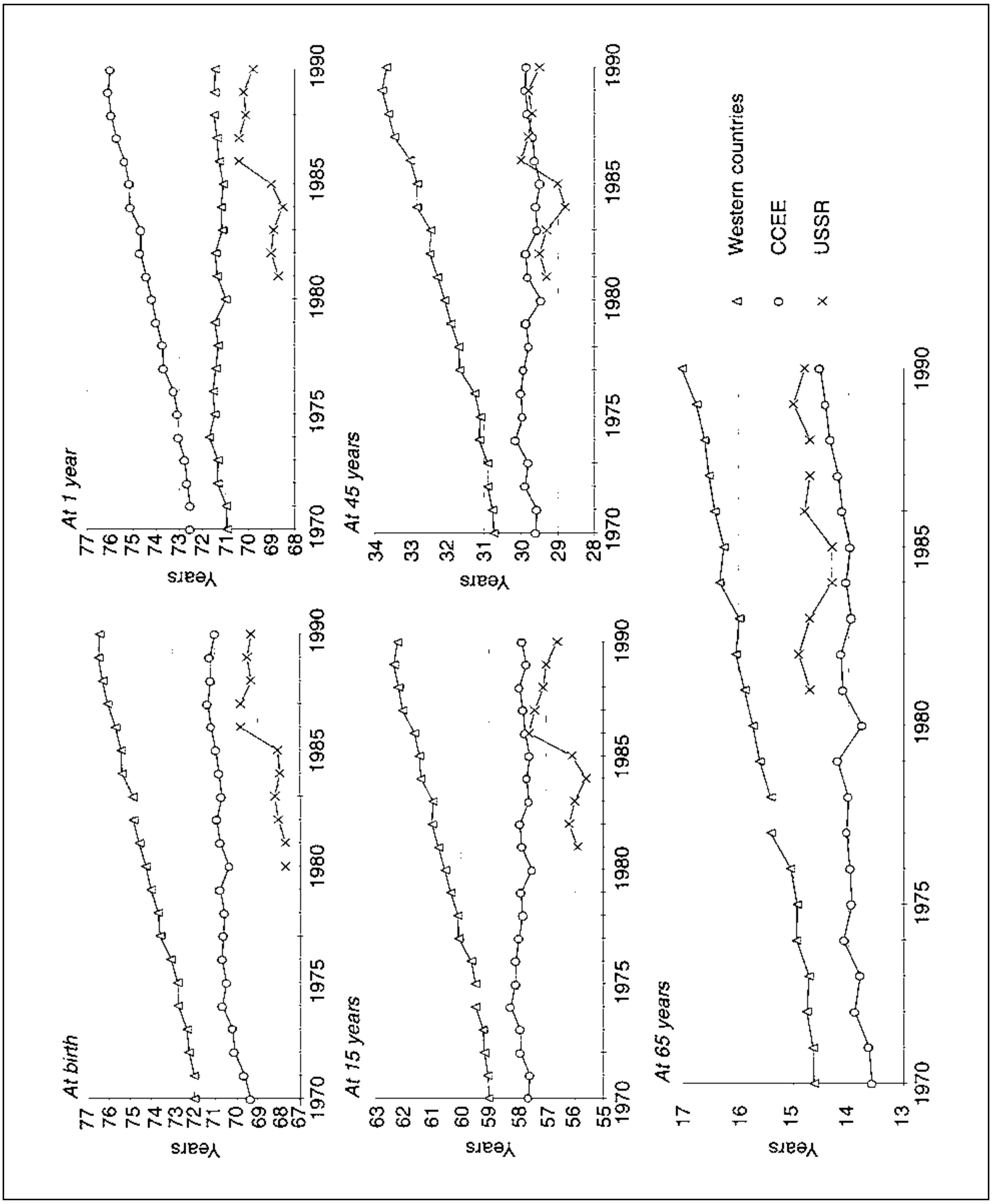


Fig. 4.6: Life expectancy in the WHO European Region by age, 1970–1990

country group (Fig. 4.7). For all groups of countries, life expectancy was higher in females than in males. On the other hand, while the increase in life expectancy was more or less similar for males and females in the western countries, the pattern in the CCEE and USSR was quite different. In the 1980s a slight increase, smaller than that observed in the western countries, was observed for females in the CCEE and USSR, but life expectancy for young and middle-aged males clearly decreased, from the 1980s in the CCEE and in the second half of that decade in the USSR.

In summary, life expectancy data clearly indicate that young and middle-aged males in the CCEE and USSR experienced a marked deterioration in health status in the 1980s.

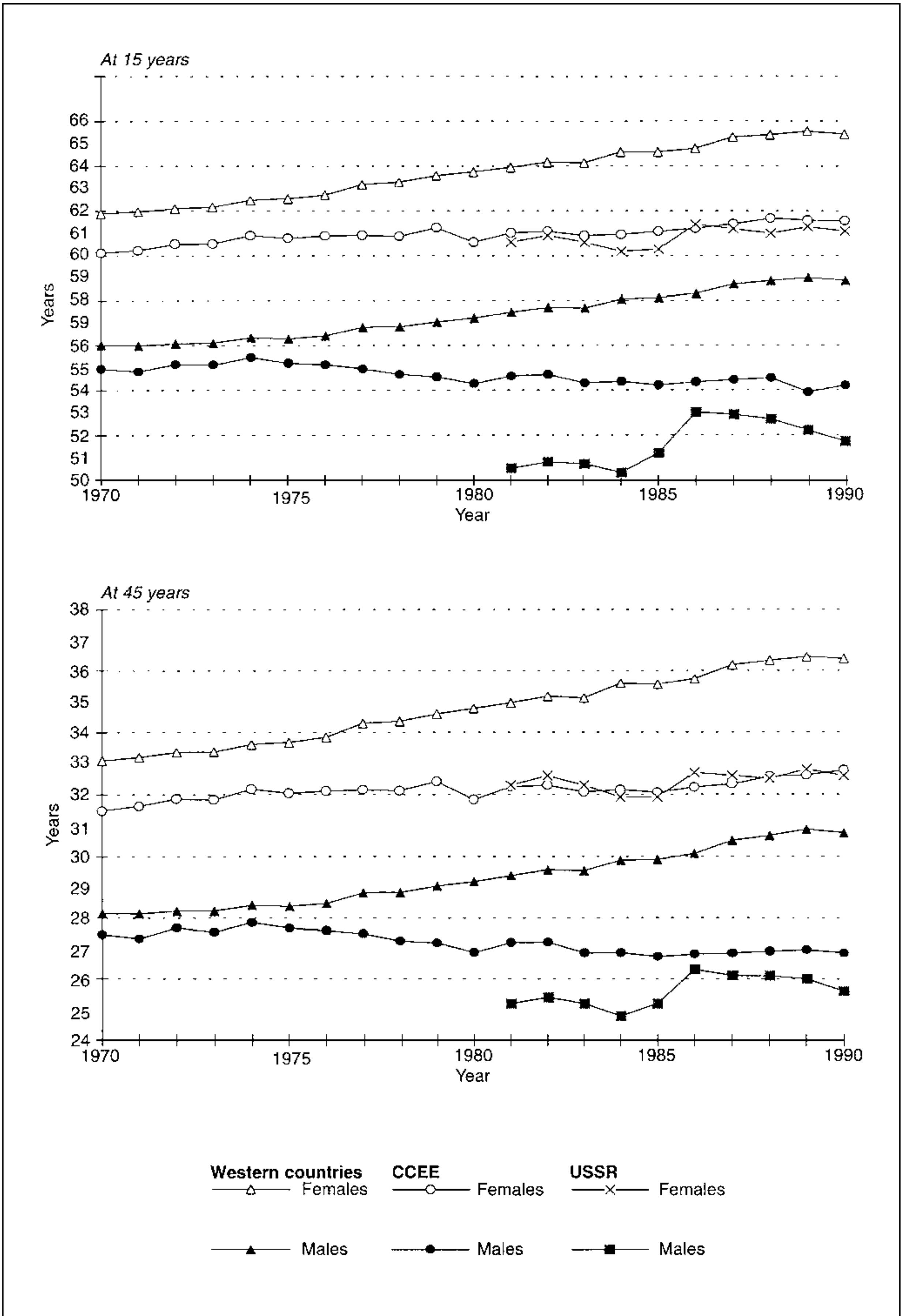


Fig. 4.7: Life expectancy in the WHO European Region by sex and age, 1970–1990

4.5.2 All causes of mortality

The age-specific mortality of the Region's population was used to interpret the differences and changes in life expectancy between the groups of countries. At the end of the 1980s, the mortality rates in the CCEE were higher than in the western European countries in all age groups. The rates in the USSR were even higher (Fig. 4.8) except those for people aged 65 years and over. In the western countries, a downward trend in mortality was observed in all age groups and both sexes, with the most rapid improvement in younger people. In the CCEE, mortality also declined significantly in children aged

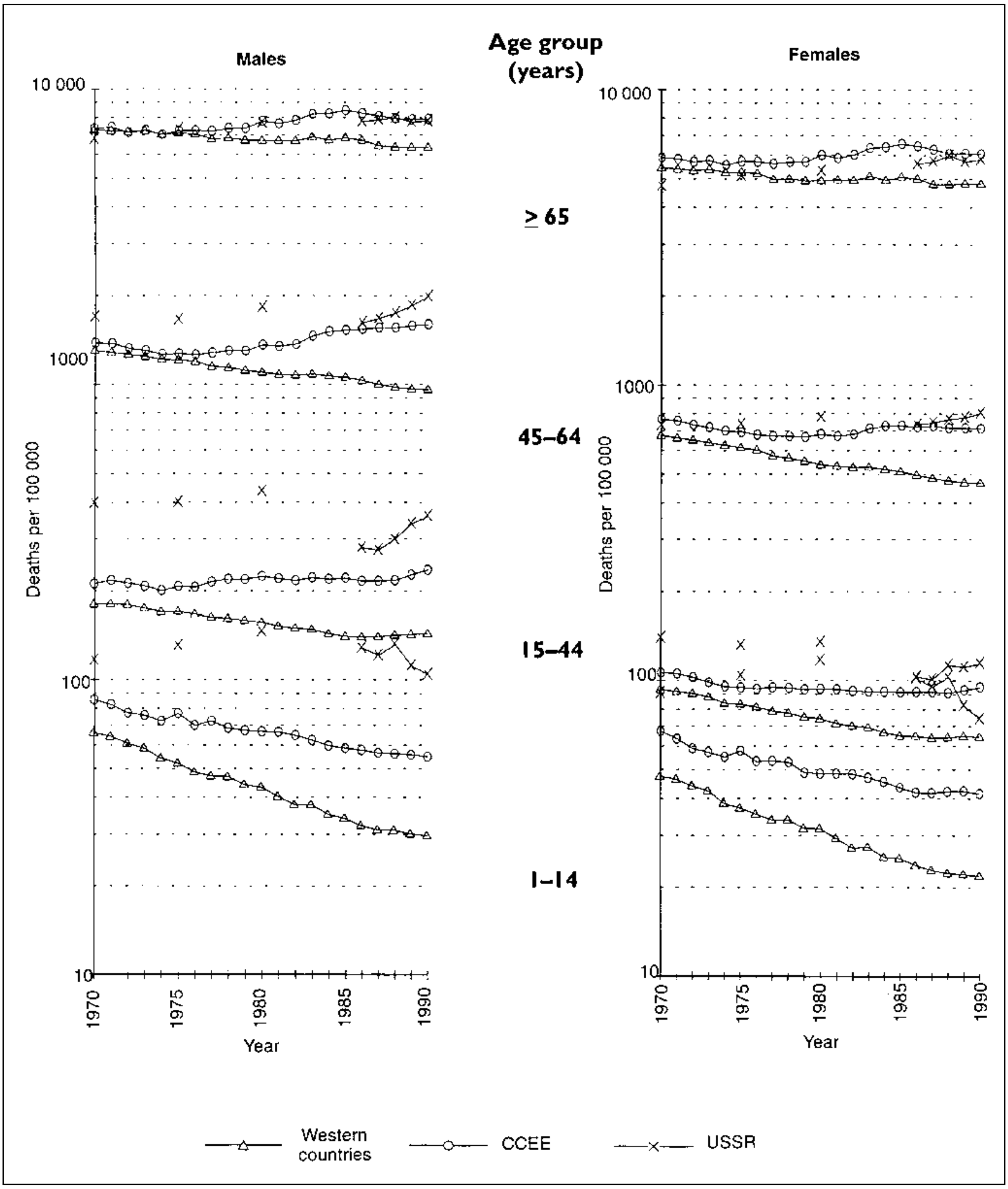


Fig. 4.8: Age-specific mortality from all causes in the WHO European Region, by sex, 1970–1990

1–14 years, but the differences in mortality between the groups of countries tended to increase for most of the period.

The trends in mortality differed markedly between the groups of countries in those aged 15–64 years. The most striking was the increase in total mortality in men aged 45–64 years in the CCEE. Until the mid-1970s, this group showed similar downward trends in mortality in the CCEE and western countries, with the rates in the eastern countries higher by about 23%. The trend then changed, and the difference in rates increased to over 60% of the western level at the end of the 1980s. In women aged 45–64 years, an upward trend in the rates was observed in the CCEE at the beginning of the 1980s; this stabilized later. With a decline in mortality in western countries, however, the difference in mortality rates increased from 14% at the beginning of the 1970s to over 50% at the end of the 1980s. A similar pattern was seen in females aged 15–44 years. The differences in mortality resulted from a steep decline in mortality in the western countries and the stabilization of the rates in the CCEE.

In men aged 65 years and over, the levels and trends in mortality were very similar in all groups of countries until the mid-1970s. Then the rates increased in the CCEE but the difference did not exceed 25% of the western rates. Mortality in women aged 65 years and over was less than 10% higher in the CCEE than in western countries in the early 1970s, but changes similar to those observed in men led to a 30% difference by the mid-1980s.

A similarly detailed comparison cannot be made for the former USSR, since sequential data sets have only been available since 1986. During this period, however, age-specific mortality has risen as much as or more than that in the CCEE. Only in the group aged 1–14 years have mortality rates decreased, although they are still significantly higher than in the western countries or the CCEE.

4.5.3 Spatial patterns at the subnational level

Mortality patterns vary not only between but also within countries. To illustrate this, the age-standardized death rates were calculated for the subnational administrative areas of the Region, using an indirect method of standardization, with a common standard for males and females based on the mortality data of all Member States. The standardization was used to eliminate the impact of differences in age structure on the mortality level in the compared areas. The data for the last available year were used: 1990 for most countries, 1985 for seven European Community countries and Norway, and 1991 for the Moldavian SSR, Romania and the RSFSR. For a few countries, only national data were available.

The age-standardized rates of mortality from all causes showed a rather consistent pattern of difference between the groups of countries (see Maps 4.1 and 4.2[a]). Most of the 10% of the male population in the Region with the highest death rates lived in the RSFSR, although males in some areas of Hungary and Romania had similar death rates. Males from most of the remaining areas of the CCEE and the USSR had mortality rates above the median level; the exceptions were some parts of Bulgaria. None of the areas of the western countries belonged to the upper quartile of mortality distribution. Of the males in the Region with the lowest mortality, 10% lived in Greece, southern Italy and parts of Norway, Spain, Sweden and Switzerland. The pattern in females showed some similarities. The highest rates were seen in Bulgaria, Hungary and Romania but in a markedly smaller part of the RSFSR than for males. Relatively high female mortality was also seen in Scotland and northern England. The lowest rates were found in Italy, the Netherlands, Norway, Sweden and Switzerland, and in northern Spain.

---

[a] Maps 4.1 and 4.2 will be found between Chapters 4 and 5.

4.6 Occurrence of Selected Diseases

4.6.1 Structure of total mortality by cause

In all countries of the European Region, the most common causes of death are cardiovascular diseases and cancer (Table 4.1). At the end of the 1980s, these were responsible for over 68 % of all deaths in the Region. The proportion of cardiovascular diseases increased in the CCEE and USSR and decreased in western countries in the 1970s and 1980s. The proportion of cancer mortality increased in all parts of the Region, particularly in the western countries. The third leading cause of death – injury and poisoning – had a relatively stable proportional mortality, while deaths due to respiratory diseases were less frequent at the end of the 1980s, and the contribution of infectious diseases to total mortality was reduced to half the 1970 level.

To a large extent, the distribution of causes within total mortality reflects the relative frequencies of diseases in the oldest age groups. Groups aged under 45 years showed a different pattern (Tables 4.2 and 4.3). Injury and poisoning accounted for some 40–60 % of all deaths in young males. Among females aged 15–44 years, cancer was the most frequent cause of death in the western countries and the CCEE, injury and poisoning in the USSR.

4.6.2 Selected groups of diseases

The following sections describe the situation for the diseases that are the most prevalent in the Region or cause most public concern. The analysis usually deals with wide groups of diseases, not particular diagnostic entities. Such grouping reduces problems related to possible differences between countries in diagnostic and reporting practices, and is imposed by the routine tabulation of diagnoses in some cases. Mortality data largely constitute the basis for the assessment. Whenever possible other data, from registers or special studies, follow the mortality analysis. While the differences in disease frequencies between the groups of countries receive the main emphasis, all data from individual countries have been analysed to detect any major deviations from the group patterns.

Cardiovascular diseases

The frequency of deaths due to cardiovascular diseases increases markedly with age (Fig. 4.9). Throughout the Region, these diseases lead to fewer deaths in children than other major causes. Among males and fe-

Table 4.1: Structure of mortality (percentages of deaths) in the WHO European Region by main causes of death, 1970 and 1988/1989

Cause of death	Western countries		CCEE		USSR	
	1970	1988/1989	1970	1988/1989	1970	1988/1989
Cardiovascular diseases	44.7	42.4	44.4	54.9	49.9	58.0
Cancer	18.5	25.6	14.2	17.3	15.8	15.9
Respiratory diseases	9.5	7.3	9.3	5.9	12.3	7.3
Injury and poisoning	6.5	6.3	6.2	6.6	10.1	9.1
Infectious diseases	1.4	0.8	2.4	0.8	3.2	1.7
Other	19.4	17.7	23.5	14.6	8.7	8.0
Standardized death rate (per 100 000)	1063	788	1216	1129	1029	1160

Table 4.2: Structure of mortality (percentage of deaths) in males of all age groups in the WHO European Region by main causes of death, 1990

Cause of death	Group aged 1–14 years			Group aged 15–44 years			Group aged 45–64 years			Group aged ≥65 years		
	Western countries	CCEE	USSR	Western countries	CCEE	USSR	Western countries	CCEE	USSR	Western countries	CCEE	USSR
Cardiovascular diseases	4.3	3.0	1.4	13.2	19.9	16.5	33.6	41.5	41.6	46.2	61.9	62.4
Cancer	14.9	11.4	7.1	14.3	12.3	8.1	37.1	27.4	27.2	25.8	16.5	16.7
Respiratory diseases	5.0	13.4	21.9	2.4	3.0	2.2	4.4	5.0	6.5	10.3	7.4	8.6
Injury and poisoning	40.9	40.4	41.8	47.3	44.0	59.9	8.0	9.6	14.3	2.9	3.2	2.9
Other	34.9	31.9	27.8	22.9	20.8	13.2	16.9	16.6	10.4	14.8	11.0	9.4
Standardized death rate (per 100 000)	29.6	54.8	103.9	143.4	235.0	358.2	958.8	1600.4	1981.9	6345.0	7899.7	7770.3

Table 4.3: Structure of mortality (percentage of deaths) in females of all age groups in the WHO European Region by main causes of death, 1990

Cause of death	Group aged 1–14 years			Group aged 15–44 years			Group aged 45–64 years			Group aged ≥65 years		
	Western countries	CCEE	USSR	Western countries	CCEE	USSR	Western countries	CCEE	USSR	Western countries	CCEE	USSR
Cardiovascular diseases	5.9	3.7	1.8	12.0	18.3	15.5	24.6	40.4	44.6	52.6	69.0	73.0
Cancer	16.6	11.2	7.6	33.4	29.4	23.8	47.9	33.5	30.0	18.5	12.0	10.3
Respiratory diseases	5.6	17.1	27.7	3.2	3.9	3.7	3.9	3.6	4.2	7.5	4.6	4.5
Injury and poisoning	31.0	29.3	29.9	27.9	22.6	33.2	6.1	5.5	8.5	3.0	2.9	1.8
Other	40.9	38.7	33.1	23.6	25.8	23.8	17.5	17.0	12.7	18.4	11.5	10.4
Standardized death rate (per 100 000)	21.8	41.4	74.1	64.4	94.9	114.3	465.7	711.7	804.8	4813.2	6069.8	5812.8

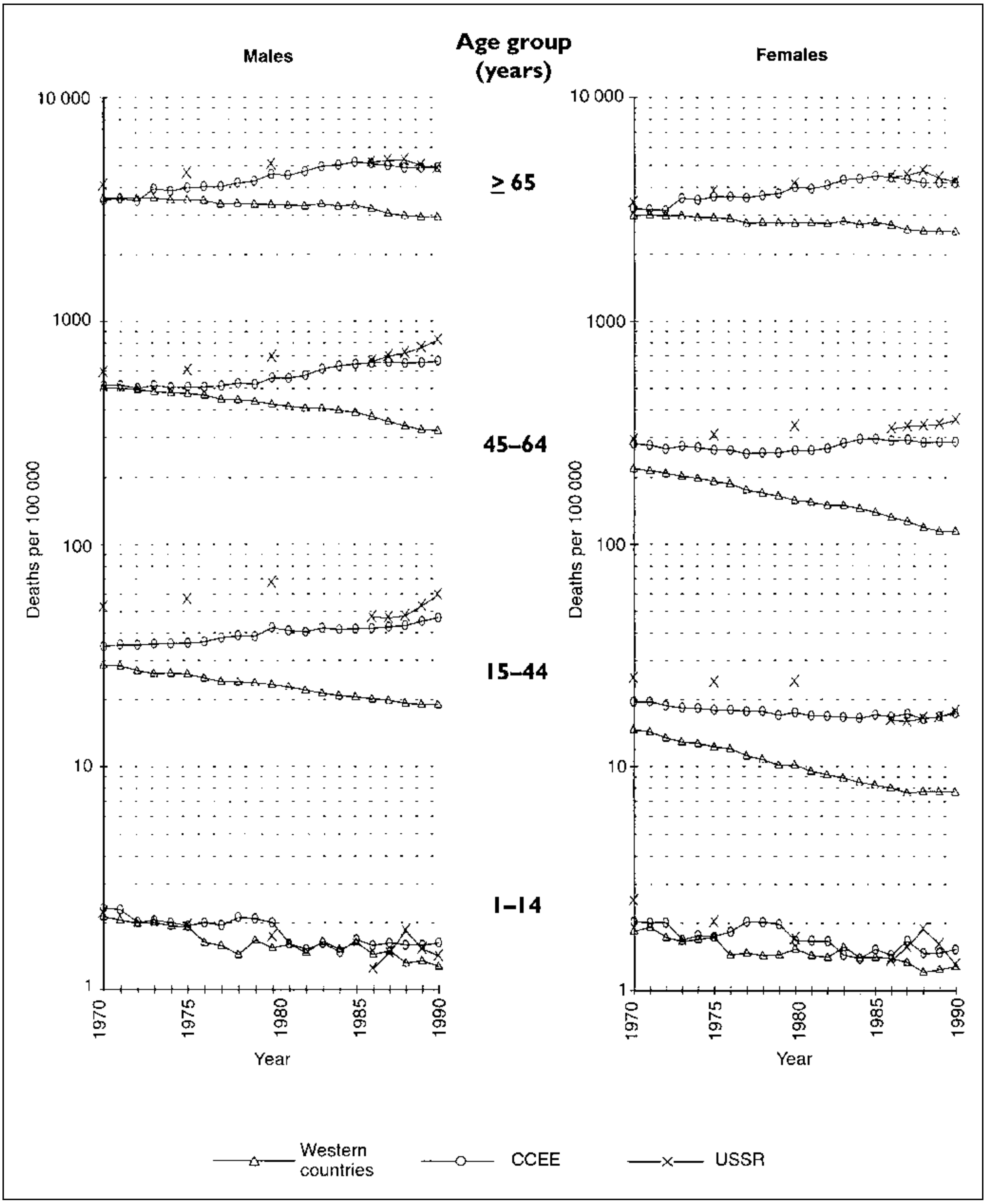


Fig. 4.9: Age-specific mortality from cardiovascular diseases in the WHO European Region, by sex, 1970–1990

males aged 15 years and over, the mortality due to cardiovascular diseases was markedly lower in the western countries than in the CCEE or the USSR. Owing to a decreasing trend in the western countries, and an increase or at best stabilization of the rates in the other two groups, the difference in mortality increased from nonexistent or small (not exceeding 33%) at the beginning of the 1970s to 100–150% in people aged 15–64 years and to 66% in the oldest age group at the end of the 1980s. An exception from the pattern in the eastern countries was the stable or decreasing mortality in the German

Democratic Republic. Within the groups of countries, the highest national rates (in Hungary) exceeded the lowest (in the German Democratic Republic) by a factor of 1.3 (in people aged 65 years or over) to 2.8 (in males aged 15–44 years).

The limited data on morbidity reported by some countries confirm that cardiovascular diseases are very common in the Region, and are more frequent in the CCEE than in the western countries [8,12]. The prevalence of these diseases was estimated to be 9–15 % in Finland, the Netherlands, Norway and Sweden, 25 % in Czechoslovakia and 31 % in Romania. Although the definitions and reporting systems used in various countries are not compatible, these data indicate that a substantial proportion of the adult population of the Region suffer from cardiovascular disorders.

An important source of information on morbidity from cardiovascular diseases is the WHO project on monitoring of trends and determinants in cardiovascular diseases (MONICA), conducted in defined communities of 27 countries throughout the world and including several European centres. The comparison of trends in mortality, using well standardized criteria, confirms decreases in disease frequency in several western countries of the Region and an increase in eastern centres over the 1980s [13,14].

The main recognized risk factors for cardiovascular diseases, and coronary heart disease in particular, are hypertension, high blood cholesterol and tobacco smoking. Preventive strategies concentrate on these factors [15]. Less clear are the roles of obesity and inadequate physical activity, interrelated factors that may be correlated with one of the three main risk factors. Several other lifestyle factors may also have a direct or indirect impact on the development of cardiovascular diseases, such as a diet rich in saturated fat (which is associated with a high cholesterol level) or in salt (which is associated with increased blood pressure). Genetic predisposition to these diseases is also considered important [16].

Cancer

The differences in the European Region in mortality from cancer are less dramatic than those seen for cardiovascular diseases and depend on the age group (Fig. 4.10). Among children aged 1–14 years, cancer mortality has declined throughout the Region but, owing to a faster decline in western countries, excess mortality appeared in the other two groups of countries by the late 1970s. By the late 1980s, the rates in the CCEE exceeded those in western countries by 22 %, but mortality was even higher in the USSR. In the group aged 15–44 years, cancer mortality in both sexes increased in the CCEE and declined or stabilized in the western countries. As in the younger age group, this led to a marked difference in rates by the end of the 1980s, from similar levels 20 years earlier. This pattern was repeated in the group aged 45–64 years, although in women the differences between the groups of countries remained very small. In this age group, some deviation from the general pattern observed for the western countries was seen in men in France and Italy: an increase in mortality in the early 1980s, with subsequent stabilization. Data on the USSR were less comprehensive, but the trend in cancer mortality in the second half of the 1980s was similar to that in the CCEE.

In the group aged 65 years and over, cancer was more frequently diagnosed as a cause of death in western countries than in the CCEE or the USSR. All three groups showed an upward trend, and the differences in rates between them remained the same throughout the 1970s and 1980s. At the end of the 1980s, the mortality rates exceeded the level for the early 1970s by 9–18 %.

The ratio of the highest to the lowest national rates within the groups of countries ranged from 1.5 to 2.3. The greatest difference was found in people aged 65 years and over in the CCEE, resulting from comparison of high rates in Hungary with low rates in Romania.

Differences in diagnostic and coding practices between and within countries may

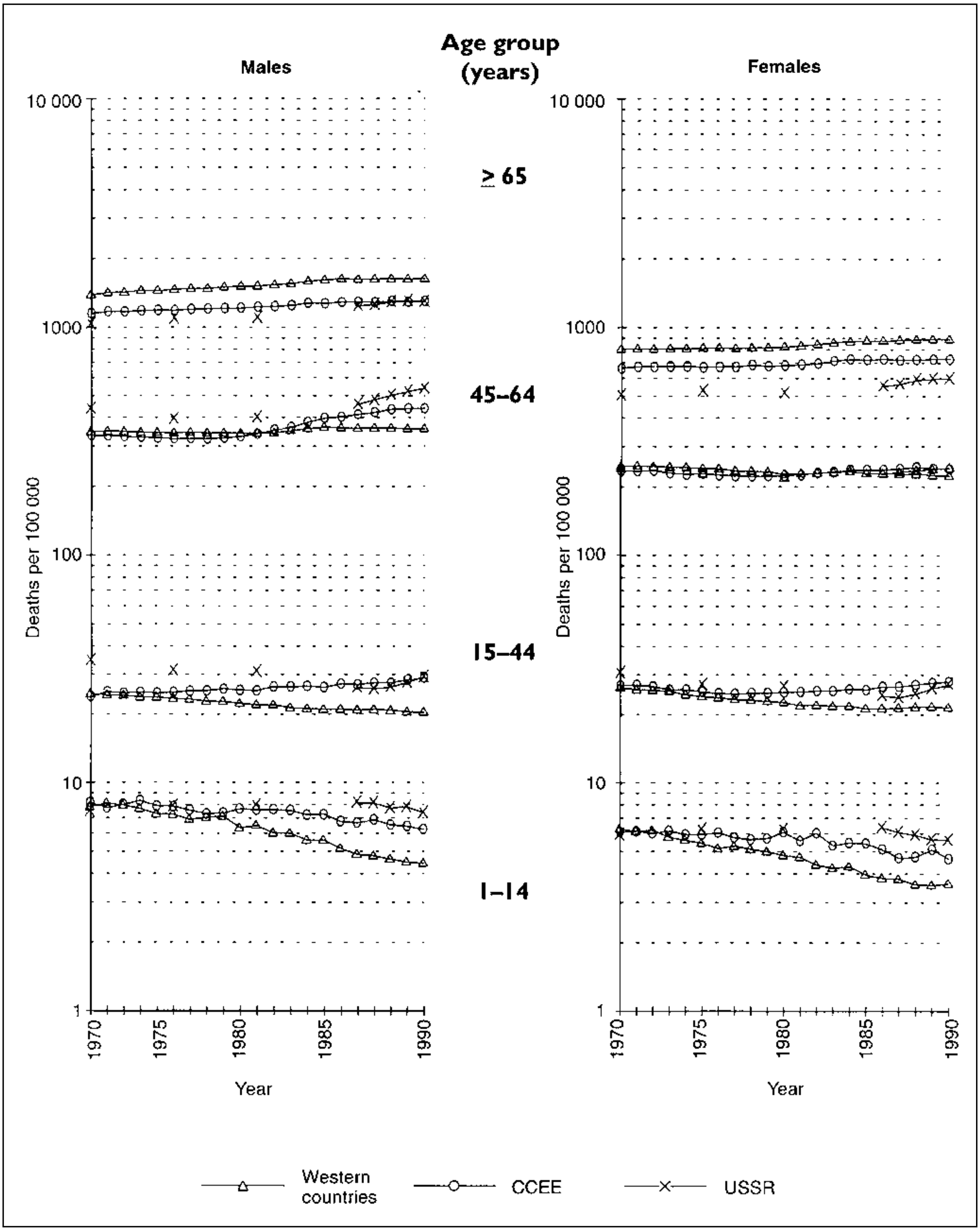
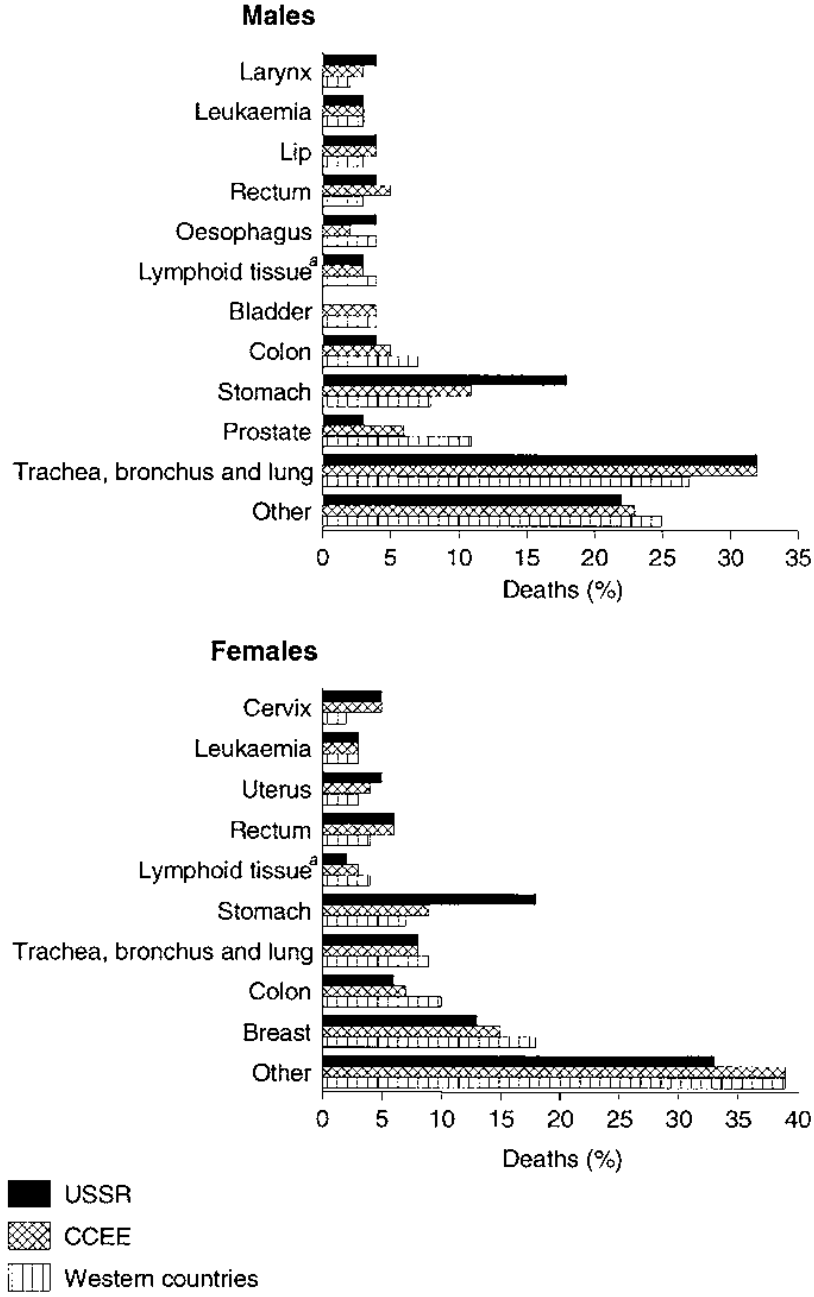


Fig. 4.10: Age-specific mortality from cancer in the WHO European Region, by sex, 1970–1990

hamper a more detailed analysis of geographical variation in cancer mortality, including cancer sites [17]. The overall distribution of the most common types of fatal cancer, as reflected in the mortality statistics, however, should roughly correspond to cancer site distribution in the Region's population. Recent IARC publications [17,18] provide extensive discussion of the spatial and temporal patterns in cancer morbidity and mortality.

The types of cancer most commonly diag-



[a] This refers to all cancers of lymphoid and haemopoietic tissue except leukaemias.

Source: World Health Organization *(1)*.

Fig. 4.11: Proportional mortality due to cancer by type in the WHO European Region, 1989–1990

nosed as causes of death differ in males and females. Fig. 4.11 illustrates the proportional contributions of the types of cancer that caused over 3% of all cancer deaths in at least one group of countries. In males, cancer of the trachea, bronchus and lung caused about 30% of cancer deaths in the Region, but mortality varied markedly between countries and was over twice as high in countries with the highest rates (Czechoslovakia, Hungary, the Netherlands and the United Kingdom) than in those with the lowest rates (Iceland, Portugal and Sweden). In females, this type of cancer was much less frequent than in males (from 1.4 times less frequent in Iceland to 8.8 times in Spain) but was responsible for a greater proportion of cancer deaths in the western countries than in the rest of the Region. The dominating risk factor for lung cancer is tobacco smoking: about 85% of all cases in males is attributable to it [19]. Exposure to high levels of radon gas may be a significant risk factor for lung cancer in areas with uranium-bearing rocks, but the risk is greater for smokers than for nonsmokers (see Chapters 12 and 18).

In females, breast cancer was the most common cause of death. The highest mortality rates were registered in Austria, the Federal Republic of Germany, the Netherlands and the United Kingdom, and the lowest in the USSR and Yugoslavia. The factors that determine the incidence of breast cancer are uncertain at present [20]. Several lifestyle factors (having a late first child, giving birth after the age of 35 years, prolonged use of oral contraceptives, increased alcohol intake and post-menopausal body mass increase) have been suggested to be relevant, as well as genetic predisposition. A diet rich in fat is also considered a possible risk factor.

Stomach cancer was a relatively common cause of death in both sexes but its frequency is declining in general. The mortality rates varied markedly, being highest in Portugal and the USSR, and in a group of countries in central and southern Europe. The lowest rates were noted in France, Greece, Iceland and Ireland. A more detailed analysis, conducted by IARC for nine countries of the European Community, indicates a distinct subnational pattern of mortality due to stomach cancer [17]. Among the factors suspected of increasing the risk of stomach cancer is a diet rich in starchy food (such as wheat, potatoes and beans) and smoked, salted and fried foods. The consumption of green vegetables and citrus fruit is thought to decrease the risk. No convincing evidence has been found to incriminate nitrates and nitrites in drinking-water [19].

Cancer of the colon and rectum were frequently considered together because of possible difficulties in correct diagnosis and classification. Both types are relatively common causes of death from cancer in both sexes. More specific data show that the mortality rates in females were close to those in males for colon cancer, but lower for cancer of the rectum. The mortality in Austria, the Federal Republic of Germany and Hungary was three times that in Greece or Yugoslavia. Dietary factors seem to influence the risk of colon and rectum as well as stomach cancer. A high intake of fat is thought to increase the risk, while the consumption of vegetables or fibre may reduce it.

Prostate cancer was one of the most common forms of malignant disease in men, although very rare in those aged under 50 years. Mortality rates varied widely between countries, and the proportion of all cancer deaths caused by prostate cancer ranged from 3% in the USSR to 11% in western countries. The death rates in France, Norway and Sweden were four to seven times those in Poland, the USSR and Yugoslavia; the rates for men aged 65 years and over showed less variation and differed by a factor of three to four. The etiology of this type of cancer is unclear, but hormonal factors are likely to be implicated.

The mortality rates for leukaemia differed little between the three groups of countries. The known environmental hazards are unlikely to account for the majority of cases. High doses of ionizing radiation undoubtedly cause some types of leukaemia, although quantitative estimates of the impact of low doses are still being studied. Evidence on the role of electric and magnetic fields is inconclusive but any increase in risk appears to be very small (see Chapter 11). Occupational exposure to some chemicals (such as chronic exposure to benzene) and the treatment of prior malignant diseases with chemotherapeutic agents are known risk factors for some forms of leukaemia, and infections may have a role in the etiology of some types of childhood leukaemia.

The incidence of cancer markedly exceeds the number of deaths that result. Relevant data are available for approximately 26% of the Region's population, but the coverage and quality of registration data varies significantly [20]. For western countries, however, incidence exceeded mortality by 1.4 times (in men aged 65 years and over) to 4.5 times (in women aged 0–44 years) [21, 22]. For 1980, crude rates of cancer incidence (at all sites except the skin) were estimated to range from 243 to 374 cases per 100 000 males, and from 212 to 341 per 100 000 females, with lower numbers estimated for eastern Europe (defined as the CCEE without Yugoslavia) [23].

Malignant melanoma of the skin shows markedly different trends in incidence and mortality rates. In general, it is not a frequent disease, comprising less than 1% of all cases of cancer. A rapid increase in incidence (up to 20–30% every five years), however, has been observed in some populations in the last 2–3 decades [18]. The highest incidence in the Region is in the Nordic countries, but the incidence is increasing as fast in eastern Europe as in western countries. The increase in mortality is much slower (some 10% every five years), probably owing to improved early diagnosis and treatment of less advanced cases. The most important current risk factor is intentional exposure to ultraviolet radiation while sunbathing (see Chapter 11).

Projections made for some countries of the Region suggest that cancer mortality will increase. For EU countries, a 31% increase (with 17% attributed to the increasing proportion of older people in the population) was predicted to occur between 1982 and 2000 [24]. Another analysis predicts that, even if progress in screening programmes and treatment leads to reduced mortality in some populations, the incidence of cancer may still increase in the next 10 years [21].

Respiratory diseases

While diseases of the respiratory system are a less frequent cause of death than cardiovascular diseases or cancer, and their share in total mortality has diminished, they remain an important problem in some parts of the Region. In the USSR, respiratory diseases (mainly pneumonia and other acute respiratory infections) were diagnosed as the cause of death in about 25% of children aged 1–14 years (Tables 4.2 and 4.3). In the rest of the Region, this cause of death in children was less important: the mortality rates in the USSR were 3 times those in the CCEE and more than 20 times those in the western countries. In the group aged 65 years and over, deaths due to respiratory diseases constituted a greater share of all deaths in the western countries of the Region than in the remainder, although chronic respiratory diseases were most common in older people in all groups of countries.

Among children aged 1–14 years, mortality from respiratory diseases decreased in the western countries and the CCEE from 1970, and in the USSR from 1980 (Fig. 4.12). In both the CCEE and the USSR, the rates in children exceeded the mortality in adults (those aged 15–44 years). This pattern is the opposite of that observed for the western countries and of that characteristic of most other causes of death.

Among adults, the mortality rates in females declined over the last two decades in all groups of countries (by 25–55% of the level in the early 1970s). A remarkable exception was the trend in females in Denmark, mainly because of an increase in mortality from bronchitis, emphysema and asthma (see below). An improvement was also seen among males, but the trend in the CCEE was less stable than that in the western countries, particularly for the groups aged 15–64 years. This was due to an increase in respiratory mortality in Hungary and Romania around 1980. Mortality rates for respiratory diseases varied more within groups of countries than those for other frequent causes of death. The ratio of the highest to the lowest national rates varied from 1.7 to 3.5 in men and women aged 65 years and over in the western countries, mainly owing to high rates in Ireland; the ratio was 4.5 in males aged 15–44 years in the CCEE, owing to very high mortality in Romania.

Chronic airways diseases, including bronchitis, emphysema and asthma, are an important group of respiratory diseases. They affect large parts of the population and may severely restrict normal activity for decades

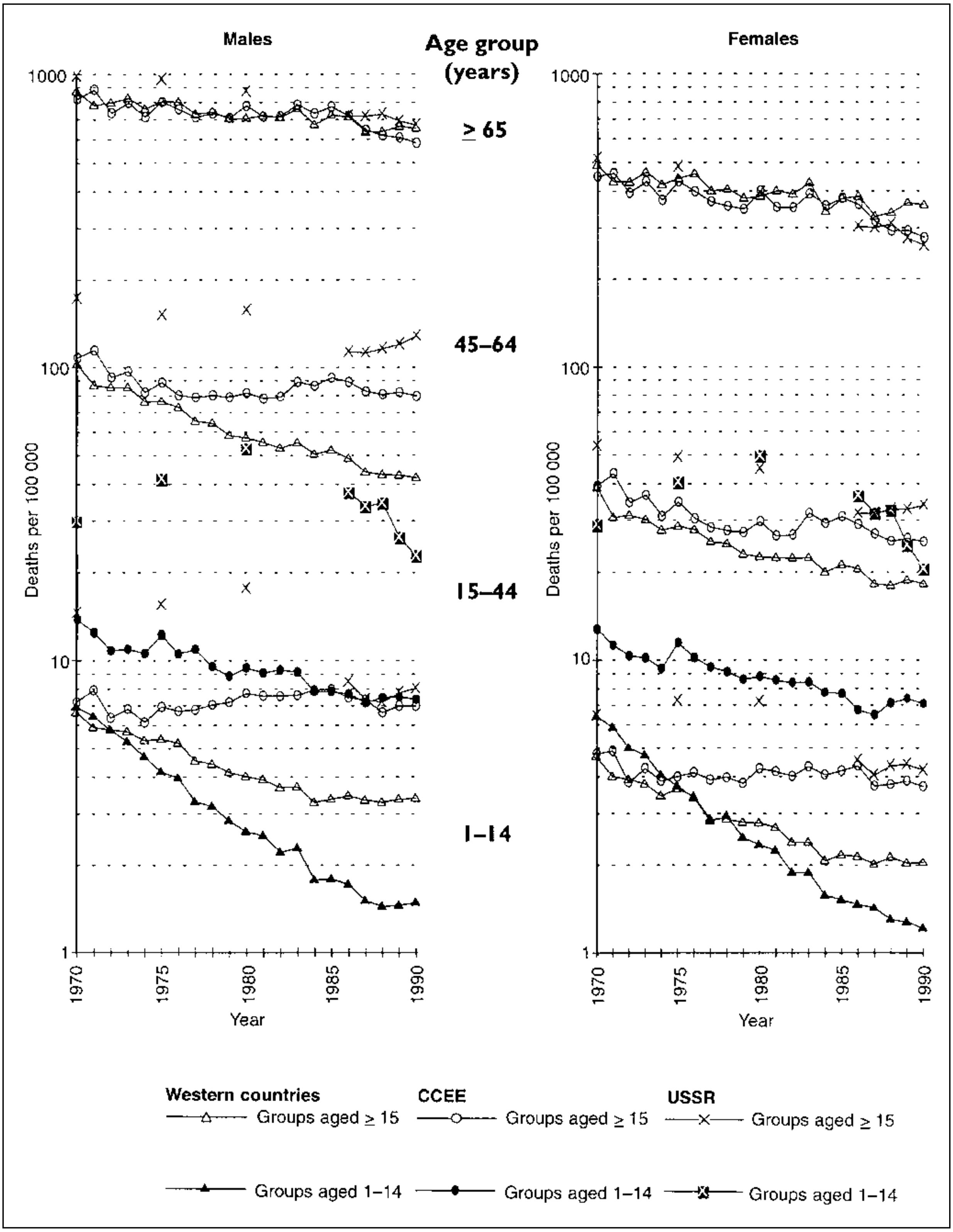


Fig. 4.12: Age-specific mortality from diseases of the respiratory system in the WHO European Region, by sex, 1970–1990

of life. Owing to improvements in treatment, these diseases have tended to cause fewer deaths in recent years than at the beginning of the 1970s (Fig. 4.13). This improvement is most visible in people aged 45–64 years, and particularly in western European males, where mortality rates were three times lower at the end of the 1980s than 20 years before.

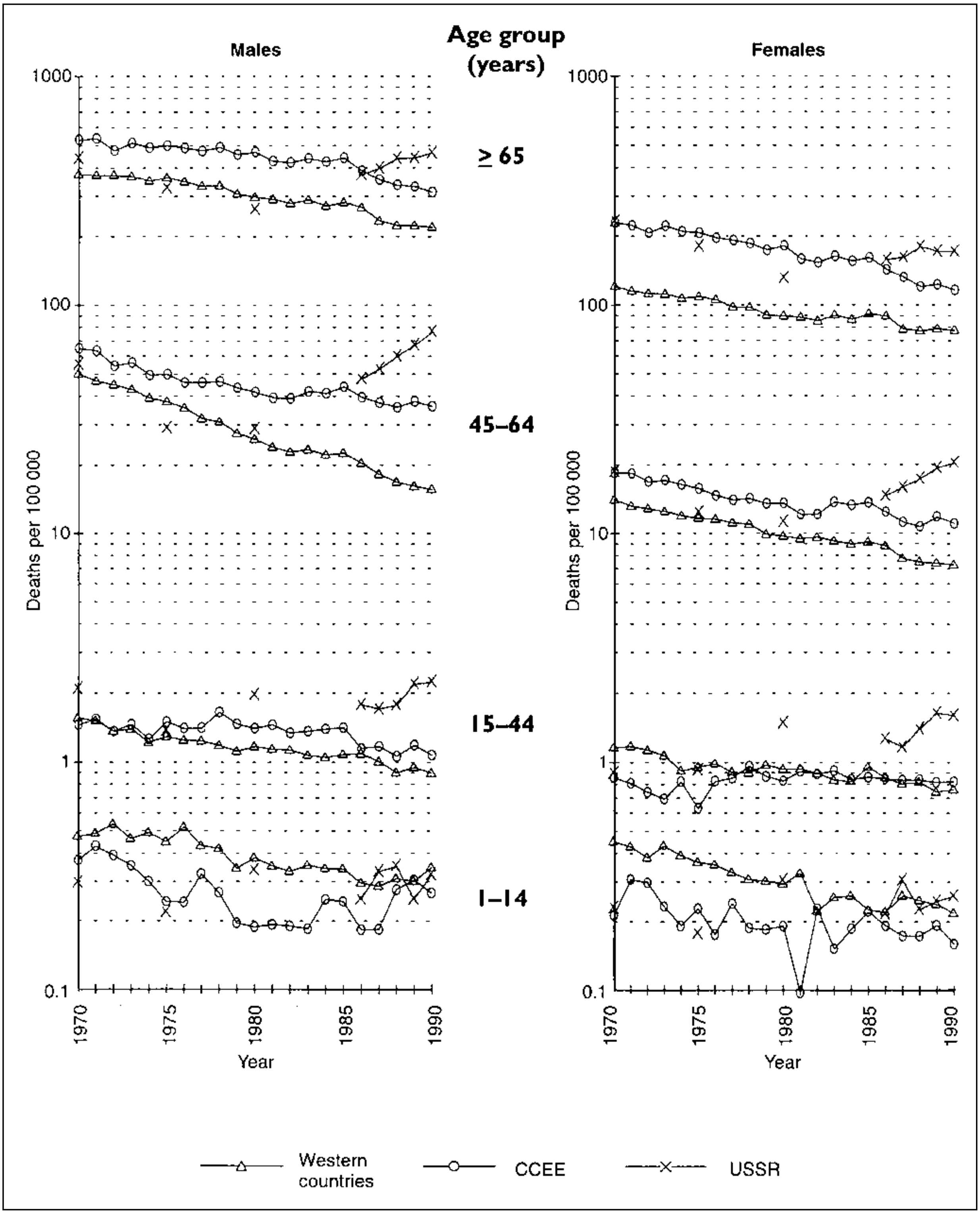


Fig. 4.13: Age-specific mortality from bronchitis, emphysema and asthma in the WHO European Region, by sex, 1970–1990

A markedly different trend was observed among Danish women aged 45–64 years; the rates for this group were average for a western country in 1970, but had tripled by the late 1980s. The rates for Danish men of the same age did not rise, although they were relatively high. Improvement is less evident in younger people, in whom asthmatic rather than obstructive forms of respiratory disease are more frequent.

In the USSR, the trend was the opposite of that seen in other countries. To some ex-

Table 4.4: Prevalence of chronic bronchitis (CB) and chronic nonspecific respiratory disease (CNRD) reported by epidemiological studies in the WHO European Region

Country	Condition and study population	Prevalence (%)		Reference
		Males	Females	
Finland	CB in nonsmokers/smokers	12/33		*25*
France	CB in nonsmokers/smokers	16/25	8/27	*25*
Italy	CB	13	3	*25*
Italy	CB in nonsmokers/smokers	4/9	4/6	*25*
Netherlands	CNRD in country population	6	6	*26*
Poland	CB in nonsmokers/smokers	5/20	4/10	*27*
Lithuanian SSR	CB in people aged 25–29/40–44/55–59	5/11/20	4/6/12	*25*
Romania	CNRD in country population	5	2	*12*
Sweden	CB	10	7	*28*
Switzerland	CB in nonsmokers/smokers	2/5	1/3	*29*

tent, this may be due to differences in diagnostic practice, since the overall mortality due to respiratory diseases does not follow the trend seen for chronic airways diseases.

The prevalence of chronic bronchitis and chronic nonspecific respiratory disease, assessed in studies conducted in selected adult European populations in the past 20 years, varies considerably between populations and depends on smoking status and age (Table 4.4). The accumulated evidence indicates that close to 10% of the total adult population may suffer from chronic nonspecific respiratory disease. Data from the Latvian and Lithuanian SSRs and Poland suggest a decrease in prevalence of the disease in adults in the 1980s [30,31]. Comparable data on asthma prevalence are available from only a few countries. Asthma diagnosed by a physician was recently reported in 5–6% of adults in Sweden [28], in 5% of adults in Ireland [32] and in 6–7% in a Swiss study [29]. Preliminary reports from a respiratory health study under way in the European Union indicate that the annual incidence of asthmatic attacks amounts to 3–4% in adult populations in several locations in Italy and 2–3% in several Nordic countries [33–36]. In Italian schoolchildren, the prevalence of asthma was found to be about 6% [37]. Recent studies from England [38] and from the Nordic countries [28] suggest that the prevalence of asthma is increasing in some parts of the population. Similar conclusions emerge from a study completed in the United States [39].

While tobacco smoking is the main risk factor for chronic obstructive airways disease, outdoor and indoor air pollution (both occupational and residential) has a significant contributory role. Host factors (bronchial hypersensitivity and atopy) are important risk factors for asthmatic forms of chronic airways disease, and several chemical and biological pollutants present in outdoor and indoor air, as well as in the workplace, may induce or aggravate asthma [40,41].

Injury and poisoning

Although injury and poisoning are responsible for less than 7% of all deaths in the western countries and the CCEE, and for less than 10% in the former USSR, they remain the leading cause of death in males aged 1–44 years and females aged 1–14 throughout the Region.

In the western countries, the mortality rates have declined in all age groups and both sexes for most of the past two decades (Fig. 4.14). A deviation from this pattern was observed in Finland, where mortality in males and females aged 15–64 years declined in the 1970s and the beginning of the 1980s but recently rose by 20%, leading to a return to the level observed in the early 1970s.

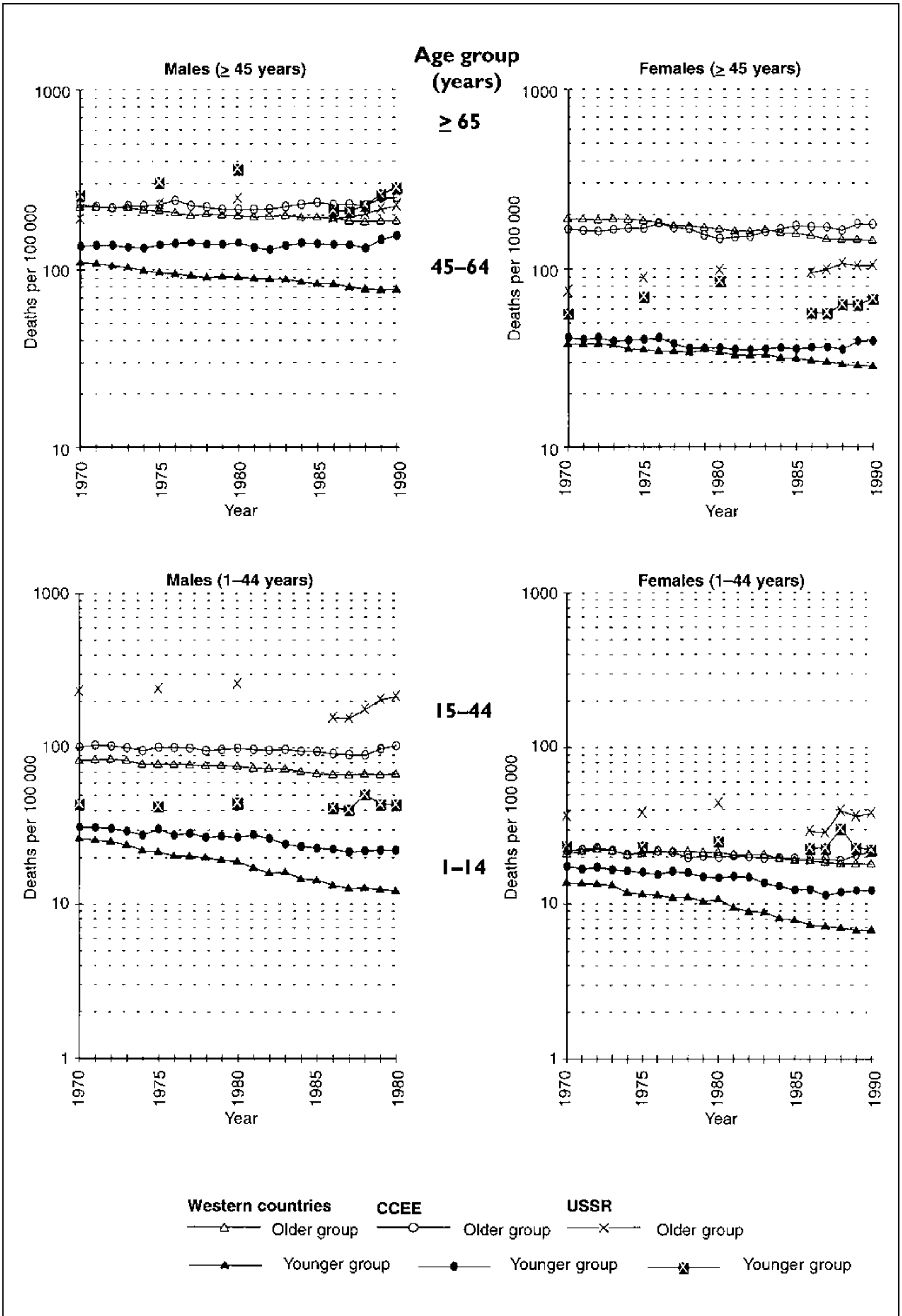


Fig. 4.14: Age-specific mortality from injury and poisoning in the WHO European Region, by sex, 1970–1990

In the CCEE, the mortality from injury and poisoning was higher than that in the western countries by almost 100 % in males and 70 % in females during most of the past two decades, and decreased more slowly. An increasing trend was seen in most age groups in Hungary, and in the oldest group of women in Czechoslovakia. In these groups the rates were higher by 25 % in the late 1980s than 20 years earlier.

In the USSR, mortality due to external causes for people under 65 years exceeded the rates observed in the rest of the Region by at least 100 %, with a further increase at the end of the 1980s in males aged 15–64 years. In older people, the rates in men were similar to those elsewhere in the Region, and the rates in women markedly lower, but the trends were increasing.

The variation within groups of countries was substantial. The highest rates exceeded the lowest by a factor of more than four, in both the western countries and the CCEE. In the latter, this was mainly due to relatively high rates in Hungary. In western Europe, relatively high rates were observed in Denmark, Finland, France and Spain.

The main causes of fatal accidents were road traffic accidents, and suicide or self-inflicted injuries. In males, these two causes were responsible for 83 % of accidents in the western countries, 76 % in the CCEE and 62 % in the USSR. In females they were responsible for 50 %, 53 % and 58 % of accidents, respectively. Accidental poisoning was identified most often in the USSR: in 21 % of all fatal accidents to both sexes. This markedly exceeded the proportion of accidental deaths attributed to poisoning in the CCEE (8 % in males and 6 % in females) and the western countries (3 % in males and 5 % in females). The mortality rates due to accidental poisoning were extremely high in the USSR (24 per 100 000 in males and 6 per 100 000 in females), more than three times the rates in the CCEE and over ten times those in the western countries. The only country reporting similar mortality rates was Finland (17 per 100 000 in males and 4 per 100 000 in females). Chapter 16 gives a more detailed analysis of traffic accidents.

Congenital malformations

Congenital malformations are one of the few causes of morbidity for which data are available for several countries or subnational areas. Two major networks are operating in Europe: EUROCAT (see footnote on page 95) and the International Clearinghouse for Birth Defects Monitoring Systems, an international nongovernmental organization for worldwide monitoring [42,43]. Two registers report data from the CCEE (the former Czechoslovakia and Hungary), but there are no data from the NIS. The registers cover the whole population in only a few countries: Denmark, Finland, Hungary, Luxembourg, Malta, Norway and Sweden. In some other countries, such as the former Czechoslovakia and the United Kingdom, large parts of the population are included. Some registers (those in Israel and Italy) are based on selected areas spread across the country. Others collect information from small parts of a country.

Cumulative data for the period 1980–1988 were used to explore the differences in patterns of birth defects in the European Region. The limited extent of and different methods used for population coverage by the various registers hampered a more comprehensive analysis of spatial patterns of occurrence of malformations. Five types of malformation were selected which should be easily diagnosed at birth. This minimized the possibility of ascertainment bias.

Fig. 4.15 shows the cumulative incidence rates at birth, by register and type of malformation. Data show marked differences between countries. The ratio between the highest and lowest rates (after excluding the two extreme values to minimize the effect of outliers) is 3.4 for anorectal atresia, 2.8 for cleft lip, 2.4 for limb reduction defects, 2.3 for oesophageal atresia and 2.1 for cleft palate.

Even for the types of malformation chosen for this analysis, some degree of variation in ascertainment and reporting cannot be ex-

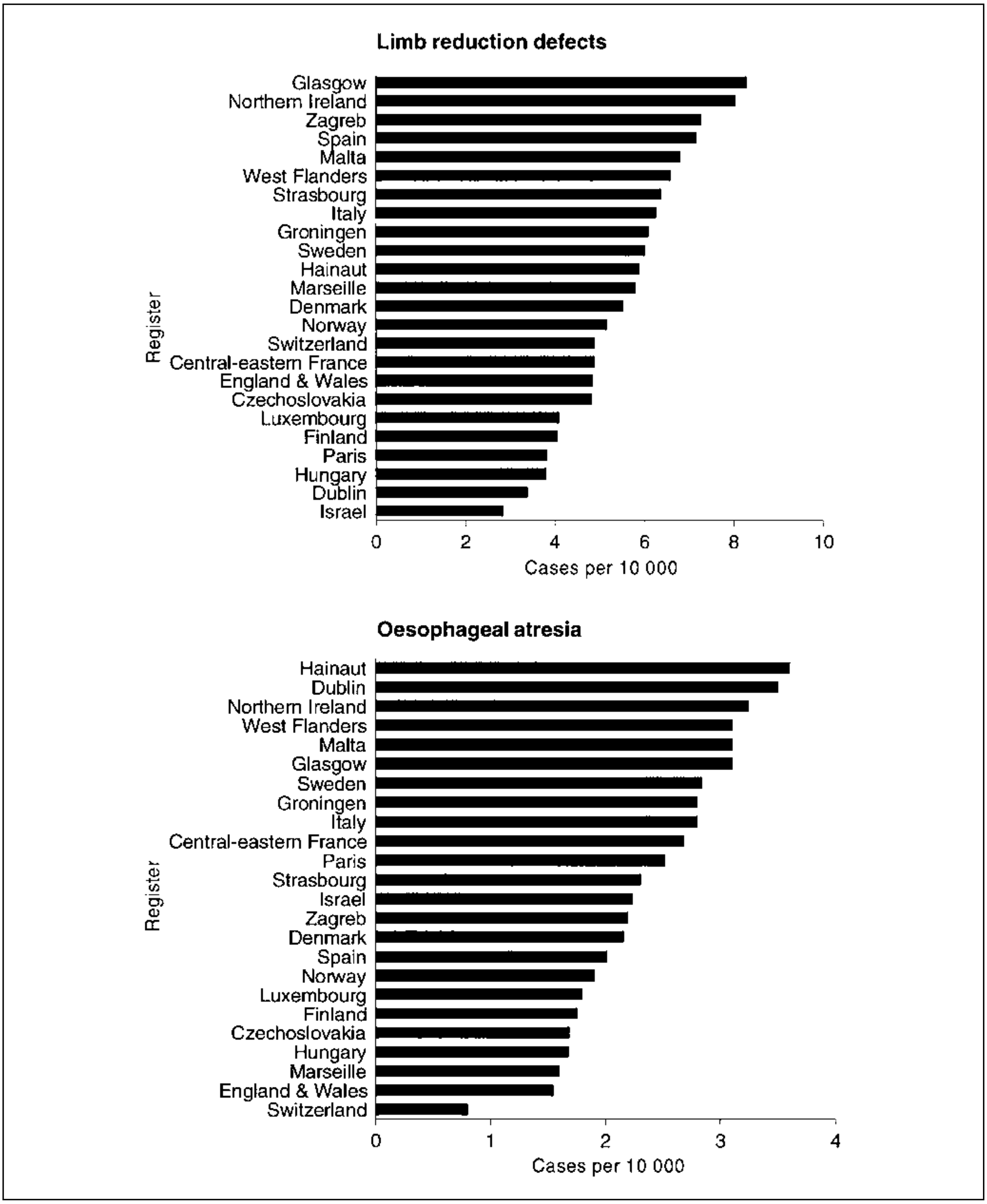


Fig. 4.15 a: Incidence at birth of limb reduction defects, oesophageal atresia, anorectal atresia, cleft lip and cleft palate recorded in some registers in the WHO European Region, 1980–1988

cluded. Registers differ in several important characteristics, such as the source of data (hospital-based or population-based), working definitions of the malformations, length of follow-up after birth, composition of coordinating unit (clinical or statistical) and type of notification (voluntary or mandatory). Estimating the proportion of the differences in rates that is attributable to ascertainment is difficult, although various methods have been proposed [44]. It is unlikely, however, that differences of the magnitude observed

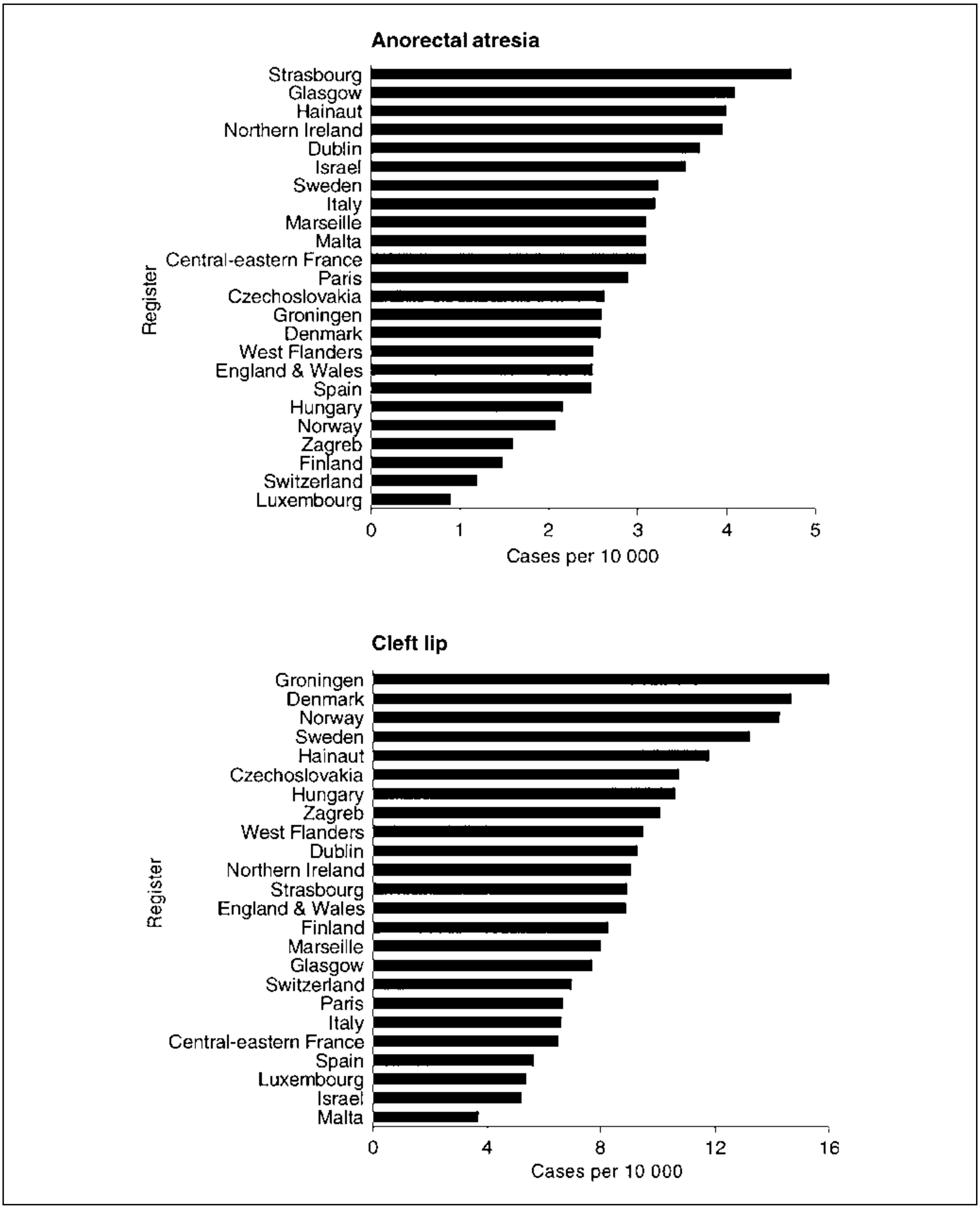
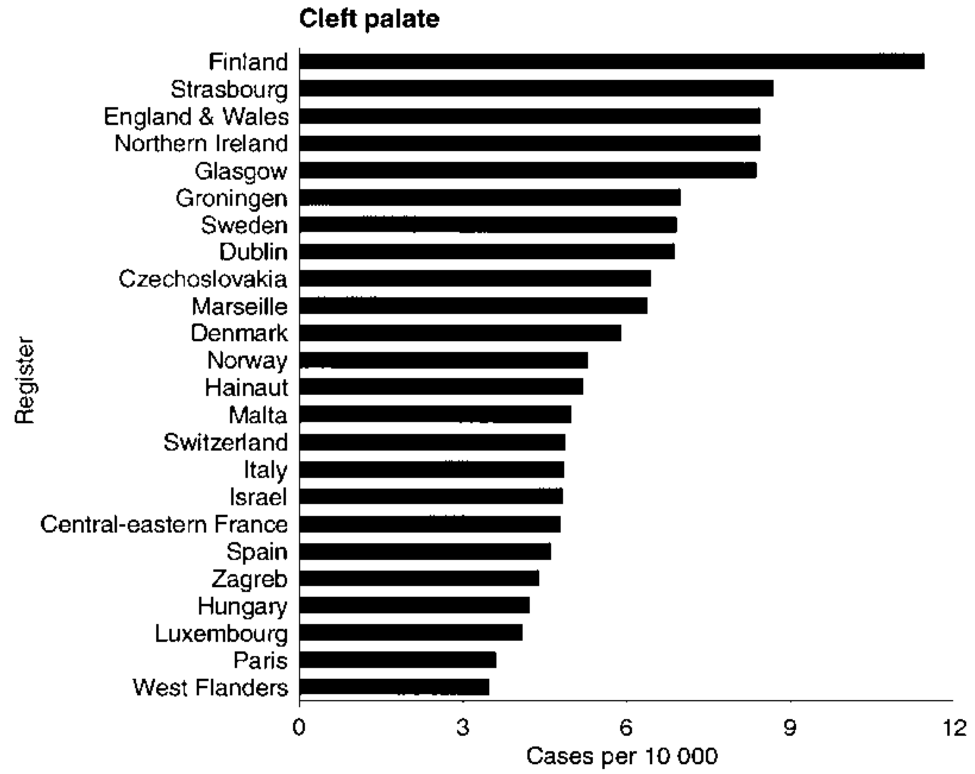


Fig. 4.15 b: Incidence at birth of limb reduction defects, oesophageal atresia, anorectal atresia, cleft lip and cleft palate recorded in some registers in the WHO European Region, 1980–1988

here are due only to ascertainment problems. Other factors such as lifestyle and genetic predisposition may well play a significant role.

The incidence of congenital malformations has been judged to be an indicator of environmental effects on health [45] although the sensitivity of registers to detect variations in incidence at birth over space and time has been questioned [46]. The available data do not indicate any pattern in geographical distribution. Environ-



Sources: EUROCAT *(42)*; International Clearinghouse for Birth Defects Monitoring Systems *(43)*.

Fig. 4.15 c: Incidence at birth of limb reduction defects, oesophageal atresia, anorectal atresia, cleft lip and cleft palate recorded in some registers in the WHO European Region, 1980–1988

mental exposure has been suspected of being the cause of a cluster of congenital malformations [47].

Communicable diseases

As mentioned, infectious and parasitic diseases have had a diminishing role as a cause of death in the Region over the past two decades. The average age-standardized death rates for the Region declined from 18.9 per 100 000 population in 1970 to 6.7 in 1990. In the USSR, mortality was markedly above the average at the end of the 1980s, and the decline was slower: from 24.8 deaths per 100 000 in 1970 to 17.2 in 1990. In Israel, however, mortality from infectious diseases increased: from 13.6 deaths per 100 000 to 14.2. At the end of the 1980s, the mortality rates ranged from 3–4 per 100 000 in several countries (Austria, Czechoslovakia, the German Democratic Republic, Iceland, Italy and the United Kingdom) to 17 per 100 000 in Albania and the USSR. The main fatal infectious diseases were respiratory tuberculosis, which accounted for up to 45% of all deaths in this group of diseases in several countries, and various forms of septicaemia.

Registers of infectious diseases exist in all countries of the Region and provide an important basis for the management of epidemics and for assessing the effectiveness of vaccination programmes and other preventive measures. The incidence of several infectious diseases has markedly decreased in most countries, and several countries have reached a stage at which diphtheria, poliomyelitis and neonatal tetanus do not occur. This is due to effective immunization programmes. Inadequate maintenance of prevention programmes seems to be the reason for the dramatic increase in diphtheria in some of the NIS, mainly the Russian Federation and Ukraine; 3130 cases were reported in 1991 and 5703 in 1992. The more recent data indicate that over 15 000 cases of diphtheria were registered throughout the Russian Federation in 1993 [48].

In addition, poliomyelitis seemed close to elimination but recurred in the Region at the beginning of the 1990s. In 1992, however, 170 cases were reported: 52% less than in 1991. Of these, 64 cases occurred in the Netherlands in members of religious groups that refuse vaccination.

Further, the AIDS epidemic continues, with a slower increase in the annual number of new cases in 1991 and 1992 than in previous years. In mid-1993, the cumulative number of cases in the Region was estimated to be close to 100 000 [49]. The highest cumulative rates per 100 000 population are observed in Spain (51), Switzerland (47), France (45) and Italy (31). Over 67% of all AIDS cases in the Region were registered in these four countries.

Several other infectious diseases are still prevalent in the Region's population. The incidence of tuberculosis is declining on average, falling from 59 cases per 100 000 population in 1974, through 34 in 1985, to 29 in 1990. Romania showed a different trend, however, with the incidence increasing from 46 cases per 100 000 in 1985 to 70 in 1990. While the incidence of tuberculosis was high in Portugal (52 cases per 100 000 in 1990) it showed a decreasing trend over the 1980s. In several of the western countries the decline in notification has recently ceased, and the trend has reversed in some. It is unclear to what extent this deterioration is due to social and economic factors, multiple drug resistance or, in some countries, to the spread of HIV infection.

Hepatitis remains a public health problem in many countries. Although it has much less direct impact on mortality than tuberculosis its complications can be serious, including liver cancer, which occurs with an increased frequency also among carriers of the hepatitis B virus. The average incidence of hepatitis A remained almost constant in the Region (146 cases per 100 000 in 1980 and 156 in 1990) but some countries showed a rapid increase between 1980 and 1990 (from 225 to 321 cases per 100 000 in Romania and from 111 to 268 in Bulgaria). Several countries, however, report an incidence not exceeding 10 cases per 100 000. Similar contrasts between countries were seen for hepatitis B incidence, with the rates ranging from 0.6 cases per 100 000 in Ireland and the United Kingdom to 37–43 per 100 000 in Poland, Romania and the USSR at the end of 1990.

Mental disorders

Mental disorders do not lead to death as directly as many other diseases, but alcohol abuse, depression and anxiety disorders and aggressive behaviour – the most common mental disorders – have been found to precede the majority of suicides [50]. Since mortality registration includes information on suicides, this aspect of mental disorder is available for international analysis. At the end of the 1980s, 13 suicides per 100 000 population were registered in the European Region, which means that suicides caused 1.5% of all deaths and 23% of deaths due to "non-natural causes", that is, injury and poisoning.

The patterns of suicide incidence in the Region differ from the distribution of other causes of death. Suicide was most frequent in Finland and Hungary, where the rates exceeded the European average by factors of 2.1 and 2.9, respectively (Fig. 4.16 and 4.17). The lowest rates were registered in most of the Mediterranean countries and the Netherlands and the United Kingdom. It must be recognized, however, that possible underreporting of suicides as a cause of death in some countries may hamper an international comparison. Deaths due to suicide were almost 2.8 times more frequent in males than in females, with the ratio ranging from 1.8 in the Netherlands to over 5 in Iceland and Poland. On average, mortality from suicide tended to decrease in the last decade, but more countries noted an increase rather than a decrease in mortality rates for males. Suicide rates dropped sharply in the USSR; the 40% decline among males between 1984 and 1986 may be related to the reported

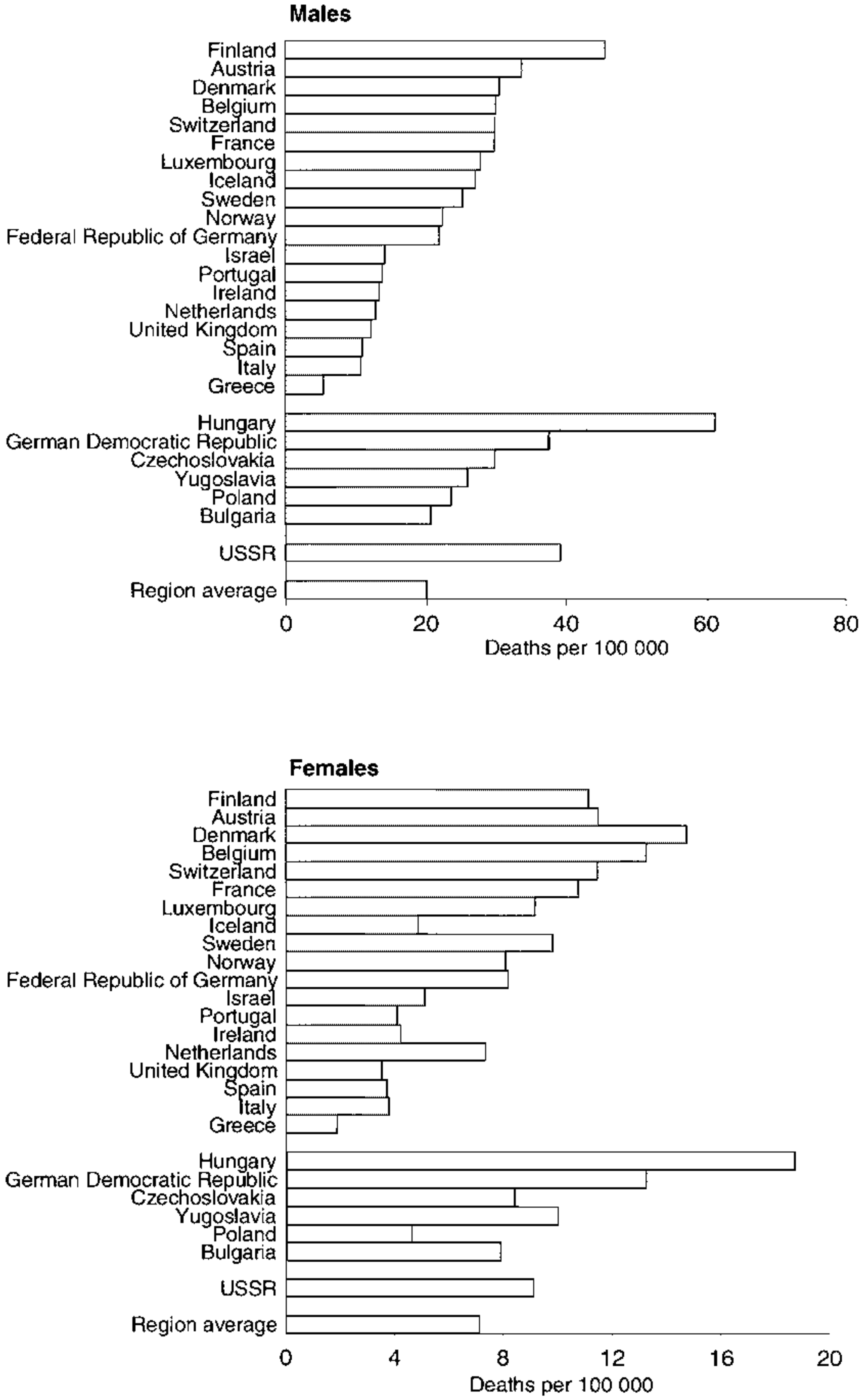


Fig. 4.16: Standardized death rates for suicide and self-inflicted injury in groups of countries in the WHO European Region, by sex, 1990 or last available year

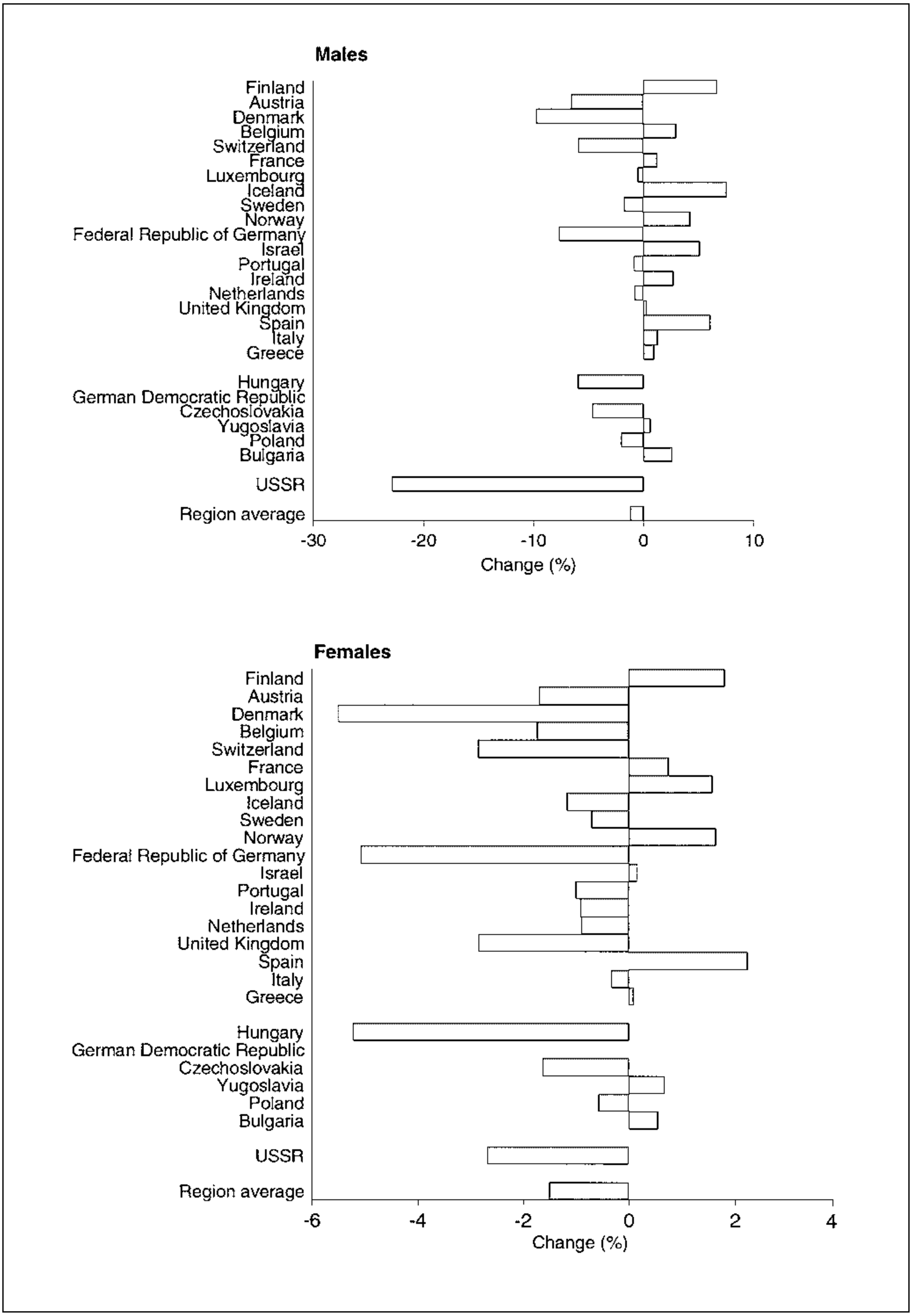


Fig. 4.17: Trends in standardized death rates for suicide and self-inflicted injury in groups of countries in the WHO European Region, by sex, 1980s

50% decrease in alcohol consumption in this period [51], but mortality increased for the rest of the 1980s.

A lack of studies using comparable methodology hinders the assessment of the prevalence of mental disorders in the Region. The available (American) data indicate that the most common disorders, diagnosed as anxiety or depression, are encountered in up to 7% of children (aged 4–16 years) in its severe form, and in a further 19% in a moderate form [52]. Studies in various populations of European adults report the prevalence of anxiety and depression to range from 6% [53] to 15% [54] and 22% [55]. Higher rates (18–26%) are observed in elderly people [56] and in residents of nursing homes in particular, where the rates reach 27%. More severe mental disorders such as schizophrenia are found with a frequency of 1.5–4.2 cases per 1000 population, according to a review of 15 surveys conducted in 12 countries [53]. The annual incidence of mental disorders, as indicated by the rate of first visits to a psychiatric clinic or hospital, is 4.0 per 1000 population in Poland [57] and 2.6 per 1000 in the Netherlands [26].

In general, the studies suggest that the incidence of mental disorders is higher in women, groups with low socioeconomic status, separated and bereaved people and the unemployed.

4.7 Inequalities in Health Status

A variety of factors may be involved in determining the observed differences in health status between different parts of the Region's population. The analysis presented indicates significant variation in mortality and morbidity between countries, but subjective assessments of health status also differ markedly (Fig. 4.18). Although different populations define health in different ways, the degree of satisfaction with health status can be considered a relevant indicator of the state of wellbeing essential for health as defined by WHO. Even such a "soft" indicator of health status was found to be predictive of long-term survival in cohort studies [58].

Health status, as determined by self-assessment, improved with increasing level of education in various countries of the Region. In Bulgaria, the proportion of the population reporting good or very good health was over 75% among people with at least full elementary education, but was scarcely 57% among people with less [59]. In the Netherlands, good or very good health was reported by 87% of university graduates and 62% of people with elementary school education [26]. In an international comparison of self-reported health status of adults in Denmark, Finland, the Netherlands, Sweden and the United Kingdom, long-standing health problems were found to be some 20% less frequent in people with an average or better level of education than in those with fewer years at school [60].

A prospective study in Moscow and St Petersburg examined the relationship between coronary heart disease mortality and educational attainment [61]. In this study, only 22% of the twofold excess in mortality associated with low educational attainment was statistically attributable to the major risk factors: age, blood pressure, cholesterol, body mass index, smoking and alcohol intake. Several studies reported mental disorders to be more frequent in populations with lower socioeconomic status [53]. Increased mortality or morbidity in people with lower socioeconomic status was also seen even after allowing for personal habits such as tobacco smoking [62–64]. An example of issues related to lower socioeconomic class, and possibly linked to health status, is perception of excessive body weight. In a study of an urban population in Poland, overweight people with elementary education were significantly more likely to be unaware of their excessive body weight than those with more education [65].

The social status of mothers, as expressed by their level of education, was found to be an indicator of conditions affecting the

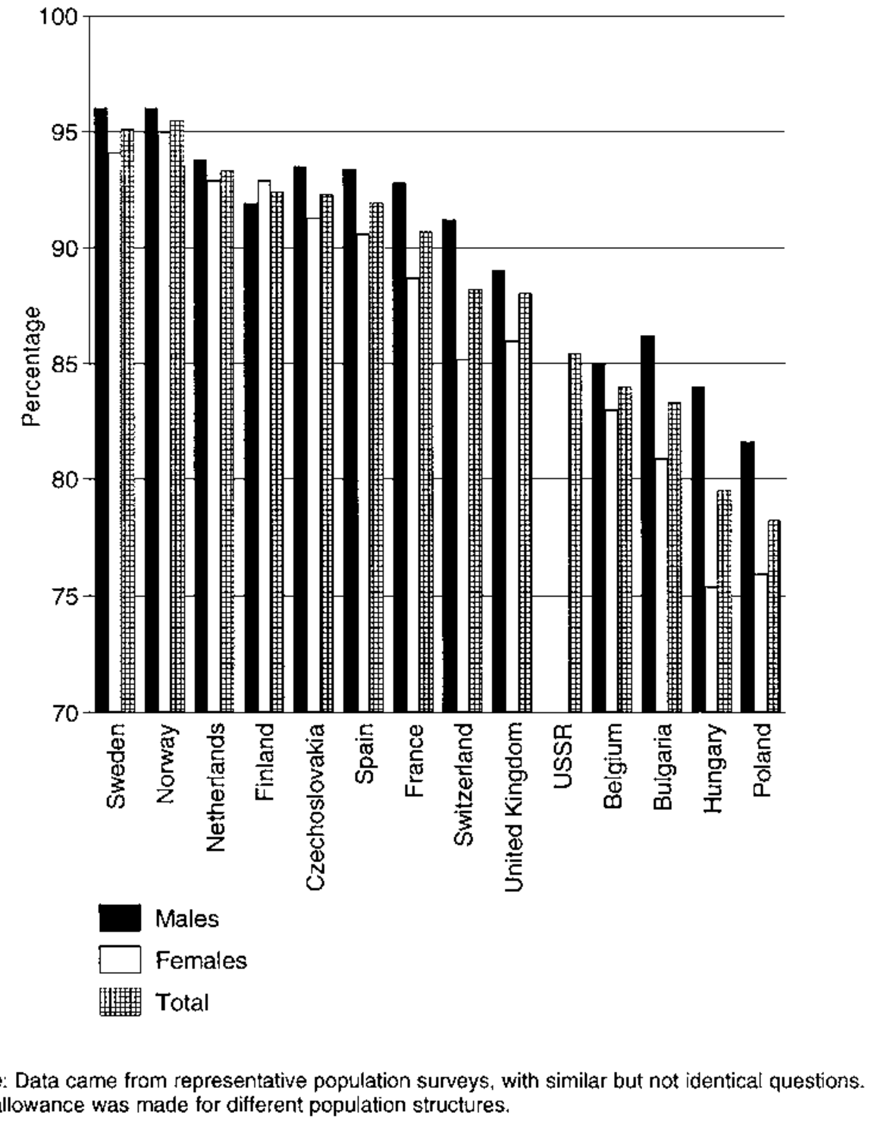


Fig. 4.18: Percentage of the population in countries reporting health status as fair/average or better in the late 1980s

health of their children. In Poland in 1987, infant mortality ranged from 10.6 deaths per 1000 live births for mothers with a university education, to 18.7 and 28.3 per 1000 for mothers with elementary and lower levels of education, respectively [66]. The corresponding rates for Hungary in 1987 were very similar: 10.3, 19.0 and 36.1 per 1000 [67]. This association was not present in Sweden, however, where adequate environmental conditions and efficient health care are accessible to all residents irrespective of their social status and associated educational attainment, and where infant mortality is very low [68].

Further, the distribution of personal income in countries was found to have an important association with health. In a health and lifestyle survey conducted in Great Britain in 1981, standards of health for three different measures of morbidity improved rapidly as income increased from the low end towards the middle of the range; no further gains in health accompanied increases in income beyond this point [69]. In England, a study using a composite index showed that social deprivation was related to premature mortality (death before 65 years of age) throughout the range of affluence; it was not limited to the poorest areas [70].

Comparable data are not available from the eastern countries of the Region, but an analysis based on grouped data for subnational regions of Bulgaria, Poland and the USSR did not reveal any consistent relationship between higher levels of affluence and better health indicators [71].

In some eastern countries, mortality rates were still higher in rural than in urban populations at the end of the 1980s. This was observed in all age groups in Bulgaria and the USSR. In Hungary, infant mortality rates decreased more rapidly in cities than in rural areas. This can be explained not only by better access to health care in cities but also by less developed sanitary infrastructures and more difficult living conditions in rural areas. In Poland, the advantage of urban populations was reversed in 1987. The life expectancy (at birth and at ages 45 and 60 years, and in both males and females) in rural areas exceeded that in urban populations. The excess mortality in urban populations is related mostly to coronary heart disease and digestive diseases [57]. This may indicate that the unfavourable lifestyles and dietary factors prevalent in the cities have outweighed such advantages of urban living as better access to health care.

Great disparities in the distribution of health resources between regions have persisted virtually unchanged since the early 1970s. The increase in the effectiveness of health care is still much smaller in the eastern than in the western European countries, as illustrated by the slower decline in mortality from causes that are considered to be amenable to medical care [72]. Nevertheless, mortality from causes not amenable to care rose in the eastern countries in recent decades, in contrast to the declining trends observed elsewhere. This suggests that lifestyle factors and adequate living and environmental conditions may be even more important in achieving an overall improvement in health status than the availability of curative services.

Among lifestyle factors affecting health, tobacco smoking and the excessive consumption of alcohol are particularly important. It has been estimated that as much as 20% of deaths in developed countries can be attributed to smoking [73]. Extensive literature demonstrates that the incidence of cancer at various sites (lung, trachea, bronchus, oesophagus, urinary bladder), cardiovascular diseases and chronic obstructive airways diseases are significantly higher in smokers than in nonsmokers, and maternal smoking was found to affect infant mortality in Sweden, for example [68]. Data from Poland [74] and the USSR [51] show that excessive alcohol drinking, even as represented by total alcohol sales, can be correlated with several indicators of ill health such as premature mortality, cirrhosis of the liver and some cancers of the digestive tract.

4.8 Conclusions

This overview indicates vast differences in many aspects of health status between various parts of the population of the European Region. The most general conclusions, based on several indicators, are as follows.

The health of people in the western countries has improved in recent decades while, according to the information available, health has not improved or has deteriorated in some populations in the CCEE and NIS. These diverging trends are reflected in markedly higher mortality rates in the eastern than in the western parts of the Region. The differences are greatest among young adults and people of middle age, particularly men. The most pronounced differences in premature mortality between the groups of countries are in mortality from cardiovascular and respiratory diseases and, in males, in injury and cancer. These diseases contribute most to the difference in total mortality between parts of the Region. The limited data on morbidity support the conclusions based on the evaluation of mortality patterns.

As to the impact on society, the most significant findings are the unfavourable trends in middle-aged people in the CCEE and NIS.

The impaired health of the most economically and socially active part of the population has a direct impact on the overall well-being of society. It is also important to stress the significance of even relatively mild diseases experienced in childhood or as a young adult. Besides their immediate effect on the individual's life, these diseases may affect development and/or health status later in life. Such diseases include common respiratory infections in childhood, which have a negative impact on pulmonary function, or viral hepatitis, which increases the risk of liver cancer.

Preventing disease, as well as trying to cure it, should be emphasized as the way to improve the health status of a population. Lifestyle factors, particularly smoking, alcohol and dietary habits, clearly need improvement. The elimination of tobacco smoking would result in significant reductions in cancer and in cardiovascular and respiratory diseases. The current patterns and trends in tobacco consumption correspond well to the overall patterns of health deficiencies in the Region. In addition, environmental factors may be important determinants of health for certain groups, including occupational groups (see Chapter 18).

Continuing or renewing effective immunization programmes will reduce infectious diseases and prevent a repetition of recent epidemics of, for example, diphtheria and poliomyelitis. This approach, based on the WHO strategy for health for all [11], should be adopted and efficiently implemented by all countries, particularly the CCEE and NIS. The experience of the western countries shows that major improvement is possible. No less important is the effort to identify the reasons for deviations from the general pattern at national and subnational levels. Understanding the reasons for these differences can contribute to the improvement of the health of all people in the European Region.

References

[1] *World health statistics annual 1991*. Geneva, World Health Organization, 1992.

[2] United Nations Economic Commission for Europe. Aging in the ECE region: demographic aspects, 1950–2025. *In*: *Demographic causes and economic consequences of population aging*. New York, United Nations, 1992, pp. 13–74,

[3] Horiuchi S. Global trends of age distribution. *In*: *Changing population age structures, 1990–2015. Demographic and economic consequences and implications*. Geneva, United Nations, 1992.

[4] Wilkinson, R.G. Income distribution and life expectancy. *British medical journal*, **304**: 165–168 (1992).

[5] World Bank. *World development report 1993. Investing in health*. New York, Oxford University Press, 1993.

[6] Piha, T. Tobacco control activities of the World Health Organization in Europe. *In*: Richmond, R., ed. *Intervention for smokers: an international perspective*. Baltimore, Williams and Wilkins (in press).

[7] *Tobacco: supply, demand and trade projections,1995 and 2000*. Rome, Food and Agriculture Organization of the United Nations, 1990.

[8] *Implementation of the Global Strategy for Health for All by the Year 2000, second evaluation: Eighth report on the world health situation, Vol. 5, European Region*. Copenhagen, WHO Regional Office for Europe, 1994 (WHO Regional Publications, European Series, No. 52).

[9] *Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 1975 revision*. Geneva, World Health Organization, 1977.

[10] Bracken, M.B. *Perinatal epidemiology*. Oxford, Oxford University Press, 1984.

[11] *Health for all targets. The health policy for Europe*. Copenhagen, WHO Regional Office for Europe, 1993 (European Health for All Series No. 4).

[12] [*Study of population health status 1989, Vol. II.*] Bucharest, Health Statistics Centre, Ministry of Health, 1990.

[13] Pearson, T.A. & Pyorala, K. Trends in CHD in selected countries – overview. *International journal of epidemiology*, **18**(Suppl. 1): S99–S100 (1989).

[14] Thom, T.J. International mortality from heart disease: rates and trends. *International journal of epidemiology*, **18**(Suppl. 1): S20–S28 (1989).

[15] Blackburn, H. Trends and determinants of

CHD mortality: changes in risk factors and their effects. *International journal of epidemiology,* **18** (Suppl. 1): S210–S215 (1989).
[16] SING, C.F. & MOLL, P.P. Genetics of variability of CHD risk. *International journal of epidemiology,* **18**(Suppl. 1): S183–S195 (1989).
[17] SMANS, M. ET AL., ED. *Atlas of cancer mortality in the European Economic Community.* Lyon, International Agency for Research on Cancer, 1992 (IARC Scientific Publications No. 107).
[18] COLEMAN, M.P. ET AL. *Trends in cancer incidence and mortality.* Lyon, International Agency for Research on Cancer, 1993 (IARC Scientific Publications No. 121).
[19] *Tobacco smoking.* Lyon, International Agency for Research on Cancer, 1985 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans No. 38).
[20] TOMATIS, L., ED. *Cancer: causes, occurrence and control.* Lyon, International Agency for Research on Cancer, 1990 (IARC Scientific Publications No. 100).
[21] HAKULINEN, T. & HAKAMA, M. Predictions of epidemiology and the evaluation of cancer control measures and the setting of policy priorities. *Social science and medicine*, **33**: 1379–1383 (1991).
[22] JENSEN, O.M. ET AL. Cancer in the European Community and its member states. *European journal of cancer*, **26**: 1167–1256 (1990).
[23] PARKIN, D.M. ET AL. Estimates of the worldwide frequency of sixteen major cancers in 1980. *International journal of cancer*, **41**: 184–197 (1988).
[24] ESTÈVE, J. & COLEMAN, M. *Projections of cancer mortality in European Community for the year 2000.* Dublin, EC Committee of Cancer Experts, 1990.
[25] WOOLCOCK, A.J. Epidemiology of chronic airways disease. *Chest*, **96**(Suppl.): 302s–306s (1989).
[26] [*Handbook of health statistics of the Netherlands, 1992.*] The Hague, Central Bureau of Statistics Publications, 1992.
[27] KRZYZANOWSKI, M. & WOJTYNIAK, B. *Chronic airways disease in Cracow. Final report from a 13-year follow-up study.* Warsaw, National Institute of Hygiene, 1990.
[28] LUNDBACK, B. *Asthma, chronic bronchitis and respiratory symptoms: prevalence and important determinants. The obstructive lung disease in northern Sweden study I.* Umeå, Umeå University, 1993 (Umeå University Medical Dissertations No. 387).
[29] ZEMP STUTZ, E. ET AL. SPALDIA: prevalence of chronic respiratory illness by smoking status in men and women. *European respiratory journal*, **6**(Suppl. 17): 342s (1993).
[30] WOJTYNIAK, B. & WYSOCKI, M. Chronic airways disease in Poland. Recent trends. *Chest*, **96**(Suppl.): 324–328 (1989).
[31] UTKIN, V.V. ET AL. Epidemiology of chronic bronchitis in the Baltic republics of the USSR. *Chest*, **96**(Suppl.): 321–323 (1989).
[32] SREENAN, S. ET AL. Risk factors associated with asthma and respiratory symptoms in Irish adults. *European respiratory journal*, **6**(Suppl. 17): 482S (1993).
[33] LO CASCIO, V. ET AL. Age and sex effect on respiratory symptom prevalence in a general population sample in Verona. *European respiratory journal*, **6**(Suppl. 17): 339s (1993).
[34] MARINONI, A. ET AL. Prevalence of respiratory symptoms and current asthma in general population sample of Northern Italy. *European respiratory journal*, **6**(Suppl. 17): 339s (1993).
[35] IVERSEN, M. & DAHL, R. Prevalence of self-reported asthma and respiratory symptoms in Denmark. EC-Respiratory Health Survey Phase I. *European respiratory journal*, **6**(Suppl. 17): 339s (1993).
[36] JANSON, C. ET AL. Respiratory symptoms and the use of medication for asthma in 6 Nordic areas. *European respiratory journal*, **6**(Suppl. 17): 340s (1993).
[37] FORASTIERE, F. ET AL. Indices of nonspecific bronchial responsiveness in a pediatric population. *Chest*, **100**: 927–934 (1991).
[38] BURNEY, P.G.J. ET AL. Has the prevalence of asthma increased in children? Evidence from the National Study of Health and Growth 1973–86. *British medical journal*, **300**: 1306–1310 (1990).
[39] YUNGINGER, J.W. ET AL. A community based study of the epidemiology of asthma: incidence rates, 1964–1983. *American review of respiratory diseases*, **146**: 888–894 (1992).
[40] WARDLAW, A.J. The role of air pollution in asthma. *Clinical and experimental allergy*, **23**: 81–96 (1993).
[41] CHAN-YEUNG, M. Occupational asthma. *Chest*, **98** (Suppl.): 148s–161s (1990).
[42] *Surveillance of congenital anomalies 1980–1988.* Brussels, EUROCAT Central Registry, Department of Epidemiology, Catholic University of Louvain, 1991 (EUROCAT Report No. 4).
[43] INTERNATIONAL CLEARINGHOUSE FOR BIRTH DEFECTS MONITORING SYSTEMS. *Congenital malformations worldwide*. Amsterdam, Elsevier Science Publishers, 1991.
[44] KÄLLÉN, B. *Epidemiology of human reproduction*. Boca Raton, FL, CRC Press, 1988.
[45] JANERICH, D.T. & POLEDNAK, A.P. Epidemiology of birth defects. *Epidemiological review*, **5**: 16–37 (1983).
[46] KHOURY, M.J. & HOLTZMAN, N.A. On the abil-

ity of birth defects monitoring to detect new teratogens. *American journal of epidemiology*, **126**: 138–143 (1987).

[47] Ceizel, A.E. et al. Environmental trichlorfon and cluster of congenital abnormalities. *Lancet,* **341**: 539–542 (1993).

[48] *Incidence of communicable diseases in the Russian Federation* [12 months of 1993] Moscow, Russian Information Analytical Centre, 1994.

[49] *AIDS surveillance in Europe.* Saint-Maurice, European Centre for the Epidemiological Monitoring of AIDS, 1993 (Quarterly Report No. 38).

[50] Shaffer, D. Suicide: risk factors and the public health. *American journal of public health*, **83**: 171–172 (1993).

[51] Mezentseva, E. & Rimachevskaja, N. The Soviet country profile: health of the USSR population in the 70s and 80s – an approach to a comprehensive analysis. *Social science and medicine*, **31**: 867–877 (1990).

[52] Verhulst, F.C. & Koot, H.M. *Child psychiatric epidemiology. Concepts, methods and findings*. Beverly Hills, Sage Publications, 1992 (Developmental Clinical Psychology and Psychiatry No. 23).

[53] Newton, J. *Preventing mental illness*. London, Routledge & Kegan Paul, 1988.

[54] Vázquez-Barquero, J.L. et al. A community mental health survey in Cantabria: a general description of morbidity. *Psychological medicine*, **17**: 227–241 (1987).

[55] Marino, S. et al. Psychiatric morbidity in a general practice in Italy. A point-prevalence survey in a defined geographical area. *Social psychiatry and psychiatric epidemiology*, **25**: 67–72 (1990).

[56] Saunders, P.A. et al. The prevalence of dementia, depression and neurosis in later life: the Liverpool MRC-ALPHA Study. *International journal of epidemiology*, **22**: 838–847 (1993).

[57] [*Health status of the Polish population in 1991.*] Warsaw, National Institute of Hygiene, 1992.

[58] Krzyzanowski, M. & Wysocki, M. The relation of thirteen-year mortality to ventilatory impairment and other respiratory symptoms: the Cracow study. *International journal of epidemiology*, **15**: 56–64 (1986).

[59] Minev, D. et al. The Bulgarian country profile: the dynamics of some inequalities in health. *Social science and medicine*, **31**: 837–846 (1990).

[60] Central Bureau of Statistics. *International variations in socioeconomic inequalities in self-reported health. A comparison of the Netherlands with other industrialized countries.* The Hague, SDU Publishers, 1992.

[61] Dennis, B.H. et al. The association of education with coronary heart disease mortality in the USSR Lipid Research Clinics Study. *International journal of epidemiology*, **22**: 420–427 (1993).

[62] Krzyzanowski, M. & Kauffmann, F. The relation of respiratory symptoms and ventilatory function to moderate occupational exposure in a general population. *International journal of epidemiology*, **17**: 397–406 (1988).

[63] Krzyzanowski, M. & Wojtyniak, B. Ten-year mortality in a sample of an adult population in relation to air pollution. *Journal of epidemiology and community health*, **36**: 262–268 (1982).

[64] Spruit, I.P. Health and social inequities in the Netherlands. *Social science and medicine*, **31**: 319–329 (1990).

[65] Gorynski, P. & Krzyzanowski, M. A study of the self-perception of being overweight in adult inhabitants of Cracow. *Journal of clinical epidemiology*, **42**: 1149–1154 (1989).

[66] Wnuk-Lipinski, E. The Polish country profile: economic crisis and inequalities in health. *Social science and medicine*, **31**: 859–866 (1990).

[67] Orosz, E. The Hungarian country profile: inequalities in health and health care in Hungary. *Social science and medicine*, **31**: 847–857 (1990).

[68] Nordström, M.L. et al. Social differences in Swedish infant mortality by cause of death, 1983 to 1986. *American journal of public health*, **83**: 26–30 (1993).

[69] Blaxter, M. *Health and lifestyles.* London, Tavistock, 1990.

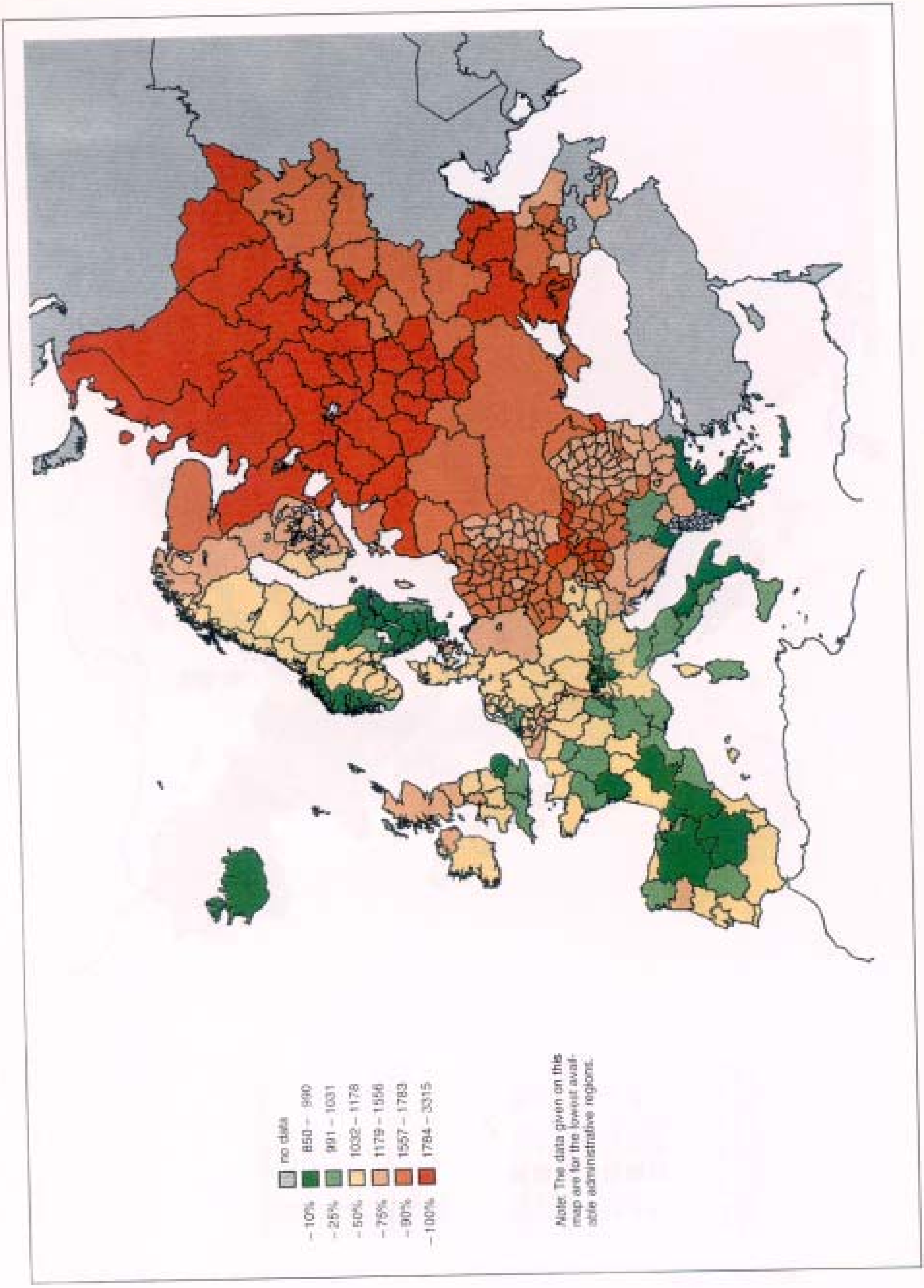
[70] Eames, M. et al. Social deprivation and premature mortality: regional comparison across England. *British medical journal*, **307**: 1097–1102 (1993).

[71] Wnuk-Lipinski, E. & Illsley, R. International comparative analysis: main findings and conclusions. *Social science and medicine*, **31**: 879–889 (1990).

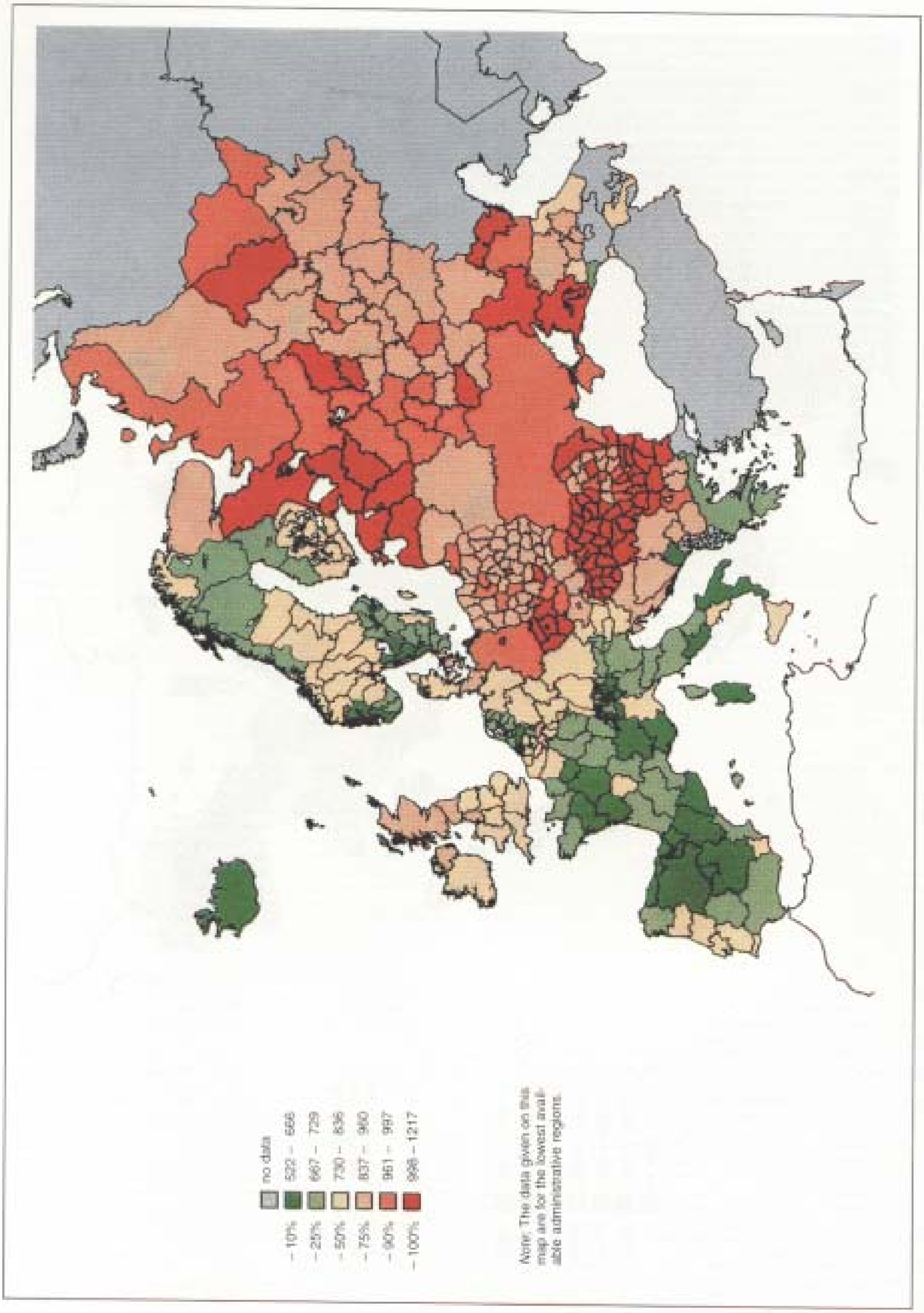
[72] Boys, R.J. et al. Mortality from causes amenable and non-amenable to medical care: the experience of eastern Europe. *British medical journal*, **303**: 879–883 (1991).

[73] Peto, R. et al. Mortality from tobacco in developed countries: indirect estimation from national vital statistics. *Lancet,* **339**: 1268–1278 (1992).

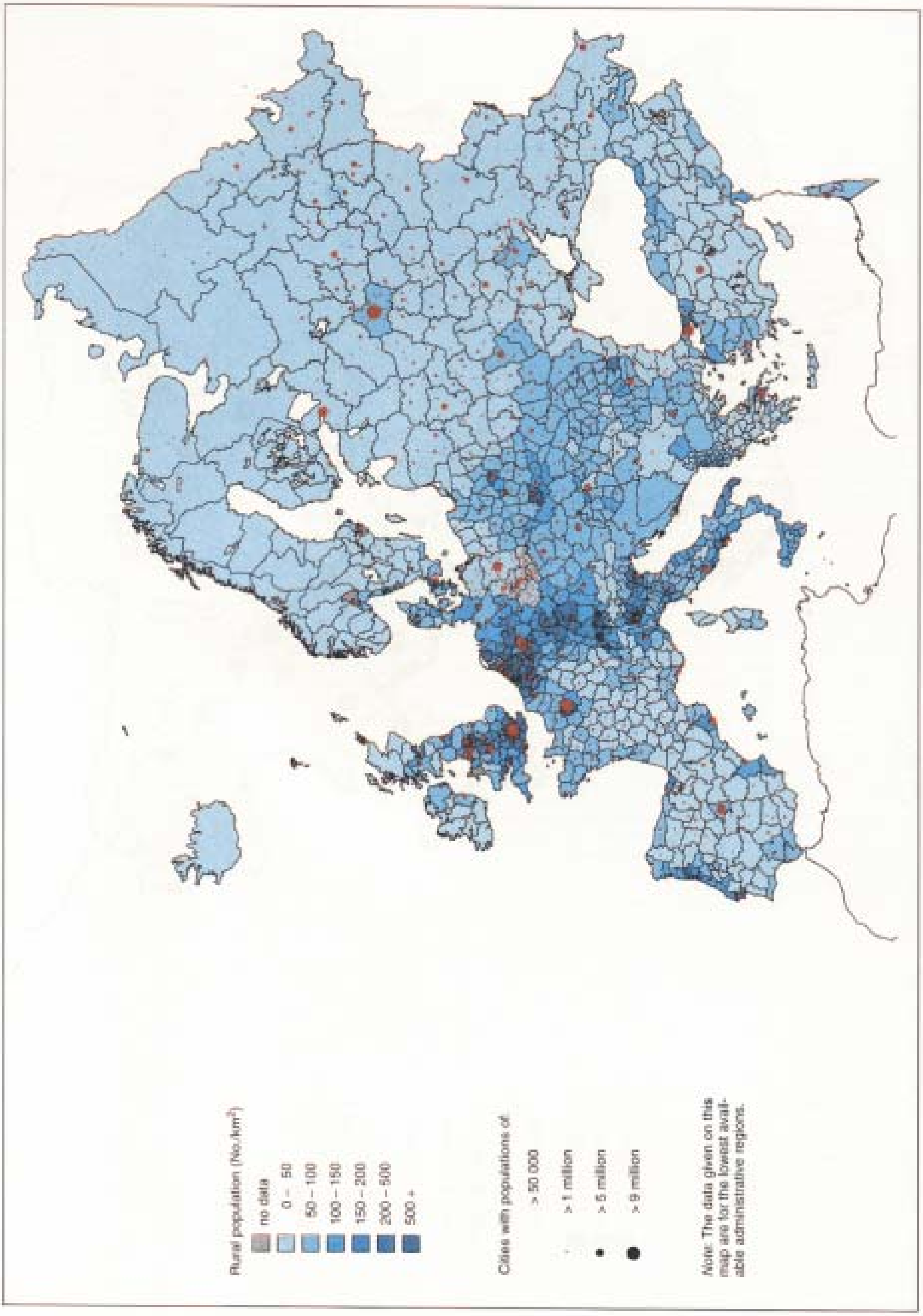
[74] Wojtyniak, B. & Kopczynski, J. [*Premature mortality in Polish population: levels and trends.*] Warsaw, National Institute of Hygiene, 1992.



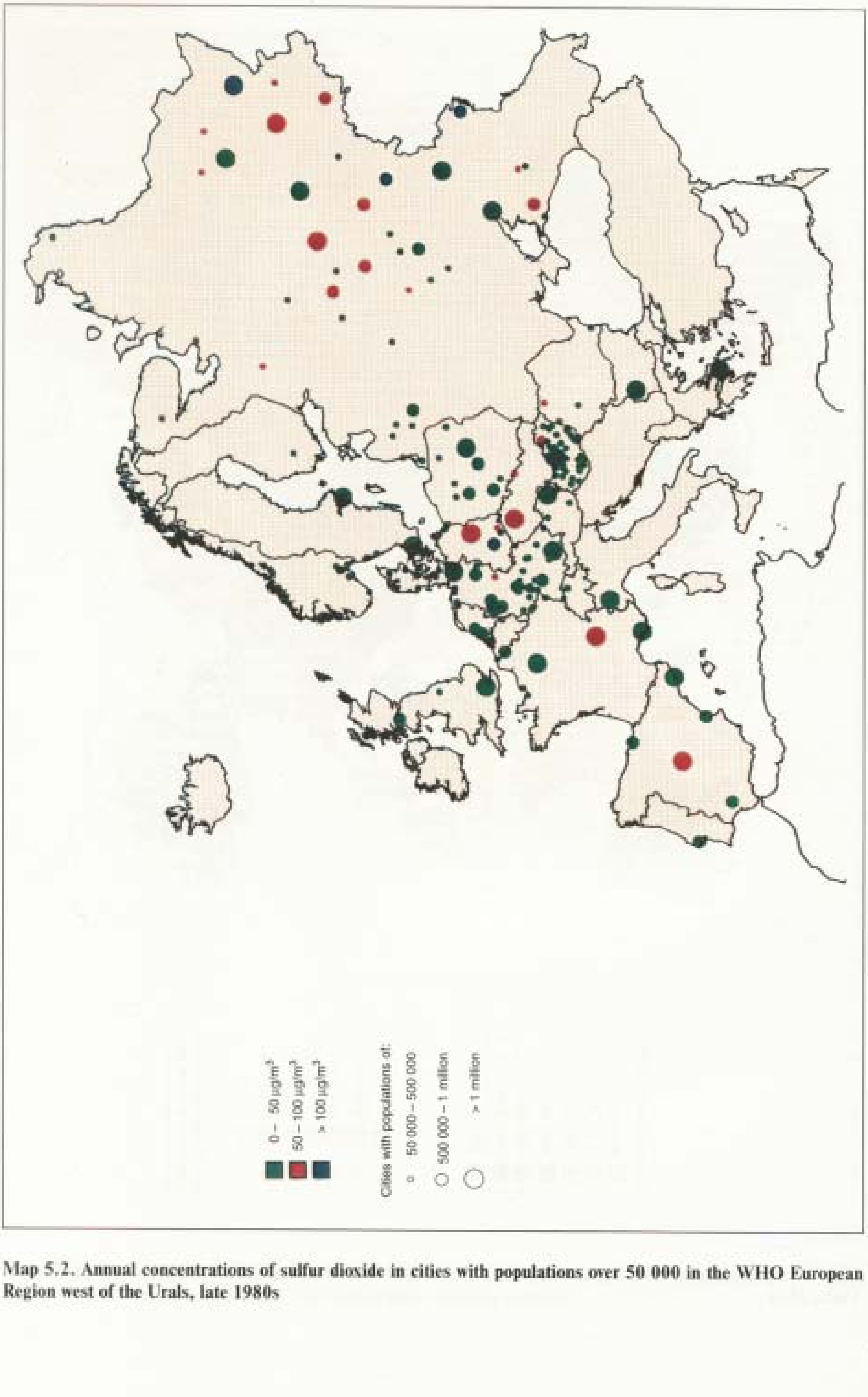
Map 4.1. Age-standardized death rates per 100 000 males for all causes of death in subnational areas of the WHO European Region west of the Urals, 1990 or latest available year



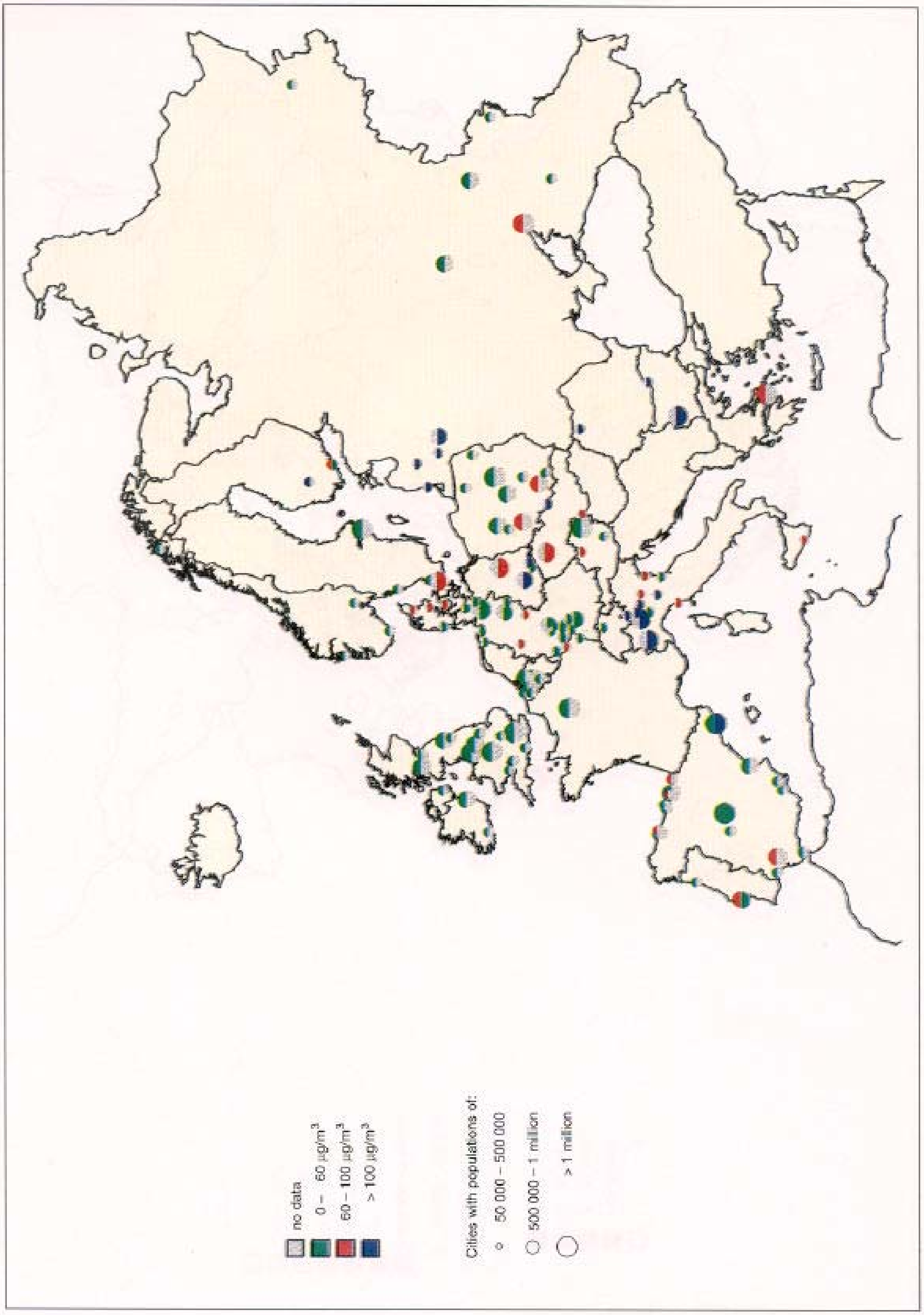
Map 4.2. Age-standardized death rates per 100 000 females for all causes of death in subnational areas of the WHO European Region west of the Urals, 1990 or latest available year



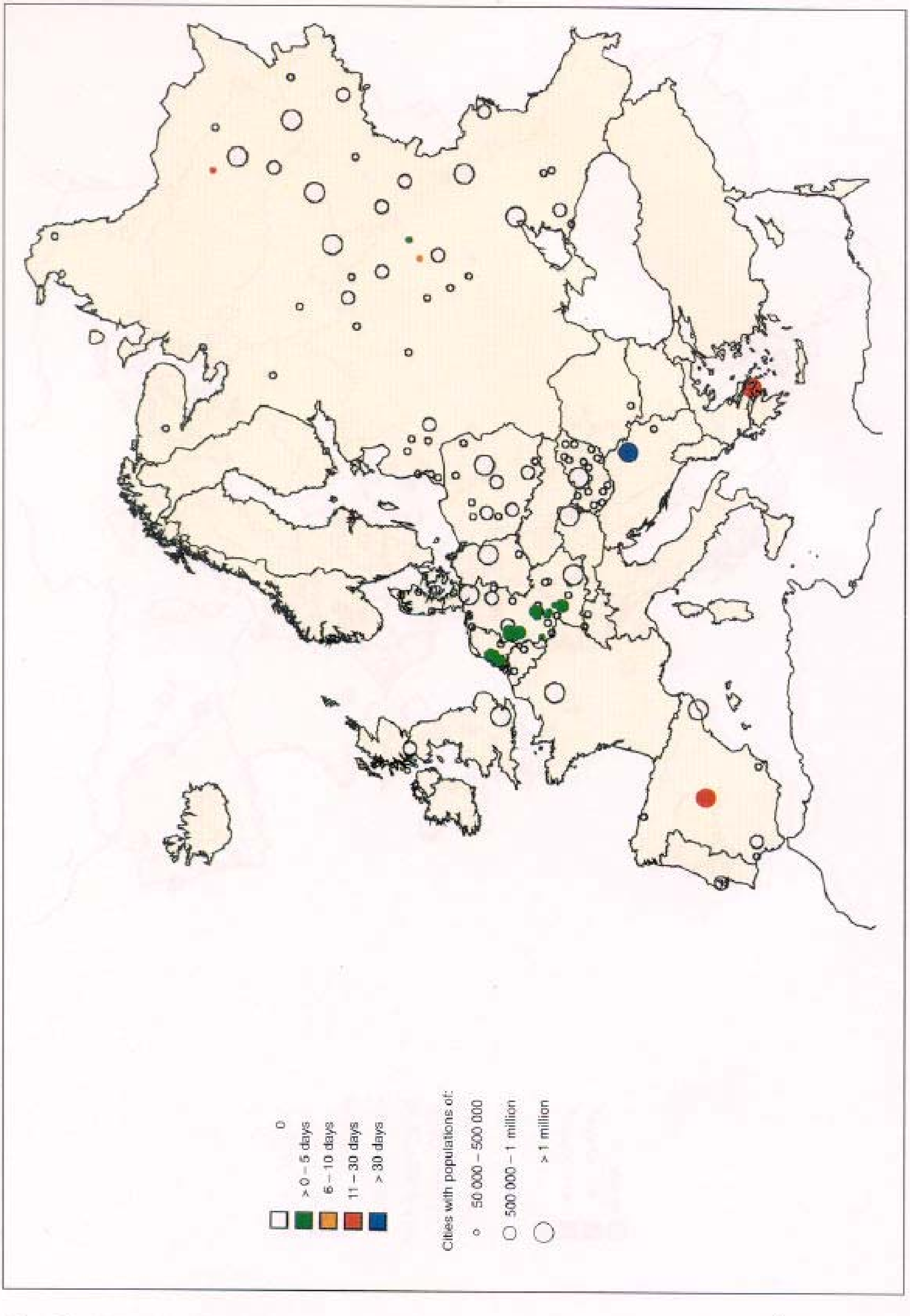
Map 5.1. Population densities and cities with populations over 50 000 in the WHO European Region west of the Urals, 1989



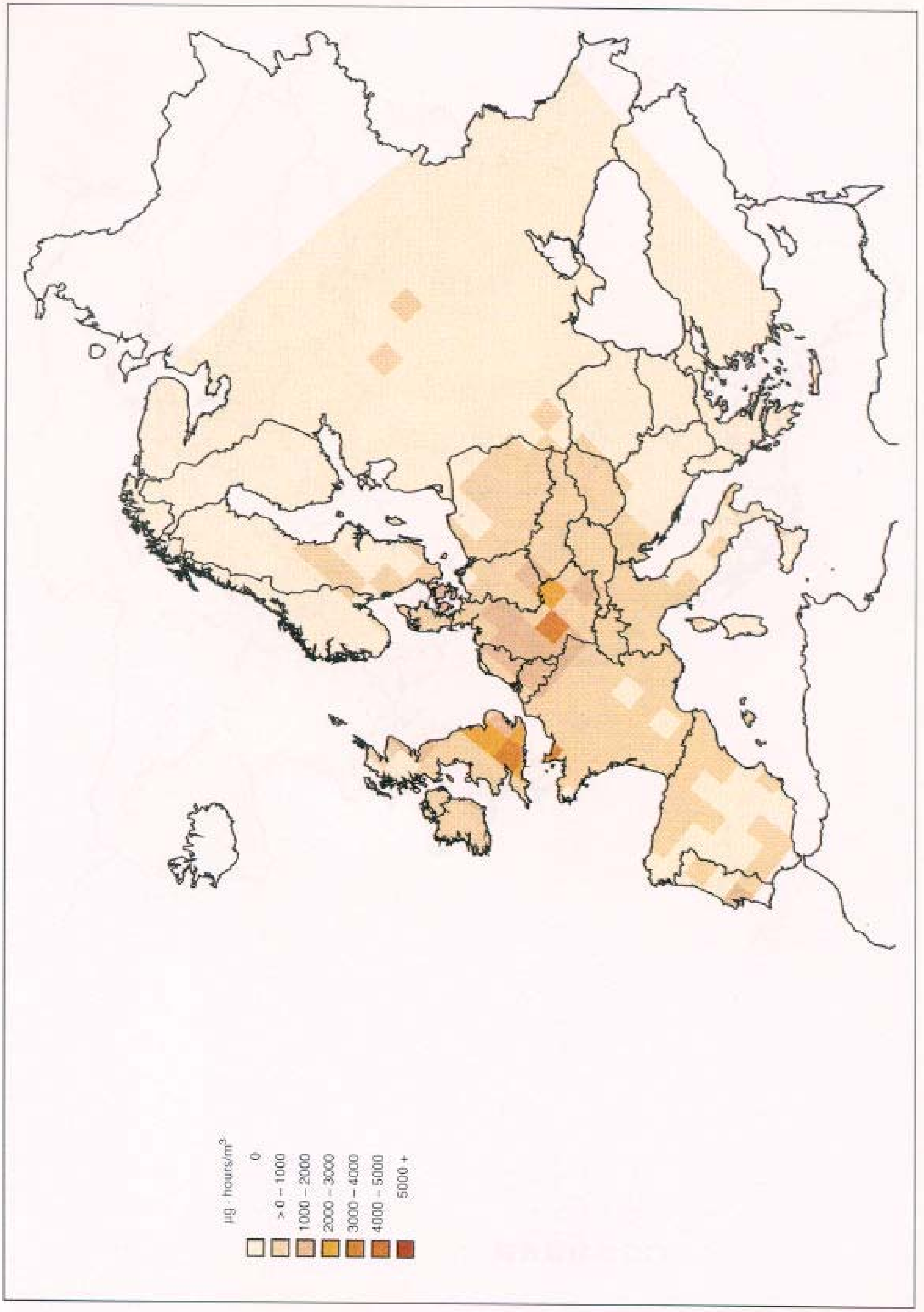
Map 5.2. Annual concentrations of sulfur dioxide in cities with populations over 50 000 in the WHO European Region west of the Urals, late 1980s



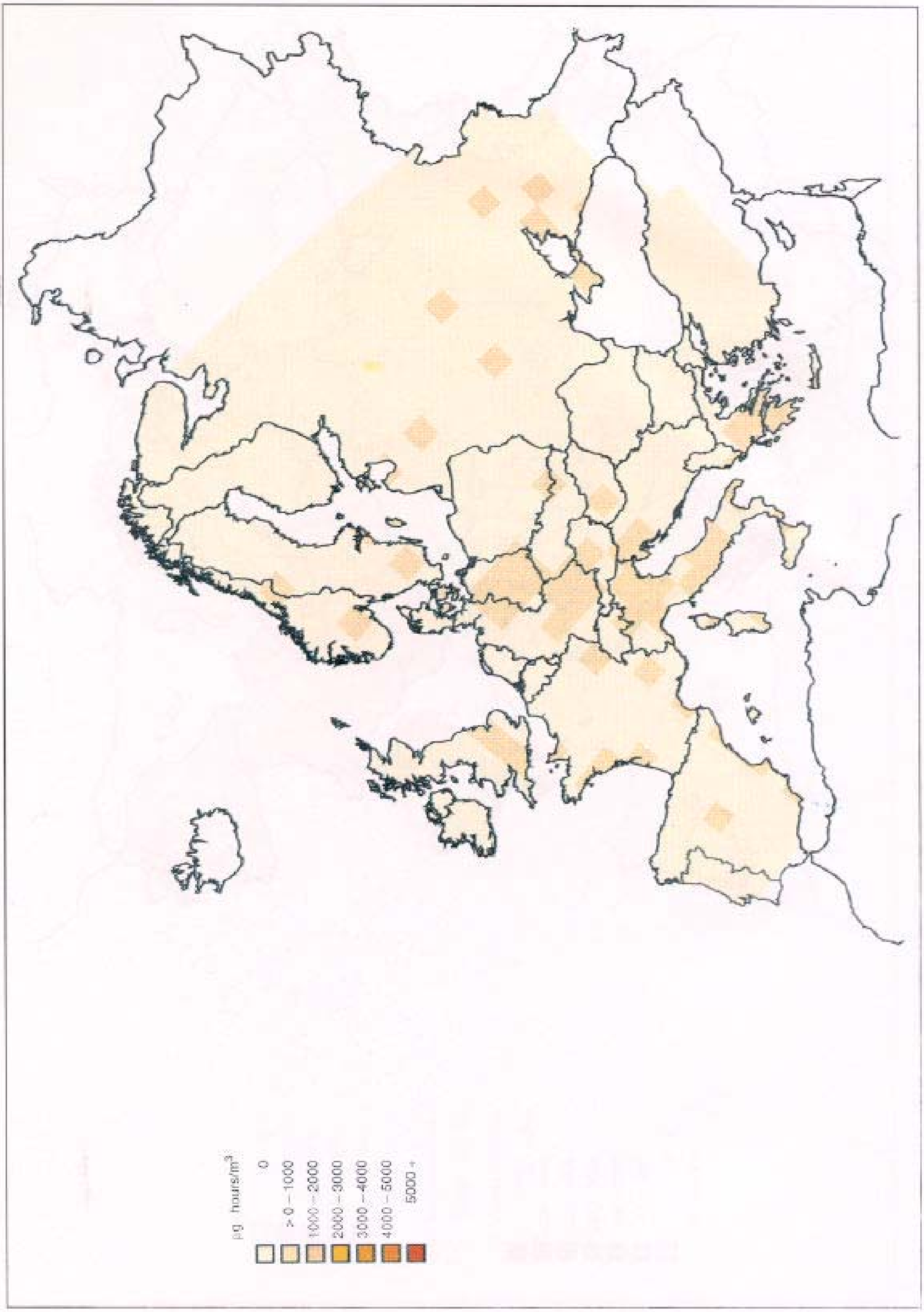
Map 5.3. Annual concentrations of total suspended particulate matter or black smoke in cities with populations over 50 000 in the WHO European Region west of the Urals, 1986–1991



Map 5.4. Average number of days per year with levels of nitrogen dioxide over 150 μg/m³ in cities with populations over 50 000 in the WHO European Region west of the Urals, 1986–1991



Map 5.5. Estimated excess ozone loads (1-hour average) in the WHO European Region west of the Urals, April–September 1989



Map 5.6. Estimated excess ozone loads (1-hour average) in the WHO European Region west of the Urals, April–September 1985

Part II

Environmental Exposure

Chapter 5
Air Pollution

5.1 Introduction

The existence of air pollution and the need for laws to protect the health and wellbeing of the population are not modern phenomena. In the thirteenth century, the burning of soft coal polluted the air of several English towns to such a degree that a law to reduce it was passed in 1273. The first causal relationships between high air pollution levels and excess mortality were established during the winter smog episodes in the Meuse Valley in Belgium in 1930 [1] and in Donora-Webster, Pennsylvania in 1948 [2], which caused 60 and 48 excess deaths, respectively. As early as 1931, Firket published an article on the causes of the excess deaths in the Meuse Valley episode, and predicted that some 3000 people would die if similar conditions occurred in London [3]. Just over 20 years later, the health implications of air pollution were clearly manifested during the London smog episode in December 1952, when more than 4000 people died [4].

Although air pollution was once thought to be only a local problem, occurring in large cities and near industry, it was realized in the 1970s that air pollutants can travel long distances and have negative environmental effects far from their sources [5]. Since then, it has been recognized that rural populations may sometimes be exposed to high levels of certain atmospheric pollutants that may adversely affect their health.

Many air pollutants can have negative effects on human health and, starting in the 1950s and 1960s, many countries have enacted laws and regulations to protect their populations. At the international level, WHO published a first set of air quality guidelines for 28 different atmospheric pollutants in 1987 [6]. They are now being revised and supplemented, and the new guidelines will cover some 38 pollutants or mixtures of pollutants. The guidelines are formulated on the basis of current knowledge and expert judgement to ensure that, in principle, populations that are exposed to levels below the guideline values will not experience adverse health effects. The guidelines are not simple threshold values, and it cannot be assumed that exposure to concentrations at or above the levels given will inevitably be associated with adverse health effects. In addition, however, the guideline levels may not sufficiently protect highly sensitive groups, and health effects at or below these levels can result from combined exposure to various pollutants. Many countries have used the WHO guidelines as the basis for developing their own air quality standards or other regulations.

Evaluating the real risks associated with exposure to the various air pollutants requires the assessment of their actual concentration levels in the air, the number of people exposed including sensitive groups, and the observed adverse health effects that have been associated with each pollutant. In the past, it has been possible to identify important pollutants that have caused large effects on health; these are sulfur dioxide (SO_2), suspended particulate matter (SPM) including lead, nitrogen dioxide (NO_2) and ozone (O_3). These pollutants are major elements of the four main air pollution phenomena observed in the European Region, and identified by WHO in a report to the United Nations Economic Commission for Europe (ECE) [7] as:

1. summer-type smog episodes, characterized by increased levels of O_3 and NO_2;
2. winter-type smog episodes characterized by increased levels of SO_2 and SPM;
3. long-term exposure in urban areas to SO_2, NO_2 and SPM;
4. long-term multimedia exposure to pollutants emitted into air (for example heavy metals such as lead).

Besides these important pollutants, several others such as volatile organic compounds can be present in ambient air. The monitoring data available for these, however, are not sufficient to permit discussion on the extent of exposure in the population of the Region. Similarly, exposure to indoor air pollutants is difficult to quantify; the importance of this issue is discussed below.

This chapter describes the major health effects associated with each of the most important pollutants, and the current concentration levels in cities and rural areas, along with the identification of the major emission sources (including trends in both concentrations and emissions, where possible). It also attempts to estimate the potential population exposure throughout the Region west of the Ural Mountains.

5.2 Potential Health Effects

This section summarizes the main types of health effect considered in the 1987 WHO air quality guidelines [6] and reviews the results of subsequent studies. The review was based on a comprehensive survey of the scientific literature; the studies will also be assessed in the revision of the guidelines. The review focused on studies that provided a quantitative estimate of health effects from exposure to relatively low levels of air pollution, and took proper account of possible confounding factors, including exposure to air pollutants other than the one being considered. Estimates obtained in individual studies are quoted to illustrate the magnitude of the health effects discussed. Some of the results of recent studies have yet to be confirmed by further research. It must also be recognized that the magnitude of the detected effects of air pollution in concentrations close to the guideline levels is rather small, frequently very close to no effect. As a result, any risk assessment based on these studies may be associated with substantial uncertainty.

5.2.1 Sulfur dioxide and suspended particulate matter

Assessments of the health effects of SO_2 and SPM are often based on studies conducted in populations exposed simultaneously to both pollutants. Sulfur dioxide and SPM are often released from the same emission sources, and therefore occur together in ambient air. In 1990, a WHO consultation evaluated the acute effects of winter-type air pollution episodes [8]. Effects on human health include acute decreases in pulmonary function (sometimes persisting for several weeks), other respiratory effects, increased morbidity as reflected by admissions to clinics, and even increased mortality. A strong correlation between both pollutants complicates an assessment of the relative significance of SO_2 and SPM.

The analysis of the health effects of SPM is further complicated by the complex nature of particulate matter pollution. The respirable part of SPM, i.e. particles with an aerodynamic diameter of less than 10 μm (PM_{10}), has long been recognized as having the greatest significance to health, but this fraction has not been measured in all studies. Many studies use black smoke as the indicator of particulate pollution. This works well if most of the pollution comes from coal combustion but clearly leads to underestimation of the particle concentration in other situations, such as when mineral particles are present in the mixture. The chemical characteristics of the particles (such as their acidity), as well as the presence of air pollutants that can adhere to a particle's surface (such as more or less volatile organic substances), are seldom measured or evaluated. For example, exhaust from diesel engines, which contains organic particulate matter and has been classified as a probable human carcinogen, may significantly contribute to the total level of pollution by particles [9]. The specific characteristics of particles may significantly modify the health effects from a given concentration of particulate pollution.

All of these factors should be kept in mind when considering the evaluation of the health effects of SO_2 and SPM presented below.

Sulfur dioxide

Owing to its high solubility in water, only minimal amounts of SO_2 reach the lower parts of the respiratory tract. Acute responses from the upper airways, in the form of bronchospasm, were seen after a 10-minute exposure of exercising asthmatics to concentrations above 1000 $\mu g/m^3$.The occupational exposure of non-asthmatics to very high concentrations of SO_2 (over 10 000 $\mu g/m^3$) has caused bronchoconstriction, chemical bronchitis and tracheitis [6]. Epidemiological studies suggested that increased morbidity and mortality can be seen after a 24-hour exposure to levels above 250 and 500 $\mu g/m^3$, respectively. Prolonged exposure to SO_2, with average annual concentrations of 100 $\mu g/m^3$, was found to increase the prevalence of respiratory symptoms or illness. On the basis of these results, a 1-hour WHO guideline value of 350 $\mu g/m^3$ was set for SO_2. The guideline values for longer averaging times were set for situations in which people were exposed to SO_2 and SPM simultaneously: 125 and 50 $\mu g/m^3$ for 24-hour and 1-year periods, respectively [6].

Since the publication of the guidelines, several new studies have been reported. An acute deterioration in the health status of a population was observed on days with increased SO_2 concentrations or on subsequent days, independent of other types of air pollution and meteorological factors. In Cracow, this was expressed by an increase in the number of adults visiting general practitioners during a year with annual mean SO_2 levels of 131 $\mu g/m^3$ and 71 days with daily mean concentrations over 75 $\mu g/m^3$, but with no days with levels exceeding 350 μg/m^3 on average. The daily number of all visits increased by 10% for each 100 μg SO_2 per m^3, with visits due to respiratory diseases increasing the most rapidly [10]. In Barcelona, emergency admissions due to exacerbation of chronic obstructive lung disease increased by 17% for each 100 μg SO_2 per m^3. In this case, the maximum daily level did not exceed 160 μg/m^3, and a significant association between SO_2 levels and emergency admissions was also seen at mean daily concentrations below 100 μg/m^3 [11].

Several recent studies have shown an increase in mortality related to daily levels of SO_2. In Athens, a 4% increase in total daily numbers of deaths and an 11% increase in mortality due to respiratory diseases were seen on days with daily mean SO_2 concentrations above 150 μg/m^3 [12]. The most pronounced effect was seen in people over 75 years of age. In Lyon and Marseille, the number of deaths from respiratory diseases in people over 65 years of age rose 9–11% for each 100 μg SO_2 per m^3 (expressed as the mean concentration on 10 days preceding death) [13]. In this study, the annual mean levels did not exceed 65 μg/m^3 and daily levels did not exceed 500 μg/m^3 [13].

Another French study confirmed the long-term effects of air pollution with SO_2 [14]. Levels of pulmonary function decreased in people with increasing average levels of SO_2 at their place of residence; lung function was 4–7% lower in residents of cities with annual mean SO_2 concentrations above 100 μg/m^3 than in residents of cities with levels below 50 μg/m^3.

Suspended particulate matter

The penetration of particulate matter into the respiratory system depends on particle size. Fine particles are deposited primarily in the pulmonary region; larger ones are usually stopped in the tracheobronchial region. Particles with a diameter over 10 μm are primarily deposited in the upper, nasopharyngeal part of the airways, and are most easily removed.

Particulate pollution is known to affect respiratory function as well as the development and course of chronic obstructive pulmonary disease. The evidence available before publication of the WHO air quality guidelines indicated short-term, reversible decreases in ventilatory lung function following 24-hour exposure to levels over 110 μg/m^3 of PM_{10} and 180 μg/m^3 of total SPM. Acute respiratory morbidity and mortality in adults increased after exposure to levels of black smoke with mean 24-hour concentrations above 250 and 500 μg/m^3, respectively. Long-term exposure to black smoke levels over an annual mean of 100 μg/m^3 promoted an increase in respiratory morbidity; long-term exposure to levels of total SPM above 180 μg/m^3 caused a decrease in lung function. These results led to the setting of WHO guideline values for black smoke (combined with SO_2) of 125 μg/m^3 for a 24-hour concentration and 50 μg/m^3 for an annual mean [6]. Guideline levels (for 24 hours) were also set for SPM (120 μg/m^3) and for PM_{10} (70 μg/m^3).

Since the publication of the WHO guidelines, some studies have addressed the health effects of particulate matter in concentrations similar to the guideline levels; concentrations of PM_{10} were sometimes measured. The acute effects of short-term changes in pollution levels were most often the subject of these studies. An association of respiratory morbidity with daily levels of total SPM, smoke or PM_{10} was observed in studies conducted in Europe and the United States.

In a study in Germany, where 90% of the daily total SPM levels were below 118 μg/m^3 even in the most polluted communities, the daily frequency of visits to hospitals and paediatricians due to acute respiratory illness increased by 37% with a rise in total SPM levels of 10–70 μg/m^3 [15]. A Swiss study reported a 10% increase in the daily incidence of upper respiratory symptoms with each rise of 22 μg/m^3 in the daily average level of total SPM on the previous day [16]; in this case, total SPM concentrations were below 100 μg/m^3 on most of the days studied. In a study of children from Utah Valley, the incidence of cough and lower respiratory symptoms increased by 80 % and 45 %, respectively, per 100 μg/m^3 of PM_{10} (5-day moving average), with even greater changes in asthmatic children [17]. This association was still seen when days with PM_{10} levels above 150 μg/m^3 were excluded from the analysis. In addition to the changes in the incidence of respiratory symptoms, a 2–4 % decrement of pulmonary function per 100 μg/m^3 of PM_{10} was seen in the Utah Valley studies [18], as well as in a study in the Netherlands in which a group of children with chronic respiratory symptoms were exposed to daily PM_{10} levels below 174 μg/m^3 [19]. Analyses of the relationship between daily mortality and total SPM levels, based on data from several cities in the United States, indicate a 4–7 % increase in daily mortality, particularly from cardiovascular and respiratory diseases, per 100 μg/m^3 total SPM. These studies found no independent effects of SO_2 pollution and in some cities the SO_2 concentrations were very low [20,21].

In addition, the effects of long-term exposure to elevated levels of total SPM have been reported. In residents who lived in locations where the average quarterly level was 87 μg/m^3, pulmonary function as expressed by forced vital capacity decreased by 3 % for each 50 μg total SPM per m^3; this decrease was observed only above a threshold concentration of 60 μg/m^3 [22]. The frequent exceeding of hourly total SPM levels of 100, 150 or 200 mg/m^3 (but not 60 or 75 μg/m^3) was found to be associated with the incidence of chronic respiratory disease in residents of California; during a follow-up period of 10 years, for every 1000 hours in which total SPM levels exceeded 200 μg/m^3 the risk of obstructive airways disease increased by 36 % and that of asthma by 74 % [23]; the average levels of SO_2 were below 25 μg/m^3.

Winter-type air pollution

The effects discussed in this section are those for which it is not evident whether they are due to SO_2 or SPM, or a combination of the two. Winter-type air pollution episodes, as well as the background situation of winter-type air pollution in some cities, are characterized by increased concentrations of both SPM and SO_2. In the Netherlands, lung function decreased transiently by 5 % of average values a few weeks after winter smog episodes in which the 24-hour concentrations of SO_2 and total SPM were close to 300 μg/m^3 [24, 25]. During an episode in a part of the Federal Republic of Germany in 1985, in which SO_2 and SPM reached 24-hour concentrations of 830 and 600 μg/m^3, respectively, hospital admissions were 12 % higher than in a control area where the respective concentrations were 320 and 190 μg/m^3. Admissions due to cardiovascular and respiratory diseases were 14 % and 7 % higher, respectively. A 6 % increase in total mortality was also observed during this episode, due partly to respiratory diseases [26].

The incidence of lung cancer in males in Cracow may provide further evidence of the long-term health effects of mixtures of SPM and SO_2 in urban air pollution. Annual mean black smoke levels exceeded 150 μg/m^3 and SO_2 levels exceeded 104 μg/m^3 for several years before registration of the cancer cases. The incidence of lung cancer among males living for an average of 30 years in polluted parts of the city was 46 % higher than that in residents of less polluted areas [27]. Although the risk estimate provided by this study agrees, in general, with that found in recently reviewed studies comparing cancer risk in urban and rural areas [28], quantifying the impact of air pollution on cancer incidence remains difficult. In part this is due to the uncertain estimate of past exposure to air pollutants.

A study from the Czech Republic suggested effects of winter-type air pollution on the health of infants [29]. Postneonatal mortality was 20–30 % higher in districts with annual mean concentrations of total SPM and SO_2 over 85 and 58 μg/m^3, respectively, than in those with concentrations below 54 and 13 μg/m^3, respectively. The analysis, which considered potential confounding factors, indicated that the relationship was stronger for total SPM than for SO_2, and that the risk estimates were higher for respiratory than for other causes of death.

5.2.2 Lead

Most of the lead in ambient air is in the form of very fine particles, less than 1 μm in diameter. Some 30–50 % of inhaled particles are taken up by the respiratory system and absorbed by the body. Larger particles are deposited in the lungs or absorbed through the gastrointestinal tract. Air is, however, only one of several routes of human exposure to lead; Chapter 10 includes a more extensive discussion of the health effects of lead exposure.

Depending on concentrations of lead in ambient air, the exposure from air is estimated to range from 17 % to 67 % of total exposure in adults, and from 2 % to 17 % in children, with food or ingested dust usually a predominant source. For adults, an increase in exposure to lead in air by 1 mg/m^3 is associated with a 10–20 μg/litre increase in the concentration of lead in blood. No such relationship can be established for children [6]. Data from the United States demonstrated a correlation between atmospheric emissions of lead due to the combustion of leaded petrol, ambient lead concentrations and levels of lead in blood. All three showed a parallel decline between 1986 and 1990, when both the total lead used in petrol and average blood lead levels decreased by 50 % [30].

Recognizing the multimedia nature of lead exposure, and the role of air as a medium through which lead may be transported to soil, water and food, the WHO guideline level was set at 0.5–1.0 mg/m^3 (for an annual mean) [6]. This level is considered to be safe for adults. Since most of the exposure of children to lead occurs through other media, however, the guideline level does not offer sufficient protection.

Even at relatively low levels, lead causes changes in haematological and neurological parameters, and the impairment of neuropsychological development in children with associated deficits in cognitive ability. Several studies conducted after publication of the WHO guidelines confirm the impact in children of relatively low levels of exposure to lead [31]. Exposure producing blood lead levels of 250 μg/l, in cities with elevated concentrations of lead in air, may affect cognitive ability as expressed by the IQ index. The IQs of children with such exposures to lead are estimated to be some 2–10 points lower, on average, than those of children not exposed. The shift in the IQ distribution in such an exposed population is estimated to result in a threefold increase in the percentage of children with low cognitive ability (an IQ below 80 points), and the proportion of children with high intelligence (an IQ above 125 points) is estimated to be reduced from 5 % to zero. Some studies indicate that neuropsychological development in children is affected at exposure levels corresponding to a level of lead in blood of 100 μg/litre and above, but other reports suggest that no threshold exists and that effects can be seen at even lower levels of exposure [32].

5.2.3 Nitrogen dioxide

The evidence related to the health effects of NO_2 in concentrations frequently encountered in ambient air is still not well understood. Upon inhalation, 80–90 % of NO_2 can be absorbed and remain within the lung for prolonged periods. An increased susceptibility to infection may be related to exposure.

Animal studies indicate that NO_2 at relatively low concentrations (380 μg/m^3 for 30 minutes) can trigger biochemical changes, including initiation of lipid peroxidation and an increase in lung enzymes, which may lead to cell injury or death. The biological relevance of these changes, however, is still poorly understood. Animals exposed for 1–6 months to NO_2 concentrations of 190–940 μg/m^3 showed changes in lung structure and lung metabolism, and impairment of lung defences against infection. Controlled clinical studies in human subjects and limited epidemiological studies, conducted in the 1970s and early 1980s, produced conflicting results. The lowest NO_2 level at which an effect on pulmonary function in humans was seen, after a 30-minute exposure, was 560 μg/m^3; this exposure caused a small, reversible decrease in lung function in a group of exercising asthmatics. In normal subjects the threshold was much higher, about 3000 μg/m^3, for 10–15 minutes. On the basis of this limited evidence, WHO recommended a 1-hour guideline value of 400 μg/m^3 and a 24-hour guideline level of 150 μg/m^3 [6].

Some later studies confirmed the increased bronchial responsiveness in asthmatic and non-asthmatic subjects exposed for a short time to NO_2 concentrations above 500 μg/m^3. The results, however, lack consistency, reflecting large variations in individual susceptibility [33]. Nevertheless, a recent study confirmed a deterioration of the defence mechanisms of the lung against influenza viruses after an exposure to relatively high NO_2 concentrations (1120 μg/m^3) [34].

Several recent studies evaluated the health effects of short-term increases in NO_2 levels. An increase in the frequency of eye irritation, sore throat and phlegm was observed among student nurses in Los Angeles following an increase in exposure to NO_2 for one hour, with maximum concentrations not exceeding 240 μg/m^3. The relative risk estimates from this study were 1.3 for each 170 μg NO_2 per m^3 [35]. Several studies reported an association between daily NO_2 levels and the daily rate of hospital admissions due to acute respiratory diseases. Using data on the hospitalization of children in five German cities, Schwartz et al. [15] found a 28% increase in the number of cases of respiratory tract infection associated with a rise in ambient NO_2 levels from 10 to 70 μg/m^3. A number of researchers evaluated the effects of NO_2 on ventilatory lung function, but only a few studies demonstrated a decrease in the expiratory flow rate, mainly in subjects with underlying chronic respiratory diseases. Quackenboss et al. [36] observed a 3% decrease in pulmonary expiratory flow rate in a group of asthmatic children per 20 μg/m^3 NO_2 hourly outdoor concentration. They also reported prolonged effects, expressed as a 10% decrease in pulmonary expiratory flow rate per increase of 20 μg/m^3 in the weekly average outdoor level of NO_2.

Other studies also observed health effects associated with long-term exposure to NO_2. A Swiss study of children aged 5 years or under, living in cities with annual average levels of NO_2 in ambient air not exceeding 51 μg/m^3, found a 20% increase in the incidence of upper respiratory symptoms per 20 μg/m^3 increase in NO_2 for a continuous period of six weeks [16]. This study also indicated a 13% increase in the duration of any respiratory symptom with an increase in NO_2 of 20 μg/m^3. Similar results were reported for children exposed to NO_2 indoors.

Several studies found decreased ventilatory function or accelerated decline of function with aging in residents of areas with high long-term average levels of NO_2. An ecological analysis based on data collected in 60 neighbourhoods in the United States indicated a decrease in pulmonary function by approximately 5% of the predicted value for each 40 μg NO_2 per m^3 (measured as an annual value) [37].

In most of the studies of short- and long-term effects of NO_2, differences in the NO_2 levels were correlated with levels of other air pollutants. It can therefore be assumed that NO_2 concentrations are also indicative of levels of some other pollutants, such as those related to road traffic emissions. The combined evidence from all studies, including those on indoor exposure, however, suggests that NO_2 at least contributes to respiratory effects.

5.2.4 Ozone

Ozone is the predominant photochemical oxidant in summer-type smog, and its most important component in affecting health. It enters the human body through inhalation and penetrates the respiratory system. Acute O_3 exposure causes transient decreases in lung function and an inflammatory response of the lower airways; typical symptoms include cough, chest pain, difficulty in breathing and headache. Substantial acute adverse effects undoubtedly occur at exposure to levels above 1000 $\mu g/m^3$ for 1 hour, and more recent studies with ozone levels over 740 $\mu g/m^3$ for 2 hours showed an inflammatory response of the lower airways. Limited data from laboratory and epidemiological studies conducted in the early 1980s indicated that ambient O_3 concentrations above 220 $\mu g/m^3$ could lead to decreases in pulmonary function, especially in children and exercising adults. Some of the other symptoms, including cough and headache, were associated with O_3 concentrations of 160–300 $\mu g/m^3$. These data led to the recommendation of a 1-hour WHO guideline value of 150-200 $\mu g/m^3$, and of an 8-hour value of 100-120 $\mu g/m^3$ [6].

Since then, several important studies on the health effects of O_3 at concentrations similar to the guideline values have been published. Lippmann [38] reviewed some of these and WHO held a consultation in 1990 to evaluate the acute effects of summer-type air pollution episodes [8]. All studies indicate large variations between individuals in response to O_3 exposure. The effects seem to be more pronounced in children than in adults [39]; no characteristics of the responsive group, other than age, have yet been identified. Most studies evaluated acute effects on pulmonary function or symptoms from short-term episodes of elevated O_3 levels. They showed a 1–4 % decrease in pulmonary function in children for each 100 μg O_3 per m^3 [40–42]. In adults, similar effects were observed but they were limited to measurements taken shortly after exercise and therefore with an increased inhalation rate [43]. Increases in the incidence of cough and eye irritation were seen in children on days with elevated O_3 concentrations. Krzyzanowski et al. [41] reported a 30 % increase in symptoms when 8-hour ambient O_3 levels exceeded 110 $\mu g/m^3$; Berry et al. [44] reported that symptoms were twice as frequent in children exposed to 1-hour ambient O_3 concentrations over 240 $\mu g/m^3$ than in those exposed to levels below 160 $\mu g/m^3$.

Far fewer studies have attempted to assess long-term effects in people living in areas with high average O_3 levels (around 200 $\mu g/m^3$). The results indicate a small long-term effect on lung function, including a 6–8 % decline in pulmonary function in people aged 6–24 years for each 100 μg O_3 per m^3 above 90 $\mu g/m^3$ [37]. A cross-sectional study of children in the Austrian Alps [45] reported a similar relationship. In adults living in the Los Angeles area, with an annual average O_3 level over 150 $\mu g/m^3$, the normal rate of decline in pulmonary function, which occurs with age, increased significantly as a function of levels of oxidants in which O_3 predominated [46]. A recent analysis of a longitudinal study in California, however, did not provide conclusive support for an effect of long-term exposure to O_3 on the incidence of respiratory symptoms [23].

It should be noted that, although volatile organic compounds have recently aroused concern as precursors of photo-oxidant formation (such as O_3) some of them, such as benzene and 1,3-butadiene, are carcinogenic and have themselves, therefore, important potential health implications.

5.3 Ambient Air Pollution and Exposure Assessment

This section estimates the exposure of populations to the five air pollutants discussed above. These are approximate estimates because relatively few data on air quality were available.

5.3.1 Methodology

Separate estimates of exposure to air pollutants are given for populations living in urban agglomerations with more than 50 000 inhabitants and in smaller towns and rural areas. The exposure estimates are based on levels of outdoor ambient air pollution and on the assumption that these concentrations are representative of the levels to which people are exposed in their daily lives.

Map 5.1[a] depicts the density and distribution of populations into urban and rural areas. In total, 700 million people live in the countries of the European Region that lie west of the Ural Mountains, of which 314 million live in large urban areas of more than 50 000 inhabitants and 386 million in rural areas and smaller towns. The large-scale ambient air pollution models presented in this chapter consider only those people who live inside the modelling grid used by UN ECE EMEP[b] (as shown in Map 5.1), that is, a total of 656 million people of whom 278 million live in large urban areas and 378 million in the remaining areas. No larger modelling area has yet been used in a consistent way for the whole of Europe.

Exposure calculations for urban and rural populations

Estimating the exposure of urban populations to air pollution concentrations is currently a rather difficult and uncertain task. The main problem is the scarcity of concentration data and particularly of information on the representativeness of the available data. In general, concentrations of air pollution vary markedly across a city, as has been shown in detailed studies such as that of NO_2 in the United Kingdom [47]. Differences in reported concentrations could therefore as easily reflect differences in the location of monitoring sites (in distance from roads, or the city centre, for example) as real differences between air pollution loads in different cities. Unfortunately, much of the urban concentration data available throughout Europe covers only one or a few sites per city, and frequently only a few cities per country. Until more data become available to allow a better characterization of urban air pollution levels, it has to be assumed that the existing data reflect a representative sample of urban air pollution concentrations across Europe. Nevertheless, the errors of extrapolation based on this assumption may be substantial.

Concentration data obtained from several sources have been analysed and empirical regression models applied to enable population exposure calculations to be made for those cities for which at least the annual mean concentrations were available. Box 5.1 gives details of data sources and modelling methodology.

Calculations of the exposure of rural populations were based on population densities as shown in Map 5.1, and ambient air concentrations calculated with long-range transport models (see Box 5.1).

5.3.2 Sulfur dioxide

Urban population exposure

The analysis of SO_2 concentrations in the late 1980s was based on data from 162 cities in 21 countries, covering a population of 98 million or 31 % of the total urban population in the Region west of the Urals. The best population coverage, 47 %, was obtained for the CCEE (Map 5.2). For over 20 % of the population with data the annual guideline value for SO_2 of 50 $\mu g/m^3$ was exceeded, and for 3 % of the population levels exceeded 100 $\mu g/m^3$. The proportion of city residents with high long-term average SO_2 levels was markedly higher in the USSR and the CCEE than in western countries (Table 5.1). The comparison of annual mean SO_2 levels before and after 1985, for cities with data from both periods, as well as the trends from a number of other cities [51] indicate a decrease in the average SO_2 pollution levels over the decade. The highest annual average

[a] Maps 5.1–5.6 referred to in this chapter will be found between Chapters 4 and 5.

[b] United Nations Economic Commission for Europe Environmental Monitoring and Evaluation Programme.

Box 5.1: Assessing exposure to air pollutants

This chapter presents two different approaches to establishing population exposure to outdoor air pollution. For rural areas, ambient air concentrations were calculated with long-range transport models. For urban areas, actual measurement data were used as the basis for the analysis.

For the rural population, the exposure was computed based on population densities in the 150 150 km^2 EMEP grid and ambient air concentrations in the same grid, calculated with long-range transport models such as EMEP for SO_2, NO_2 and O_3 [48,49] and TRACE for lead [50]. These models calculate ambient rural background concentrations in air, based on first principles and input data on air pollutant emissions, meteorological data and dispersion parameters. Both models have been tested against ambient monitoring data. As the results of the models are in general compatible with the observed measurements, both models can be considered reasonably reliable. Moreover, members of the ECE use the EMEP model within their programme on the Convention on Long-range Transboundary Air Pollution.

For exposure of the urban population, ambient concentration data from the following sources were analysed:

(*a*) the Exchange of Information (EOI) database of the EU;
(*b*) the database of the ECE Cooperative Programme on Effects on Materials at the Norwegian Institute for Air Research (1992);
(*c*) data returned directly from countries in response to the 1992 WHO Protocols for the Concern for Europe's Tomorrow data collection exercise, comprising 25 responses received from countries that represent 96 % of the population of Europe and 90% of the population of the WHO European Region (Austria, Bulgaria, the former Czechoslovakia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Lithuania, the Netherlands, Norway, Poland, Romania, the Russian Federation, Slovenia, the former USSR, Spain, Sweden, Switzerland, the United Kingdom and the former Yugoslavia);
(*d*) metropolitan area air quality data from the Helsinki Metropolitan Area Council (1992);
(*e*) *The Environment in Europe and North America* [51]; and
(*f*) for O_3, the EMEP long-range transport model for photochemical oxidants [49].

The following table summarizes exposure monitoring in urban areas (agglomerations greater than 50000 inhabitants).

Pollutant	Population of cities with data		Number of cities			Total	Number of countries
	Estimates (millions)	Percentage of total European urban population	Western countries	CCEE	NIS		
SO_2	103	33	100	38	42	180	21
Total SPM	38	12	75	8	4	87	13
Black smoke	63	20	81	11	6	98	13
NO_2	91	29	76	35	42	153	18
Lead	47	15	39	55	15	109	16

Box 5.1: Assessing exposure to air pollutants

Data on SO_2 came from cities in the following countries: Austria, Bulgaria, the former Czechoslovakia, Denmark, Finland, France, Germany (including two cities in the former German Democratic Republic), Greece, Hungary, Italy, Lithuania, the Netherlands, Norway, Poland, Portugal, Romania, the Russian Federation, Spain, Sweden, Switzerland and the United Kingdom.

Data on total SPM came from cities in the following countries: Austria, Bulgaria, the former Czechoslovakia, Denmark, Finland, France, Germany (including two cities in the former German Democratic Republic), Italy, Lithuania, Portugal, Romania, Spain and Switzerland.

Data on black smoke came from cities in the following countries: Austria, Belgium, Finland, France, Greece, Ireland, Norway, Poland, Portugal, the Russian Federation, Spain, Sweden and the United Kingdom.

Data on NO_2 came from cities in the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Hungary, Lithuania, Netherlands, Poland, Portugal, Romania, the Russian Federation, Spain, Sweden, the United Kingdom and the former Yugoslavia.

Data on lead came from cities in the following countries: Belgium, the former Czechoslovakia, Denmark, Finland, Germany, Greece, Iceland, Ireland, Lithuania, Norway, Poland, Romania, the Russian Federation, Sweden, Switzerland and the United Kingdom.

The long-term annual averages were available for the largest number of cities, mostly from responses to the WHO protocols. For some cities, the reported annual mean concentrations were already an average over several monitoring sites, while several sites were individually reported for one city in other cases. The years for which data were available varied from country to country and even from city to city, and ranged from 1976 to 1990.

Based on the daily or hourly data available for some cities on the European Union's database, empirical regression models were applied to describe the relationship between annual average values and levels above the 24-hour guideline values. These models were then used to estimate levels above the 24-hour guideline values for the cities for which only annual average pollution levels were available. Calculations of population exposure were then made for the cities that had at least annual mean concentration data.

Table 5.1: Exposure of the populations of cities with data to annual mean sulfur dioxide (SO_2) concentrations

Annual mean SO_2 concentration ($\mu g/m^3$)	Percentage of city populations exposed							
	Western countries		CCEE		USSR		All countries	
	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985
< 50[a]	41.8	85.7	62.7	88.9	22.1	51.9	36.9	79.5
50–100	51.2	14.3	37.3	8.0	29.5	35.2	43.7	17.3
> 100	6.9	0.0	0.0	3.1	48.3	12.9	19.4	3.1
Number of people in cities with data (millions)	(37.7)	(60.9)	(3.6)	(17.5)	(18.5)	(19.5)	(59.9)	(98.0)

[a] WHO air quality guideline (annual mean concentration) = 50 $\mu g/m^3$.

Table 5.2: Exposure of the populations of cities with data to daily sulfur dioxide (SO_2) concentrations above 125 μg/m^3, 1986–1991

Number of days per year with SO_2 concentrations >125 μg/m^3 [a]	Percentage of city populations exposed			
	Western countries	CCEE	USSR	All countries
1–49	48.9	0.9	24.1	35.4
50–99	5.6	3.1	24.1	8.9
≥100	0.0	3.1	5.1	1.6
Total	54.6	7.0	53.2	45.8
Number of people in cities with data (millions)	(60.9)	(17.5)	(19.5)	(98.0)

[a] WHO air quality guideline (24-hour mean concentration) = 125 μg/m^3.

concentrations reported at the end of the 1980s were in Leipzig (200 μg/m^3) and in Saratov, USSR (160 μg/m^3).

Over 45 % of the population living in cities with SO_2 data experienced days with pollution levels exceeding the daily guideline level of 125 μg/m^3 (Table 5.2). In the CCEE and USSR, the levels were higher than 200 μg/m^3 on most of these days, and levels over 125 μg/m^3 were more common than in western countries. In Leipzig and Saratov, the 24-hour average concentrations exceeded 125 μg/m^3 for 191 and 147 days per year, respectively, and levels were above 250 μg/m^3 on 77 and 55 days per year, respectively.

In comparison with the early 1980s, the frequency and magnitude of exposure decreased markedly in all groups, with relatively greater improvement in the western countries. The population in these countries experiencing pollution episodes exceeding 250 μg/m^3 SO_2 decreased from 71 % to 33 % in the 1980s, while the change in the USSR was from 74 % to 51 %. Data were available for only three cities in the CCEE and only for the beginning of the 1980s, which prevented comparison.

Rural population exposure

Exposure to SO_2 in rural areas was estimated for three different years: 1985, 1988 and 1989, using the EMEP long-range transport model as described by Sandnes & Styve [48] (see Box 5.1). Annual average SO_2 levels and the frequency of days with daily concentrations over 125 μg/m^3 were calculated.

The highest annual mean SO_2 concentrations, in the range 50–65 μg/m^3, were estimated for the so-called Black Triangle between the German Democratic Republic, Czechoslovakia and Poland. During 1985, 1988 and 1989, 1.7–2.2 million people (around 0.5 % of the rural population of Europe) were estimated to have experienced such annual averages, which exceeded the guideline level of 50 μg/m^3. In 1989, 26 % of the rural population were estimated to have been exposed to SO_2 concentrations exceeding the daily guideline level of 125 μg/m^3. Only 2 % (or 7.2 million people), however, were estimated to be exposed to such levels for more than 25 days a year (with a maximum of 50 days per year). Pollution episodes were less common than in 1985, when 33 % of the rural population were estimated to have experienced them. Excess pollution was estimated for large parts of central Europe in all three years, and in eastern Ukraine in 1985. The highest levels estimated, for both 1985 and 1989, were above 350 μg/m^3 for up to 10 days per year, and found in the Black Triangle.

Total population exposure

The available data on urban and rural areas indicate that, at the end of the 1980s, at least 22 million people in the Region west of the Urals (3% of the total population) lived in areas with annual average SO_2 levels above 50 μg/m^3. This includes 3 million people in cities with long-term SO_2 levels over 100 μg/m^3. A daily average above 125 μg/m^3 was estimated for at least 144 million people (21% of the total population). If these estimates are extrapolated to the European population (assuming that the cities with data are representative for all urban agglomerations with at least 50 000 residents) then some 65 million people would be expected to live in areas where the annual guideline level was exceeded at the end of the 1980s, including 10 million in cities with annual levels exceeding 100 μg/m^3. The extrapolation of short-term exposure data indicates that 241 million people might have been exposed to daily levels above the WHO guideline [6].

The urban data clearly show a decrease in SO_2 concentrations in the 1980s. This trend in concentrations corresponds to that in the total SO_2 emissions in the Region, which decreased by an average of 28% from 53 million tonnes in 1980 to 38 million tonnes in 1990 (Simpson, D., personal communication, 1993). This decrease resulted from the implementation of the international ECE Protocol calling for a 30% reduction in SO_2 from 1980 levels, which most European countries signed in Helsinki in 1985. The decrease was slightly greater in the western countries (30%) than in the eastern ones (27%). The contributions to emissions remained about the same, with 55% coming from eastern and 45% from western countries.

In the western countries, the levels in urban areas that exceed the WHO guidelines are mostly due to emissions from power stations, central heating plants and industry; in eastern countries, domestic heating probably also continues to contribute significantly to total SO_2 emissions.

5.3.3 Suspended particulate matter

The data on SPM analysed below were collected according to two different methods. These comprised the measuring of concentrations of total SPM, irrespective of size or colour of the particles, and of black particles or black smoke. The correlation between these two assessment methods, as well as their correlation with the concentration of PM_{10}, depends on the local characteristics of sources and pollution dispersion. Particulate pollution is therefore evaluated separately for total SPM and black smoke.

Urban population exposure

The analysis of black smoke at the end of the 1980s was based on data from 110 cities in 13 countries, covering 61 million people or 19% of the urban population; the coverage reached 30% in the western countries. Data on total SPM were available from 70 cities in 14 countries, covering almost 31 million people or 10% of the urban population. Again, the best coverage (15%) was obtained for the western countries. Only for four cities (with a total of 7 million residents) were there data on both total SPM and black smoke. Data on at least one SPM indicator were available for 29% of Europeans living in cities with a population of over 50 000 (Map 5.3).

At the end of the 1980s, about 23% of the people living in the towns reporting on black smoke concentrations (over 14 million people) were exposed to annual mean levels above the guideline value of 50 μg/m^3 (Table 5.3). The highest levels (above 100 μg/m^3) were reported from Tampere in Finland. The data from eastern Europe, however, indicated more frequent exposure to long-term concentrations above 50 μg/m^3. According to the available data, exposure in the most polluted towns declined markedly in the western countries and the CCEE in the 1980s; lack of sufficient data for the USSR in the early 1980s precludes any comparison. In all cities with an annual mean of over 50 μg/m^3, the daily guideline level of 125 μg/m^3

Table 5.3: Exposure of the populations of cities with data to annual mean concentrations of suspended particulate matter (SPM)

Annual mean SPM concentration (μg/m³)	Percentage of city populations exposed							
	Western countries		CCEE		USSR		All countries	
	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985
Black smoke								
< 50[a]	74.5	80.9	34.3	41.8	0.0	74.5	67.6	77.1
50–100	2.4	18.7	30.1	58.2	100.0	25.5	8.2	22.6
> 100	23.1	0.3	35.4	0.0	0.0	0.0	24.1	0.3
Number of people in cities with data (millions)	(6.0)	(51.6)	(2.3)	(5.3)	(0.5)	(3.9)	(18.8)	(60.9)
Total SPM								
< 60[b]	8.4	48.2	–	0.0	–	0.0	–	39.0
60–100	52.4	27.9	–	37.0	–	0.0	–	28.0
> 100	39.1	23.9	–	63.0	–	100.0	–	33.1
Number of people in cities with data (millions)	(12.8)	(24.6)	–	(4.5)	–	(1.4)	–	(30.5)

[a] WHO air quality guideline (annual mean concentration) = 50 μg/m³.
[b] No WHO air quality guideline; 60 μg/m³ is the lowest level at which long-term exposure is reported to cause respiratory effects.

Table 5.4: Exposure of the populations of cities with data to daily concentrations of total suspended particulate matter (total SPM) above 150 μg/m³, 1986–1991

Number of days per year with total SPM concentrations >120 μg/m³ [a]	Percentage of city populations exposed			
	Western countries	CCEE	USSR	All countries
1–49	48.6	0.0	0.0	39.3
50–99	21.6	48.0	15.0	25.2
100–149	1.5	18.8	43.1	5.9
150–199	7.5	3.4	0.0	6.5
≥200	15.0	29.9	42.0	18.4
Total	94.1	100.0	100.0	95.2
Percentage of population with total SPM >150 μg/m³ for at least 100 days per year	21.6	40.6	42.0	26.0
Number of people in cities with data (millions)	(24.6)	(4.5)	(1.4)	(30.5)

[a] WHO air quality guideline (24-hour mean concentration) = 120 μg/m³.

was exceeded on at least 22 days a year, with an average daily concentration reaching 200 μg/m^3 on such days.

In the cities with total SPM data at the end of the 1980s, over 61 % of the residents (over 18 million people) were exposed to annual mean concentrations of total SPM exceeding 60 μg/m^3. This is the level above which effects on pulmonary function from long-term exposure have been reported; this was chosen as a reference point since there is no long-term guideline level for total SPM. This level was exceeded in all eight cities of the CCEE with data and in four cities in the Lithuanian SSR (the only part of the USSR with data). The highest values were reported from Sofia and Ruse in Bulgaria (up to 185 μg/m^3) and from the Lithuanian SSR (a maximum of 270 μg/m^3). In the western countries, annual average levels of 100–165 μg/m^3 were reported from several Italian and Spanish cities. The comparison of the available data from these cities for the periods before and after 1985 does not indicate a major reduction in total SPM concentrations.

In most of the cities reporting total SPM data, the daily concentrations exceeded the 24-hour guideline level of 120 μg/m^3 for at least a few days a year, and as much as 18 % of the population covered by the data were exposed to levels of over 120 μg/m^3 for at least 200 days a year (Table 5.4). Levels of over 120 μg/m^3 were most frequently recorded in Kaunas and Shyaulyay in the Lithuanian SSR, Sofia and Ruse in Bulgaria, Barcelona in Spain, and Turin in Italy. In these cities – as well as in Baia Mare in Romania, Ostrava in Czechoslovakia and several cities of northern Italy – total SPM levels exceeded 150 μg/m^3 for more than 100 days a year. In the Italian cities with data from both the early and late 1980s, high pollution days did not become less frequent in the second half of the decade.

Rural population exposure

No special modelling of SPM concentrations was performed for this analysis. The scarcity of emission data, as well as a lack of uniform data on SPM concentrations, restricted the calculations. A report from the Netherlands based on an atmospheric dispersion model [52] indicates that the estimated annual average concentrations of total SPM exceed 50 μg/m^3 in two rural areas: the so-called Black Triangle and the Donetsk region in eastern Ukraine.

Total population exposure

The inadequacies of the data for rural populations have been explained. Further, although most of the data on SPM related to urban areas, those for total SPM were limited to a relatively small number of cities, especially in the CCEE, and many of the cities where high total SPM levels would be expected were included. It was considered, therefore, that the cities with data were not sufficiently representative to provide a reasonable basis for extrapolation to all other urban areas. The estimate of population exposure is therefore limited to the urban populations with data. The major emission sources are probably the combustion of coal, especially in eastern countries, and the use of diesel heavy goods vehicles and cars; up to one third of PM_{10} may originate from vehicles with petrol engines. Indoor sources of SPM also contribute to total exposure.

5.3.4 Lead

Urban population exposure

For the early 1980s, data on lead concentrations in air, reported as annual average values, were available for 49 cities in 10 countries, covering about 27 million people or 9 % of the urban population of the Region west of the Urals. For the late 1980s, data were available from 76 cities with a total of 42 million people or 13 % of the urban population. Out of this number, 23 million lived in 27 cities in 11 western countries, and 19 million in 49 cities in 5 eastern countries.

In the early 1980s over 2 million people, or almost 10% of the urban population with data, lived in areas where the upper limit of the annual WHO guideline values (1.0 μg/m³) was exceeded. The highest concentration of 1.29 μg/m³ was reported from Dublin. A further 15 million (a total of 63%) lived in cities where the lead concentration exceeded the lower limit of the guideline values (0.5 μg/m³). According to the data from the late 1980s, urban populations in the western countries were no longer exposed to airborne lead at concentrations above 0.5 μg/m³. In the cities of eastern countries with data for both the beginning and the end of the 1980s, lead concentrations also declined or remained unchanged over the decade. Among the large cities in eastern countries, Bucharest, Baia Mare and Medias in Romania, which are inhabited by over 2 million people (11% of the eastern population in cities with data), still showed lead concentrations above 0.5 μg/m³. In Medias, which had a population of 75 000, the annual average lead concentration was 1.11 μg/m³.

In addition to the data from cities, data on lead concentrations in ambient air were available from a few small towns with fewer than 50 000 residents. Most of these had lead concentrations below 0.25 μg/m³ at the end of the 1980s. The exceptions were two industrial towns in Romania (Copsa Mica and Zlatna, with some 28 000 people exposed) where the annual mean concentrations were 1.2 and 2.5 μg/m³, respectively.

These data indicate that certain hot spots of lead pollution in air still exist, in small as well as in large urban areas, that require urgent action for control.

Rural population exposure

Lead exposure in rural areas was calculated for four different years: 1980, 1982, 1985 and 1989, using the long-range transport model developed by Alcamo et al. [50]. Estimated maximum annual average rural concentrations were up to 0.1 μg/m³. In general, monitoring data for lead from more than 60 rural sites [50] support the computed concentration patterns. As in the case of urban lead concentrations, these calculations indicate a clear decrease in lead levels in ambient air between the early and late 1980s.

Total population exposure

Based on the above computations, the total population exposure can be summarized as follows. In the early 1980s, 5% of Europe's urban population in cities with data were exposed to lead in ambient air at concentrations above 0.5 μg/m³, with almost 1% exposed to levels over 1 μg/m³. If these data are taken as representative of all European cities, it can be calculated that up to 200 million people (63%) lived in areas with lead levels above the lower guideline limit in the early 1980s. During the decade, lead concentrations decreased markedly and levels above 0.5 μg/m³ were reported for less than 1% of the urban population of Europe in the late 1980s. At the end of the decade, levels above the guideline values were no longer reported from the western countries, but were still found in the eastern part of the Region, notably in Romania.

The emission data clearly reflect the temporal changes in and the spatial pattern of lead concentrations in ambient air. In 1982, the amounts of lead emitted by western and eastern countries were 48 000 and 42 000 tonnes, respectively. By 1989, the emissions decreased by 50% in western countries but remained the same in eastern countries. The decrease can be attributed predominantly to a reduction in the use of lead additives in petrol, which declined by a factor of two between 1985 and 1990 (Pacyna, J., personal communication, 1992). This emission situation, the expected future growth in vehicle stock and kilometres driven, and the experience from western Europe in the early 1980s (when lead from petrol was the predominant source of lead in city air) indicate that lead concentrations in eastern Europe will continue to exceed the guideline level of 0.5 μg/m³ unless measures to reduce emissions are promptly implemented.

The monitoring data and estimates presented are insufficient to indicate some peak exposures at particular locations. Such hot spots may still occur around large, uncontrolled smelters of ferrous and non-ferrous metals, in other metal industries, in power plants and in cement factories in such industrial cities as Medias, Copsa Mica and Zlatna in Romania. Incomplete data from Bulgaria indicate that high levels of lead in air (above 1 μg/m^3) can be found in a number of industrial cities such as Burgas, Plovdiv and Kurdzhali, which have close to 700 000 inhabitants [53].

One should remember that people can be exposed to lead through several media. Nevertheless, although lead in ambient air is responsible for only about 20 % of total exposure [6] much of the lead found in water, food and soil is initially emitted into, transported by and deposited from the air. Thus, effective control of overall exposure still means tight control of all lead-emitting sources of air pollution.

5.3.5 Nitrogen dioxide

Urban population exposure

Data on annual mean NO_2 concentrations at the end of the 1980s were available from 144 cities in 18 countries, covering a population of 91 million people or 29 % of the urban population of the Region west of the Urals. The distribution of populations with data was fairly uniform, with the poorest coverage (21 %) in that part of the USSR west of the Urals (Map 5.4). For 19 % of the residents of cities with data, the annual average NO_2 level exceeded 60 μg/m^3. This is the level above which population studies show effects on the respiratory system from long-term exposure; it is used as a reference point because there is no WHO guideline level for long-term exposure to NO_2. Only one city, Belgrade, had levels above 100 μg/m^3, which is the national ambient air quality standard in the United States. The available data indicated no large differences between groups of countries in the distribution of average long-term levels of NO_2 and no changes in pollution levels over the 1980s (Table 5.5).

The daily average WHO guideline level for NO_2 (150 μg/m^3) was exceeded in 25 cities inhabited by 21 million people, or by 23 % of people in cities with NO_2 data (Table 5.6). Such levels were more common in the western than the eastern countries. The days with levels above 150 μg/m^3, however, were fewer than 10 per year in most of the cities. Only in three cities were such concentrations seen for longer periods in the second half of

Table 5.5: Exposure of the populations of cities with data to annual mean concentrations of nitrogen dioxide (NO_2)

Annual mean NO_2 concentration (μg/m^3)	Percentage of city populations exposed							
	Western countries		CCEE		USSR		All countries	
	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985	Up to 1985	After 1985
< 60[a]	79.7	76.1	61.5	75.9	80.8	96.3	79.2	80.9
60–100	20.3	23.9	0.0	15.4	12.0	3.7	16.2	17.9
> 100	0.0	0.0	38.5	8.7	7.2	0.0	4.6	1.3
Number of people in cities with data (millions)	(32.8)	(56.2)	(3.0)	(13.2)	(20.1)	(21.7)	(55.9)	(91.1)

[a] No WHO air quality guideline; 60 μg/m^3 is the lowest level at which long-term exposure is reported to cause respiratory effects.

Table 5.6: Exposure of the populations of cities with data to daily nitrogen dioxide concentrations above 150 $\mu g/m^3$,[a] 1986–1991

Countries	Exposure (average number of days per year)	Percentage of the population exposed for at least 1 day	Number of people in cities with data (millions)
Western countries	13.4	27.9	56.2
CCEE	32.4	24.1	13.2
USSR	5.4	9.7	21.7
All countries	15.5	23.1	91.9

[a] WHO air quality guideline (24-hour mean concentration).

the 1980s: almost 30 days per year in Madrid and Athens and as many as 88 days per year in Belgrade. In these three cities, the daily average concentrations occasionally exceeded 300 $\mu g/m^3$.

Rural population exposure

In general, estimated NO_2 concentrations in rural areas do not seem to exceed the daily WHO guideline value of 150 $\mu g/m^3$. This is suggested by EMEP long-range transport model calculations for three different years: 1985, 1988 and 1989 [48] and confirmed by the available NO_2 monitoring data. On average, therefore, the rural population of Europe is not exposed to any NO_2 concentrations above the daily WHO guideline value. It should be noted, however, that the calculations as well as most of the measurements indicate only relatively large-scale, long-term trends; they do not imply that people living in rural areas never experience any elevated NO_2 levels in ambient air. These may well occur during local, high-level pollution episodes, and from indoor emission sources.

Total population exposure

The available data indicate that at least 7% of the urban European population (21 million people) or 3% of the total European population west of the Urals, experience concentrations of NO_2 exceeding the daily guideline level. If these data are taken as representative of all cities in Europe and extrapolated to provide exposure estimates, 20% of the urban population (56 million people), or 8% of the total population may be exposed to NO_2 levels above the guideline level. On average, exposure to NO_2 in ambient air does not seem to differ in any important way between eastern and western European cities, and no definite trend in concentrations can be indicated. Indoor sources such as gas stoves have an important impact on the patterns of exposure to NO_2, affecting both short-term peak exposure as well as long-term average exposure, and may relate both to urban and to rural populations.

The total European emissions of nitrogen oxides (NO_x), which determine ambient NO_2 levels, remained approximately stable between 1980 and 1990 at 21 million tonnes per year (Simpson, D., personal communication, 1993). In 1980, 52% of these emissions stemmed from western Europe and 48% from eastern Europe; this picture had changed little by 1990, when 51% came from western Europe and 49% from eastern Europe.

In general, road traffic is the major source of NO_2 exposure and levels above the WHO guidelines in cities in Europe. Motor vehicles contribute around 50% of total emissions in Europe; the second largest source is power and heating plants, which account for another 30% [54]. In western Europe, the contribution from road traffic is somewhat higher (about 60%), while power and heating plants give rise to about 20% of emissions. In eastern Europe, the shares are about equal at 40% each. While emissions from the two main sources remained more or less constant between 1980 and 1990 in eastern Europe, an increase in traffic emissions in western Europe was offset by a comparative emission decrease from stationary sources [54]. It should further be noted that, although traffic contributes on average 50% to total NO_x emissions, it contributes significantly more to ground-level NO_2 concentrations in cities because of the low height of these emissions [55]. Thus, reducing population exposure in urban areas to below the daily WHO guideline value would require the implementation of strict emission controls on all road vehicles, and the limiting of traffic in congested areas of cities. Reducing emissions from stationary sources would require improved energy conservation measures and the installation of NO_x reduction equipment in all large power stations and heating plants. So far, there has been no substantial emission reduction on a European scale. The 1987 ECE Protocol on NO_x emission reductions only requires emissions to remain stable, which does not appear to be sufficient to ensure the attainment of the WHO guideline level for daily exposure.

5.3.6 Ozone

In contrast to the other pollutants discussed in this chapter, O_3 is a so-called secondary pollutant; that is, it is not directly emitted but is formed from other pollutants, particularly volatile organic compounds (VOC) and NO_x, through chemical reactions in the atmosphere. Although NO_x emissions contribute to the formation of O_3, elevated ambient NO_2 levels also act as an O_3 sink. Thus, O_3 levels tend to be lower in areas of intense NO_x emissions, such as city centres with heavy traffic, and build up slowly downwind from these sources. The actual amount of O_3 formed mainly depends on the level and ratio of precursor emissions, ambient temperature, and the amount of sunshine. These factors also determine how quickly O_3 is formed. In cities in southern Europe, where temperatures in the summer are high and sunshine is intense, photochemical smog builds up very quickly close to urban centres. In contrast, the build-up is slower in northern Europe where temperatures are lower, and the highest O_3 levels usually occur well away from city centres, in the suburbs and surrounding rural areas. Ozone pollution can, therefore, be both a local and a wider problem.

For these reasons, O_3 monitoring is relatively rare in city centres and much of it focuses on concentrations in rural areas. Insufficient urban data were available to allow a separate estimation of urban population exposure. Consequently, only rural concentration data were used to estimate combined urban and rural exposure. This probably does not lead to an underestimate of the total population exposure for two reasons. In northern Europe, population exposure is, in general, lower in cities than in the surrounding suburbs and rural areas. Almost no excess O_3 is observed in city centres, as has been shown for London [47]. As a result, population exposure is somewhat overestimated in northern Europe. In southern Europe, especially in Mediterranean cities, urban O_3 concentrations can be high, as the limited monitoring data for Athens suggest. In this case, the use of data on surrounding rural concentrations seems somewhat to underestimate O_3 concentrations in southern cities. Population exposure may therefore also be slightly underestimated. Only 13% of the total European population, however, lives in large cities in southern Europe.

Since O_3 formation and thus O_3 exposure depend very much on the weather conditions in the summer, observed annual levels vary with meteorological conditions; hot, sunny summers usually lead to greater exposure than do cool, wet summers. Exposure calculations were therefore based on EMEP model results for two different years, 1985 and 1989; the summer of 1989 was particularly hot and sunny, while that of 1985 was comparatively cold and wet.

According to calculations based on the EMEP model, the lower limit of the range of the hourly WHO guideline values (150 μg/m^3) was exceeded during both years over most of Europe, the only exceptions being parts of northern Scandinavia. The upper limit of the range of the guideline values (200 μg/m^3) was also estimated to have been exceeded in some places during both years. In 1989, the area with high levels was relatively extensive, including parts of Austria, Belgium, Denmark, France, the German Democratic Republic, the Federal Republic of Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, Spain, Switzerland and the United Kingdom, and extending north to southern Norway and Sweden. In 1985, on the other hand, hourly O_3 concentrations exceeded 200 μg/m^3 over a much smaller area, affecting mostly central and southern Europe. These patterns compare well with observed O_3 measurements from the TOR[a] and EMEP OXIDATE[b] rural monitoring networks.

Owing to the lack of available data on urban concentrations, two different assumptions were made about the population that could be exposed to O_3. First, it could comprise the total European (urban and rural) population, minus that of large cities north of the Alps (north of latitude 47°) with a total of 463 million people. This represents the lower estimate and was chosen because, as noted above, hourly concentrations of O_3 in northern cities are not likely to exceed 200 μg/m^3. Second, the exposed population could include the whole population within the EMEP grid, with a total of 656 million people. This is justified because, although people living in city centres in northern Europe are not greatly exposed to excess O_3, concentrations in the suburbs may often be more similar to those in rural areas, so that at least part of the urban population is probably exposed.

On the basis of the EMEP model results, the annual average of maximum daily 1-hour O_3 concentrations was calculated for 1985 and 1989. The long-term population exposure was calculated assuming that high concentrations are not likely to last long in the cities of northern Europe (i.e. according to method 1 above).

Total population exposure in 1989 and 1985

Based on the upper estimate of the population potentially exposed and on calculated O_3 concentration fields over Europe for the summer of 1989, the estimated number of people who lived in areas where hourly O_3 averages sometimes exceeded 200 μg/m^3 amounted to 367 million, or 56% of the European population west of the Urals. The highest O_3 levels were computed in southern England and in the region around Lisbon. The extent of the exposure over the 200 μg/m^3 level can be described by the "excess load" or the product of the concentration over 200 μg/m^3 and the time for which O_3 exceeds this level. Peak values of excess load ranged between 1200 and 2100 μg·hours/m^3. Some 50% of the exposed population experienced a total of 337 μg·hours/m^3 excess load of O_3. In general, the highest levels of excess O_3 occurred in areas with a high population density, especially in Belgium, Luxembourg and the Netherlands, southern England, the German Democratic Republic, the Federal Republic of Germany, northern France and Switzerland (Map 5.5).

Using the lower estimate of 463 million people, it was calculated that 38% lived where the 200 μg/m^3 hourly value was sometimes exceeded. The median excess O_3 load was computed as 299 μg·hours/m^3.

[a] Tropospheric Ozone Research (TOR) project under the EUROTRAC programme (a Eureka environmental project).

[b] EMEP oxidant data collection in OECD-Europe 1985–87 (OXIDATE).

The frequencies of occurrence of these excess levels in 1989 were computed; the results indicate that the upper hourly guideline value of 200 μg/m^3 was exceeded, on average, on 3.8 days per year. The number of days ranged from 1 to 19 in the various areas. The highest frequency was estimated for an area near the borders between France, the Federal Republic of Germany and Luxembourg.

Population exposure calculations for 1985, when O_3 levels were relatively low throughout the year, suggest that 16–22 % of the total European population was exposed to hourly O_3 concentrations above 200 μg/m^3, with the median excess load for those exposed ranging from 60 to 70 μg·hours/m^3. The ranges indicate the lower and upper estimates of likely exposure, assuming 463 or 656 million people potentially exposed, respectively. Such levels occurred on an average of 1.5 days per year. In 1985, the highest O_3 exposures occurred in central and southern Europe (Map 5.6).

Long-term exposure of the total population

Maximum annual mean O_3 concentrations were estimated to be 130 and 139 μg/m^3 for 1985 and 1989, respectively. In the cool year, the annual O_3 concentrations were estimated to exceed 90 μg/m^3 in areas inhabited by 431 million people, or 65 % of the European population covered by the models. This is the level above which effects on pulmonary function from long-term exposure have been observed; it was chosen as a reference point since there is no long-term WHO guideline value for O_3. In northern Europe, the proportion of the rural population exposed to levels above 90 μg/m^3 was estimated to be 63 % in 1985 and 95 % in 1989. For southern Europe, it was calculated that over 95 % of the population was exposed to such concentrations in both years, with 10 % of the population (22 million people) living in areas with long-term O_3 averages in the range of 110–140 μg/m^3 even in 1985. Model calculations indicated a rather uniform distribution of high (over 110 mg/m^3) levels of O_3 in the central and eastern parts of southern Europe in 1985, the highest values for 1989 occurring in central continental Europe with a maximum over the Alpine countries.

Overall exposure

The annual variations in meteorological conditions can particularly affect the magnitude of exposure to peak ozone levels. During both 1985 and 1989, at least one sixth of the Region's population west of the Urals, or almost 150 million people, was estimated to have been exposed to 1-hour concentrations above 200 μg/m^3. As an upper estimate, it can be expected that more than 50 % of the population may experience such concentrations in warm, sunny years. Levels above the guideline value of 150 μg/m^3 are experienced by 63–95 % of the population, depending on climatic conditions and assumptions related to the population potentially exposed. Further, long-term average O_3 concentrations are relatively high in a large part of Europe, even in the less sunny years. Exposure to high concentrations of O_3 is a widespread problem across Europe, affecting both urban and rural populations. The area most heavily affected by short-term episodes of high concentrations is central north-western Europe, while the southern countries have high long-term average levels and probably high short-term levels in cities.

At this stage, it is difficult to predict trends in O_3. Although levels in the troposphere have increased over the past decade, urban O_3 concentrations have probably decreased on average owing to increased NO_x emissions from traffic. Overall trends in O_3 concentrations in Europe therefore remain unclear. Any trend in precursor emissions may, however, also be taken as an indication of the likely trend in O_3 concentrations and exposure. As discussed above, total NO_x emissions remained relatively stable throughout the 1980s but NO_x emissions from traffic increased, especially in urban areas. Total

VOC emissions in Europe increased by an average of 18% between 1980 and 1990, from 22 to 26 million tonnes per year. The increase was somewhat lower in western Europe (only 7%), and higher in eastern Europe (27%). With these trends, exposure to O_3 does not appear likely to decrease.

If population exposure to O_3 in Europe is to be substantially reduced, strict emission controls are needed on VOC and NO_x sources. For NO_x, these are motor vehicles and stationary combustion sources. Man-made VOC emissions also stem from mobile sources (about 45%), ineffectively controlled industrial processes (around 15%) and widespread solvent use (about 40%) [51].

5.4 Indoor Air Pollution

Over the last few years, increasing attention has been paid to both indoor climate and indoor air quality. One of the main reasons is the fact that people usually spend most of their time in different types of indoor environment, including the home or workplace, in transit, and educational or leisure facilities. On average, people spend more than 50% of their time at home and some groups, such as small children and elderly people, may spend 90% or even more time indoors. Another important factor is the recognition that the increased use of new materials in the construction and furnishing of buildings has resulted in exposure to an increasing number of compounds indoors. Further, recent data indicate that exposure to several pollutants may be much greater indoors than outdoors, owing to additional indoor sources. Finally, efforts in many countries to conserve energy, following the energy crisis in the 1970s, have sometimes resulted in a marked reduction in air exchange rates in both new and older buildings, and consequently in an increase in indoor air pollutant levels.

5.4.1 Pollutants and their sources

Many air pollutants are present in indoor environments, and their concentrations may vary widely not only between locations but also between buildings at the same location and even rooms in the same building. As shown in Table 5.7, the sources of airborne contaminants in indoor environments are numerous [57–59]. Some indoor air pollutants are primarily generated outdoors, but may also have indoor sources. Such pollutants include SPM, SO_2, NO_2, carbon monoxide (CO), photochemical oxidants, lead and some VOC. In the absence of additional indoor sources, the ratio of indoor to outdoor concentrations is, in general, in the range of 0.7 to 1.3.

The pollutants generated or released indoors can be divided into two categories. The first is related to human presence or activities. For example, combustion, particularly with inadequate ventilation, or the evaporation of solvents can result in substantial releases of gaseous and particulate pollutants including CO, carbon dioxide (CO_2), NO_2, SO_2, water vapour and VOC. The principal combustion sources are tobacco smoking, gas cooking stoves and unvented heaters (such as kerosene heaters), as well as the burning of wood or coal in stoves and open fireplaces. The second category of pollutants with predominantly indoor sources are those released from buildings and furnishings. Formaldehyde may be released from a number of building materials, particularly from particle board and plywood as well as from urea formaldehyde foam insulation, furnishings and/or household products. Other VOC may also be released from furnishings or household products. Asbestos and other mineral fibres used in insulation may be present in indoor air. Radon and its decay products may accumulate indoors, mainly from the ground beneath a given building but sometimes from the building materials themselves.

In addition to chemical and physical contaminants, various biological agents that may affect human health are frequently pre-

Table 5.7: Major indoor air pollutants and their principal sources

Pollutants	Principal sources
Predominantly indoor sources	
Aerosols	Consumer products
Allergens	House-dust mites, animal dander, fungal moulds
Ammonia	Metabolic activity, cleaning products
Asbestos, man-made mineral fibres	Fire retardants, insulation
Formaldehyde	Particle board, insulation, furnishings, tobacco smoke
Volatile organic compounds	Adhesives, solvents, cosmetics, cooking
Polynuclear aromatic hydrocarbons, arsenic, nicotine, acrolein, etc.	Tobacco smoke
Radon	Ground beneath buildings, some building construction material
Both indoor and outdoor sources	
Carbon monoxide, nitrogen oxides	Combustion
Carbon dioxide	Metabolic activity, combustion
Volatile organic compounds	Solvents, paints, pesticides, metabolic activity,combustion
Particles	Resuspension, condensation of vapours, combustion products
Water vapour	Metabolic activity, evaporation, combustion

Sources: WHO Regional Office for Europe *(57);* Samet, J.M. et al. *(58);* Samet, J.M. et al. *(59).*

sent in indoor air environments [7]. Bacteria (including actinomycetes), fungal spores, algae, the fragments and droppings of house-dust mites, and animal dander are among the most prevalent. These produce illness through infection of the respiratory tract or by stimulating an immune response. Many indoor environments provide sufficient moisture and an appropriate temperature for the growth of microorganisms and mites (see also Chapter 14). Measures taken to conserve energy may enhance these conditions. For example, a recent study from Sweden found such homes to have a level of infestation with domestic mites similar to that reported from subtropical regions [60].

5.4.2 Effects on health

The large diversity of indoor air pollutants may have various adverse effects on health, ranging from sensory annoyance or discomfort to severe effects [58,59,61,62]. Establishing causal relationships between specific exposures and defined health outcomes is often difficult, however, mainly because of the multifactorial nature of exposure to indoor air pollutants. Few studies have been carried out in Europe to quantify particular exposures and related health effects. Table 5.8 lists examples of health effects that may result from exposure to certain indoor air pollutants.

Indoor air pollutants may affect different organs and systems but the primary target of most air pollutants is the respiratory system. Observed effects include changes in pulmonary function, an increase in respiratory symptoms (such as coughing, wheezing, shortness of breath and phlegm), respiratory infections, the sensitization of airways to allergens in the indoor environment, and asthmatic attacks. The principal agents affecting the respiratory system include combustion products (such as particulate matter, NO_2 and SO_2), environmental tobacco smoke,

Table 5.8: Health effects of selected indoor air pollutants

Pollutant	Possible health effects
Asbestos	Asbestosis, lung cancer, mesothelioma
Carbon monoxide	Headache, nausea, lethargy, unconsciousness, cardiovascular effects, death
Environmental tobacco smoke	Respiratory symptoms and diseases in children, lung cancer
Formaldehyde	Eye and upper respiratory tract irritation, headache, nausea, sensitization, cancer (?)
Nitrogen oxides	Headache, nausea, pulmonary effects, respiratory illnesses in children
Volatile organic compounds	Eye and respiratory tract irritation, headache, nausea, target organ toxicity, cancer
Biological particles (house-dust mites, fungal moulds, pollen, bacteria, viruses)	Allergic reactions, eye and upper respiratory tract irritation, infections
Radon	Lung cancer

formaldehyde, allergens and infectious organisms.

Among the effects of indoor air pollutants on the respiratory system, those of environmental tobacco smoke are relatively well established. A recent review from the United States showed that the incidence of acute respiratory infections in children of mothers smoking at home is 1.5–2 times higher than that in other children [63]. The correlation depends on the extent of the exposure and is more pronounced in younger children, as indicated by recent epidemiological studies. In a cohort of British children, the prevalence of wheezy bronchitis in those aged 1–10 years was 14% higher when mothers smoked 4–13 cigarettes a day, and 49% higher when mothers smoked more, than in the children of nonsmoking mothers [64]. The effects observed in infants are even more pronounced. In a large cohort followed through the first year of life, the prevalence of lower respiratory illness was 50% higher when the mother smoked, and the risk increased to 2.7 when the mother smoked at least a pack of cigarettes per day and the child stayed at home rather than attending daycare [65].

Other effects on the respiratory system may be related to an increased indoor exposure to NO_2 associated with the use of gas stoves. Analysis of data from 11 studies [66] showed about a 20% increase in the incidence of respiratory illness in children with a 30 $\mu g/m^3$ increase in long-term average concentrations of NO_2. In addition, respiratory function in children, especially in asthmatics, was found to be adversely affected by increased levels of formaldehyde emitted by building materials and home equipment [67].

Indoor air pollutants may affect the immune system and provoke allergic responses, including rhinitis and conjunctivitis, asthma and alveolitis, and atopic dermatitis. The continued exposure of sensitized individuals may result in permanent lung damage. Pollutants triggering such responses include allergens from house-dust mites, dander from pets, fungi (including yeasts and moulds) and bacteria (including actinomycetes) [68]. Epidemiological studies have shown that exposure to house-dust mites during childhood may be an important risk factor for the development of allergic asthma [69].

Some indoor air pollutants are carcinogenic. In particular, environmental tobacco smoke (which contains a number of carcinogenic agents), radon and its decay products, and asbestos fibres have been demonstrated to increase the risk of lung cancer developing, and there may be synergism between the actions of these agents. Chapter 12 discusses in detail the cancer risk related to indoor radon exposure. Several epidemiological studies have examined the relationship between lung cancer and exposure to environmental tobacco smoke. The combined evidence from 25 of them indicates an increase in risk by 20–30 % in nonsmokers married to smokers [70]. For other potential carcinogens – including benzene, formaldehyde, polynuclear aromatic hydrocarbons (PAHs), pesticides and nitrosamines – no firm evidence exists of carcinogenic effects at the concentrations encountered in non-occupational indoor environments. Indoor environments, however, may have a significant impact on the extent of total exposure to these substances from air. As illustrated by an American study [71], the contribution to total individual exposure to benzene in air from active and passive smoking and other personal activities at home may amount to 78 %, with an additional 5 % due to exposure inside vehicles during travel. These indoor sources are only responsible for up to 3 % of all benzene emissions to air, while motor vehicles and industry contribute 83 % and 14 %, respectively.

Indoor air pollutants may affect the skin and mucosal tissues, resulting either in primary sensory irritation or in irritation secondary to inflammatory changes in the skin, mucous membranes or other tissues. In general, the symptoms observed are non-specific. Formaldehyde and other aldehydes, VOC and environmental tobacco smoke may evoke such responses.

The effects of indoor air pollutants on the nervous system encompass effects on the senses and the central nervous system. Sensory effects include those related to odours and eye irritation or dry skin, which may be caused by VOC, formaldehyde and environmental tobacco smoke. Effects on the central nervous system include toxic and hypoxic or anoxic damage to nerve cells. Such effects may be the consequence of exposure to VOC, various pesticides and CO.

Exposure to CO may also adversely affect the cardiovascular system; cardiac arrhythmia and aggravation of angina symptoms have been observed at the relatively low exposure levels encountered indoors or in enclosed spaces such as inside vehicles or in street tunnels [72]. Despite the recognition of the hazard of CO poisoning, domestic fatalities from acute exposure are still reported, often as a result of faulty installation or use of gas appliances [73].

The sick building syndrome is a term used to describe a set of various symptoms that are observed mainly, but not exclusively, in air-conditioned buildings not directly contaminated by industrial processes. They typically include mucous membrane and eye irritation, cough, chest tightness, fatigue, headache and malaise.

The following criteria are used to define the sick building syndrome [62]. First, a high proportion of the occupants of the building react. Second, the symptoms and reactions observed include acute physiological or sensory reactions (such as sensory irritation of mucous membranes or skin, general malaise or headache, non-specific hypersensitivity reactions, dryness of the skin, and complaints about odours or taste) and psychosocial reactions (such as decreased productivity, contact with primary health care services, and initiatives to modify the indoor environment). Irritation in eyes, nose and throat dominate, and systemic symptoms are infrequent. Finally, there is no obvious causal relationship with high exposure to a single agent.

In principle, the symptoms are mainly reports of discomfort or the feeling of being less than well. In general, these symptoms disappear when the person leaves the building. The sick building syndrome usually cannot be attributed to excessive exposure to a known contaminant or to a defective ventilation system. A number of factors may be involved:

- physical factors, including temperature, relative humidity, ventilation rate, artificial light, noise and vibration;
- chemical factors, including environmental tobacco smoke, formaldehyde, VOC, pes-

ticides, odorous compounds, CO, CO_2, NO_2, and O_3; and

- biological and psychological factors.

The interaction of several factors involving different reaction mechanisms is assumed to cause the syndrome, but there is as yet no clear evidence of any exposure–effect relationship [74].

5.4.3 Exposure in Europe

Indoor concentrations of air pollutants are influenced by outdoor levels, indoor sources, the rate of exchange between indoor and outdoor air, and the characteristics and furnishings of buildings. Concentrations are subject to geographical, seasonal and diurnal variations. The exposure varies significantly between and within various populations, depending on occupancy patterns and the factors already mentioned.

Indoor levels of NO_2, for example, depend on the presence of gas heaters and cooking ranges (used in 20–80% of houses in some countries). In dwellings with gas equipment, the average NO_2 concentrations (over 2–7 days) observed in European countries were 20–40 μg/m^3 in living rooms and 40–70 μg/m^3 in kitchens, while they were 10–20 μg/m^3 in dwellings without gas equipment. These values may be doubled in rooms facing streets with heavy motor traffic. The average levels reported by five countries fell within these ranges. These exposure levels may have an effect on respiratory function, as already discussed. People may be exposed to higher NO_2 levels under certain circumstances, as in dwellings equipped with unvented cooking ranges. In addition, short-term measurements reveal concentrations that may be fivefold higher than those averaged over several days. Peak values of up to 3800 μg/m^3 for 1 minute have been measured in the Netherlands in kitchens with unvented gas cooking ranges [75,76].

In general, average CO concentrations in Europe are well below the short-term WHO guideline values of 60 mg/m^3 for 30 minutes or 30 mg/m^3 for 1 hour. In kitchens with gas stoves, short-term values of up to 15 mg/m^3 have been measured. The highest values were measured in bars and pubs, where smoking is common, with average concentrations of 10–20 mg/m^3 but peak levels of up to 30 mg/m^3 [76].

Formaldehyde concentrations in indoor air, as reported by five countries, ranged from 9 to 70 μg/m^3. These values agree well with the data reviewed in the literature, where mean indoor air levels of formaldehyde were found to be 5–63 μg/m^3 with higher values occasionally encountered, especially in dwellings with urea formaldehyde foam insulation [77]. The WHO guideline value of 100 μg/m^3 for short-term exposure, which is based on irritative effects, is on average not exceeded.

The geographical variation in exposure to radon in the European Region is discussed in Chapter 12. In general, average levels indoors are 20–70 Bq/m^3 [78] although they may be ten times higher in certain areas.

Exposure to environmental tobacco smoke is an important factor in indoor air quality assessment. The particulate and vapour phases of such smoke are complex mixtures of several thousand chemicals, including known carcinogens such as nitrosamines and benzene. One of the most commonly used indicators of concentrations of environmental tobacco smoke is the level of PM_{10} pollution. This is 2–3 times higher in houses with smokers than in other houses [35]. Nicotine is present in the vapour phase, with concentrations of up to 10 μg/m^3 in houses with smokers. Data from nine countries revealed that 33–66% of households had at least one smoker. The proportion of children with mothers smoking at home varied from 20% to 50%, that of children with fathers smoking at home from 41% to 57%. A recent German study confirmed these estimates, indicating that exposure to maternal and/or paternal smoking was considerably higher among children of less educated parents [79]. Exposure to tobacco smoke, particularly the exposure of children, is therefore a major environmental health problem throughout the European Region.

Scattered data are available on exposure to other indoor air pollutants, including VOC and biological contaminants, but assessments are hindered by large differences in sampling design and methodology, as well as in analytical techniques. A comprehensive study conducted in 479 dwellings in Germany measured a total of 172 different VOC [80]. Mean concentrations were almost always below the WHO guideline values. The full extent of European population exposure to biological particles promoting allergic sensitization is difficult to assess. Some evidence links dampness in houses with mite numbers, mould growth and respiratory effects. Surveys from the Netherlands and the United Kingdom suggest that around 15–20 % of houses may be affected to some extent by dampness [68].

The potentially important contribution of indoor air pollutants to total exposure requires the indoor environment to be considered in the overall assessment of the health risks of air pollution. There is a strong need for coordinated studies of exposure to indoor air pollutants and of their possible health effects.

5.5 Global and Transboundary Air Pollution

The chemical composition of the global troposphere, the lowest 10–15 km of the atmosphere, is changing. Various trace gases that are chemically inert in the troposphere (greenhouse gases), such as CO_2, nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), as well as some more reactive components such as methane (CH_4), CO and O_3, show a strong increase in concentration. This is associated with the possibility of global warming.

The observed depletion of the ozone layer in the stratosphere (the upper atmosphere, above 10–15 km) during recent decades is a truly global air pollution problem. It is now evident that the principal cause is the substantial increase in industrially produced CFCs and halons that have found their way to the stratosphere. Owing to their long life, they are expected to cause ozone depletion until at least 2100.

Another important large-scale change is the decline in the self-cleaning ability of the troposphere, due to a lowering of the level of hydroxyl radicals as a result of an increase in CH_4 and CO_2 emissions. Although these radicals are present in very small concentrations in the atmosphere, hydroxyl reacts with virtually all trace gases including those that would otherwise be inert. If concentrations of hydroxyl decrease, trace gases will have a longer atmospheric lifetime and thus increase in concentration. This includes greenhouse gases such as CH_4 and substitutes for CFCs such as hydrochlorofluorocarbons, which could reach the stratosphere and deplete ozone.

Although the Region's population represents only about 15 % of the world's population, its nations contribute a larger percentage of the greenhouse and ozone-depleting gases: 30 % of CO_2 and 36 % of CFCs. At the same time, global air pollution problems may greatly affect the Region's 850 million inhabitants. The combined problems of global warming, stratospheric ozone depletion and increased tropospheric pollution may have important implications for human health. The magnitude of these effects will be determined to a considerable degree by energy policies and the control of emissions of greenhouse gases and CFCs.

Acid deposition is a regional air pollution problem that has been observed in Europe for the past two decades and is now also being seen in other parts of the world. The major precursors of acid deposition are SO_2, NO_x, ammonia and their oxidation products. Until now, acidification has been seen mainly as a threat to the natural environment, since it has eliminated fish in Scandinavian lakes and contributed to forest dieback. Owing to the mobilization of heavy metals, however, human health may also be affected.

5.5.1 Climate change in the European Region

Greenhouse gases regulate the temperature of the earth and its atmosphere. The most important of these are water vapour and CO_2; of lesser importance but still significant are CFCs, CH_4, N_2O and O_3. According to global warming theory, an increase in the concentration of these gases should cause an increase in global average surface temperatures. Indeed, palaeoclimatological data provide some support for this theory [81]. Emissions of SO_2 lead to the build-up of sulfate aerosols in the atmosphere, however, and these aerosols may partly offset the effect of greenhouse gases by reflecting solar radiation back into space and by increasing cloud cover [82].

Although observations are broadly consistent with the theoretical predictions of climate models, the timing and extent of global warming remain rather uncertain. This is because large gaps remain in knowledge of the global climate system, such as the strength of feedback to the climate from the atmosphere, oceans and biosphere (including the role of clouds, for example) or the influence of particles on the earth's energy balance and potential warming. The International Panel on Climate Change (IPCC) [83] estimates that a doubling of pre-industrial levels of CO_2 would lead to an increase in the global average temperature of 1.5–4.5 °C.

To evaluate the consequences of climate change, it is common to take as a reference point the doubling of CO_2, or an equivalent amount of total greenhouse gases, in the atmosphere relative to its pre-industrial level, i.e. before the period 1750–1800. As to the likely timing of a doubling of CO_2 in the atmosphere, the IPCC "business as usual" scenario, which is considered a high emissions scenario, predicts it will occur by 2025; under the IPCC low emissions scenario, doubling will take place around 2060 [84]. While the timing and extent of global warming are uncertain, the changes of climate at the regional level in Europe and other parts of the world are still more indefinite. General circulation models, however, consistently predict that temperature increases will be greater at the high than at the low latitudes. Hence the extent of temperature increases in the European Region is expected to be larger on average than that in the tropics.

The IPCC [82] collected best-guess models of the change in climate for southern Europe from pre-industrial times to the year 2030, under the assumption that average global warming would be 1.8 °C by that year. The temperature was predicted to be 2 °C warmer in winter and 2–3 °C warmer in summer, precipitation 0–10% greater in winter and 5–15% lower in summer. Yet more important for the potential health implications is the likelihood not only of moderate changes in average temperature and weather conditions but also of the increased frequency of extreme events such as droughts, heat waves and cold spells.

Human beings are better able to cope with extreme environmental conditions than any other species, and can live in virtually every climate on earth. Changing climatic conditions exert stress on the body, however, requiring the regulation of bodily functions to re-establish balance and conscious modification of behaviour.

Disorders due to heat most frequently occur with sudden increases [85]. Heat waves regularly produce casualties, and newcomers to very hot climates are at particular risk during the first few days of heat exposure. Acute heat illnesses are by no means confined to the tropics; some serious manifestations have occurred in urban communities in temperate zones, and these episodes are likely to increase with global warming. Since the cardiovascular system primarily controls the body's conservation and loss of heat, heat stress may aggravate pre-existing cardiovascular disease [86]. Intermittent regional variations in temperature would have a more profound direct effect on health than long-term climatic trends to which populations become adapted. The indirect effects of any long-term changes in climate may, however, be of considerable importance.

Communicable diseases may increase as a result of a warmer climate, and the availability and quality of water for drinking, cooking and sanitation could change. Global warming may modify the incidence and/or distribution of vector-borne diseases. If global warming were to change rainfall and temperature patterns, the seasonal and geographic distribution of some disease-carrying vectors such as mosquitoes could change, and those diseases might move further north into the European Region. Other indirect effects on human health could result, for example, from the disturbance of agricultural production caused by inadequate water supplies for irrigation, or the inundation of farmland from a rise in seawater levels. Deterioration of the environment could displace large numbers of people.

5.5.2 Ozone depletion in the European Region

The major concern with the depletion of the stratospheric ozone layer by CFCs is that more ultraviolet radiation from the sun penetrates to the earth's surface. As a consequence, increases in skin cancer (non-melanoma and malignant melanoma) may be expected, as well as possible increases in eye diseases, primarily cataract; there may also be alterations in the immune response. It has been estimated that for a 1% depletion in stratospheric ozone, non-melanoma skin cancer can be expected to increase by about 3% [87,88]; this projection does not take account of any protective measures that might be adopted. Indirect effects on human health could result from impairment of photosynthesis in the food chain by increased levels of ultraviolet radiation. Chapter 11 discusses these effects of ozone depletion on health in more detail.

The countries of the European Union, along with many others, have recognized the potentially harmful effects of CFCs and halons on human health and the environment, and two protocols have been drawn up within the framework of the United Nations Environment Programme: the 1985 Vienna Convention for the Protection of the Ozone Layer, and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. More than 60 countries have now signed the Montreal Protocol, including those in the European Union and most eastern European countries. Although the Protocol calls for a reduction in CFC production to 50% of the 1986 level by the year 1999, it ignores the fact that the CFC destruction rate in the atmosphere is only 15% of the 1986 production rate. Ozone depletion would therefore continue, even if the Montreal Protocol were fully implemented. It was therefore amended in London in 1990 to incorporate a complete termination of CFC and halon emissions by the year 2000, and a ban on carbon tetrachloride and methyl chloroform before 2000 and 2005, respectively. The European Union has already adopted a mandatory reduction scheme with a shorter timescale than this London amendment.

Only full implementation of the amended Protocol and additional, similar restrictions for the CFC alternatives with smaller ozone depleting properties will result in limiting the effects on health due to ozone depletion before the second half of the next century. It is calculated that postponing the effective ban for both CFCs and alternatives for another five years will result in continuing stratospheric ozone depletion over an additional period of nearly 20 years in the second half of the next century.

5.5.3 Acid deposition in the European Region

Acid deposition has been recognized for over two decades in the European Region, mainly as a threat to the natural environment. This recognition has resulted in major research programmes and important political commitments to reduce precursor emissions of sulfur and nitrogen, particularly the ECE Convention on Long-Range Transboundary Air Pollution and the SO_2 and NO_2 Protocols. As mentioned, the implementation of the SO_2 Protocol significantly decreased emissions in the Region (by 28 % on average) and the resulting deposition has also declined.

The major human health concern related to acidification is the mobilization of heavy metals. First, lead and copper may be leached from the piping of municipal water supply systems and ingested via drinking-water. Second, cadmium and mercury may be mobilized from acidic soils and reach humans via bioaccumulation in the food chain. The health effects of heavy metals are discussed in Chapter 10.

5.6 Trends

5.6.1 Ambient air

Table 5.9 summarizes the estimated number of Europeans west of the Urals who lived in areas where the WHO guideline levels for the five major air pollutants discussed in this chapter were exceeded in the late 1980s. For the most common pollutants in urban areas (SO_2, total SPM and NO_2) the figures are probably underestimates of the true number exposed because of the gaps in the coverage of European cities. For some urban areas where high levels of pollution are to be expected, no data meeting the criteria for inclusion in the analysis were available. The model estimates, although validated by comparison with the results of air pollution monitoring, provide estimates averaged over relatively large areas and are not suitable for indicating high local concentrations. These reservations apply particularly to the pollutants that are closely related to local sources and dispersion characteristics. In spite of these reservations and the incompleteness of available measurements, the data at hand enabled a limited analysis of trends in air pollution concentrations, and indicate the wide extent of exposure in Europe to levels of air pollution exceeding WHO guidelines.

Table 5.9: Populations in the areas where available air pollution concentration data or model estimates indicate that selected levels have been exceeded (late 1980s)

Pollutant	Averaging time	Concentration ($\mu g/m^3$) exceeded at least 1 day per year	Population exposed	
			Number (millions)	Percentage of population with data
Sulfur dioxide	24 hours	125[a]	144[b]	46
	1 year	50[a]	22	20
Total suspended particulate matter	24 hours	120[a]	29	95
	1 year	60	18	61
Black smoke	24 hours	125[a]	14	23
	1 year	50[a]	14	23
Lead	1 year	0.5[c]	2	5[d]
Nitrogen dioxide	24 hours	150[a]	21	23
	1 year	60	17	19
Ozone	1 hour	200[e]	105–367[b]	16–56
	1 year	90	431[b]	65

[a] WHO air quality guideline.
[b] Results come from or include model estimates.
[c] Lower limit of WHO guideline range.
[d] 11% for eastern European cities with data.
[e] Upper limit of WHO guideline range.

For SO_2, an improvement in air quality can be reported in all parts of Europe; the most significant decrease in average levels, as well as in the number of acute pollution episodes, occurred in the western countries. This improvement is due to the reduction in the combustion of sulfur-containing fossil fuels, and effective emission controls on large combustion installations. It further reflects the international agreement on a 30% reduction in SO_2 levels. This pollutant remains a problem in large parts of Europe, however; one third of the population may still live in urban areas and some more rural areas where ambient SO_2 levels continue to exceed the WHO guideline levels. The highest levels are found in the CCEE and NIS, but the WHO guideline levels are also exceeded in cities in southern Europe. The reported health effects appear to justify further measures to reduce SO_2 emissions.

Air pollution from lead has also decreased significantly in most parts of Europe. While a large proportion of the European population still lived in areas where the WHO guideline level of 0.5 $\mu g/m^3$ was exceeded in the early 1980s, western Europe reports no more such excessive levels and eastern Europe only relatively few. The improvement, particularly in western Europe, resulted from the introduction of lead-free petrol and effective control of industrial sources of particulate emissions. The remaining hot spots in eastern Europe are usually found around lead-emitting industries, particularly smelters and metallurgical industries. The possibility of impaired neuropsychological development in children necessitates urgent action to clean up these hot spots. Further, the introduction of lead-free petrol should be encouraged in eastern Europe, so that the WHO guideline level will not be exceeded despite the likely increase in the number of vehicles. Even in areas where the WHO guideline level is now being met, but earlier air concentrations and deposition were high, total lead exposure remains a significant problem owing to soil contamination.

Concentrations of SPM have tended to decrease in a number of cities; in the large agglomerations of southern Europe, however, where total SPM concentrations were high in the early 1980s, the situation did not change significantly during the course of the decade. For eastern Europe, general conclusions on SPM pollution trends are very uncertain, although the rather limited data indicate a decrease in ambient concentrations of black smoke and/or total SPM, and a reduction in dust emissions from industrial sources. In spite of the uncertainty in exposure estimates, attempts should be made to decrease population exposure to SPM because of the associated adverse health effects. In addition to the combustion of coal for energy production, diesel exhausts from heavy goods vehicles and cars are an important source, which may be expected to increase with the expansion of trade between countries. Petrol-fuelled engines also give rise to a significant proportion of PM_{10}. Finally, indoor sources of SPM are important contributors to the total population exposure, and any control strategies should include their reduction.

The available data do not show any decrease in ambient air concentrations of NO_2. Elevated urban NO_2 levels occur in all parts of Europe; as many as 8% of all Europeans may experience concentrations above the WHO guideline levels. In cities, the principal source of population exposure is road traffic. Exposure to NO_2 can be expected to increase unless strict emission controls on vehicles are implemented and current traffic congestion in cities is reduced. In addition, the reduction of NO_2 emissions from power and heating plants may be necessary in some countries. The health effects associated with ambient NO_2 pollution, however, are in general less severe than those associated with SPM or SO_2.

Exposure to levels of O_3 above accepted guideline values is a widespread problem in Europe, felt by urban and rural populations alike; more than half of all Europeans may be exposed to short-term O_3 levels above 200 $\mu g/m^3$ (the upper limit of the WHO guideline range). On the other hand, most of the health effects from short-term O_3 exposure observed to date have been transient. So far, only one study has linked long-term exposure to O_3 levels over 90 μg/m^3 to chronic effects on lung function. Calculations show that some 10 % of Europe's population may experience such annual concentrations. No clear indication of trends in ambient concentration can yet be discerned, but the emissions of O_3 precursors (VOC and NO_2) are increasing. Effective control of both VOC and NO_2, especially from traffic, could significantly help reduce exposure to O_3.

The data collection conducted for the above analyses confirms the limited availability of information for a proper evaluation of spatial and temporal changes in air pollution throughout the European Region. Limitations result from an insufficient density of monitoring sites in many places and/or lack of adequate reporting, and there are serious problems in data interpretation because of a lack of harmonization in monitoring and reporting methodology. The differences in reporting and information storage systems greatly restrict the exchange of data, and the possibilities for both a comprehensive comparative analysis and reliable estimates of populations at risk. An intensive effort to improve the existing data is needed for the proper assessment of exposure to air pollution in the European Region. For example, data are inadequate for SPM, and particularly PM_{10}. Finally, an improved evaluation is needed of health effects from quantified exposure to air pollutants prevalent in European cities. An example of pollutants for which exposure and health data are scarce is VOC.

5.6.2 Indoor air

Although a number of health effects can be related to indoor air pollution, particularly respiratory illnesses in children, knowledge about the magnitude of its impact on the European population remains limited. A fundamental requirement is exposure assessment. The large variations in indoor air pollutant levels make it essential to design adequate exposure assessment studies. The contribution of indoor exposure to total exposure to certain pollutants also needs to be assessed. The significance of indoor exposure may be expected to increase as a result of both changes in building construction to conserve energy and the use of new building materials. Analytical methodologies need to be developed and refined, particularly with respect to biological air contaminants, and exposure–reponse relationships established.

Quantifying indoor air pollution risks is a complex task; priorities for research need to be determined and information obtained for policy development [89].

Depending on the type of pollutant involved and the related health risk assessment, mitigation measures may have to be taken. These can include increased ventilation; source control or removal, substitution or modification; or air cleaning. In the case of environmental tobacco smoke, adjustment of behaviour is required; legal measures can prohibit smoking only in public places.

5.6.3 Problems in exposure and health risk assessment

As indicated above, exposure–response data for a number of individual ambient and indoor air pollutants are far from complete. Both indoors and outdoors, however, people are exposed to mixtures of pollutants on which few data are available for health impact assessment. Further, the importance of possible interactions is largely unknown, with the exception of tobacco smoking and exposure to radon or asbestos.

Another problem that is common to the assessment of the health effects of both indoor and outdoor air pollution is the lack of definition of susceptible groups in the population, and of an understanding of the mechanisms involved. The question of the role of air pollutants in the increasing prevalence of asthma in some countries is a related issue.

Finally, it is recognized that improved health risk assessment requires the further development of methods to assess exposure and to diagnose early effects that predict disease. Multidisciplinary work is certainly needed to improve existing methods, ranging from the miniaturization of monitors to measure concentrations of air pollution, through the improved design of epidemiological studies, to a better understanding of biomarkers of exposure and effects.

Notwithstanding the limitations in the availability of data, Chapter 18 attempts to assess the overall impact of exposure to air pollutants on the health of the population.

5.6.4 Global and transboundary air pollution

The European Region contributes significantly to the emissions that may cause changes in global climate, and has 850 million people who may suffer from the effects. Consideration of the possible health effects has until now received less attention than other likely consequences on the natural environment, which appear to be much greater. This is because of the large uncertainty about potential effects, and the fact that humans can more easily modify their immediate environment to protect themselves from adverse consequences than other, less adaptable species. It is increasingly recognized, however, that the consequences of global environmental change may severely affect human health and wellbeing in the long term by indirect as well as direct mechanisms. Despite the difficulties in predicting the timing and the likely severity of such effects, preventive action should be taken now in order to avoid these possible serious consequences. Very recently the United Nations Climate Convention entered into force. The next step will be to develop protocols requiring the reduction of greenhouse gas emissions worldwide.

Evidence that ozone depletion in the northern hemisphere is accompanied by increased terrestrial levels of ultraviolet radiation was lacking until recently (see Chapter 11). Although lifestyle is currently the predominant risk factor for adverse health effects, there is a clear need to restrict further depletion of the stratospheric ozone layer to prevent future direct and indirect effects on health. The latest adjustments to the Montreal Protocol on Substances that Deplete the Ozone Layer, made in Copenhagen in 1992, advance the phasing out of CFCs (and carbon tetrachloride and methyl chloroform) to 1996 and of halons to 1994.

Although acid deposition was first seen as an environmental threat, it is now recognized to have important potential consequences for human health, largely as a result of mobilization of heavy metals into water and the food chain. In June 1994 a new SO_2 protocol was signed (by 25 Member States of the WHO European Region) in the framework of the ECE Convention on Long-range Transboundary Air Pollution. This has the overall aim of a 60% reduction in SO_2 emissions from 1980 levels.

5.7 Conclusions

The ambient air pollutants of major concern to health in the European Region are particulate matter and SO_2. Exposure to elevated levels of NO_2 and O_3 is also very widespread, but has less severe and extensive health effects. In certain populations, air pollution with lead remains an important health problem.

In addition to these pollutants in ambient air, a variety of indoor air pollutants contributes significantly to total exposure, and hence to health risks; many people, including young children, spend about 90% of their time indoors. Energy conservation measures may increase exposure to pollutants indoors.

Road traffic contributes a significant share of outdoor air pollution with NO_x, VOC and, secondarily, O_3, as well as particulate matter, including lead. Trends in the numbers of kilometres travelled and both petrol- and diesel-fuelled vehicles suggest that such pollution can be expected to continue to increase in the 1990s; the increase may be especially marked in eastern European countries. The problem is particularly severe in large cities, and urban planning measures (including public transport policies) and vehicle emission control will be important in finding a solution.

Particularly in eastern countries, emissions from large industrial sources, including coal-fired power and heating plants and metal smelters, contribute significantly to air pollution. In addition, domestic heating with coal still prevails in some areas, causing high local levels of SO_2 and particulate matter. Although cost-effective in the medium and long term, the initial installation of emission control equipment requires considerable capital outlay, which may currently pose a problem for the CCEE and NIS.

Current international agreements on emission reductions are insufficient to reduce population exposure everywhere in the Region to levels below the WHO guideline values. Until emission sources are effectively controlled, measures are needed to deal with acute pollution episodes. For example, warning systems can be adopted to inform the public of elevated pollution levels and of measures that can be taken to reduce personal exposure; temporary restrictions on emission sources during severe pollution episodes may also be necessary.

The potential adverse effects on health associated with global climate change and ozone depletion necessitate the immediate adoption of preventive measures.

Reliable data on emissions and ambient air quality are needed for the monitoring and verification of the effectiveness of controls. Harmonized data reporting throughout the European Region could significantly improve the understanding of the current air pollution situation and assessments of related risks to health.

References

[1] FIRKET, M. Fog along the Meuse Valley. *Transactions of the Faraday Society,* **32**: 1192–1197 (1936).

[2] SHRENK, H.H. ET AL. *Air pollution in Donora, PA – epidemiology of the unusual smog episode of October 1948.* Washington, DC, Federal Security Agency, 1949 (Public Health Bulletin No. 305).

[3] FIRKET, M. Sur les causes des accidents survenus dans la vallée de la Meuse, lors des brouillards de décembre 1930. *Bulletin de l'Académie royale de Médicine belgique,* **11**: 683–734 (1931).

[4] *Mortality and morbidity during the London fog of December 1952.* London, H.M. Stationery Office, 1954 (Reports on Public Health and Medical Subjects No. 95).

[5] *The OECD programme on long-range transport of air pollutants – measurements and findings*, 2nd ed. Paris, Organisation for Economic Co-operation and Development, 1979.

[6] *Air quality guidelines for Europe.* Copenhagen, WHO Regional Office for Europe, 1987 (WHO Regional Publications, European Series, No. 23).

[7] *Impacts on human health of air pollution in Europe. Report submitted by the World Health Organization Regional Office for Europe.* Geneva, United Nations Economic Commission for Europe, 1990 (document EB.AIR/WG.1/R.54).

[8] *Acute effects on health of smog episodes.* Copenhagen, WHO Regional Office for Europe, 1992 (WHO Regional Publications, European Series, No. 43).

[9] *Diesel and gasoline engine exhausts and some nitroarenes.* Lyon, International Agency for Research on Cancer, 1989 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans No. 46).

[10] SEROKA, W. & KRZYZANOWSKI, M. [Daily visits to a general practitioner and air pollution.] *Przeglad lekarski,* **41**: 433–437 (1984).

[11] SUNYER, J. ET AL. Effects of urban air pollution on emergency room admissions for chronic obstructive pulmonary disease. *American journal of epidemiology,* **134**: 277–285 (1991).

[12] KATSOUYANNI, K. ET AL. Air pollution and cause-specific mortality in Athens. *Journal of epidemiology and community health,* **44**: 321–324 (1990).

[13] DERRENIC, F. ET AL. Short-term effects of sulphur dioxide pollution on mortality in two

French cities. *International journal of epidemiology,* **18**: 186–197 (1989).

[14] KRZYZANOWSKI, M. & KAUFFMAN, F. The relation of respiratory symptoms and ventilatory function to moderate occupational exposure in a general population. *International journal of epidemiology,* **17**: 397–406 (1988).

[15] SCHWARTZ, J. ET AL. Air pollution and acute respiratory illness in five German communities. *Environmental research*, **56**: 1–14 (1991).

[16] BRAUN-FAHRLÄNDER, C. ET AL. Air pollution and respiratory symptoms in preschool children. *American review of respiratory diseases,* **145**: 42–47 (1992).

[17] POPE, C.A. & DOCKERY, D.W. Acute health effects of pollution on symptomatic and asymptomatic children. *American review of respiratory diseases,* **145**: 1123–1128 (1992).

[18] POPE, C.A. ET AL. Respiratory health and PM10 pollution – a daily time series analysis. *American review of respiratory diseases,* **144**: 668–674 (1991).

[19] ROEMER, W. ET AL. Effect of ambient winter air pollution on respiratory health of children with chronic respiratory symptoms. *American review of respiratory diseases,* **147**: 118–124 (1993).

[20] SCHWARTZ, J. Particulate air pollution and daily mortality in Detroit. *Environmental research*, **56**: 204–213 (1991).

[21] SCHWARTZ, J. & DOCKERY, D.W. Particulate air pollution and daily mortality in Steubenville, Ohio. *American journal of epidemiology,* **135**: 12–25 (1992).

[22] CHESTNUT, L.G. ET AL. Pulmonary function and ambient particulate matter: epidemiological evidence from NHANES I. *Archives of environmental health,* **46**: 135–144 (1991).

[23] ABBEY, D.E. ET AL. Long-term ambient concentrations of total suspended particulates, ozone and sulfur dioxide and respiratory symptoms in a nonsmoking population. *Archives of environmental health,* **48**: 33–45 (1993).

[24] DASSEN, W. ET AL. Decline in children's pulmonary function during an air pollution episode. *Journal of the Air Pollution Control Association,* **36**: 1223–1227 (1986).

[25] BRUNEKREEF, B. ET AL. Pulmonary function changes associated with an air pollution episode in January 1987. *Journal of the Air Pollution Control Association,* **39**: 1444–1447 (1989).

[26] WICHMANN, H.E. ET AL. Health effects during a smog episode in West Germany in 1985. *Environmental health perpectives*, **79**: 89–99 (1989).

[27] JEDRYCHOWSKI, W. ET AL. Case-control study of lung cancer with special reference to the effect of air pollution in Poland. *Journal of epidemiology and community health,* **44**: 114–120 (1990).

[28] PERSHAGEN, G. & SIMONATO, L. Epidemiological evidence on outdoor air pollution and cancer. *In*: Tomatis, L., ed. *Indoor and outdoor air pollution and human cancer.* Berlin, Springer-Verlag, 1993.

[29] BOBAK, M. & LEON, D.A. Air pollution and infant mortality in the Czech Republic, 1986–88. *Lancet,* **340**: 1010–1014 (1992).

[30] *Air quality criteria for lead*. Research Triangle Park, NC, US Environmental Protection Agency, 1986 (EPA-600/8-83/028aF).

[31] THACKER, S.B. ET AL. Effect of low-level body burdens of lead on the mental development of children: limitations of meta-analysis in a review of longitudinal data. *Archives of environmental health*, **47**: 336–345 (1992).

[32] BECK, B.D. An update on exposure and effects of lead. *Fundamental and applied toxicology*, **18**: 1–15 (1992).

[33] FOLINSBEE, L.J. Human health effects of air pollution. *Environmental health perspectives*, **100**: 45–56 (1992).

[34] FRAMPTON, M.W. ET AL. Nitrogen dioxide exposure *in vivo* and human alveolar macrophage inactivation of influenza virus *in vitro*. *Environmental research,* **48**: 179–192 (1989).

[35] SCHWARTZ, J. & ZEGER, S. Passive smoking, air pollution and acute respiratory symptoms in a diary study of student nurses. *American review of respiratory diseases,* **36**: 62–67 (1990).

[36] QUACKENBOSS, J.J. ET AL. Exposure assessment approaches to evaluate respiratory health effects of particulate matter and nitrogen dioxide. *Journal of exposure analysis and environmental epidemiology,* **1**: 83–107 (1991).

[37] SCHWARTZ, J. Lung function and chronic exposure to air pollution: a cross-sectional analysis of NHANES II. *Environmental research*, **50**: 309–321 (1989).

[38] LIPPMANN, M. Health effects of ozone. A critical review. *Journal of the Air Pollution Control Association,* **39**: 672–695 (1989).

[39] MCDONNELL, W.F. ET AL. Predictors of individual differences in acute response to ozone exposure. *American review of respiratory diseases,* **147**: 818–825 (1993).

[40] KINNEY, P.L. ET AL. Short-term pulmonary function change in association with ozone levels. *American review of respiratory diseases,* **139**: 56–61 (1989).

[41] KRZYZANOWSKI, M. ET AL. Relation of peak expiratory flow rates and symptoms to ambient ozone. *Archives of environmental health,* **47**: 107–115 (1992).

[42] HOEK, G. ET AL. Acute effects of ambient ozone on pulmonary function of children in the Netherlands. *American review of respiratory diseases,* **147**: 111–117 (1993).

[43] Spektor, D.M. et al. Effects of ambient ozone on respiratory function in healthy adults exercising outdoors. *American review of respiratory diseases*, **138**: 821–828 (1988).

[44] Berry, M. et al. Accumulated exposure to ozone and measurement of health effects in children and counselors at two summer camps. *Environmental research*, **54**: 135–150 (1991).

[45] Schmitzberger, R. et al. Effects of air pollution on the respiratory tract in children. *Pediatric pulmonology,* **15**: 68–74 (1993).

[46] Detels, R. et al. The UCLA population studies of chronic obstructive respiratory disease. IX. Lung function changes associated with chronic exposure to photochemical oxidants; a cohort study among nonsmokers. *Chest*, **92**: 594–603 (1987).

[47] United Kingdom Photochemical Oxidants Review Group. *Oxides of nitrogen in the United Kingdom. Second Report of the United Kingdom Photochemical Oxidants Review Group*. Harwell, Harwell Laboratory, 1990.

[48] Sandnes, H. & Styve, H. *Calculated budgets for airborne acidifying components in Europe, 1985, 1987, 1988, 1989, 1990 and 1991.* Oslo, Norwegian Meteorological Institute, 1992 (Report EMEP/MSC-W 1/92).

[49] Simpson, D. *Long period modeling of photochemical oxidants in Europe – calculations for April–September 1985, April–October 1989.* Oslo, Norwegian Meteorological Institute, 1991 (Report EMEP/MSC-W 2/91).

[50] Alcamo, J. et al. Computing heavy metals in Europe's atmosphere. I. Model development and testing. *Atmospheric environment,* **26**: 3355–3369 (1992).

[51] *The environment in Europe and North America: annotated statistics 1992*. New York, United Nations Statistical Commission, 1992.

[52] *The environment in Europe: a global perspective*. Bilthoven, National Institute of Public Health and Environmental Protection, 1992.

[53] Basmadijeva, K. et al. *Health and ecological characteristics of risk cities in Bulgaria*. Sofia, National Institute of Hygiene and Public Health, 1991.

[54] Springmann, F. *NO_x emissions in Europe*. Laxenburg, International Institute for Applied Systems Analysis, 1989 (IIASA Working Paper).

[55] Simpson, D. *An analysis of nitrogen dioxide episodes in London*. Stevenage, Warren Spring Laboratory, 1987 (Report LR 575 (AP)).

[56] United Nations Economic Commission for Europe. *VOC Task Force – emissions of volatile organic compounds (VOC) from stationary sources and possibilities of their control. Final report*. Karlsruhe, Institute for Industrial Production, University of Karlsruhe, 1990.

[57] *Health aspects related to indoor air quality*. Copenhagen, WHO Regional Office for Europe, 1979 (EURO Reports and Studies No. 21).

[58] Samet, J.M. et al. Health effects and sources of indoor air pollution. Part I. *American review of respiratory diseases,* **136**: 1486–1508 (1987).

[59] Samet, J.M. et al. Health effects and sources of indoor air pollution. Part II. *American review of respiratory diseases*, **137**: 221–242 (1988).

[60] Wickman, M. *Residential characteristics and allergic sensitization in children, especially to mites*. Stockholm, Karolinska Institute, 1993.

[61] *Indoor air pollutants: exposure and health effects*. Copenhagen, WHO Regional Office for Europe, 1983 (EURO Reports and Studies No. 78).

[62] *Effects of indoor air pollution on human health*. Luxembourg, Office for Official Publications of the European Communities, 1991 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 10).

[63] *Respiratory health effects of passive smoking: lung cancer and other diseases*. Washington, DC, US Environmental Protection Agency, 1992 (document EPA-600/6-90/006F).

[64] Neuspiel, D.R. et al. Parental smoking and post-infancy wheezing in children: a prospective cohort study. *American journal of public health,* **79**: 168–171 (1989).

[65] Wright, A.L. et al. Relationship of parental smoking to wheezing and non-wheezing lower respiratory tract illnesses in infancy. *Journal of pediatrics*, **118**: 207–214 (1991).

[66] Hasselblad, V. et al. Synthesis of environmental evidence: nitrogen dioxide epidemiology studies. *Journal of the Air and Waste Management Association,* **42**: 662–671 (1992).

[67] Krzyzanowski, M. et al. Chronic respiratory effects of indoor formaldehyde exposure. *Environmental research,* **52**: 117–125 (1990).

[68] *Biological particles in indoor environments.* Luxembourg, Office for Official Publications of the European Communities, 1993 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 12).

[69] Wickman, M. et al. House dust mite sensitisation in children and residential characteristics in a temperate region. *Journal of allergy and clinical immunology,* **88**: 89–95 (1991).

[70] Pershagen, G. Passive smoking and lung cancer. *In*: Samet, J.M. ed. *Epidemiology of lung cancer.* New York, Marcel Dekker, 1994.

[71] Wallace, L.A. Major sources of benzene exposure. *Environmental health perspectives*, **82**: 165–169 (1989).

[72] Coutlas, D.B. & Lambert, W.E. Carbon monoxide. *In*: Samet, J.M. & Spengler, J.D., ed. *Indoor air pollution. A health perspective*. Baltimore, Johns Hopkins University Press, 1991.

[73] Health and Safety Commission. *Annual report 1992-93. Statistical supplement*. London, HSE Books, 1993.

[74] *Sick building syndrome - a practical guide*. Luxembourg, Office for Official Publications of the European Communities, 1989 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 4).

[75] *Indoor pollution by NO_2 in European countries*. Luxembourg, Office for Official Publications of the European Communities, 1989 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 3).

[76] Seifert, B. Innenräume. *In*: Wichmann, H.E. et al., ed. *Handbuch Umweltmedizin*. Landsberg, ECOMED Fachverlag, 1993.

[77] *Indoor air pollution by formaldehyde in European countries*. Luxembourg, Office for Official Publications of the European Communities, 1990 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 7).

[78] *Radon in indoor air*. Luxembourg, Office for Official Publications of the European Communities, 1988 (European Concerted Action on Indoor Air Quality and its Impact on Man, Report No. 1).

[79] Brenner, H. & Mielck, A. Children's exposure to parental smoking in West Germany. *International journal of epidemiology,* **22**: 818-823 (1993).

[80] Bundesgesundheitsamt. Bekanntmachungen des BGA: Bewertung der Luftqualität in Innenräumen. *Bundesgesundheitsblatt,* **3**(93): 117-118 (1993).

[81] Schneider, S.H. The changing climate. *Scientific American*, **261**: 38–47 (1989).

[82] Houghton, J.T. et al., ed. *Climate change. Scientific assessment.* Cambridge, Cambridge University Press, 1990.

[83] Houghton, J.T. et al., ed. *Climate change 1992. The supplementary report to the IPCC scientific assessment.* Cambridge, Cambridge University Press, 1992.

[84] Intergovernmental Panel on Climate Change. *Climate change: the IPCC response strategies*. Geneva, Word Meteorological Organization and United Nations Environment Programme, 1990.

[85] Weiner, J.S. et al. Heat-associated illnesses. *In*: Strickland, G.T., ed. *Hunter's tropical medicine*, 6th ed. Philadelphia, W.B. Saunders Co., 1984, pp. 873–879.

[86] Weihe, W.H. *Life expectancy in tropical climates and urbanization*. Geneva, World Meteorological Organization, 1985, pp. 313–353.

[87] Slaper, H. & van der Leun, J.C. Human exposure to ultraviolet radiation: quantitative modelling of skin cancer incidence. *In*: Passchier, W.F. & Bosnjakovic, B.F.M., ed. *Human exposure to ultraviolet radiation; risks and regulations*. Amsterdam, Elsevier Science Publishers, 1987, pp. 155–177.

[88] Urbach, F. Potential effects of altered solar ultraviolet radiation on human skin cancer. *Photochemical photobiology*, **50**: 507–514 (1989).

[89] Teichman, K. Indoor air quality: exploring policy options to reduce human exposures. *In*: *Proceedings, Indoor Air '93. Vol. 3. Combustion products, risk assessment, policies*. Helsinki, Indoor Air '93, 1993, pp. 3–19.

Chapter 6
Water Supply and Quality

6.1 Health Effects

The quality of a substantial proportion of the drinking-water resources in Europe is endangered by increasing pollution. In many areas, contamination of surface water and groundwater used for abstraction has resulted from the absence or lack of use of appropriate methods for disposing of liquid and solid wastes from industrial and municipal sources. These wastes contain a variety of chemical and pathogenic agents that can have serious health consequences. Contamination from wastes is paralleled by the introduction of chemicals such as pesticides and nitrates into the environment. Disease outbreaks, mainly of a sporadic and local nature, have been caused by inadequate or even a lack of water treatment and supply processes (arising from breakdowns, shortages of materials and ineffective operations) or a lack of maintenance of distribution pipelines in many countries of the WHO European Region.

Hazards in drinking-water may be chemical, such as pesticides, nitrates and heavy metals, or microbiological, for example bacteria, protozoa and viruses. Hazardous chemicals may occur naturally or be introduced accidentally or deliberately through human activity. Natural hazards include substances such as fluoride and arsenic derived from natural mineral formations. Industrial, agricultural and other activities release chemicals through wastes, or as a result of the use of pesticides for specific purposes. Some water contaminants are disinfection chemicals or their by-products, for example trihalomethanes and chlorophenols. Whether these groups of substances or agents constitute a risk to human health depends on conditions and routes of exposure.

The characteristics of the waste discharged and the behaviour and characteristics of the contaminants in the environment will be important factors in determining concentration in the water and the duration and frequency of exposure. Relatively little information is available on the quality of drinking-water "from the tap". Confounding factors such as the pre-existing health of exposed individuals, difficulties in dealing with exposures to multiple hazards, and the need to take account of background levels of particular disease end-points often limit interpretation of studies. In short, study of the exposure of populations to hazards via drinking-water and demonstration of any resultant effects on health is difficult, for the same reasons that all environmentally mediated low-level exposure is difficult to investigate. The factors influencing actual exposures and effects are many, and their interaction and the ultimate impact of particular contaminants, especially chemical contaminants, are difficult to establish. When exposures are sufficient to cause acute health effects in a population (as, for example, in an accident) causal relationships are easier to demonstrate.

The European Region has a wide variety of natural geological conditions and agricultural, urban and industrial activities that all combine to influence water quality. Combined with economic, social and political factors and with the availability of water resources, these elements determine access to a supply of good quality drinking-water. The differences in these important factors in different parts of the Region mean that substantial differences exist in the quality of the supplies and the associated status of environmental health.

6.1.1 Guidelines and standards for drinking-water

Epidemiological data on links between chemical water quality and human health are, on the whole, rather poor. These data, together with animal toxicology studies and estimates of human exposure, are used as the basis for the setting of standards to protect human health. This is a complicated process, and the lack of knowledge on actual environmental exposure and any related health effects means that wide safety margins are commonly used in practice to reduce risk as much as is possible.

In 1984 the World Health Organization developed a system of guidelines for the quality of drinking-water, with the aim of protecting health, and has recently revised these [1]. The guidelines are intended to provide the basis for national standards that will ensure the safety of drinking-water supplies by eliminating or reducing to a minimum concentrations of substances known to be hazardous to human health. It is not intended that the guidelines be used automatically as standards – it is important that standards be developed appropriately in the context of national or local environmental, social, economic, dietary and cultural conditions.

Microbial contamination of water supplies by pathogens can have severe consequences, but quantification of the associated risks is difficult. The consequences of exposure to microbial pathogens involves factors such as degree of exposure, human immunity and the pathogenicity of the microorganism. The control of microbial disease is of extreme importance and, although a reduction in microbial contamination can be expected to reduce health risks, the difficulties in calculating risks precisely mean that the guidelines are based on the premise that there is no tolerable lower limit of contamination for effective health protection.

Guideline values for concentrations of chemicals in drinking-water aim at controlling risks from prolonged exposure to low levels of chemicals, estimating "the concentration of a constituent that does not result in any significant risk to the health of the consumer over a lifetime of consumption"[1]. The calculation of risk takes account of accumulation and of exposure to degradation and metabolic by-products of certain chemicals. The guidelines are set on the assumption that exposure through drinking-water may only be one route; the risk estimation calculates the possible contributions of water, food and other environmental sources to total exposure.

The guidelines have the primary aim of protecting health. The national standards derived from the guidelines will take account of the benefits and costs of control and exposure at the national or local level. Thus national standards will be based to some extent on national policy priorities, on local health conditions, and on calculations of the costs and benefits of health protection and water quality management. For example, certain disinfectants and their by-products may have potential adverse effects on health, but the risks to health of microbial contamination are likely to be far greater. Standards and management strategies will be tailored to minimizing the combined risks from exposure through the consumption of drinking-water.

The guidelines set by WHO are based on usual human consumption and domestic use, but do take account of vulnerable groups within the population such as children and elderly people. Different standards may be needed for particular uses such as renal dialysis. In addition, the guideline values will not indicate the effects of contaminants on aquatic life. The guidelines are set for minimum quality compatible with the effective protection of public health. Exceeding standards derived from the guidelines may be a cause for remedial action and health surveillance. However, short-term deviations in the levels of particular chemicals may be acceptable in view of local priorities and practical considerations. The guideline values relate to daily consumption over a lifetime, and do not imply that occasional intakes in excess of this value will be harmful to health.

National standards in Europe at present are in general either based on the 1984 WHO guidelines, or drawn from the system of guidelines and maximum admissible concentrations in the European Union (EU) directive on drinking-water [2]. However, drinking-water standards in the CCEE and NIS are still based on those of the former USSR [3,4].

6.1.2 Microbial contaminants

Gastrointestinal infections encompass a wide variety of symptoms and recognized infectious agents. Infectious diarrhoea is among the most common debilitating infectious disease and is the greatest single cause of morbidity and mortality, especially in infants and small children. A number of bacteria are involved in both diarrhoeal and systemic illnesses, such as *Campylobacter* spp., *Salmonella* spp., *Escherichia coli, Shigella* spp. and *Vibrio cholerae*. Contamination of well water with faecal material (human or sometimes animal) is a particular source of infection, although person-to-person transmission is also important. Certain bacteria of low pathogenicity may be found in water, and may infect individuals with low immunity such as some hospital patients. The relative importance of various organisms for health, in terms of outbreaks in Europe, is discussed in the section on exposure to microbial contamination (see page 184).

A number of viral diseases are transmitted through drinking-water. Also, acute infectious nonbacterial gastroenteritis may result from infection by a group of what are now termed Norwalk-like viral agents. Epidemics from waterborne transmission via the faecal–oral route has been noted for a number of viruses in this and other groups.

Infection with the hepatitis A virus, via the faecal–oral route in contaminated water or food (especially shellfish) or through physical contact, does not necessarily result in overt illness but may sometimes be associated with acute hepatitis of varying severity, and in the longer term with liver cancer.

Infection with the protozoan parasite *Cryptosporidium parvum* can cause acute self-limiting gastroenteritis. Transmission of the oocysts via water has attracted attention recently because of outbreaks in the United Kingdom and the United States affecting a number of people. The protozoans have a global distribution, with particular species infecting numerous birds, reptiles and fish as well as humans and other mammals. Incidents of infection have been reported for western Europe, but data on health implications for the CCEE and NIS are sparse.

Another microorganism, *Giardia lamblia*, is a common intestinal parasite in humans, and contaminated water supplies may cause diarrhoea. It can be found in a wide range of mammals and produces cysts that are difficult to inactivate during chlorination of drinking-water.

Microbial contamination of surface water by the groups of organisms mentioned above is extremely widespread in Europe. Epidemics are relatively rare, but it is difficult to assess the extent of low-level endemic gastroenteric disease in the east and south of the Region. In general, disease outbreaks occur as a result of poor source water quality, inadequate treatment, treatment breakdown or contamination by sewage during distribution, all of which can result in human exposure to faecal pathogens. Such problems are more frequent in some parts of the Region (see the section on exposure to microbial contamination, page 184) but the quality of analysis and reporting is variable.

The traditional approach to the measurement of the microbial quality of drinking-water has been to examine the water for indicators of faecal contamination. The aim of monitoring for these indicators is to ensure that there are no pathogenic organisms in the water, but there are some limitations to the use of the traditional indicators. These limitations centre on the different rates of survival of bacteria, viruses and protozoa in different environmental conditions and their different responses to water treatment and disinfection. In particular, general coliform counts may be less reliable as indicators of faecal pollution in untreated surface water, especially in warmer climates. Under some conditions, or in particular studies of outbreaks, it may be necessary to examine the water for specific pathogens or to look for indicator viruses.

The guidelines, as stated above, work on the assumption that there is no safe lower limit to microbial contamination of drinking-water; the standards usually demand what is effectively zero contamination. The reasons for the difficulty in establishing "safe" levels of contamination are many, but in essence some microbial contaminants have very different rates of persistence from the indicator organisms and extremely low infective doses. The organisms multiply rapidly in the human body and the risk of acute effects on health is very different from that associated with low-level chemical contamination.

6.1.3 Chemical contaminants

Chemical substances in water originate from a number of sources. They may occur naturally, originate from water treatment or supply technology, or be attributable to industrial or agricultural wastes or operational chemical use. The reasons for controlling some of these substances may be either that they are health hazards or that they affect the acceptability of the water to the consumer, due to taste or smell.

It is rare that sudden, massive pollution occurs without rapid remedial action; in such cases the water is often undrinkable or tastes very unpleasant [1]. The guideline values for controlling risks from long-term exposure indicate tolerable concentrations, not target values; the latter should be as low as practicable in order to minimize exposure. The guidelines are based on scientific evidence on routes of exposure, consumption of water, dose–response relationships (taking account of vulnerable groups), analytical data for the frequency of occurrence of contamination and magnitude of concentration, and the potential application of available control techniques [1]. For many substances, tolerable daily intakes (TDI) have been calculated; the contribution of water to total exposure from a number of sources is important in setting the guideline for drinking-water. The TDI represents daily intake over a lifetime without appreciable health risk. For genotoxic carcinogens, when no threshold for effect is assumed, the guidelines are set at the concentration in drinking-water for which an excess lifetime risk of 10^{-5} is estimated, i.e. one additional case of cancer per 100 000 population ingesting drinking-water containing the substance at the guideline value for 70 years [1].

There are obvious uncertainties attached to the guidelines. Extrapolation from non-human toxicological data for some substances, together with a lack of information on overall exposure of humans to low levels and any associated effects, mean that a considerable safety margin is introduced between exposure at the guideline value and exposure at which health effects may occur. Where there is uncertainty but some evidence for health effects a provisional guideline is given, as is also the case for substances where the guideline would be below detection limits or below practical treatment possibilities. For a large number of substances such as uranium, many pesticides and certain disinfectant by-products, not enough data are available to recommend guidelines. Continual progress is made in the study of health effects; on the basis of new information the revised WHO drinking-water guidelines cover a wider range of substances, and some of the guidelines for substances covered in 1984 have changed.

Some substances are regulated by national standards on the basis of acceptability to the consumer because of taste, smell or appearance. The aesthetic qualities of water are important for public confidence in the overall quality of water. Aluminium, for example, does not have a WHO health-based guideline value; at normally occurring concentrations no health effects are observed. The EU Maximum Admissible Concentration (MAC) is 0.2 mg/l; intake at this level would be very small compared with normal food intakes, reports of which vary between 3 and 160 mg/day [5]. The level of 0.2 mg/l is primarily associated with aesthetic problems, since at greater concentrations aluminium hydroxide floc can form with consequent consumer complaints. Excretion of aluminium takes place primarily through the kidneys, with the result that people with impaired kidney function accumulate excess aluminium. It is important that water used for renal dialysis does not contain significant concentrations of aluminium, since aluminium accumulation in the brain can lead to severe effects including impaired memory, aphasia, dementia, ataxia and convulsions [5].

There follows below a discussion of concerns in relation to some important substances. Some recommended guideline values, together with information on the contribution of drinking-water to intakes, are shown in Table 6.1. (See also Chapter 10.)

Arsenic is readily absorbed from water and

Table 6.1: Estimated percentage contribution to intake of some inorganic constituents from drinking-water at WHO guideline concentrations

Constituent	Percentage of intake	Guideline value (mg/l)
Arsenic	16[a]	0.01
Cadmium	10[a]	0.003
Cyanide	20[b]	0.07
Lead	42[a]	0.01
Mercury	7[a]	0.001

[a] Provisional tolerable weekly intake (PTWI).
[b] Tolerable daily intake (TDI).

Note: Estimates based on consumption of 2 litres of water per day by a 60-kg person; except for lead, which is based on consumption of 0.75 litres per day by a 5-kg bottle-fed infant.

Source: World Health Organization *(1)*.

widely distributed in various tissues. The most important effects of consuming arsenic-contaminated drinking-water are the development of skin tumours on the hands and feet and peripheral vascular disturbances that can lead to gangrene. Thickening of the skin of the palms of the hands and soles of the feet, together with increased pigmentation, is also characteristic [6]. These effects contrast with an increased risk of lung cancer in people who inhale arsenic at work.

The seriousness of the risk associated with arsenic concentrations in drinking-water has recently been evaluated by Smith et al. [7]. Estimates of cancer risk attributable to ingested arsenic are currently based on skin cancer risks alone. This more recent study examines the possible risks from ingestion of arsenic in drinking-water, based on mortality from internal cancers. Excessive levels of arsenic have been reported in natural groundwater in a number of the CCEE and NIS. Industrial sources may also be important.

The average daily intake of ***cadmium*** in Europe has been estimated to be 10–20 μg [8]. The contribution from water is of minor importance. Long-term ingestion of cadmium leads to accumulation in the kidney, with possible damage and disturbance of calcium metabolism – with associated osteoporosis – when the critical level of 200 mg/kg is reached in the kidney. There is no reliable evidence for carcinogenicity in humans from ingested cadmium. The guideline of 0.003 mg/l in drinking-water aims to restrict intake so that long-term concentrations in the kidney will not exceed 50 mg/kg.

Fluoride levels over 1.5 mg/l in drinking-water give rise to dental fluorosis; over a 20-year period or more skeletal fluorosis may occur. The drinking-water concentrations at which fluorosis is observed are different in different regions, important factors being climatic conditions, water intake and food intake. These conditions, although seen in western Europe in earlier years, are now mainly seen in certain republics of the former USSR such as Kazakhstan. In parts of Europe, fluoride is added to water artificially with the intention of reducing dental decay.

Lead contamination of water arises principally from reticulation through lead pipes, especially in areas where the water is plumbosolvent, i.e. is "soft" with a pH below 8. Guideline values for lead in drinking-water aim at minimizing exposure of pregnant women and young children, there being no defined tolerable weekly intake values. The aim of the current provisional WHO guideline, now lowered to 0.01 mg/l [1] is to reduce the risk of exceeding blood levels of 30 μg/dl from combined food and water intake. The major health concern associated with lead relates to learning disabilities and behavioural changes resulting from effects on the developing central nervous system. However, there is increasing evidence that no threshold value for blood lead level can be assumed below which neuropsychological development is not impaired. Exposure of the fetus and young children should therefore be reduced to the minimum possible.

Mercury in drinking-water is primarily inorganic and is poorly absorbed but, as for other toxic substances, guidelines aim to minimize total exposure from food and water.

The possible link between health and the ***hardness*** of drinking-water is an issue of continuing importance, but there is as yet no agreement on whether there is a causal link between drinking-water with a low total hardness and increased incidence of heart disease. The difficulty in identifying the link arises in part from problems in epidemiological studies to do with controls and the aggregation of data. Pocock et al. [9] describe a two-phase study in the United Kingdom as part of the British Regional Heart Study. This study first examined the co-occurrence of heart disease with various factors in 234 towns in the United Kingdom. A negative association was found between total hardness and cardiovascular disease in the towns, allowing for climate and social and economic factors. The second phase studied 7735 middle-aged men and found a negative association between ischaemic heart disease and alkalinity, calcium, lead, potassium and silicate levels, and the total hardness of the drinking-water, after taking account of personal risk factors such as tobacco smoking and blood pressure. Despite this negative association, however, the authors suggest that personal risk factors were more significant in determining heart disease. WHO [1] considers that, although a number of epidemiological studies show a statistically significant inverse relationship between the hardness of drinking-water and cardiovascular disease, the available data are inadequate to establish a causal relationship. No health-based guideline for hardness of water has therefore been proposed.

Nitrate in drinking-water, predominantly arising from agricultural practices, may cause methaemoglobinaemia in infants, in which the oxygen-carrying capacity of the blood is impaired. It may prove fatal in extreme cases. This condition is now reported only in some of the CCEE. It has been suggested that increased levels of nitrate in drinking-water could cause stomach cancer. Despite the existence of a theoretical basis for such an effect, most of the epidemiological evidence does not support such an association. WHO's guideline is not based on carcinogenic effects. Exposure through vegetables is more important than through water where concentrations in drinking-water are below 10 mg NO_3/l. Water is the more significant source, however, where concentrations exceed the guideline value of 50 mg NO_3/l (based on prevention of methaemoglobinaemia). (See also Box 6.1.)

A large amount of toxicological data exists for ***pesticides*** and is primarily derived from laboratory studies examining short- and long-term exposure and toxic and carcinogenic effects. Some data also exist for exposure and effects in humans, including data from occupational exposure or self-induced poisonings. These data are the basis for the WHO guidelines. Concentrations in drinking-water are usually very low. Drinking-water standards for individual pesticides (such as atrazine) or total pesticides are often exceeded, but no related health effects have been reported. Indeed, guideline values for drinking-water and exposures from this source are many orders of magnitude lower than exposures to the same compounds through food.

Levels of ***trihalomethanes*** (such as chloroform and bromoform) in chlorinated drinking-water, although low, may present a health risk. Chloroform and bromoform are carcinogenic to laboratory animals at high doses, while other trihalomethanes are mutagenic. Nevertheless, the risks of not chlorinating the water supply (to control microbial contamination) far outweigh potential health problems with chlorination. Epidemiological studies offer conflicting evidence of links between chlorinated water supply and human cancers. A recent meta-analysis concluded that an increased incidence of bladder cancer and rectal cancer can be seen in populations drinking chlorinated surface drinking-water for many years [14]. Nevertheless, a causal link has not been established [15] and the interpretation of the data is debated.

There is currently no basis for accurately comparing drinking-water quality on a pan-European scale. Data are not collected and organized in comparable systems, and monitoring and management strategies are not similar for the whole Region. In addition, data on water-related diseases or effects of chemical contamination, while available to some extent, are certainly not in a form to allow valid comparison.

Because of public concern over the quality of drinking-water (often related to taste and smell) at locations in a number of countries, bottled water has assumed increasing importance as drinking-water. The rise in the sales of bottled water has, in some countries, been quite spectacular. Natural mineral water may be of various types, with "spring water" one of the common descriptions. The composition may vary considerably in terms of, for example, mineral salts.

Regulations in some countries place natural mineral water within the food category and thus differ from the EU directive. Consequently fewer limits are set for natural min-

Box 6.1: The nitrate problem in European drinking-water sources

The release of nitrate from soil into surface water and groundwater is a natural process. However, it is greatly increased by agricultural activities, especially the application of nitrogenous fertilizers or organic manures in excess of crop requirements. Nitrate is released by leaching from the soil and/or through runoff, and the rate of release varies with the type of crop and climatic conditions.

In Europe, rural populations are often the most at risk from exposure to nitrates in drinking-water. This is because many such areas are intensively agricultural and receive their water supply from shallow wells. Several of the CCEE (Bulgaria, the Czech Republic, Hungary, Poland and Slovakia) are particularly affected; in this region of Europe a number of cases of methaemoglobinaemia have been reported.

The control of nitrate leaching is particularly difficult and is now recognized as a serious problem, because the speed at which nitrate reaches groundwater varies considerably and present levels may reflect activity in the past, perhaps over several decades. Even when agricultural restrictions on the use of fertilizers are imposed, no immediate improvement in water quality results. Even in the shallow, relatively fast-responding aquifers typical of continental Europe, it may take up to ten years for water to percolate down to the aquifer. Agricultural controls operating in Europe tend to be mainly aimed at groundwater protection, since approximately 70 % of drinking-water in Europe comes from that source.

The seriousness with which the nitrate problem is now being considered in Europe has prompted a number of control measures and changes in practice in several countries. In order to conform to the European Union's limit for nitrate in drinking-water of 50 mg/l, many member states are now imposing their own agricultural restrictions either nationally or regionally. These restrictions most commonly involve limiting the application of manure to land to levels set by livestock density and crop requirements. National restrictions on the rate and timing of manure application are enforced in Denmark and the Netherlands, while regional restrictions are enforced in Germany [10]. In these countries also, water protection zones are designated to control land use around groundwater abstraction points and, hence, to reduce nitrate leaching to aquifers.

Zones of "hygienic protection" have been established in the Czech Republic to protect both surface water and groundwater sources of drinking-water. Practical experience has shown, however, that the measures taken for resource protection are insufficient and that water quality has not improved. In a number of cases, such as the Zelivka reservoir where the nitrate concentration is increasing by 2–4 mg/m^3 per year, water quality continues to deteriorate [11].

In the Czech Republic, the distribution of bottled mineral water, along with a well functioning warning system in the central Bohemian region, has considerably reduced the incidence of methaemoglobinaemia in infants. However, economic constraints in recent years have led to the abandonment of such government action because of its high annual cost. It is planned to re-establish the distribution of bottled water on a commercial basis, especially for babies and the sick.

During the period 1980–1988, the total use of nitrogenous fertilizers in the European Community increased by 50 % and available data suggest that, except in a few countries, the use of fertilizers in Europe is still increasing. Although in most countries the rate of increase slowed during the late 1980s due to the imposition of various control measures, in

Box 6.1: The nitrate problem in European drinking-water sources

some (Greece, Ireland, Portugal and Spain) fertilizer use is increasing more rapidly [12]. The CCEE do not show a general increase in fertilizer use. Consumption in most of these countries has recently fallen dramatically, mainly because of changing economic conditions. In 1990 the average consumption of fertilizers (tonnes N/km^2) was 7.1 in western Europe and only 3.7 in the CCEE [13]. It is important that further environmental initiatives and control measures to reduce nitrate levels in European waters are developed.

eral waters, and often there are no limits set for nitrate, nitrite, pesticides, polynuclear aromatic hydrocarbons (PAHs) or solvents. Sources of mineral waters are usually not regularly monitored, but are subject to periodic checks.

6.2 Exposure

In Europe, the quality and availability of data on exposure that can link drinking-water quality with health varies greatly between countries. In western Europe, the quality and coverage of exposure data for a variety of chemical and microbiological agents range from "excellent" to "acceptable". In eastern Europe, data are generally inadequate and health consequences often cannot be evaluated. The quality of studies on chronic disease epidemiology is inadequate in this area, as are the data on numbers of people at risk at the local level from contaminants in water. As a consequence, the data are not reliable for policy-making except in a few situations. The priority of drinking-water quality is becoming greater as concern rises over contamination by substances such as nitrates and pesticides, as well as with pathogenic microorganisms.

6.2.1 Exposure to microbial contamination

The type of data available makes it difficult to assess the exposure of European populations to microbial contamination. Much of the information is either in the form of non-compliance with standards or epidemics of disease, some of which are attributed to particular organisms while others are not. It is particularly difficult to assess the incidence of low-level gastroenteric problems.

In western Europe, drinking-water is usually safe in microbiological terms because effective treatment processes have largely eliminated outbreaks of infectious diseases. Although infant mortality is 2.31 and 2.97 times higher, respectively, in the CCEE and NIS compared with that in the European members of the Organisation for Economic Co-operation and Development (OECD), the contribution of waterborne communicable and diarrhoeal diseases to these figures is unknown [16]. Differences in infant mortality also occur locally and according to socioeconomic conditions. (See Chapter 4.)

Lack of a safe water supply can be associated with the occurrence of cholera, typhoid fever, hepatitis A, gastrointestinal diseases and a number of parasitic diseases. Incidents of these diseases linked with poor water quality have been recorded in many countries of the Region, but especially in the CCEE and NIS. The most common type of local epidemic would appear to be gastrointestinal disease attributable to bacterial, viral or protozoal agents, but hepatitis A is of particular concern in the NIS. The levels of general low-level morbidity are impossible to assess.

Diseases such as cholera are usually restricted to isolated outbreaks. In many countries of the Region occasional cases of cholera are "imported". In other countries indigenous cases are reported: in 1993, for example, there were 165 indigenous cases in Tajikistan, 10 in Romania and 5 in the Russian Federation (WHO, unpublished data, 1993).

Information is sometimes given on the proportion of samples exceeding standards or on the number of treatment works failing to meet technical standards. In some cases it might be possible to assess the consequent exposure of the population to contaminants, but this would only be at a very local level where detailed information is available. Non-compliance is a result of many factors, including poor raw water quality, inadequate treatment, contamination of treated water and the monitoring strategy. Non-compliance information rarely indicates by what degree the standards have been exceeded, or to how many people the water of substandard quality was supplied and for how long. It may, however, give a useful indication of the effectiveness of treatment at treatment works and is useful for management and policy purposes.

On average, 16 % of samples of drinking-water in the former USSR did not comply with quality standards. This figure varied widely between the former republics, from 7 % in the Russian Federation to 48 % in Georgia.[a] A recent ten-year study showed that only 21 % of 245 rivers were acceptable from the point of view of bacterial pollution. Thirty-five percent of the water bodies examined exceeded bacterial standards by factors of ten or a hundred. Those that were acceptable tended to be the larger rivers and lakes in the north.

In the Russian Federation, contaminated drinking-water has given rise to infectious diseases in St Petersburg, Volgograd and Murmansk, while some 60 % of the population are believed to be exposed to unsafe drinking-water [17]. The incidence of some bacterial diseases such as typhoid is falling, though salmonellosis is still a problem (16 outbreaks in 1990) and isolated outbreaks of cholera occur. There are particular problems with the suitability of bacteria as indicators of viral pathogens. Viral diseases are increasing and are now estimated to be responsible for 70 % of morbidity.[a] Large outbreaks of acute enteric infections and hepatitis A related to the use of poor quality drinking-water have been "continuously reported" in the Russian Federation [18]. The use of contaminated water in food processing and milk bottling plants is reported to have caused diarrhoeal diseases in a number of countries including Latvia. Sporadic hepatitis A outbreaks have been recognized in Riga in Latvia following the drinking of contaminated and improperly treated water from the Daugava river. In one episode in 1988/1989, up to 2000 cases were reported. Cases of waterborne hepatitis A are also reported from Lithuania, but evidence of occurrence in Estonia is poorly documented. It has been stated that in Estonia the water supply systems in many towns are obsolete and often break down, with resulting deterioration in the quality of the water [19].

Waterborne outbreaks of disease involving *Campylobacter* and *Salmonella* spp. have been described from Hungary, while in Poland outbreaks over several years have involved *Salmonella* spp., *Shigella* spp. and *E. coli*.[a] In Hungary, non-compliance of drinking-water with standards, on the basis of faecal indicators, is on average about 8 %.

In the former Yugoslavia, outbreaks of hepatitis A were recorded in 1987, 1989, 1990 and 1991 and involved around 7000 cases, in addition to other waterborne diseases.[a] Hepatitis A outbreaks were also reported from Romania in 1986, 1988 and 1989, as well as outbreaks of typhoid and other, unidentified, waterborne diseases. Localized outbreaks of cholera have also been reported (see above). Waterborne disease incidents have also been reported in Bulgaria.

Large waterborne disease outbreaks have occurred in Israel. In the period 1981–1985 there were 27 such outbreaks with 10 880 cases; just one outbreak was responsible for

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

over 9000 cases. During 1986–1990, documented outbreaks of waterborne diseases included four from community and nine from non-community water sources. The incidence of typhoid has dropped since the 1960s, but there was a large outbreak in the Krayot communities in 1985. Shigellosis and hepatitis incidence have probably levelled off, but also peaked in the 1980s. Shigellosis, which peaked in 1985, was also due to a waterborne outbreak in the Haifa area (the Krayot). The organisms involved in recent outbreaks were predominantly *Shigella* spp. (1376 cases), faecal coliforms (300 cases) and *Salmonella* spp. (151 cases). Empirical evidence suggests that mandatory chlorination in 1988 and more stringent water standards (such as the change in the definition of substandard water from 10 to 3 coliforms/ 100 ml) have had an important impact on water quality, waterborne disease outbreaks and the total burden of enteric disease in Israel. The improvement in quality is suggested by a lower incidence of non-compliance with standards in drinking-water samples (8.4% in 1989; 6.4% in 1991). It has been suggested that the increased incidence of salmonellosis in recent years is attributable in part to food contamination.

In Finland, no waterborne epidemics were reported between 1982 and 1988. In 1989–1990 six epidemics were recorded, involving some 5000 people [20]. The causative agents were *Campylobacter* spp., *Salmonella* spp. or viruses. The Norwalk virus was considered responsible for a small outbreak in eastern Finland[a] arising from a contaminated wastewater basin. Other disease outbreaks have been recorded in Finland and, although the agents have not been identified, viruses have been isolated from sewage-contaminated water. In one viral epidemic, some 4400–5000 people contracted diarrhoea.

In Norway, it is estimated that infections from contaminated water cause several hundred thousand days of diarrhoea each year [21]. Outbreaks of *Campylobacter* infection have been reported, involving nearly 1000 people, as well as an outbreak of waterborne hepatitis A in 1990 and one of Norwalk virus infection in 1992.[a]

In Sweden, waterborne outbreaks of *Campylobacter, Giardia, E. coli* and viral infection have been described.[a]

As hepatitis A is not a reportable disease in many countries, and as most primary infections are subclinical, the number of cases is probably greatly underreported. Some studies in the United States show that 30–50% of the adult population has serological evidence of past infection. The infection rate in Belgium and the former Yugoslavia has been reported to be high.

A particular problem with drinking-water supplies is found in Tallinn, where groundwater resources are nearly exhausted. Consequently, Tallinn relies mostly on surface water from Lake Ulemiste where regular blue–green algal blooms can produce unsatisfactory taste and odour, making the water unacceptable for drinking. Toxins are also produced, which may produce lethal effects in some animals, but information about effects on human health is limited.

Blooms of blue–green algae are implicated in poisoning incidents worldwide [22]. There are no confirmed reports of deaths in humans attributable to toxins produced by these algae although deaths of farm animals, dogs, birds, amphibians and fish have been reported, especially following ingestion of algal blooms on the water surface [23].

Toxic blue–green algal blooms have been reported from 16 European countries: the former Czechoslovakia, Denmark, Finland, France, the former German Democratic Republic, the Federal Republic of Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, the Russian Federation, Sweden and the United Kingdom. The occurrence of these algal blooms is much wider than could be inferred from suspected poisoning incidents: up to 75% of all the blue–green algal blooms tested have been found to produce toxins [24]. Three

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

categories of toxins are produced: neurotoxins, hepatotoxins and lipopolysaccharides.

Blue–green algae have been reported to produce allergic reactions, skin and eye irritation, respiratory problems and gastrointestinal disturbances in swimmers in freshwater lakes and reservoirs in a number of countries [25,26]. With the increase in eutrophication from fertilizers entering many lakes and reservoirs, the incidence of health effects from blue–green algae can be expected to increase.

Infection by *Cryptosporidium* spp. has been described, with a prevalence of 0.6–20 % in western countries [27]. In the United Kingdom, a number of drinking-water-associated gastroenteritis outbreaks have been documented around the country.[a] Where a cause of gastroenteritis was identified, *Cryptosporidium* spp. was responsible for 8 % of cases in England & Wales and 13 % in Scotland, accounting for a total of 9147 cases in 1989. In the last six or seven years, a series of outbreaks of *Cryptosporidium* infection in the United Kingdom (and in the United States) has drawn attention to waterborne transmission arising from inadequate water treatment and ineffective filtration, leaving oocytes present in drinking-water. Where the cause of diarrhoea was established, *Cryptosporidium* spp. was the fourth most commonly identified cause after *Campylobacter* spp., *Salmonella* spp. and viruses [28]. One waterborne outbreak of giardiasis has been reported in the United Kingdom [29]. Gastroenteritis outbreaks due to viruses have been described in the United Kingdom in recent years, possibly as a result of increased surveillance and awareness. Since symptoms are mild, however, most cases go unreported.

Such patterns of occasional outbreaks are similar in other western European countries, such as France, where individual outbreaks of salmonellosis and shigellosis were recorded in the late 1980s.

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

6.2.2 Exposure to chemical contamination

Chemical contamination of drinking-water provides a major route of exposure for a number of potential environmental health effects, particularly in the CCEE and NIS. The main concerns seem to be nitrate, arsenic, fluoride and pesticides.

In six countries – Belarus, Bulgaria, Hungary, Lithuania, Romania and Slovakia – locations are known where nitrate concentrations in drinking-water are high enough to cause methaemoglobinaemia [16].

High nitrate concentrations in drinking-water from shallow wells are caused principally by excessive fertilizer applications, large feedlots and rural septic tank effluents. A large part of the rural population is affected. An association has been reported between the incidence of digestive tract cancer and high nitrate levels in drinking-water in Borsod County, Hungary, although food may also be involved [16].

In many of the Danube countries in particular, bank-filtered river water is an important source of drinking-water. In such situations the problem lies less with long-term aquifer contamination by nitrates than with levels of nitrates in surface water and soil. The actual sources are not always identified. In management terms and in assessing the vulnerability of water resources to contamination, it is sometimes useful to make the distinction between surface water, shallow unprotected groundwater (such as alluvial aquifers) and groundwater protected by an impermeable layer and with a relatively distant recharge zone.

Elevated nitrate levels would seem to be a serious problem in most of the districts in Romania [30]. Some 17 % of samples from over 2000 locations exceeded 100 mg/l, and a further 19 % exceeded 45 mg/l. This can be compared with the WHO guideline for nitrates in drinking-water of 50 mg/l. Not surprisingly, a number of deaths from methaemoglobinaemia have been reported in babies from seriously affected areas such as Dolj and Mehedinti.

In Bulgaria also, nitrate levels regularly exceed 100 mg/l. In Turgoviste, Stara Zagora and Burgas, values may reach 200 mg/l. The majority of the populations in these areas are drinking water with nitrate levels above the guideline values [31]. Methaemoglobinaemia has again been reported.

Somlyody [32] calculates that 80 % of the drinking-water in Hungary comes from groundwater, and nitrate contamination can therefore have serious implications. This figure for the use of groundwater differs considerably from the 10 % quoted after the Water Decade [33]. This may result from different classifications of bank-filtered water, which is classified sometimes as groundwater and sometimes as surface water. In view of the very high nitrate levels in groundwater in some parts of Hungary, a "plastic bag" water supply has been provided for about 700 settlements with 300 000 inhabitants [32]. Obviously, the options for controlling nitrate will be different for bank-filtered sources and deeper aquifers.

In Slovakia, where nitrate values can exceed 200 mg/l, over 2000 cases of methaemoglobinaemia with 12 deaths were reported in the 1970s. Incidence decreased by an order of magnitude in the 1980s following recognition of the problem and the supply of low-nitrate water to infants.

Around 57 % and 43 % of drinking-water in the Czech Republic is derived from surface water and groundwater, respectively [11]. Elevated nitrate concentrations have been recorded in groundwater in a number of areas. Values of up to 800 mg/l have been reported in the quaternary basin of the river Labe. Only 57 % of the treated water from a total of both sources complied with the national standard for drinking-water. The standard was exceeded for heavy metals at 123 localities (553 000 people exposed), for cyanides at 10 localities (10 000 people), for phenolics at 57 localities (230 000 people), for oil substances at 169 localities (1 million people) and for enhanced radioactivity at 100 localities (300 000 people).

In Poland, 84 % of water consumption is met from surface water and about 14 % from underground sources [34]. A large part of the rural population is affected by nitrate pollution.

In Denmark, more than 95 % of drinking-water is abstracted from groundwater. The public supplies serve 95 % of the population, the remainder relying on individual wells or boreholes. High nitrate concentrations have forced some small waterworks to close. In 1980, the rate of pollution of potential groundwater resources increased, particularly around major cities due to the previous use of oil, petrol (older equipment and design of petrol stations led to contamination problems in a number of countries) and chlorinated organic compounds. It may be necessary to close down some municipal water supply plants and to collect water from other parts of the area [35].

In Finland, nitrates and pesticides do not pose a serious problem to the public water supply [20]. In Norway, drinking-water quality is reported to be acceptable for the majority of the population, which is served by the larger waterworks [21].

High natural arsenic concentrations are recorded in drinking-water in parts of Hungary, including Bekes County (in the south-east) and the nearby districts of Arad, Lipova and Ineu in Romania. Arsenic concentrations reach 100 μg/l or more in water in both countries [16,36]. Some 100 000 people are potentially at risk in Romania, while a report by the Hungarian Academy of Sciences indicates that in Hungary nearly half a million people are exposed to drinking-water containing arsenic at levels above the guideline concentration of 10 μg/l.

Arsenic concentrations in the drinking-water of the Great Hungarian Plain are moderately well correlated with concentrations of arsenic in hair [37]. The highest accumulation was found in children, drawing attention to the high level of risk in the young population.

Epidemiological studies carried out on some 25 000 people living in south-east Hungary, with access to deep-well water contaminated with arsenic throughout their lives, revealed many cases of skin thickening and increased pigmentation in both children and adults [38]. An increased incidence of peripheral vascular disorders was not found [38]. A supply of “plastic-bagged” water in Bekes County has been the main public health response. Alternative drinking-water sources low in arsenic are often difficult to locate at the local level because groundwater in Hungary accounts for 90% of the drinking-water. Similar epidemiological studies have not been carried out in Romania, but “high rates” of skin cancer have been reported [16].

Further epidemiological research is required in Hungary and Romania to confirm these results and to seek to establish a sound dose–response relationship. The total exposure of these populations to arsenic, as a result of intake from water, food and air, remains to be determined. Such research seems warranted, as arsenic-rich groundwater from deeper aquifers has been reported to be used in Hungary for irrigating local crops.

High concentrations of arsenic – up to 50 times the guideline values – have also been described in surface water and well-water near a copper smelter at Srednogorie in Bulgaria, and in water from the Topolnitsa river downstream from Srednogorie [39]. Exposure to arsenic can also occur via irrigated crops (especially rice) in the area.

High fluoride concentrations (up to 6.3 mg/l) occur in groundwater in central, eastern and western Estonia and the incidence of dental fluorosis in children is high. However, insufficient fluoride (<0.5 mg/l) can be recorded in some surface waters. Elevated fluoride levels have been recorded in some well waters in Finland. Elevated fluoride levels in drinking-water, particularly well water, and associated dental and/or skeletal fluorosis have been described from locations in Bulgaria, Hungary, northern Kazakhstan (Pavlodar Kokchetau and Karaganda provinces), the Republic of Moldova, Spain, Turkey (at Dogu-be-Yazit), Ukraine (Bucak) and also in eastern Siberia (Argun region) where concentrations can exceed 10 mg/l [40]. In the early 1990s, dental fluorosis was also recognized at locations across Europe, including sites in France, Germany, Italy, the United Kingdom and the former Yugoslavia, especially where the groundwater had elevated levels of fluoride. In areas of the United Kingdom where fluoride levels are low, fluoride is added to drinking-water to raise concentrations as high as 1.1 mg/l in order to reduce dental caries in children [41]. This policy is followed in various parts of Europe, the relative percentages of the population exposed to some degree of artificially elevated fluoride being, for example: Czechoslovakia 20, Finland 1.5, Ireland 50, Poland 4, Switzerland 4 and the United Kingdom 10.

High concentrations of pesticides and other inorganic and organic contaminants have been recorded in drinking-water at various locations in Europe, although their significance in terms of health effects is mostly unknown. In the Russian Federation, nearly half of the 60 million cubic metres of drinking-water piped daily to the population does not meet the national hygiene standards. Around 24% of drinking-water samples failed to meet the state standards for chemical contaminants [18]. An additional problem reported is that of disinfection chemicals and their by-products increasing exposure to halogenated organic compounds, particularly in Moscow and other large cities.

Elevated concentrations of chlorinated pesticides have been recorded in the Danube and some of its tributaries; during 1979–1982 in Yugoslavia, 93% of samples contained raised levels of lindane and 40% raised levels of aldrin, dieldrin and DDT. The levels did not, however, exceed WHO guidelines [42].

Pesticides and organic chemicals are the focus of concerted control efforts in western Europe. In 1990–1991 in France, 0.7% of the population (224 277 people) received drinking-water containing more than the WHO guideline value for atrazine of 2 μg/l, and there were a number of situations with increased exposure to trichloroethene and tetrachloroethene. There have been recent improvements in the quality of water supplied, but there are still three million people in Italy who have drinking-water with trichloroethene and tetrachloroethene at levels up to 50 μg/l, and an unknown number are supplied with water containing up to 30 μg/l. WHO [1] quotes a provisional guideline value for trichloroethene of up to 70 μg/l. Failure of drinking-water samples to meet EU pesticide standards is increasing, for example in Germany and the United Kingdom [23,43]. This may be attributable to more frequent monitoring for selected pesticides.

A recent epidemiological study in Finland on long-term exposure to chlorophenols identified an excess of soft tissue sarcomas and non-Hodgkin lymphomas in a population of 2000 [44]. A sawmill had used chlorophenols over a long period for wood preservation, and the population was exposed through drinking water and eating fish.

Despite a high level of compliance with standards in the United Kingdom (98.7% of samples in 1991) there are continuing problems in particular areas for nitrate, PAHs and lead that have resulted in more focused monitoring.

Elevated concentrations of metals have been found in drinking-water samples from areas in the Czech Republic, affecting 553 000 people [11].

High concentrations of lead in drinking-water have been reported but, with the exception of infants, this route may be less important than other exposure routes such as air and food. Detailed studies have been carried out only in a few countries, but evidence of neurobehavioural deficits among exposed children is reported to have been obtained in several of the CCEE.

The difficulties of establishing the effects of exposure to particular chemicals are well illustrated by the Lowermoor incident in 1988 in Cornwall, United Kingdom. Twenty tonnes of aluminium sulfate were accidentally released into the supply system, leading to aluminium concentrations typically of 10–50 mg/l and up to 620 mg/l for about three days, far above the EU MAC of 0.2 mg/l [45]. Short-term gastrointestinal problems were reported, but after a few days of flushing the concentration fell below 0.2 mg/l. However, there continued to be complaints of effects (such as joint and muscle pain, fatigue, skin problems and memory loss) for a prolonged period.

The Lowermoor Incident Health Advisory Group [45,46] reviewed the likelihood of long-term effects. There were considerable difficulties in determining whether the longer-term effects reported by sufferers after acute exposure were attributable to the aluminium. Measurements of serum and bone aluminium and reviews of aluminium toxicity suggested that symptoms apparent after six months, such as joint and muscle pain or skin problems, could not be linked to aluminium exposure. For other problems such as memory loss or birth defects, aluminium could neither be implicated nor dismissed. The group suggested that a substantial proportion of real health problems might have arisen from anxiety associated with the incident, but that nevertheless routine observation for longer-term effects should be implemented [45].

The Lowermoor incident demonstrates the difficulty of separating health effects arising from drinking-water contamination from general or parallel health problems. Despite the body of toxicological evidence, it was not known what symptoms (other than acute toxic effects) could either be predicted or ruled out as a result of environmental exposure to aluminium.

The effects of combined exposure to a number of chemicals are rarely established, but a pilot study reported from Permsko-Krasnokam in Russia[a] demonstrated a correlation between water quality in the river Kama (which has high levels of oxides and amino compounds, hydrocarbons, zinc, copper, iron and synthetic compounds) and human health. The effects reported included gastritis, duodenal ulcers, chronic nephritis, liver disease, gall bladder and pancreas problems, stillbirths and premature births.

---

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

In general, there are substantial difficulties in identifying actual exposures and consequent health effects. For example, contamination of water is reported as non-compliance with standards, but it may not be clear whether the contaminated water was actually supplied, to how many people and for what length of time, or in which other way the contamination related to actual exposure. The other evident difficulty is that, in some areas, monitoring may not be adequate to identify contamination, such as that by pesticides. There is little possibility at present of assessing the total exposure of populations on a European scale (see also Chapter 10).

6.2.3 Water supply coverage and shortages

The years from 1981 to 1990 were the focus of international activity on water supply and sanitation – the International Drinking Water Supply and Sanitation Decade. The target of the Decade in Europe was that "by 1990, all people of the Region should have adequate supplies of safe drinking-water, and by the year 1995 pollution of rivers, lakes and seas should no longer pose a threat to human health" [33]. This objective engendered a programme supporting national activities to set quality criteria, to improve source protection, networks, technical abilities and management, and to develop human resources and stimulate research.

Fig. 6.1 shows the percentage coverage of the rural populations of the WHO European Member States at the end of the 1980s in terms of piped supplies, public standpipes and inadequate supplies. Fig. 6.2 gives the same information for urban populations.

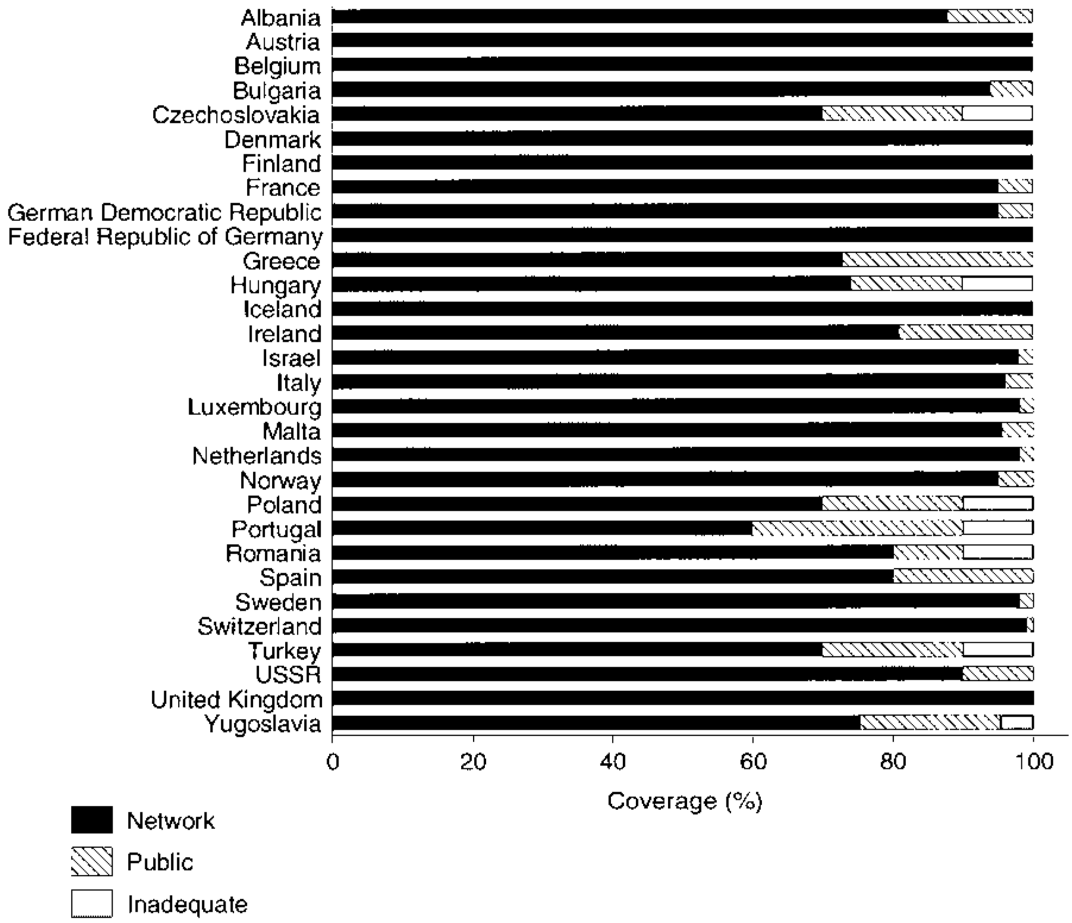
Some urban slum areas still have poor coverage but these are not typical. However, many rural communities in certain areas are poorly covered, although it is envisaged that the whole rural population should have "easy access" to a proper water supply system by the turn of the century [33]. Recent data regarding coverage in some of the CCEE and NIS are given in Table 6.2.

The withdrawal of water for all uses contributes to water shortages in particular areas. Table 6.3 indicates the situation for certain countries in the late 1980s. Agricultural use of water for irrigation predominates in some southern European countries, whereas in industrialized countries energy and industry consume about 50% of the water supply.

The data do not give great insight into patterns of shortage over Europe because there is substantial variation in availability in certain countries. Particular areas or countries around the Mediterranean are vulnerable to shortages, particularly when summer populations are substantially increased by holiday-makers. This is true of the Greek Islands, parts of southern Italy and Sicily, Malta, the Balearic Islands, the Canary Islands and parts of eastern and southern Spain. In peninsular Spain, in particular, excessive exploitation of aquifers has led to saline intrusion in coastal areas.

Sustainable consumption of water means restricting its use to renewable sources and limiting the rate of withdrawal to the rate of replenishment by the natural water cycle. Most countries of the Region for which data are available meet these requirements, and have adequate resources to meet demands in the foreseeable future. In 1990, however, water withdrawal in Israel was 110% of the renewable supply and only $461 m^3$ of water per person was available from renewable sources. Israel is considered to suffer from a scarcity of water [48]. Similar data were not available for the arid central Asian parts of the Region, but water shortages are known to occur.

Water shortages have health implications for various reasons. A water shortage will mean greater pressure to use poorer quality water, with a consequent risk of higher levels of pollution. Unless action is taken to control demand, the demands of users for abstraction and effluent disposal may remain the same as in periods of plentiful supply. Flow will be reduced and the capacity of



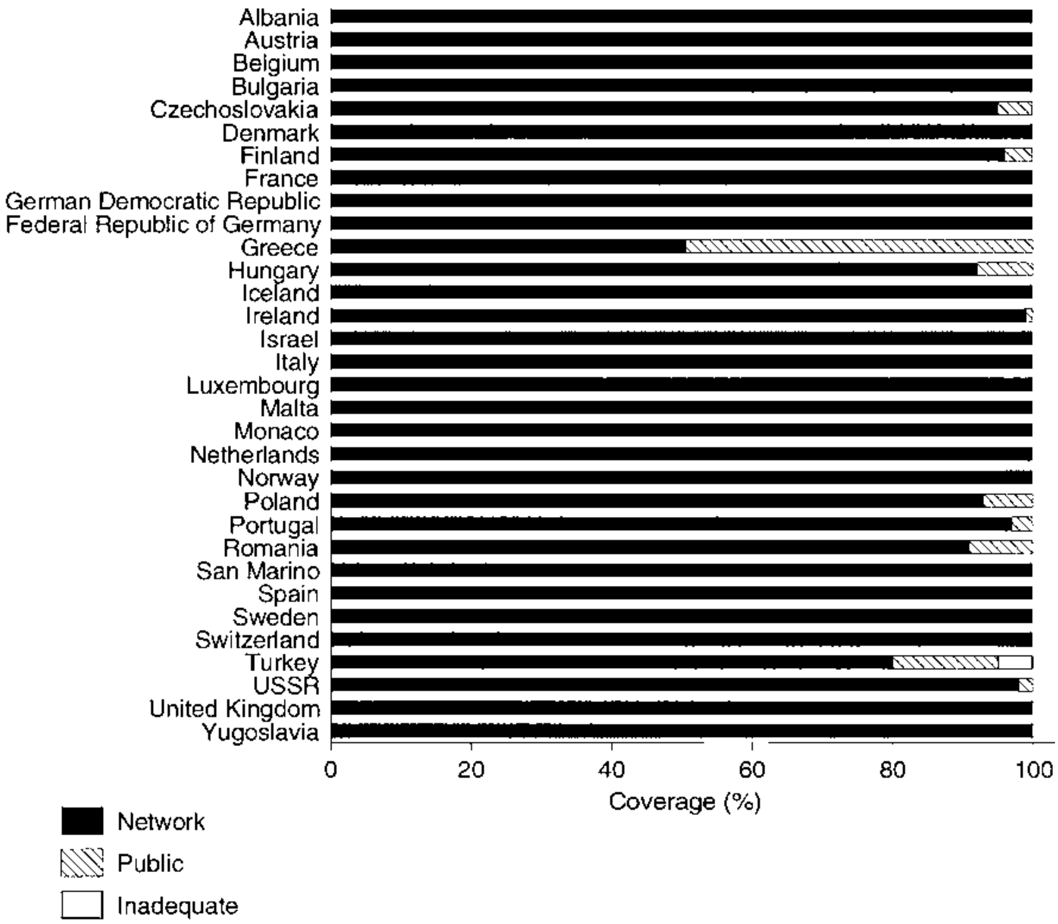
Source: WHO Regional Office for Europe *(33)*.

Fig. 6.1: Rural water supply coverage in the WHO European Region, late 1980s

Table 6.2: Water supply coverage in some of the CCEE and NIS

Country	Percentage coverage: Rural	Percentage coverage: Urban
Estonia	60	80–95
Kazakhstan	30–50	92
Latvia	55	89
Republic of Moldova	17.5	97.5
Slovakia	77.6	
Slovenia	95	100
Ukraine	<50	99
Uzbekistan	45.8	82

Sources: WHO Regional Office for Europe *(47);* World Health Organization, unpublished data, 1992.



Source: WHO Regional Office for Europe *(33)*.

Fig. 6.2: Urban water supply coverage in the WHO European Region, late 1980s

Table 6.3: Annual water use in some European countries, late 1980s

Country	Total withdrawals (10^6 m^3)	Per caput withdrawals (m^3)	Total as a percentage of renewable resources	Percentage of total to public supply	Percentage of total to irrigation
Austria	2 120	278	2.4	24.8	2.6
Denmark	1 170	228	9.0	41.0	34.2
Finland	3 001	605	2.7	14.1	0.7
France	43 673	782	23.6	13.5	5.8
Federal Republic of Germany	44 582	728	27.5	11.0	0.5
Iceland	100	411			
Italy	56 200	980	30.1	14.2	57.3
Luxembourg	59	156	1.2	95.0	0.3
Netherlands	14 471	999	16.1	7.7	–
Norway	2 025	488	0.5	26.6	3.4
Portugal	1 290	125	2.0	–	–
Spain	45 845	1186	41.2	11.6	65.5
Sweden	2 996	353	1.6	32.4	3.1
Switzerland	1 166	173	2.4	58.5	–
Turkey	23 750	430	17.7	12.8	79.1
United Kingdom	14 502	253	12.1	48.6	0.8

Source: Engleman, R. & LeRoy, P. *(48)*.

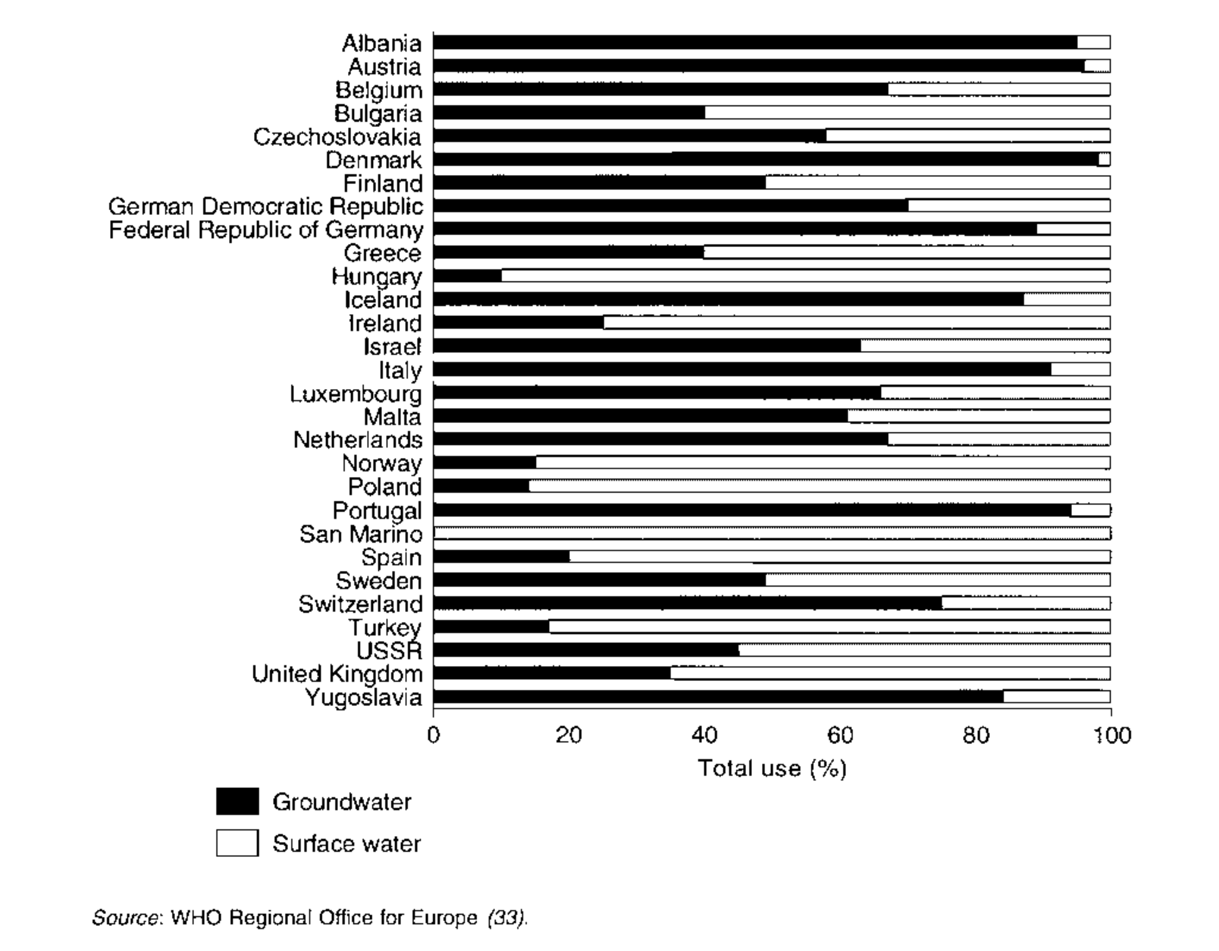


Fig. 6.3: The contribution of groundwater and surface water to drinking-water in countries of the WHO European Region, late 1980s

rivers to dilute wastes will fall, with the result that biological oxygen demand and concentrations of chemical substances will rise. The river will thus be less suitable as a source of water for domestic supply and other uses unless treatment can cope with these higher concentrations. Reduced flow in the water supply system may induce contamination in the network. Reduced water quality will have obvious risks for human health and reduced quantity can mean poorer standards of hygiene.

Another important issue in the supply and quality control of drinking-water is the source, i.e. groundwater or surface water. The quality issues may be different and are discussed below. The extent to which different countries rely on the two sources are shown in Fig. 6.3.

6.3 Causes of Exposure to Waterborne Hazards

Environmental health problems are related not only to particular routes of exposure but also to management and cultural practices, local physical or hydrological conditions, technical capabilities and the pre-existing health status of a population. The causes of exposure to waterborne hazards should be considered in parallel with these factors and related closely to wastewater and to surface water and groundwater pollution (see Chapter 7).

6.3.1 Inadequate raw water quality and quantity

Raw water of poor quality is at the root of many of the water-related health problems and potential health problems in Europe today, but it is not known to what extent the overall health status of European populations is related to the complex of factors that make up water quality. However, the aim of using guidelines and standards for raw water and treated water is to minimize risks to health. The implications for health and effects of poor quality raw water cannot be considered in isolation from the treatment methods and management strategies available. Treatment methods can to a great extent remove contaminants, but considerations of cost, availability and practicality will determine whether such methods are actually used.

The standards derived from the guidelines described above determine whether drinking-water complies with criteria for reducing the risks associated with the consumption of water containing particular contaminants. Statistics on non-compliance based on raw water monitoring, or during treatment, may need to be supplemented by information on non-compliance at the consumer's tap in order to assess potential health effects. Whether the supply manager prevents water that does not comply with standards from being supplied to the consumer will depend on several factors. If alternative sources of drinking-water that do meet standards are available, these may well be used. But in areas with limited sources of raw water with similar quality problems, there may be no option but to supply the substandard water in order to avoid more serious health problems. Technical remedies may be available to ensure proper treatment and, if so, exposure to substandard drinking-water may be limited. In some areas, however, this may not be possible for financial reasons, and longer-term exposure may be inevitable.

Within Europe, there are restrictions on the quality of raw water that can be abstracted and used as drinking-water. An EU directive sets standards for the quality of surface water for abstraction as drinking-water, giving three sets of parallel criteria for various contaminants depending on the degree of treatment and disinfection [49].

Germany has specific problems with groundwater quality, a serious issue considering the importance of groundwater for the drinking-water supply in that country. A recent two-year study found that 20 out of 206 areas surveyed had more than the EU MAC of 0.1 μg/l for pesticides in groundwater, and that seven out of the 35 pesticides measured were at levels of 0.1–0.5 μg/l [43]. Italy, particularly in the north, experiences groundwater contamination by industrial solvents, nitrate fertilizers, herbicides and pesticides. Other examples have been described earlier in this chapter.

In Bulgaria, the largest polluter of surface water is the chemical industry, followed by ore extraction, metallurgy, the food industry, and the cellulose and pulp industries [39]. Sofia is one of the biggest polluters in the country: some 70–75 % of the overall pollution load on the river Iskur and its tributaries comes from Sofia's sewage system.

In the former Czechoslovakia in the last decade, the main cause of water pollution (50 %) was agriculture (manure, fertilizers and pesticides) followed by industry and human settlements [50]. Many human settlements have no water treatment plants; even Prague and Bratislava do not have sufficient water treatment capacity. There is a considerable increase in contamination of groundwater by nitrates, pesticides, fertilizer residues and other substances, including chlorinated hydrocarbons. During the last 30 years, average nitrate levels in groundwater have increased fourfold from 30 to 120 mg/l.

In Hungary, the largest polluter of surface water is industry [32]. Pollutant loads contain organic substances, heavy metals and oils. Discharge of liquid manure is also a problem, around 20 % being discharged into water bodies. About 85 % of the water supply for Budapest comes from bank-filtered water resources along the Danube. The wastewater from Budapest, only 21% of which is treated biologically, has an unfavourable impact on these resources.

The chemical, petrochemical, dye, pulp and paper industries and coke-burning plants are among the significant polluters in Romania. Areas of polluted groundwater and the polluting industries have been detailed by Ognean & Vadineanu [51].

6.3.2 Inadequate treatment and distribution

If water is contaminated, it requires treatment before being supplied as drinking-water if it is to meet the required standards. Limitations on the use of contaminated raw water may be overcome by treatment as mentioned above, but there remain a number of problems. First, there may be no alternative but knowingly to supply substandard water if adequate treatment is not possible and there are no other sources. Also, monitoring strategies may not be appropriate to detect contamination, and technical inadequacies may mean that treatment is not as effective as it is intended to be. Accidents or short-term contamination affecting raw or treated water may be particularly difficult to manage unless adequate monitoring is available and provision for alternative supplies is made.

Short-term inadequacies in treatment occur across the Region. These normally result from technical problems in treatment works, and some of the sporadic outbreaks of disease or exposure to contaminants recorded in western Europe stem from technical or human failures such as breakdowns in disinfection procedures [52]. Other outbreaks of disease may result from problems that are difficult to treat and can only be avoided by using alternative sources; *Cryptosporidium* infection is a good example of this.

It is estimated that 13% of treatment plants in the Russian Federation lack the necessary equipment to treat drinking-water to meet the required standards, particularly for disinfection and the removal of viral pathogens.

Difficulties in distribution are commonly associated with aging distribution networks that allow cross-contamination from sewerage systems or from agricultural or industrial contaminants or wastes. Such problems are widespread in the Region and are responsible for a number of short-term outbreaks of disease in western Europe. These problems become more serious when combined with inadequate treatment. The Russian Federation, other countries of the former USSR and some of the CCEE suffer from chronic contamination of deteriorating distribution systems combined with poor raw water quality and treatment difficulties.

Many countries in the Region have problems in rural areas. Here networks are small or consumers depend on private wells, and treatment of drinking-water is minimal or nonexistent. This makes supplies vulnerable to possible contamination, and inefficiencies of scale mean that remedial treatment or provision of alternative sources is expensive or impractical. In the east of the Region small communities rely on a number of wells, which makes treatment and proper control of contamination difficult.

6.4 Trends

6.4.1 Demands for surface water and groundwater

Water shortage is a problem that is growing in certain areas of Europe. Reasons for this include local population changes (such as in areas where holiday resorts are developed) and increasing use per head of population. Use for irrigation is also expanding in parts of the Region. Several countries rely on groundwater for a substantial proportion of their drinking-water supply, but for many areas the details of yield and recharge are only partially known, making planning for sustainable use difficult. There is no absolute shortage of water in the Region as a whole but there are severe local difficulties, as mentioned above.

It is not possible to separate the issues of quality, quantity, technical capability and infrastructure. Quality problems limit the quantity of water available that meets standards. This is a particular problem in the east of the Region, where there is substantial contamination.

Supply networks expanded during the Water Decade, leaving isolated urban areas with inadequate supplies but larger rural areas still failing to meet basic requirements. It is anticipated that within the next ten years all rural areas will have an adequate supply [33]. However, this target is not likely to be met in full.

There are continuing problems with water loss in supply systems and cross-contamination from sewerage systems. In many cities, the supply system is aging and there is a constant need to upgrade or repair a deteriorating infrastructure. In the CCEE and NIS, the supply systems are not being maintained as rapidly as they deteriorate, and it will be important over the next decade to ensure that such repair and maintenance is adequately financed.

Issues of small-scale supply will continue to be important, particularly with regard to shallow wells and bank-filtered wells, which are vulnerable to shifts in the water table and to contamination.

Integrated planning of water resources is becoming increasingly urgent for many countries, along with integrated pollution control and remedial action. There are possibilities for increased efficiency in water use (such as the adoption of drip-irrigation techniques) and for water conservation and recycling. There are proposals in some countries to move large volumes of water from wetter areas to dry populated areas, but such initiatives require capital investment and may have important environmental consequences.

6.4.2 Quality

Quality standards for water with respect to human health are universally applied in the European Region. Most countries use either EU regulations [2] or WHO guidelines [1] as the basis for national standards, but there are obvious difficulties in meeting requirements in many areas.

In western Europe, the primary difficulties in compliance appear to be related to organic chemicals such as pesticides, PAHs, disinfection by-products and some industrial solvents. There are also continuing difficulties with nitrate. The CCEE and NIS experience many of the same problems but generally to a greater degree, and with the additional problem of contamination with pathogenic organisms. A real difficulty, particularly in the east, is in monitoring; laboratories at local level are not always equipped to monitor for many chemicals or viruses, and even if the contaminants could be detected, treatment and management options are frequently limited.

It is unlikely that the situation with regard to raw water quality will improve rapidly. Pesticides are difficult to control in a number of areas, and there is an urgent need to focus monitoring efforts on real health risks rather than just to meet legislative requirements. Treatment technologies are improving, but their wider application is limited by cost.

Efforts to improve drinking-water quality will be practical and successful only if set in a wider strategy of pollution control. This is already in place in western Europe, where much effort is put into regulating hazardous substances and waste. Such strategies help to minimize human exposure to hazards from all environmental media. There is little benefit in expending huge resources in controlling water pollution alone if food contamination is potentially a more serious health problem.

6.4.3 Sources of pollution

Pollution prevention and control and remedial action are the two greatest challenges facing environmental management in Europe. The next decade will probably bring industrial change and expansion in the southern and eastern countries of the Region, combined with the need to deal with the waste legacies of previous policies. Source protection will be critical in this respect: protection of relatively unpolluted water is essential, and polluted water will need to be subject to remedial programmes. Again, these can be successful only in the wider context of pollution control in the whole environment.

Industrial and agricultural change will mean that the distribution of factors influencing quality and monitoring needs will change across the Region. In many places, industrial expansion or change has not been matched by monitoring or pollution control capabilities. National codes of practice for different activities are required, and regulation and adherence to codes of practice will require adequate enforcement or incentive.

Waterborne infectious disease is likely to be a continuing issue. The improvement and expansion of sanitation and greater effectiveness in the treatment of drinking-water are part of the solution but must be accompanied, particularly in rural areas, by better infrastructure and public education. An increase in coverage would seem a real possibility, but is difficult to evaluate in view of recent socioeconomic changes in parts of the Region. Viral disease will continue to be important. Bacterial indicators are not always adequate, and some areas are affected by a continued high prevalence of disease with consequent morbidity. Treatment and management strategies are unlikely to be able to remedy this situation in the CCEE and NIS in the immediate future.

6.4.4 Technical and infrastructure needs

The skills and techniques needed to provide good quality drinking-water are available in parts of Europe, particularly in the west, and are always developing in response to new problems. There is a continuing commitment to transferring technology and skills to other parts of the Region where there are environmental health difficulties. It is not enough, however, to provide only equipment and training; these practical aspects must be placed in a wider context of management and policy development. This is taking place slowly, but it is at present impossible to assess when and how it will be reflected in environmental health improvements on a substantial scale.

Human resource needs can be met through training, but adequate financial resources are necessary both to maintain new systems and to train staff. The need to address specific local requirements is clear, but local conditions are so varied that adequate planning will take many years.

Laboratory facilities are a frequently cited problem. Effective monitoring is not possible in some areas because of lack of equipment or consumables, and such needs will not easily be met at the local level because of financial constraints. A future strategy of some importance will be the provision of low-cost techniques that can lead to a real improvement in standards. Economic improvement will ease the development of adequate infrastructures, but management and policy developments are at least as important and may be achieved with minimal financial support.

There is a particular need for the monitoring of bacterial indicators, to be supplemented by more effective monitoring for viral disease. Viral diseases are a particularly serious threat to human health, and effective provision for identification and control is essential.

The provision and management of data across the Region are relatively good, but the quality of the data is extremely uneven. Data are generally held at a local level, and there are not always national evaluation schemes. In addition, since many countries use different standards and monitoring procedures, data on compliance with standards cannot be compared from one country to another. A centralized European drinking-water quality database would be necessary in order properly to evaluate drinking-water quality from one European country or region to another. Apart from this purpose, such a database could also be used as an important management tool for setting priorities for improvements on a European scale.

Quality control and quality assurance will be of the utmost importance in parallel with the development of suitable laboratories, standard monitoring methodology and good laboratory practice. International standards for laboratory certification and accreditation must be used if a realistic picture of drinking-water quality in Europe within the next decade is to be obtained.

6.4.5 Management and control

There are a number of drinking-water problems that can be addressed within the sector itself. Management of supply, treatment efficiency, network development, monitoring and small-scale action are all important factors that can be strengthened through specific management restructuring and financial investment.

Sustainable improvements in the protection of human health will not be made unless drinking-water is seen as an essential element of an integrated water resources and quality management policy, which in turn falls within the wider environmental policy. Policies on drinking-water must take account of the wider issues of pollution control, water resources management and social planning. These elements are well integrated in some areas of western Europe, but there is much progress to be made in eastern Europe. Even if suitable management is in place, existing problems with industrial practice and wastes will make rapid improvements unlikely.

Land-use planning, particularly agricultural planning, is urgently needed in order to identify and protect areas vulnerable to pollution. Groundwater protection is of the utmost importance. Many deeper aquifers are only slightly or locally contaminated, and effective protection and remedial policies should be established where these are not already in place. Deterioration is of particular concern where the residence time is long and the recharge rate slow. Shallow aquifers and areas where bank filtration is used also require adequate protection and land-use control but, because of the close links, this must be done in parallel with the quality control of surface water and the introduction of early warning systems (see Chapter 7).

Enforcement strategies are developing, but their use across Europe is uneven. Particular attention over the next decade must be given to economic tools for pollution control and cost recovery for drinking-water supply. This may be very difficult to implement; the costs of past pollution are high and it is unlikely that real progress will be made except with the aid of a wider economic policy and bilateral support.

The importance of information in management and policy formulation cannot be overestimated. Many countries have relatively primitive means of information dissemination, not necessarily to policy-makers but often to the general public. A basic level of information on resources, quality and projections is essential for effective action. Public awareness, education and community management will be increasingly important in justifying the cost of environmental health controls. Research is a necessary complement to the provision of information, and monitoring of the effectiveness of technologies and management should be carried out in the context of local needs and conditions.

6.5 Conclusions

Water is an essential factor in the maintenance of human health; poor availability and quality can have severe effects on the health of populations. In Europe there are wide differences in availability per head from renewable sources and in quality, which will require action during the next decade. There are a number of areas in Europe where water shortages occur and others where such problems are developing. At present, water resource management can ensure that health is not affected by shortages but continued exploitation will further increase pressure on resources, particularly in some Mediterranean coastal areas. Increasing consumption and inadequate pollution control will restrict the overall options for use and have important implications for health. Coverage by water supplies has improved in the past decade, but there is substantial progress still to be made in rural areas; projections made in 1990 at the end of the Water Decade suggested that adequate coverage could be achieved by the year 2000. However, this target is unlikely to be met in full.

The suggestion for OECD countries that there is now "virtual elimination of significant pathogenic microbial contamination of drinking-water supplies" [12] is not applicable to the situation in Europe as a whole. The available evidence suggests that outbreaks of disease due to contamination from sewage systems or breakdowns in disinfection occur occasionally across Europe. Such events often involve large numbers of people and are relatively well reported. The possibility of low levels of chronic disease and consequent morbidity is difficult to assess. The difficulties of treatment in small rural supplies and in areas of the CCEE and NIS, together with a certain amount of reporting, would suggest that this may be a widespread but underreported problem. Outbreaks of viral and protozoan diseases are also important in the Region, and difficulties in treatment, monitoring and pathogen identification are unlikely to be resolved rapidly.

Chemical pollution by wastes and industrial and agricultural chemicals is an ever-present issue. The problem of assessing acceptable levels of risk to health from long-term exposure has meant that there is a constant requirement to revise guidelines and standards in the light of new knowledge. For many substances, there are poor epidemiological data on health effects resulting from exposure through environmental pathways. Risk assessments and guideline values are based on sound scientific evidence but allow for degrees of uncertainty in order to protect health; very little is known about long-term exposure or about the effects on human health of exposure to mixtures of substances in drinking-water. Management of water pollution must be fitted into wider strategies of integrated pollution control and water resource management in order to be effective in the long term. The protection of sources of drinking-water is essential, particularly with respect to pollutants such as nitrates and pesticides from diffuse sources; many countries rely on groundwaters that are vulnerable to pollution and that may be slow to respond to remedial action. It is evident that more sophisticated treatment for a wide range of chemicals is impractical for many countries, and that protecting drinking-water sources plays an important role in protecting health.

Monitoring and data for drinking-water quality, exposure and effects are issues of particular concern in Europe. In parts of the Region it is evident that laboratories cannot be expected to analyse effectively the range of substances controlled by standards, because they lack suitable equipment and reagents. Strategies for monitoring and the range of variables measured should be adapted to local needs, but there is a problem in the comparability of data for drinking-water in Europe. The site and frequency of sampling, quality control and quality assurance, statistical procedures and reporting differ substantially across the Region. Progress is being made on the development of common approaches and comparability for surface waters on a European scale, but a database for European drinking-water quality would be necessary in order to accomplish and sustain this development. It is currently impossible to make comparisons across the Region with any confidence. The incidence of disease outbreaks and of non-compliance with standards gives an indication of the present situation, but only more reliable data will give a better idea of where problems of quality exist and where chronic health effects might be expected to occur.

Environmental health management is obliged to compete for resources with other sectors. In a framework of limited resources, it is essential that priority-setting in the quality control and management of drinking-water is effective in obtaining the greatest possible benefit to health. Effective guidelines for management, codes of practice for pollution control, and effective provision of information for policy-making have not yet been universally applied in Europe.

The importance and potential influence of drinking-water quality on human health are sufficiently well established to allow effective management. The specific influence of drinking-water quality on the health of European populations can be identified only in certain cases.

References

[1] *Guidelines for drinking-water quality,* 2nd ed. *Vol. 1. Recommendations*. Geneva, World Health Organization, 1993.

[2] Council Directive of 15 July 1980 relating to the quality of water intended for human consumption (80/778/EEC). *Official journal of the European Communities*, **L229**: 11–29 (1980).

[3] [*State Standard: GOST 2874-82. Drinking-water health requirements.*] Moscow, Ministry of Health of the USSR, 1982.

[4] [*State Standard: GOST 2761-84. Sources of centralized drinking water supply.*] Moscow, Ministry of Health of the USSR, 1984.

[5] Elinder, C.-G. & Sjörgren, B. Aluminium. *In*: Friberg, L. et al., ed. *Handbook on the toxicology of metal*s, Vol. II. Amsterdam, Elsevier, 1986, pp. 1–25.

[6] Ishinishi, N. et al. Arsenic. *In*: Friberg, L. et al., ed. *Handbook on the toxicology of metal*s, Vol. II. Amsterdam, Elsevier, 1986, pp. 43–83.

[7] Smith, A.H. et al. Cancer risks from arsenic in drinking-water. *Environmental health perspectives*, **97**: 259–267 (1992).

[8] Friberg, L. et al. Cadmium. *In*: Friberg, L. et al., ed. *Handbook on the toxicology of metal*s, Vol. II. Amsterdam, Elsevier, 1986, pp. 130–184.

[9] Pocock, S.J. et al. The British Regional Heart Study; cardiovascular disease and water quality. *In*: Calabrese, E.J. et al., ed. *Inorganics in drinking water and cardiovascular disease*. Princeton, NJ, Princeton Scientific Publishing Co., 1980 (Advances in Modern Environmental Toxicology, Vol. 9).

[10] Cartwright, N. et al. The impact of agriculture on water quality. *Outlook on agriculture*, **20**(3): 145–152 (1991).

[11] Ministry of the Environment of the Czech Republic. [*Environment of the Czech Republic.*] Prague, Academia, 1991.

[12] *The state of the environment*. Paris, Organisation for Economic Co-operation and Development, 1991.

[13] *The environment in Europe: a global perspective*. Bilthoven, National Institute of Public Health and Environmental Protection, 1992.

[14] Morris, R.D. et al. Chlorination, chlorination by-products, and cancer: a meta-analysis. *American journal of public health*, **7**: 955–963 (1992).

[15] *Chlorinated drinking-water; chlorination by-products; some other halogenated compounds; cobalt and cobalt compounds*. Lyon, International Agency for Research on Cancer, 1991 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 52).

[16] Hertzman, C. *Environment and health in central and eastern Europe. A report for the Environmental Action Programme for Central and Eastern Europe.* Washington, DC, World Bank, 1993.

[17] Kolesnikov, G.A. *Problems of environmental pollution and health in St Petersburg*. Copenhagen, WHO Regional Offfice for Europe, 1993 (document EUR/ICP/CEH 213), pp. 95–103.

[18] Belyaev, E.N. *Environment and health in the Russian Federation.* Copenhagen, WHO Regional Office for Europe, 1993 (document ICP/CEH 229).

[19] Uibu, J. et al. Environment and health in Estonia. *In*: *Environment and health in the Baltic countries.* Copenhagen, WHO Regional Offfice for Europe, 1993 (document EUR/ICP/CEH 213), pp. 33–47.

[20] Nevalainen, A. Environment and health in Finland. *In*: *Environment and health in the Baltic countries.* Copenhagen, WHO Regional Offfice for Europe, 1993 (document EUR/ICP/CEH 213), pp. 49–55.

[21] Dybing, E. Environment and health in Norway. *In*: *Environment and health in the Baltic countries.* Copenhagen, WHO Regional Offfice for Europe, 1993 (document EUR/ICP/CEH 213), pp. 69–79.

[22] FALCONER, I.R. Effects on human health of some toxic cyanobacteria (blue-green algae) in reservoirs, lakes and rivers. *Toxicity assessment,* **4**: 175–184 (1989).
[23] DRINKING WATER INSPECTORATE. *Drinking water 1991. A report by the Chief Inspector*. London, H.M. Stationery Office, 1992.
[24] *Toxic blue-green algae. A report of the National Rivers Authority*. London, National Rivers Authority, 1990 (Water Quality Series No. 2).
[25] TURNER, P.C. ET AL. Pneumonia associated with contact with cyanobacteria. *British medical journal*, **300**: 1440–1441 (1990).
[26] *Aquatic (marine and freshwater) biotoxins*. Geneva, World Health Organization, 1984 (Environmental Health Criteria No. 37).
[27] SOAVE, R. & JOHNSON, W.D. *Cryptosporidium* and *Isospora belli* infections. *Journal of infectious diseases*, **157**: 225–229 (1988).
[28] BADENOCH, J. *Cryptosporidium* – a waterborne hazard. Opinion. *Letters in applied microbiology*, **11**: 269–270 (1990).
[29] AINSWORTH, R.G. Water treatment for health hazards. *Journal of the Institution of Water and Environmental Management*, **4**: 489–493 (1990).
[30] CUCU, M. & Ianculescu, S. *Environment and health in Romania*. Copenhagen, WHO Regional Office for Europe, 1993 (document ICP/CEH 229).
[31] HARALANOVA, M. & IVANOVA, O. *Environment and health in Bulgaria*. Copenhagen, WHO Regional Office for Europe, 1993 (document ICP/CEH 229).
[32] SOMLYODY, L. Water quality management in Hungary: past experiences and future needs. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 143–166.
[33] *International Drinking Water Supply and Sanitation Decade: final evaluation report (Europe only)*. Copenhagen, WHO Regional Office for Europe, 1990 (document EUR/ICP/CWS 011 (1)).
[34] ROMAN, M. Problems of municipal sewage treatment in protecting the water resources of Poland. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 175–186.
[35] THOMSEN, A.S. Environment and health in Denmark. *In*: *Environment and health in the Baltic countries.* Copenhagen, WHO Regional Offfice for Europe, 1993 (document EUR/ICP/CEH 213), pp. 25–31.
[36] CSANÁDY, M. ET AL. [Arsenic occurrences in lowland subsurface waters.] *Egészségtudomány*, **29**: 240–249 (1985).
[37] BOZSAI, G. ET AL. [Determination of the arsenic content of hair samples to assess the role of drinking-water in the arsenic load of the population.] *Egészségtudomány*, **33**: 115–124 (1989).
[38] BÖRZSÖNYI, M. ET AL. Epidemiological studies on human subjects exposed to arsenic in drinking water in southeast Hungary. *Archives of toxicology*, **66**: 77–78 (1992).
[39] SADOVSKI, A.N. Water pollution problems and priorities in Bulgaria. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 103–112.
[40] PETERSON, P.J. & LI RIBANG. *Endemic fluorosis – a global health issue*. Nairobi, United Nations Environment Programme, 1993.
[41] DEPARTMENT OF THE ENVIRONMENT. *Digest of environmental protection and water statistics*, No. 13. London, H.M. Stationery Office, 1991.
[42] MAYBECK, M. ET AL. *Global freshwater quality: a first assessment*. Oxford, Blackwell, 1989.
[43] *Facts and figures on the environment in Germany 1988/1989*. Berlin, Umweltbundesamt, 1990.
[44] LAMPI, P. ET AL. Cancer incidence following chlorophenol exposure in a community in southern Finland. *Archives of environmental health*, **47**: 167–175 (1992).
[45] DEPARTMENT OF HEALTH. *Water pollution at Lowermoor, North Cornwall. Second report of the Lowermoor Incident Health Advisory Group*. London, H.M. Stationery Office, 1991.
[46] *Water pollution at Lowermoor, North Cornwall. Report of the Lowermoor Incident Health Advisory Group*. Truro, Cornwall and Isles of Scilly District Health Authority, 1989.
[47] *Drinking-water-related environmental health aspects in the catchment area of the river Danube.* Copenhagen, WHO Regional Office for Europe, 1995 (document ICP/CWS 304).
[48] ENGLEMAN, R. & LEROY, P. *Sustaining water: population and the future of renewable water supplies*. Washington, DC, Population Action International, 1993.
[49] Council Directive of 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking-water in the Member States (75/440/EEC). *Official journal of the European Communities*, **L194**: 26–31 (1975).
[50] STOKLASA, J. Environmental problems in the CSFR: solutions through international co-operation. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 121–141.
[51] OGNEAN, T. & VADINEANU, A. Quality of the environment in Romania. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 245–258.
[52] BENTON, C. ET AL. The incidence of waterborne and water-associated disease in Scotland from 1945 to 1987. *Water science and technology*, **21**: 125–129 (1989).

Chapter 7
Wastewater and Surface Water

7.1 Health Effects

In a number of countries in Europe, wastewater and poor surface water quality are serious problems. In all countries, the management and disposal of wastewater is an important issue from the point of view of human health and environmental quality. In particular areas the development of coverage and effectiveness of treatment, together with quality management, has not kept pace with urban and industrial growth. This, together with increased pressure on available water resources, has had an adverse effect on human health both through pollution of water resources used for drinking-water and through direct contact with contaminated water.

The issue of poor raw water quality for drinking-water supplies is addressed in Chapter 6, and is an important focus for approaches to the treatment of wastewater. Some contaminants in surface water and groundwater arise from sources other than wastewater: for example, pesticides and a substantial proportion of nitrates, together with animal husbandry wastes, arise from agricultural sources. In the absence of adequate treatment of sewage, not only does microbial contamination of water result (see below) but organic materials may give rise to high biological oxygen demand (BOD); the resulting oxygen depletion adversely affects aquatic fauna and flora. Poor sanitation facilities and untreated industrial discharges to rivers, lakes and coastal areas used for recreation have given rise to a number of undesirable and recurring health effects, particularly in the CCEE and coastal regions of the Mediterranean, Black and Baltic Seas.

A survey of 13 000 popular bathing areas in the European Community during the 1991 bathing season showed that there were large differences in bathing water quality [1]. Guideline values for total and faecal coliforms were exceeded in a number of coastal bathing areas as well as in freshwater bathing areas. Bathing was prohibited in a number of areas in many member states.

The risks encountered in bathing and water-contact sports undertaken in contaminated water, and those associated with wastewater workers, relate primarily to a range of microorganisms but also to the presence of organic substances such as pesticides, phenols and trihalomethanes, and gases such as methane. Cabelli et al. [2] have reported that potentially all of the diseases that are spread by the faecal–oral route and whose etiological agents are shed in the faeces could be contracted by swimming in sewage-polluted water. Such diseases include salmonellosis (including typhoid and paratyphoid fevers), shigellosis, cholera and gastroenteritis caused by other pathogenic bacteria, viral diseases such as hepatitis A, illnesses caused by a variety of other viruses, and diseases caused by a variety of parasites including *Giardia* and *Cryptosporidium* spp. (see also Chapter 6). All of these diseases can also be contracted by consumption of raw or inadequately cooked shellfish, as discussed in Chapter 9.

In addition, a number of diseases other than gastrointestinal ones have been associated with swimming in contaminated water. These include eye, ear, skin and upper respiratory tract infections [3].

Recreational exposure to water polluted by human and animal sewage, with resultant gastrointestinal symptoms, has received much attention, although there are no routinely available statistics. Data on correlations between gastrointestinal illness and water-based activities are available from examination of disease outbreaks and specific epidemiological studies. However, the reliability and value of the data that can be derived from epidemiological studies depends on the appropriate measurement of exposure, often to complex mixtures of chemicals and other agents. The validity of results will also depend on the accurate diagnosis of health outcomes and the extent to which account can be taken of lifestyles and other confounding factors.

Although epidemiological studies differ in design and in the approach adopted, certain elements aid in an evaluation of health risks from water-related activities:

- questionnaires to estimate exposure (degree of head immersion, inadvertent ingestion of water)
- recruitment of subjects for control studies
- measurement of water quality (microorganisms and chemicals)
- reporting of gastrointestinal illness.

In general, because of the dearth of data on the health effects of contaminated surface water in the CCEE and NIS, and often inconclusive data for western Europe, problems of water pollution frequently do not receive the same attention as air pollution, for which characteristic health effects have been recorded and have led to large-scale emission-reduction programmes.

However, concerns for water quality as it affects both human health and ecosystems have led to more effective action at national level and have also been central to international cooperation on transboundary water pollution. International cooperation of this sort has the combined purpose of safeguarding raw water quality for drinking-water supplies and of protecting freshwater and marine ecosystems. Cooperation is in place for many shared waters such as the Rhine, the Danube, the North Sea, the Baltic and Black Seas and the Mediterranean.

7.1.1 Direct contact with surface water through bathing

The Mediterranean basin can be taken as an example of the problems of bathing water pollution. The sea receives waste and sewage from the 18 countries on its borders, although only four of them – France, Greece, Italy and Spain – are bound by the European Union (EU) directive on bathing water quality [4]. A number of studies have demonstrated the risks associated with exposure to wastewater when bathing. Studies in Spain have shown that ear and eye infections were significantly associated with immersion of the head in the sea water [5]. Prospective studies carried out in France [6] indicated that higher morbidity rates were found among bathers as opposed to non-bathers for each type of disease, i.e. gastrointestinal, skin, eye and ear.

While the risks of falling ill through bathing in the Mediterranean are well publicized, the problems are widespread across the Region. Many of the beaches in the Baltic states contaminated with sewage and industrial emissions are closed (for example in the Bay of Riga) with the consequence that disease outbreaks have been reduced. Lack of treatment of municipal wastewater from St Petersburg has created a public health hazard when beaches are used in the summer. At present, swimming is prohibited in the Gulf of Finland and the Neva River. In Bulgaria, the microbiological quality of surface water is seriously affected because of discharges of untreated sewage and waste from farming industries, especially in small resort settlements along the Black Sea coast where epidemics of intestinal infections have been recorded [8]. Small outbreaks of leptospirosis are reported throughout Europe, but effective rat control and prohibition of swimming in contaminated water have reduced the incidence of the disease.

The amenity value of unpolluted beaches, lakes and rivers is an important one, often affecting large numbers of people. The economic losses due to pollution of beaches and of surface water in tourist areas can be large.

7.1.2 Direct occupational contact with wastewater

Occupational exposure to *Leptospira* spp. of farmers, veterinary surgeons, abattoir workers and waterworks engineers (and recreational exposure of swimmers, campers and fishermen) can give rise to the potentially serious disease leptospirosis. Indirect contact via water contaminated with infected urine is a more common cause of human infection than direct animal contact. Rats are the most common infectious source although domestic animals, livestock and wild mammals, which may act as a reservoir for continually reinfecting domestic animals, may also be important.

7.1.3 Aerosols

Aerosols originating from aeration of wastewater can have some limited impact on air quality, as can the reuse of wastewater for agricultural purposes, particularly irrigation and especially when overhead sprinklers are used. When wind velocities are high, aerosols that may be contaminated with microorganisms may spread into areas that are not being irrigated. Even under these conditions, however, aerosol contamination is likely to affect the microclimate of only a very small area. The health effects of exposure to such aerosols are very difficult to estimate in Europe, and no data exist.

7.1.4 Smells

Malodorous substances in surface water and wastewater may be released continuously or as a result of accidents and spillages. Odour nuisance is one of the most common complaints about environmental pollution, and odours from surface water and wastewater (particularly from agricultural effluents) account for a significant proportion of them. Odour problems in wastewater are of particular concern if they occur near residential areas. Unlike many other forms of environmental pollution, the problem may disappear when the wind changes or it may be solved by dilution.

Odour concentrations and odour nuisances are closely related [9] but the composition of the odour and the frequency and duration of exposure are also important factors.

7.1.5 Wastewater irrigation

Municipal and industrial wastewater is frequently used to irrigate crops. In many European countries the wastewater is subjected to various forms of treatment before use, as a result of which excessive concentrations of suspended solids, pathogens and sometimes toxic compounds are removed. In some European countries, however, few or no wastewater treatment facilities exist, and raw sewage water is allowed to flow freely into rivers or is used directly to irrigate crops.

Untreated wastewater contains abundant microbial pathogens (the most important of which are described above) that can give rise to disease. Untreated wastewater also contains high concentrations of major nutrients such as nitrogen, phosphorus and potassium, micronutrients and some toxic metals.

In cases where untreated wastewater is used for irrigation the potential for dilution with clean water is increasingly limited, because as water withdrawals increase the amount of clean water remaining decreases while the proportionate volume of wastewater grows. Globally, wastewater can currently be diluted with clean water in a ratio of 1:25. In Europe, the ratio is 1:8 and is projected to worsen slightly by the year 2000 [10].

Potential health risks from microbial contamination of wastewater used for irrigation depend on the persistence and infective dose of the particular organism, on whether long-lasting human immunity develops, and on the relative importance of water and soil, food or personal contact as routes of exposure.

In 1989 WHO issued *Health guidelines for the use of wastewater in agriculture and aquaculture* [11], which describes simple treatments of wastewater to reduce microbial contamination to guideline levels. These levels take account of proposed conditions of use, such as whether the public will come into direct contact with lawn or parkland, or consume uncooked produce. It is recommended that in specific cases local epidemiological, sociocultural and environmental factors be taken into account, and the guidelines modified accordingly.

As far as contamination by metals is concerned, five have the potential to become health hazards: cadmium, copper, molybdenum, nickel and zinc [12]. Of these, cadmium is perhaps the most serious potential concern to health because of its long-term accumulation in the kidneys (see also Chapter 10). Other metals that may be present in treated wastewater used for irrigation are reported to be present in such small quantities that no documented cases exist where they have posed a potential health problem.

Even if wastewater to be used for irrigation is treated before application, the potential for microbiological or chemical contamination of air, soil and plants and possible health hazards to consumers, both human and animal, still exist. However, experience from Cyprus, the former Czechoslovakia, France, the former German Democratic Republic, the Federal Republic of Germany, Israel, Italy, Poland, Portugal, Ukraine and the United Kingdom suggests that the potential health effects of wastewater irrigation are minimal, provided some simple precautions are taken (see below).

The EU Urban Waste Water Treatment Directive, which required member states to establish a programme for its implementation by the end of 1993, regulates discharges from agricultural and industrial sectors as well as stipulating wastewater and sewage treatment requirements [13]. Although the directive is not directly concerned with the reuse of wastewater for irrigation, its implementation has clear implications for reducing the risk of adverse health effects from consumption of food crops irrigated with treated wastewater.

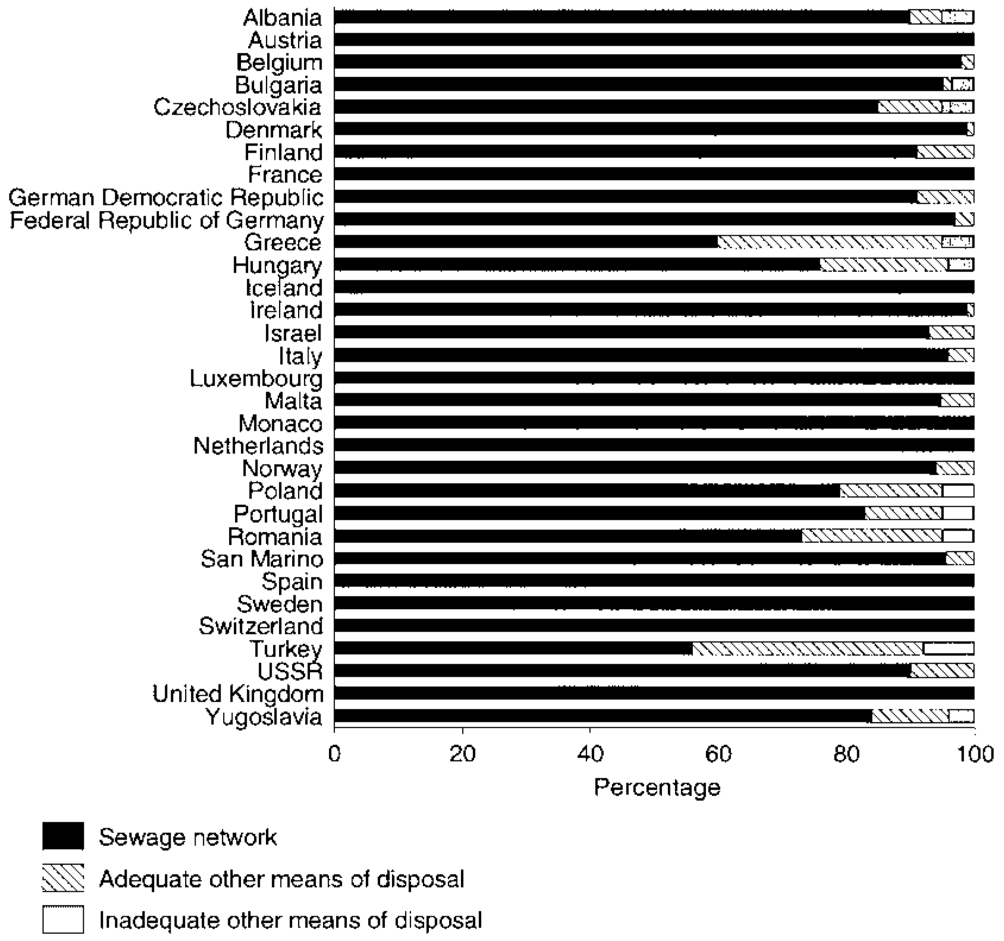
7.2 Exposure

7.2.1 Populations with inadequate sewage disposal or wastewater treatment facilities

Analyses made in 1980 at the beginning of the International Drinking Water Supply and Sanitation Decade showed certain deficiencies in the level of sewage and wastewater services provided in different countries. Moreover, a disparity was found between the services available to urban and rural areas. The results of the Water Decade indicate that a major effort is still needed in some European countries, first to provide urban areas with appropriate excreta disposal facilities, second to connect dwellings in peripheral urban belts to sewerage networks or other appropriate disposal facilities (e.g. a septic tank followed by a pipeline for the dispersion of liquid waste to the soil) and third to provide a large number of existing networks with appropriate treatment facilities to avoid the discharge of raw sewage into the aquatic environment.

Fig. 7.1 and 7.2 [14] present data for the late 1980s on populations served by sewage disposal networks and by other means of disposal (both adequate and inadequate) for urban and rural populations, respectively, in European countries. The percentage of "inadequate disposal" is generally much higher for rural than for urban areas.

Further disparities between countries be-



Source: WHO Regional Office for Europe *(14)*.

Fig. 7.1: Means of sewage disposal in urban areas, late 1980s

come apparent when assessing the level of sewage treatment after disposal through the sewerage network. There is wide variation among countries in this regard. In the late 1970s and early 1980s, existing plants were substantially improved to provide more advanced treatment. Primary treatment, normally designed to remove suspended material, was often improved to secondary treatment designed to remove oxygen-consuming materials and nutrients through biological action. Tertiary treatment involves the removal of substances such as phosphates and metals through chemical coagulation or adsorption. It has been reported that in Poland, for example, at least one third of sewage was discharged without any treatment. Countries such as Austria, Denmark, the Federal Republic of Germany, Luxembourg and Sweden enhanced their primary treatment with secondary treatment technology. By 1991, Norway, Portugal and Spain were building both primary and secondary treatment plants with advanced tertiary treatment occasionally added [15]. Fig. 7.3 presents data on the percentages of populations served by wastewater treatment in the European members of the Organisation for Economic Co-operation and Development (OECD) from 1970 to 1987, while Fig. 7.4 [14] shows the proportions of primary, secondary and tertiary sewage treatment in Europe in 1990.

The sewage system in the Czech Republic is in a much worse condition than the water supplies [16]. There are some 9700 settlements with around 2.5 million inhabitants without a sewage system, and about 2500

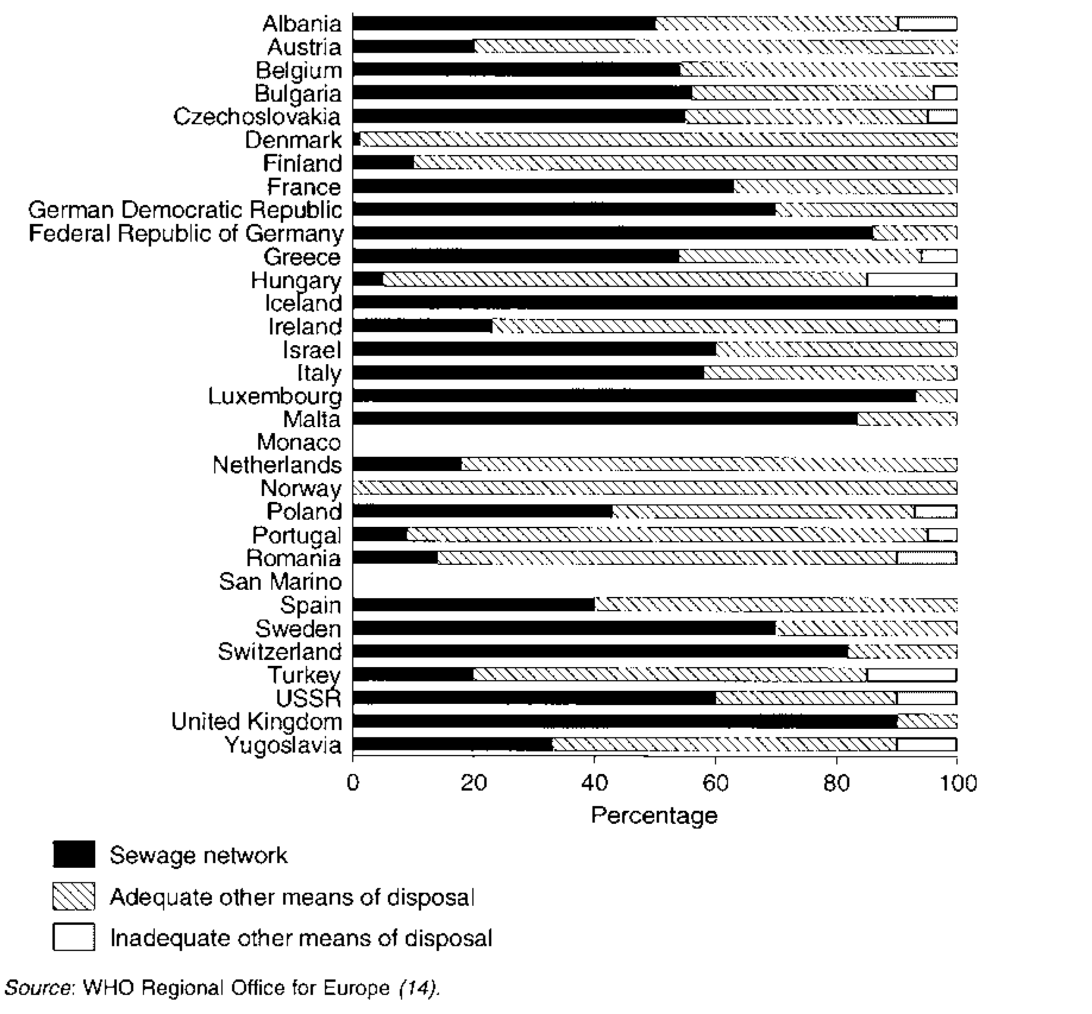
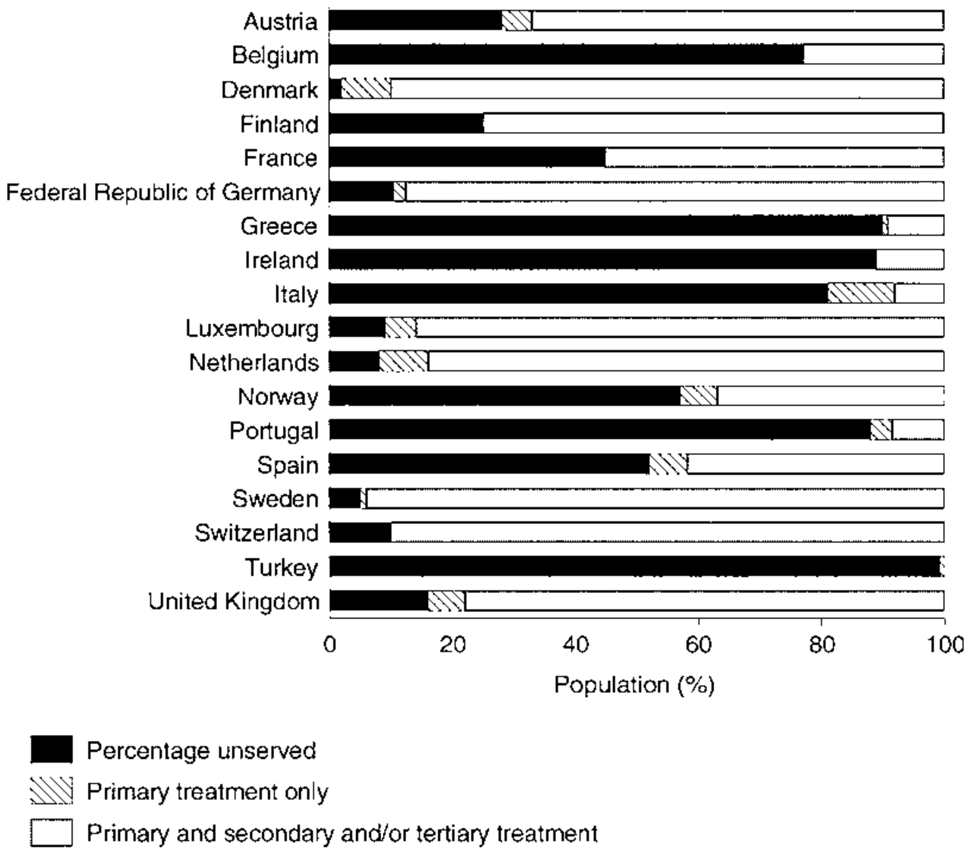


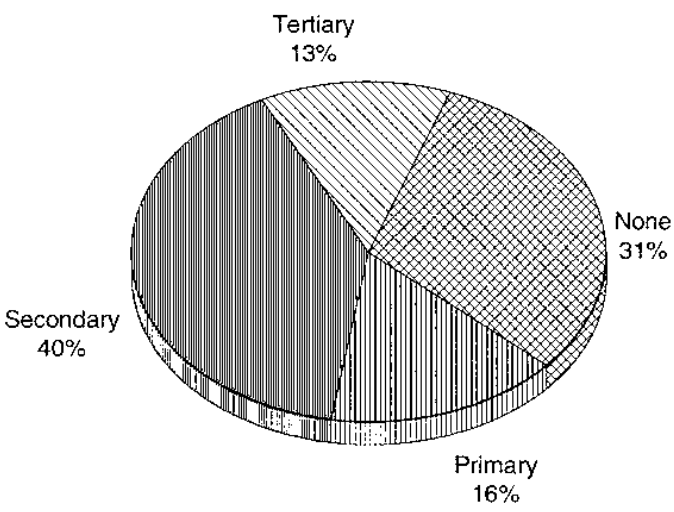
Fig. 7.2: Means of sewage disposal in rural areas, late 1980s

public sewage systems with no sewage treatment. Serious problems also arise with the handling of the sludge. In the case of the central sewage treatment plant in Prague the stabilized, fully processed sludge is released back into the water. In the Czech Republic



Source: Organisation for Economic Co-operation and Development *(15)*.

Fig. 7.3: Coverage and type of wastewater treatment, 1970–1987



Source: WHO Regional Office for Europe *(14)*.

Fig. 7.4: Types of sewage treatment in Europe, 1990

nitrogen, phosphorus, heavy metals and insoluble organics are not removed from wastewater and sewage water.

In Denmark, 93% of the population use common sewage facilities, leaving only 7% using individual facilities such as septic tanks [17]. The public sewage system in Finland serves 75% of the population, while parts of the rural population lack adequate sanitation [18].

Discharges of saline water from mines in countries such as the Czech Republic, Poland and Ukraine, and discharges with heavy BOD from pulp, paper and textile mills, can contaminate large rivers and parts of the Baltic Sea. Highly concentrated effluents from feedlots, dairy and pig farms and poultry units, discharged into neighbouring rivers, can markedly affect the quality of the river water. This is a particular problem in the CCEE and NIS with large-scale (state-owned) feedlots.

7.2.2 Exposure through recreational use

Guidelines for maintaining recreational water quality have been developed in a number of countries, including France, Israel, Spain and the United Kingdom. The quality of bathing water is also regulated in an EU directive [4]. Guidelines and standards are mainly based on the outcome of studies relating illness in swimmers with the microbiological quality of water degraded by faecal contamination, particularly from point sources such as sewage effluents.

The bacteria used most widely to indicate faecal contamination are faecal coliforms. It has been proposed that faecal streptococci should be used more often in addition to, or instead of, coliform bacteria. The reason is that streptococci survive better in marine water than do other faecal bacteria, and are thus better able to index the general risks from pathogens such as viruses and protozoa that are capable of long-term persistence [19] (see also Box 7.1).

Illness, then, is not related only to the measured numbers of faecal coliforms. D'Alessio et al. [20] reported that beach swimmers had a significantly increased risk of enteroviral illness as a result of direct transmission, in recreational water, of enteroviruses among the swimming population.

Microbiological contamination from non-point sources is usually related to animal faecal waste through urban, pastureland and forest run-off of storm water, especially to lakes and rivers. Calderon et al. [21] in the United States measured multiple bacterial in-

Box 7.1: The health effects of sea bathing. Results of the United Kingdom Randomized Clinical Trial Experiments [7]

Research method

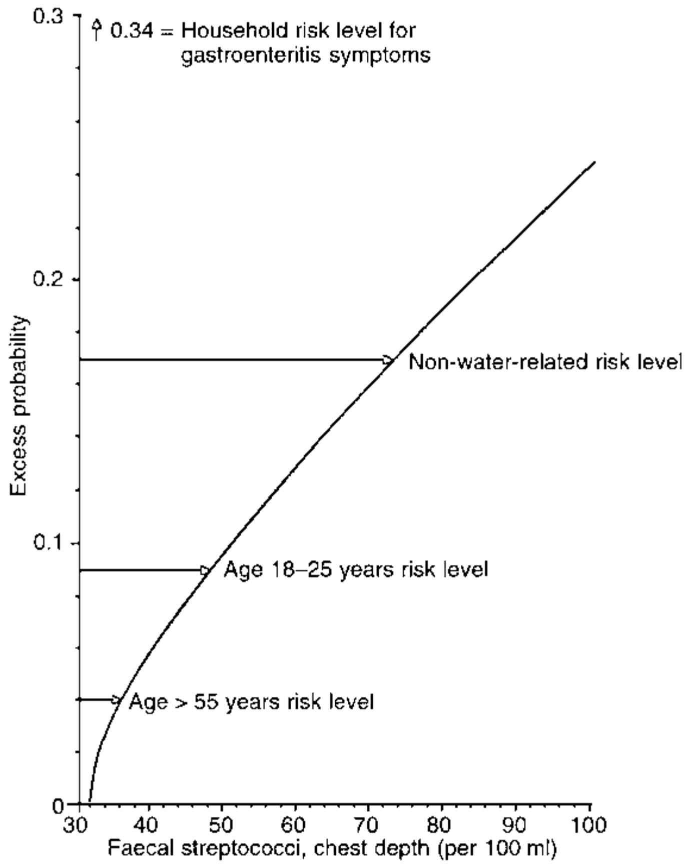
The research protocol was similar to that of a controlled clinical trial first suggested by WHO in 1972. This is the first time that a healthy volunteer experiment has been accomplished in the examination of the health effects caused by any exposure to environmental pollution.

A four-year study was conducted by the Centre for Research into Environment and Health, University of Leeds, at four seaside resorts in the United Kingdom. Each had passed the European Union's "imperative" standards [4] in the previous bathing season. Some 1305 volunteers were randomized into bather and non-bather groups on reporting to the beach. Extensive questionnaire interviews were conducted before and after exposure, together with associated clinical and medical examinations. The four-year study involved some 500 water samples analysed for bacterial and viral indicators of sewage pollution, which allowed individual estimates of "exposure" to be attributed to each bather.

Box 7.1: The health effects of sea bathing. Results of the United Kingdom Randomized Clinical Trial Experiments [7]

Results

1. Categorical and multiple logistic regression procedures were used to identify relationships between water quality and gastroenteritis, and to assess the validity of pooling the data from all four studies.
2. A significant dose–response relationship was identified between faecal streptococci (per 100 ml) measured at chest depth and gastroenteritis ($P < 0.001$). The relationship was independent of the site studied.
3. Non-water-related risk factors did not confound the relationship, and no significant interaction between confounders and the water quality index was found.
4. The threshold of risk was objectively defined as 32 faecal streptococci per 100 ml at chest depth. The resulting model ($P = 0.012$) is shown below.



Policy implications

1. The model allows prediction of the probability of gastroenteritis (i.e. the risk of illness) at a given faecal streptococcal level. This probability can be compared with the risk of illness attributable to the other risk factors such as household illness.
2. The results clearly indicate that the current mandatory standards specified in Directive 76/160/EEC [4] may not be appropriate. Consideration should be given to changing both the recommended sampling depth and the microbial indicators used.
3. The results provide the necessary scientific information for the construction of standards or objectives for marine recreational water as used by "normal" adult bathers.

dicators of water quality in a small lake and the health status of volunteer swimmers and non-swimmers. Results showed that gastrointestinal illness was associated with the number of swimmers per day, and with densities of staphylococci rather than the more usual faecal indicator bacteria. The study also stressed that the bacteriological indicators used to measure water quality cannot distinguish between human and animal faecal contamination.

Results from white water canoeing studies in the United Kingdom indicate significant differences in reported symptom rates between canoeists using a more polluted site receiving sewage effluents and those using a pristine upland channel with very low concentrations of bacterial indicators and enteroviruses [22]. Placid water canoeing studies have produced less dramatic results, probably because of the lower risk of water ingestion compared with the white water variant in which rolling is common.

In the Mediterranean area of some 130 million inhabitants, a further 100 million tourists visit the area annually [3,23]. As the sea constitutes a major recreational amenity, especially in the hot summer months, and municipal sewage may not be adequately treated before release to the sea, the potential for illness is considerable. Saliba & Helmer [3], using regression lines for gastrointestinal symptoms and microorganism contamination, concluded that some 25 000 to 40 000 people would be affected per million population. Even higher estimates have been made by European tourist authorities, according to which around 40% of tourists at Mediterranean beach resorts become ill, although some illness may be caused by consumption of contaminated food (including shellfish from contaminated coastal areas) or unsafe drinking-water. The magnitude of the problem still has to be established.

Recent work in the United Kingdom has examined the association between sea bathing and reported illness. Balarajan et al. [24] conducted a study which used self-reported illness from a sample of people using a beach. They reported significantly more gastrointestinal illness in bathers than in non-bathers, and non-significant increases in eye, ear, nose, throat and respiratory problems in the period following the use of the beach (see also Box 7.1).

In Estonia, release of untreated or inadequately treated sewage is a major problem that resulted in 1989 in the closure of 10 of the 24 public beach areas, mostly on the Baltic coast. In Lithuania, too, sewage and industrial effluents have polluted the Baltic coastline to the north of the outflow of the Curonian Lagoon, into which the contaminated river system flows; beaches closest to the outflows are closed early in the season to avoid outbreaks of waterborne infectious diseases. Around 50% of water samples failed to meet national standards for microbiological contamination. In Latvia, sewage and industrial pollutants have led to the closure of beaches at Jurmala, one of the prime summer recreation areas on the Baltic coast. Bathing has also been prohibited in contaminated rivers.

7.2.3 Production and consumption of raw foods irrigated with water of insufficient quality

Domestic and industrial wastewater constitutes the most important source of water of marginal (i.e. insufficient) quality that may be used for irrigation in Europe [12]. The use of water of marginal quality for crop production in Europe is not new. In Greece, sewage effluents were used for irrigation 2000 years ago. Farming with sewage was a common practice in Germany as early as the seventeenth century, and continued in the United Kingdom until the late nineteenth century.

Throughout Europe, countries that treat water to be used for irrigation do so by a wide variety of methods using a range of technologies, with differing degrees of effectiveness in removing microbial pathogens [12]. As already indicated above, WHO has produced guideline levels for microbial contamination according to the intended use of treated wastewater [11]. In all such cases, and of course in cases where untreated water is used for irrigation, the potential health hazard from consumption of contaminated crops remains a matter of concern.

Considerable experience exists in Europe on the use of water of insufficient quality for irrigation. Such uses are mostly local and reliable documentation often does not exist, or if data do exist they are not readily available. On the basis of returns to a questionnaire survey of European countries carried out by the Food and Agriculture Organization of the United Nations (FAO) in 1986, the following synthesis is presented on some European practices.

In the United Kingdom, spray irrigation of pastures for disposal of abattoir effluent has been practised successfully. Effluents containing animal blood are used and this does not appear to present any environmental or agricultural problems. Good growth of new grass can be observed [12].

Germany has had considerable experience with sewage farms and irrigation using wastewater. Because of land becoming overloaded with wastewater, farming with sewage has declined radically during the current century. The use of wastewater for irrigation, however, remains a thriving practice. One of the longest operational and best documented cases of the use of wastewater for plant production in Europe is at Brunswick, where some 44 500 m^3 of wastewater per day is used for irrigation in a scheme that has been operating since 1954. A nearby city, Wolfsburg, has had a similar but smaller operation since 1942, whereby 16 000 m^3 of wastewater is used daily for irrigation. Since after irrigation almost tertiary effluent quality is achieved, regardless of the degree of pretreatment (Kayser, R., unpublished data, 1985) groundwater and surface water contamination has not been a problem at these two sites. Irrigation has the effect of reducing BOD and of removing nutrients such as phosphate and nitrate from the effluent.

In the former German Democratic Republic, higher yields of cereals, sugar beet, potatoes and fodder crops were obtained when these were irrigated with wastewater.

In France, reuse of treated wastewater is encouraged. Its major use for agriculture is in small rural communities. On the Mediterranean island of Porquerolles, for example, wastewater is used to irrigate citrus crops, other fruit trees such as apricot, peach and plum, and cypress trees; treated wastewater now represents nearly 60% of the irrigation water demand.

In Portugal, research into the use of primary and secondary effluent wastewater for the production of sorghum, maize and sunflower at Evora has shown that productivity can be equivalent to that obtained with the use of tertiary treated water. Lettuces have also been grown under spray irrigation with primary and secondary effluents.

In Cyprus, it is estimated that 30–40% of spring potatoes, fodder, industrial crops, olives and citrus fruits are irrigated with water of marginal quality. In Israel, 23% of the required irrigation of cotton, citrus, field crops and fruit orchards is supplied by such water. Under existing Israeli regulations, vegetables that are eaten uncooked cannot be irrigated with wastewater unless special permission is obtained from the Ministry of Health, which specifies the effluent quality required [12].

Some parts of Italy now have advanced biological treatment systems, which not only produce water suitable for irrigation but also water consistent with drinking-water standards.

In the former Czechoslovakia, irrigation with wastewater containing high concentrations of nitrogen, phosphorus, potassium, sodium and magnesium from a starch factory is reported to have increased the production of clover and grass. A major effort is also being made in Poland to utilize treated wastewater for plant production. It is expected that 10 million hectares will be irrigated with such low quality water by the end of the century. The Polish experience so far has shown that, despite fears of resultant nutrient deficiency or salinity problems, soil fertility as measured in terms of plant yields has actually improved [12].

There is very limited information available from the countries of the former USSR on the use of treated wastewater for irrigation. In Ukraine, however, irrigation with partially treated sewage effluents has produced marked increases in soybean and maize yields, and it has been calculated that wastewater could provide 15–20 % of all irrigation water requirements [12].

No cases of gastrointestinal or other health disorders related to the consumption of these crops by humans or animals have been attributed to the use of wastewater.

7.3 Causes of Pollution

With much industrial wastewater being released untreated to rivers, the load of heavy metals and organic compounds is high. Increased use of fertilizers and pesticides to achieve high production has often resulted in contamination of surface water and groundwater. Although the objectives of environmental protection are different in rural and urban areas, in both cases it is crucial to reduce the pollutant load to water as well as to soil and air.

7.3.1 Wastewater

Inadequate sewerage coverage, poor maintenance of sewerage networks and treatment plants, and often a total lack of industrial wastewater treatment pose a serious risk to human health, particularly in the CCEE and NIS. Such an example is Albania, where the country's only industrial wastewater treatment plant was shut down in 1992. Heavy metals from old 1930s industrial techniques now load the nearby rivers.

In Turkey, also, many factories have almost no water treatment facilities, particularly in areas where rapid industrialization has taken place. Effluents from textiles, metals from industrial processes, and residues from food processing have polluted rivers such as the Ergene [25].

In Estonia in 1988, around 3163 million m^3 of wastewater was produced, almost all of which was discharged into surface water bodies. About 84 % of it does not need purification. Of the wastewater that needs purification, i.e. some 16 %, around half is inadequately treated or not treated at all [26]. Consequently, the rivers in north-east Estonia have been contaminated with industrial pollutants such as phenols.

Around 571 million m^3 of wastewater is discharged annually in Latvia, of which some 115 million m^3 receives incomplete treatment. Some of the works lack biological treatment, while chemical treatment does not exist. Consequently, levels of phenols, oils and other chemicals exceed permissible levels in rivers receiving the discharges. The city of Riga, which produces around 164 million m^3 of wastewater annually, had no treatment equipment until the autumn of 1991, when less than half of the city's wastewater was treated.

Untreated wastewater from the plating industry in St Petersburg is unsatisfactory as it leads to particularly high concentrations of heavy metals such as chromium and copper in the sludge. With around 600 industrial enterprises and 680 agricultural enterprises located around Lake Ladoga, emissions of largely untreated wastewater have polluted the lake with a variety of organic and inorganic substances.

Urban discharges to rivers, particularly of sewage, are widely reported across many European countries.[a] In addition, as water pipes and sewage pipes lie side by side and often leak badly, sewage can be sucked into drinking-water pipes. These obvious health hazards and the long lead times required to construct new facilities and repair the old, and their costs in relation to gross national product, clearly indicate that in many CCEE and in the NIS a reduction in risk is some years away. Taking Hungary as an example, the cost of necessary sewage and wastewater

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

treatment is estimated at about US $5 billion[a] [27].

Inadequacies in infrastructure, monitoring, numbers of professionals and laboratory staff, and laboratory facilities and equipment hinder immediate remedial action in many of these countries. Another major goal is to improve standard setting and enforcement procedures. Upgrading existing legislation and discharge regulations are further priorities.

7.3.2 Pollution from non-point sources

Pollutants from non-point sources have proved more difficult to control than those from point sources, and constitute a widespread problem in the Region. Those causing most concern are agricultural chemicals applied to the land, such as nitrate fertilizers and pesticides (although in certain areas animal husbandry waste may also be a problem if improperly managed). Their diffuse application means that they permeate soils and are transported by natural water movements to surface water and groundwater. Control is possible only by restricting their use or by altering agricultural practice to minimize leaching from the area of application. These substances have the potential to affect human health (see Chapter 6). For surface water, the results of control may be relatively rapid but leaching from soil may continue for some time after application ceases. Groundwater is of special concern, because in many areas the slow recharge time in aquifers means that it may take many years for the results of restrictions to become apparent.

Overuse of fertilizers has resulted, in some countries, in alternative sources of water being used for infants.

Problems related to dissolved solids, iron, fluoride and arsenic can occur in groundwater in different areas. Acidification of soils also increases the dissolved metal content of water and raises the concentrations of mercury, cadmium and lead, especially in areas where soils are weakly buffered.

Pollution of both surface water and groundwater may arise from landfills and waste dumps. The source of pollution may be localized, but the strategies for control may have to be either preventive (at the planning stage) or longer-term, since both remedial action and treatment may be expensive and complex (see also Chapter 8).

A reduction in fertilizer application to agricultural land in watersheds, and the removal of nitrate and phosphate from wastewater, can markedly reduce inputs to rivers and lakes. Tourist-related pollution can also add to nutrient levels. There are many examples of attempts to reduce nutrient inputs into lakes and thus remedy eutrophication and the consequent algal blooms, which reduce both amenity and drinking-water potential as well as damaging natural ecosystems. Excellent examples from Austria and Switzerland can be taken as models for future action. Lake Balaton, one of the largest shallow lakes in Europe and a major recreational area for Hungary, has undergone major eutrophication; nutrient loads increased by an order of magnitude between 1960 and 1980 [27]. Development of control measures to reduce eutrophication include improving phosphorus precipitation and constructing sewage treatment plants. Although the deterioration in water quality has been stopped, no improvement has yet been seen. With the current budgetary problems, further installation of treatment works has been delayed.

Extensive blooms of various species of dinoflagellate algae have been reported in the North Sea and in coastal waters around Denmark, Ireland, Norway, Sweden and the United Kingdom [28]. Many of the blooms are thought to arise from coastal water eutrophication, although the reasons are still the subject of debate. Many of the blooms are associated with the death of marine fauna. Also, a number of dinoflagellate species are consumed by shellfish, which ac-

[a] 1 billion = 10^9.

cumulate their toxins, and this can cause such human illnesses as paralytic shellfish poisoning, neurotoxic shellfish poisoning and diarrhoeal shellfish poisoning (see also Chapter 9). Direct dermal contact with toxins from marine dinoflagellates can also cause acute dermatitis [29].

The Baltic Sea receives each year about 80 billion m^3 of water from Poland, of which around 4.1 billion m^3 is wastewater discharged from cities and industrial areas [30]. Around 38 % of the total phosphorus and 37 % of the total nitrogen load from Poland is discharged to the Baltic Sea. The mean share of industrial water in municipal sewage is 30 %. A specific Polish problem is the saline wastewater discharged to rivers from the coal mines of Upper Silesia: on average around 3 million tonnes per year. Waste of this sort obviously reduces the quality of water in the rivers, with consequent limitations on its use.

7.4 Trends

7.4.1 Improvements in networks and treatment

During the next ten years, sanitation and sewage treatment will continue to be important issues in Europe. The aim of the countries participating in the Water Decade activities in Europe was to ensure that all households were connected to the sewerage network in urban areas and that rural households had at least adequate disposal facilities and hygienic latrines. The projection in 1990 was that all Europeans would have at least hygienic pit latrines by the year 2000. The question of whether such coverage will bring about improvements in water quality through waste control is entirely different. Sanitation is primarily concerned with limiting local exposure to pathogens by diverting wastewater through networks or other means to another place. Fig. 7.5 shows a parallel between income and adequate sanitation in rural areas, with a striking cut-off at a gross national product per head of population of US $ 10 000. The same pattern is true for urban areas, but the degree of urban coverage in the lower-income countries is better than in rural areas.

It seems unlikely that sufficient investment can be made over the next ten years for sufficient treatment of wastewater to minimize the introduction of pathogens and chemicals into the environment and the consequent risks to human health and ecosystems.

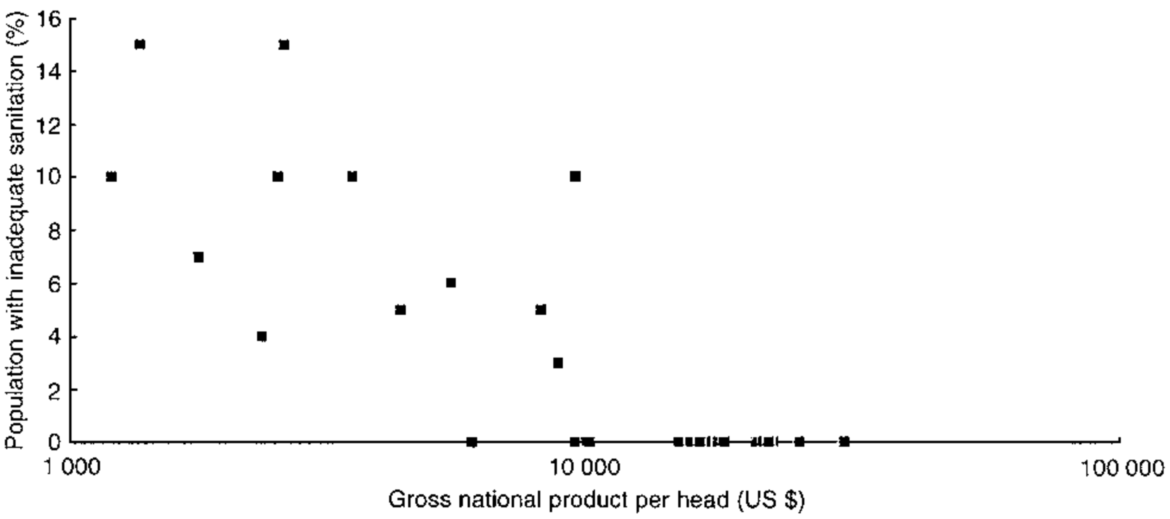
Some parts of Europe are advanced in sewage collection and treatment, particularly in the north and west. In southern Europe, coverage has increased but the quality of treatment needs to be improved. In 1990, the proportions of sewage receiving treatment in Europe were approximately as follows: no treatment 31 %; primary treatment 16 %; secondary treatment 40 %; and tertiary treatment 13 % (Fig. 7.4) [14]. Such percentages give only a vague idea of the potential effect on environmental health. The size of the community and of the receiving waters will determine what level of treatment is most suitable for any particular situation.

Poland is making serious efforts to reduce contamination of rivers and the Baltic Sea by constructing some 8000 treatment plants with a capacity of 2.3 million m^3 sewage per day. The system will involve approximately 35 000 km of municipal sewerage and 50 000 km of rural sewerage. With the present rate of implementation, a 50 % reduction of input into the Baltic Sea will take around 15 years to achieve [30].

The construction of major sewage treatment plants on the east coast of Norway has led in recent years to the improvement of the water quality in the Oslofjord [31].

Animal farming wastewater is subject to regulation in some countries, particularly in the EU, but appropriate treatment and management will probably be slow to develop.

In many countries where financial resources are limited, sewage treatment will be determined by environmental health prior-



Source: WHO Regional Office for Europe *(14)*.

Fig. 7.5: Income and sanitation in rural areas

ities and by cost recovery constraints. Treatment, along with pollution control, must be considered as part of a system of environmental health protection.

As network coverage increases and treatment improves, the issue of sewage sludge will increase in importance. Waste in water does not disappear but is converted, to a large extent, into other forms. The sheer volume of sludge will be an increasing problem, with some countries having limited options for land disposal, especially if agricultural practices already contribute to high nitrate levels in surface water and groundwater. If industrial and domestic waste is treated together, the resultant sludge may contain toxic chemicals that make it unsuitable for land disposal.

7.4.2 Reduction of pollution

Strategies for reducing pollution from wastewater and diffuse sources of contamination depend on whether the waste enters surface water directly or via treatment works. Control of chemical pollution will hinge on minimizing industrial input from point sources. Codes of practice and an EU directive on pollution caused by certain dangerous substances discharged into the aquatic environment [32] are the basis for the reuse of wastewater, recovery of chemicals and effective treatment.

A number of surveillance programmes have been carried out in the fjords and coastal areas of Norway since the early 1980s to identify specific wastewater needing treatment. A process technology change at a nickel refinery reduced emissions to the Kristiansand Fjord, while placing industrial waste in a mountain tunnel reduced emissions from three large smelters to the Sörfjord by around 90%. A new cleaning technology installed in 1990 has reduced emissions of chlorinated organic compounds from a magnesium plant into the Greenland fjords; discharges of polynuclear aromatic hydrocarbons (PAHs) have been reduced from several tonnes per year to a few hundred kg per year. Similar reductions in PAHs to the Sunndals Fjord have been recorded from a large aluminium smelter following wastewater treatment [31].

There are many areas of Europe where appreciable reductions in industrial chemical pollution will take several years, and where aid and transfer of technology will be needed to achieve that reduction.

In addition to hazardous substances as such, waste disposal technology is of obvious importance for pollution control and remedial action in degraded areas. Agricultural practices employing intensive animal farming and use of chemicals will come under more widespread scrutiny throughout the Region. Planning permission for agricultural activities should become more widespread.

Biological oxygen demand is also an important consideration in the reduction of pollution, particularly in smaller urban rivers, even if waste is treated. Nitrate concentrations are one of the most pervasive problems in the Region, both east and west; effective control of agricultural practices will be difficult to implement, and in a number of areas there are unlikely to be improvements in groundwater in the next few years. Identification of vulnerable areas and the introduction of codes of practice, source protection and effective regulation will be the best means of avoiding future problems.

7.4.3 Monitoring

The present status of monitoring and data collection is a substantial barrier to proper evaluation of wastewater, its implications for human health and the effectiveness of pollution control. Current evaluations are of significant areas and are based on representative data or case studies. For small-scale local management some countries will need far better facilities, particularly for analysis.

Epidemiological studies of disease due to wastewater are difficult to carry out. More information on freshwater systems is needed, and more insight into the degree of exposure from recreational activities in fresh water, particularly in eastern Europe.

The collection of data on sanitation coverage is relatively good, but substantial improvements in data collection and analysis must be made in parallel with improvements in treatment technology if control is to be effective. High priority should be given to monitoring and data quality, with the results presented in a form appropriate for use in water and environmental health management. Interpretation of the data, including risk implications, should also be considered. These are not universal priorities at present, often because of financial constraints.

Monitoring of effluents should become more widespread in order to evaluate compliance with regulations. Monitoring of effects on the ecosystem is to some extent in place, particularly with respect to biological quality criteria and classification.

There is considerable scope for international cooperation on technology transfer and for developing human resources in monitoring and data presentation.

7.4.4 Management

The coming ten years will see the need for developing and expanding local management at appropriate levels, with effective communication at the policy-making level. There is a need for intersectoral cooperation in planning, infrastructures (e.g. water supply, sewerage and sewage treatment works), agricultural practices and pollution control. Such arrangements are in place in many areas but are not effective in others.

Europe has good human resources but management cannot always be effective because of poor political and institutional motivation. In some areas the problems are so great that results will be slow to be seen. Environmental health is often out of phase with economic development, and international cooperation can play an important part in effective integration.

Management of surface water and wastewater quality is of increasing priority from the point of view of human health, freshwater quality and marine ecosystems. Cooperation on managing international water systems will further develop in the next decade, particularly for rivers and seas in the east of the Region such as the Danube and the Black Sea.

Management tools such as quality objectives, industrial guidelines, discharge permits and cost recovery options must be used more widely. However, these can only develop in appropriate institutional frameworks. Management should be able to apply common policies and standards, as appropriate, to local conditions.

7.5 Conclusions

Sanitation and the quality of wastewater and surface water are major concerns in Europe at present, and their importance will increase in the next ten years as requirements for more effective health protection and better environmental quality rise on the political agenda. The European Region is characterized by high population densities in cities and urban industrial areas, where surface water can be seriously contaminated, and in rural areas where agricultural pollution over many years has contaminated rivers and groundwater. Contamination of surface water by various types of waste gives cause for concern on two major counts: the quality of raw water (which may have a direct effect on human health through its use as drinking-water or indirectly through effects on aquatic ecosystems) and bathing water quality.

In general, the proportion of European populations served by adequate sewage treatment facilities is smaller than that served with safe drinking-water. Improvements have been made over the last 20 years, and it is anticipated that adequate sanitation will be available throughout the Region by the end of the century. It does seem, however, that progress in providing a suitable degree of treatment to protect human health and to meet quality objectives is slower. Many water bodies, particularly those in urban areas, are under stress because of excessive amounts of wastewater that has received too little or no treatment. In addition to the risk of microbial infection from direct contact with surface water, raw water quality is degraded and increased treatment of drinking-water is required to meet health standards. Microbial and viral illnesses may result from bathing in contaminated water, but the whole range of chemical and microbial contaminants in wastewater and surface water is of concern for exposure through drinking-water and, to a lesser degree, irrigated crops.

There is continuing difficulty in the Region in assessing the links between exposure and health effects on a large scale. The presence of particular microbial indicators is used to indicate the suitability of water for bathing, but the success of such measures in improving health protection is difficult to evaluate. Some countries lack an effective monitoring network, especially several of the CCEE and NIS, but the exploitation of water resources is difficult in many countries because of pollution by sewage.

Control of pollution of surface waters raises many of the same issues as for the quality control of drinking-water. Pollution prevention, codes of practice and planning controls are crucial for effective health and environmental protection, particularly for agricultural activities that give rise to substantial diffuse sources of pollution and are traditionally less subject to planning restrictions. Many countries regulate pesticide use, and there is a growing tendency for regulations or guidelines on fertilizer use, planning controls for agricultural waste, and land-use controls to protect vulnerable water sources such as the recharge zones of aquifers. Eutrophication of lakes and acidification of rivers and lakes is especially pronounced in eastern Europe, arising both from uncontrolled agricultural practices and industrial activities, including acid deposition from atmospheric pollutants. These effects have also been seen in western Europe, particularly a decade or so ago, but rigorous control of agricultural practices and industrial emissions has reduced or even eliminated them in several areas.

Heavy investment is required in the CCEE and NIS to build new urban sewage treatment plants, not only for national or local reasons but also because of the need to protect international rivers and the enclosed seas. These requirements will place heavy burdens on those countries compared with western Europe, where capital expenditure for treatment plants has been spread over long periods of time. To minimize cost and maximize benefits in the short term, protection of human health has priority, though the wider environmental issues cannot be ignored. At the same time, a reduction in industrial pollutants reaching wastewater should be sought in order to avoid the cost of their removal. Expenditure on wastewater treatment and reuse has to be encouraged in the Region, and placed in the perspective of the socioeconomic development of the countries concerned.

Related issues that will need increasing attention, in addition to those already discussed, are emergency measures for the protection of surface water and groundwater, and the development of suitable policies for tourism and tourist health.

Development in the protection of surface water and the management of wastewater will only be achieved within a wider policy for the development of infrastructures, human resources, institutional frameworks and international cooperation.

References

[1] *Quality of bathing water 1991.* Brussels, Commission of the European Communities, 1991 (Report EUR 142 0EN).

[2] Cabelli, V.J. et al. A marine recreational water quality criterion consistent with indicator concepts and risk analysis. *Journal of the Water Pollution Control Federation*, **55**: 1306–1314 (1983).

[3] Saliba, L.J. & Helmer, R. Health risk associated with pollution of coastal bathing waters. *World health statistics quarterly*, **43**: 177–185 (1990).

[4] Council Directive of 5 February 1976 concerning the quality of bathing water (76/160/EEC). *Official journal of the European Communities,* **L31**: 71–75 (1976).

[5] Mujeriego, R. et al. Recreation in coastal waters: public health implications. *In*: *VIèmes Journées d'Etudes sur les Pollutions Marines en Méditerranée, Cannes, 2–4 décembre 1982.* Monaco, Commission internationale pour l'exploration scientifique de la mer Méditerranée, 1983.

[6] Foulon, G. et al. Etude de la morbidité humaine et relation avec la pollution bactériologique des eaux de baignade en mer. *Revue française de sciences de l'eau*, **2**:127–143 (1983).

[7] *The health effects of sea bathing. Results of the United Kingdom Randomized Clinical Trial Experiments.* Leeds, Centre for Research into Environment and Health, University of Leeds, 1994.

[8] Haralanova, M. & Ivanova, O. *Environment and health in Bulgaria.* Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 229).

[9] *National environmental outlook 1990–2010.* Bilthoven, National Institute of Public Health and Environmental Protection, 1992.

[10] World Resources Institute. *World resources 1992–93: towards sustainable development*. Oxford, Oxford University Press, 1992.

[11] Geneva, World Health Organization, 1989. *Health guidelines for use in agriculture and aquaculture. Report of a WHO Scientific Group*. Geneva, World Health Organization, 1989 (WHO Technical Report Series No. 778).

[12] Arar, A. & Biswas, A.K. Aspects of marginal quality water use for plant production in Europe. *In*: *International Conference on "The changing face of Europe: disasters, pollution and the environment".* Bradford, University of Bradford, 1991.

[13] Wright, P. The impact of the EC Urban Waste Water Treatment Directive. *Journal of international water and environmental management,* **6**: 675–681 (1992).

[14] *International Drinking Water Supply and Sanitation Decade: final evaluation report (Europe only).* Copenhagen, WHO Regional Office for Europe, 1990 (document EUR/ICP/CWS 011 (1)).

[15] *Environmental data compendium 1991.* Paris, Organisation for Economic Co-operation and Development, 1991.

[16] Ministry of the Environment of the Czech Republic. [*Environment of the Czech Republic.*] Prague, Academia, 1991.

[17] Thomsen, A.S. Environment and health in Denmark. *In*: *Environment and health in the Baltic countries*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 213), pp. 25–31.

[18] Nevalainen, A. Environment and health in Finland. *In*: *Environment and health in the Baltic countries*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 213), pp. 49–55.

[19] Dufour, A.P. *Health effects criteria for fresh rec-*

reational waters. Cincinnati, US Environmental Protection Agency, 1984 (Report EPA-600/1-84-004).

[20] D'Alessio, D.J. et al. A study of the proportion of swimmers among well controls and children with enterovirus. *American journal of epidemiology*, **113**: 533–541 (1981).

[21] Calderon, R.L. et al. Health effects of swimmers and non-point sources of contaminated water. *International journal of environmental health research*, **1**: 21–31 (1991).

[22] Fewtrell, L. et al. Health effects of white-water canoeing. *Lancet,* **339**: 1587–1589 (1992).

[23] Stanners, D. & Bourdeau, P. *Europe's environment: the Dobris assessment*. Luxembourg, Office for Official Publications of the European Communities, 1995.

[24] Balarajan, R. et al. Health risks associated with bathing in sea water. *British medical journal,* **303**: 1444–1445 (1991).

[25] *Environmental profile of Turkey*. Ankara, Environmental Problems Foundation of Turkey, 1989.

[26] Uibu, J. et al. Environment and health in Estonia. *In*: *Environment and health in the Baltic countries*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 213), pp. 43–47.

[27] Somlyody, L. Water quality management in Hungary: past experiences and future needs. *In*: Alcamo, J., ed. *Coping with crisis in eastern Europe's environment*. New York, Parthenon, 1992, pp. 143–166.

[28] Mahoney, J.B. et al. Blooms of a dinoflagellate *Gyrodinium* cf. *aureolum* in New Jersey coastal water and their occurrence and effects worldwide. *Journal of coastal research*, **6**: 121–135 (1989).

[29] *Aquatic (marine and freshwater) biotoxins*. Geneva, World Health Organization, 1984 (Environmental Health Criteria No. 37).

[30] Halat, Z.M. *Environment and health in Poland*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 229).

[31] Dybing, E. Environment and health in Norway. *In*: *Environment and health in the Baltic countries*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 213), pp. 69–79.

[32] Council Directive of 18 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (76/464/EEC). *Official journal of the European Communities,* **L129**: 12–17 (1976).

Chapter 8
Solid Waste

8.1 Introduction

Owing to economic development and increased consumption, the quantity of waste produced worldwide has grown steadily in recent decades. The public's awareness of the related potential hazards to human health and to the environment has also increased. Public concern has grown dramatically during the last two decades, primarily spurred by numerous instances of contamination of groundwater and soil caused by improper waste treatment and disposal. In addition, the high population density in much of the European Region causes growing difficulties in siting new facilities far from residential areas and from possible sources of drinking-water.

This chapter gives an overview of the dangers posed by hazardous and non-hazardous waste to environmental health. It uses the definition of environmental health in the European Charter on Environment and Health [1] and thus considers effects on wellbeing as well as health.

8.1.1 Definitions

Countries still use many different definitions of waste and waste categories. For example, the same category of waste can be described as hazardous, chemical, special, poisonous, toxic or difficult. Countries differ both in the method of definition and in the range of waste included.

Nevertheless, countries have tried to harmonize their definitions, most importantly in the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal [2] and the European Union (EU) directive on hazardous waste [3]. The latter defines hazardous waste as that:

- included in any category contained in a scheduled list, such as wood preservatives, pharmaceutical substances, polychlorinated biphenyls; or
- derived from a certain specified source or process, such as used filters or incineration; and
- showing one or more defined properties that renders it hazardous (described as, for instance, harmful, toxic, carcinogenic, infectious or ecotoxic).

Because this definition is comprehensive enough to include most types of waste that could present a hazard to human health or to the environment, it is used in this chapter. It should be noted, however, that the analytical procedures to detect the presence of some of the hazardous properties of waste are not yet agreed within the EU.

Non-hazardous waste includes municipal waste and all waste not presenting the characteristics listed above (such as that resulting from demolition, packaging and other commercial activities, and sewage sludges not contaminated by hazardous compounds).

However, certain waste substances that are not hazardous in themselves may become so in particular situations. For instance, municipal solid waste may pose a health hazard if inadequately collected or disposed of. Household waste left as piles of rubbish can contribute to an increase in the number of rats, which are carriers of pathogens as well as vectors of leptospirosis, and cockroaches and flies, which carry most excreted pathogens.

This chapter does not cover all types of waste. Radioactive waste is discussed in Chapter 12, and wastewater in Chapter 7.

8.2 Waste Production

Although accurate information about the production of waste in the European Region is lacking, some assessments can be made using data from the Organisation for Economic Co-operation and Development (OECD) [4] and those gathered by WHO through the Concern for Europe's Tomorrow protocol (Fig. 8.1). Accordingly, the Region produces an estimated total of more than 2.6 billion[a] tonnes of waste per year, or some 7.3 million tonnes per day. This annual figure includes 220 million tonnes of municipal solid waste, 980 million tonnes of industrial waste (of which hazardous waste is estimated to comprise 120 million tonnes), about 1 billion tonnes of agricultural waste and nearly 450 million tonnes of other waste (including mining waste, sewage sludges and demolition waste).

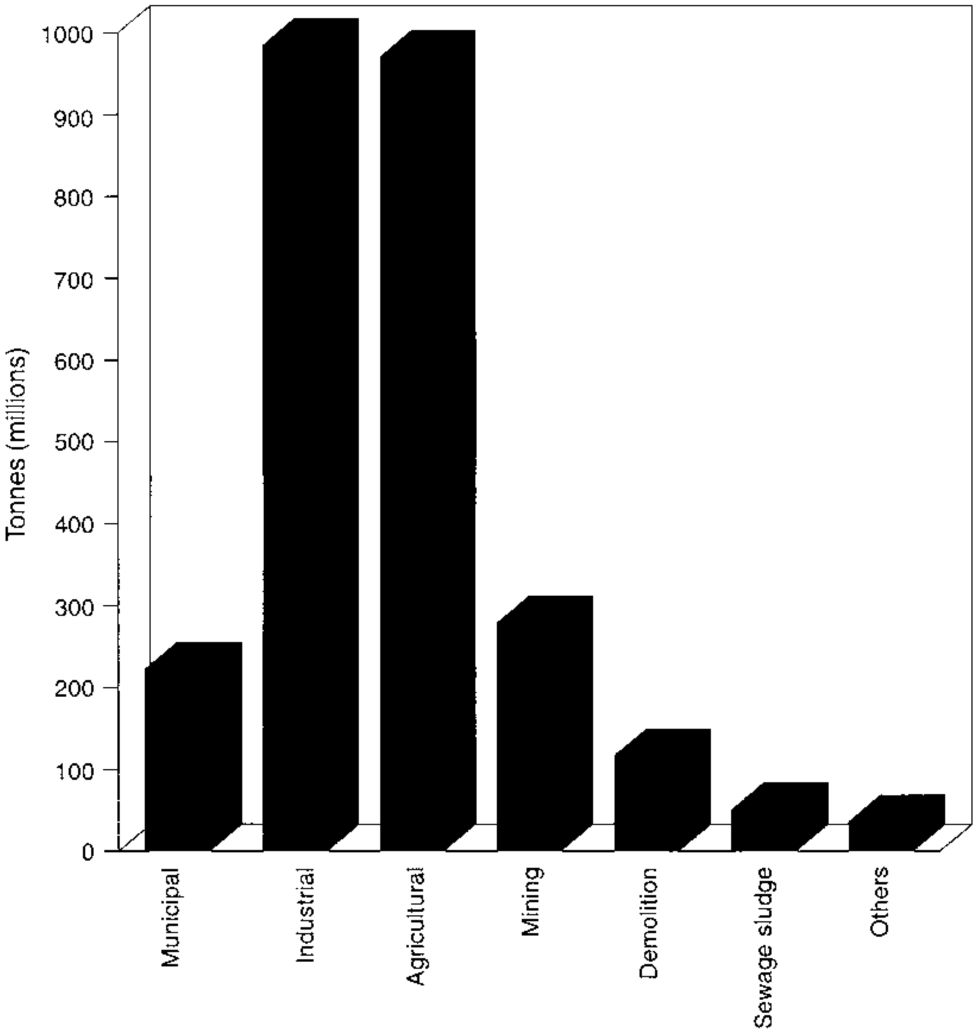
8.2.1 Municipal waste

Municipal solid waste constitutes 8 % of the total amount of waste generated in the Region, not including the NIS. In general, this category includes household waste as well as similar waste from small commercial and industrial enterprises, markets and restaurants, and gardens.

In most countries, quantities of municipal waste are rising steadily. Fig. 8.2 shows the average increase in municipal solid waste production in the European members of OECD [5]; the average annual rate of increase rose from 1.8 % in the first half of the 1980s to 2.5 % in the second half. Table 8.1 gives an overview of percentage increases in municipal solid waste per head of population in some European countries between 1975 and 1990. At the end of the 1980s, the average quantity of municipal waste per person in the Region was 353 kg per year, although this average masks significant differences between countries (Fig. 8.3).

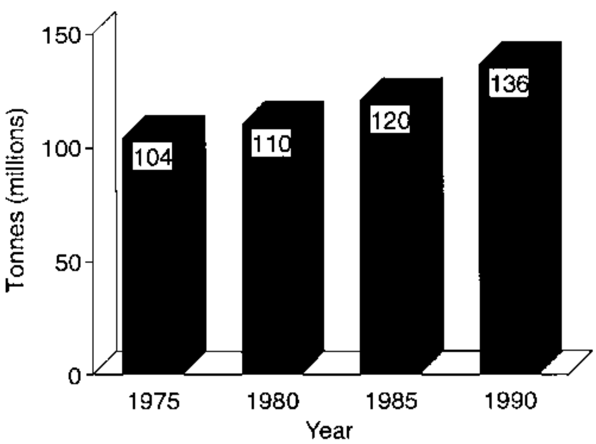
The composition of municipal waste varies widely between countries, reflecting different consumption patterns and social habits. Organic waste still accounts for the largest share everywhere in the Region. The

[a] 1 billion = 10^9.



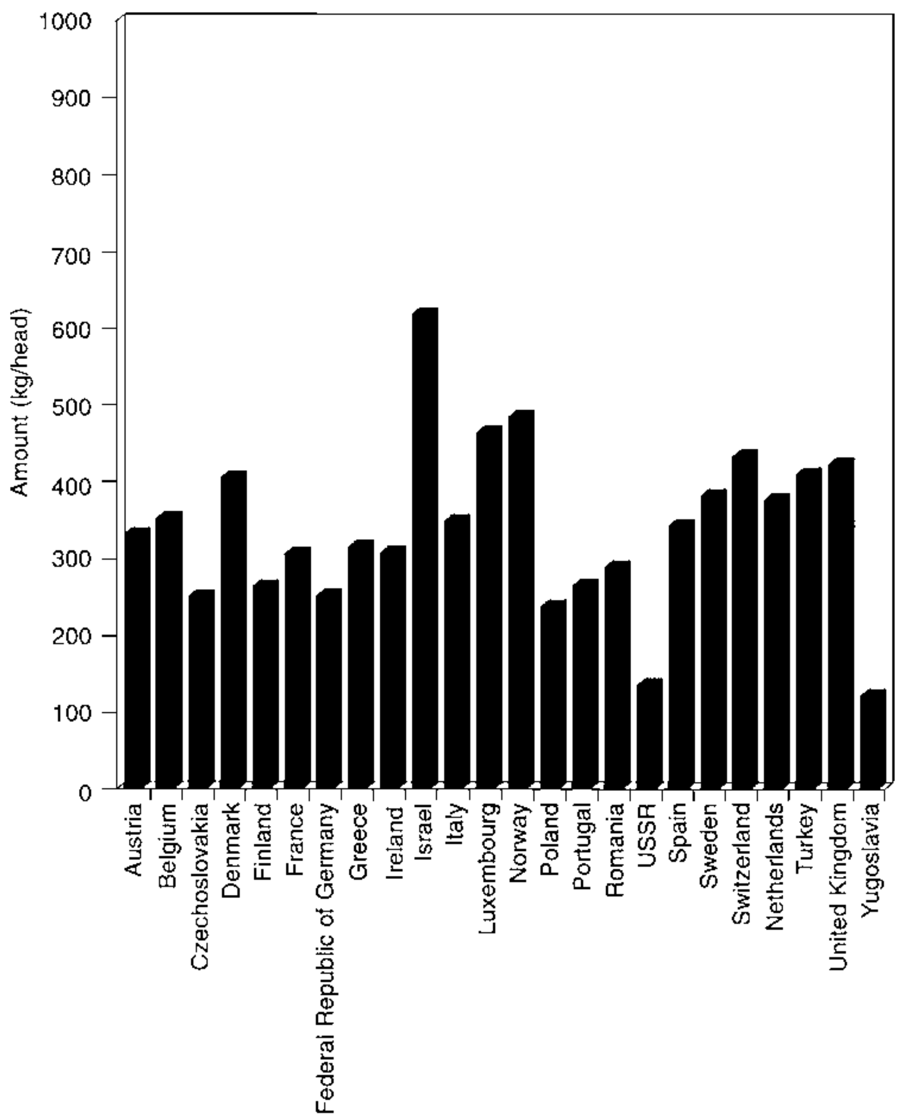
Sources: Organisation for Economic Co-operation and Development *(4)*; data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 8.1: Annual waste production in the WHO European Region according to the main waste categories



Source: Organisation for Economic Co-operation and Development *(5)*.

Fig. 8.2: Average annual production of municipal solid waste in European OECD countries, 1975–1990



Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 8.3: Annual production of municipal waste in 24 European countries, late 1980s

percentage of glass and metals is relatively steady (4–10%) although it is slowly decreasing in those countries where these products are collected separately for recycling. The proportion of plastics is higher in countries with a high production of municipal solid waste per head.

8.2.2 Industrial waste

In 1992, the countries of the Region (excluding the NIS) generated nearly 1 billion tonnes of industrial waste. The amounts of industrial waste are expected to continue to increase as industrial development expands.

The exact quantities of hazardous waste generated in the Region are still unknown because statistics are incomplete and difficult to compare, mainly owing to differences in the classification of hazardous waste. The figure mentioned above (120 million tonnes per year) is therefore only indicative. More accurate figures are expected to be available in future, as a result of international attempts to harmonize the definitions of hazardous waste and the increasing statistics provided by many countries.

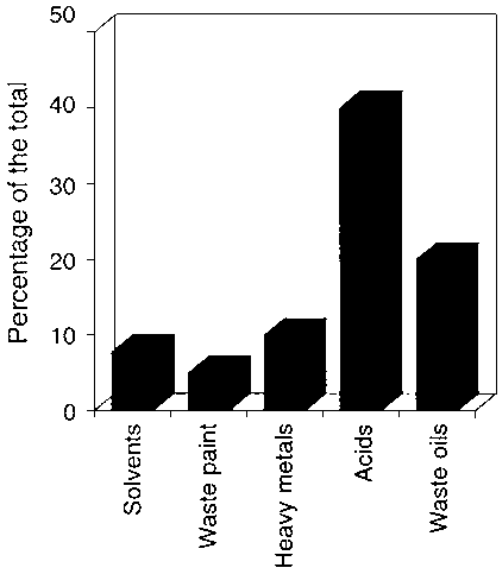
The composition of hazardous waste produced in the countries of the Region varies

Table 8.1: Increases in municipal waste generation in selected countries of the WHO European Region

Country or area	Percentage increase per head[a]		
	1975–1980	1980–1985	1985–1990
Austria	19.5	3.2	42.0
Byelorussian SSR	7.2	7.2	7.2
France	6.7	1.7	11.6
Hungary			9.6
Norway	–1.9	14.0	–0.6
Poland	39.0	7.4	18.0
Portugal		16.1	4.0
Sweden	3.1	5.1	17.8
United Kingdom	–3.6	9.0	2.3

[a] Figures indicate the amount of change between the first and last year of each period.

Source: EUROSTAT (6).



Source: Organisation for Economic Co-operation and Development *(4)*.

Fig. 8.4: The main types of hazardous industrial waste in European OECD countries, around 1990

according to the distribution of industrial activity and to the technology used, but hazardous chemicals comprise roughly 50 % of hazardous waste in most cases [4]. Fig. 8.4 gives a more accurate estimate of the composition of hazardous waste in the European members of OECD.

8.2.3 Mining waste

Many mining sites have been abandoned after decades of exploitation, leaving waste heaps with relatively high concentrations of minerals such as lead and arsenic. Mine tailings usually lack cover by vegetation and are therefore very prone to movement through drainage, erosion and windblown dust. As a consequence, areas with intensive mining activities in the past (so-called geochemical hot spots) continue to cause widespread environmental contamination through air and water, giving rise to potential hazards to health. A significant example is lead mining waste, which can increase the concentration of lead

Box 8.1: The problem of waste from lead mining

A survey carried out in the Halkyn Mountains in Wales reported soils with higher concentrations of lead (886 mg Pb per kg dry soil on average) than those in another part of Wales with no known contamination (maximum 70 mg/kg). Paired samples of garden soils and house dust were taken, along with blood samples from the residents. The levels of lead in the blood of women and children were found to be 30–50% higher in the Halkyn Mountain area than in other parts of Wales, and were correlated with lead on kitchen surfaces and with lead in dust and garden soil. The eating of locally grown vegetables was also associated with increased blood lead levels, while levels of lead in the air (except in dust) and the water supply were too low to make other than a very minor contribution to the intake of the local population. The average blood lead levels in the contaminated area (128 μg/l in adult women and 226 μg/l in children) revealed the importance of mining waste as a source of exposure to lead and the health hazard for children in the exposed population.

Source: Page, R.A. & Swires-Hennessy, E. [7].

in local soil and dust and therefore increase the level of population exposure (Box 8.1).

A survey of abandoned mining sites and planning for reclamation therefore needs to be a component of policy on environment and health in the Region. As a short-term measure, it is important to establish the status of contamination in such geochemical hot spots and to adopt any measures needed to limit the current exposure of local populations.

8.2.4 Small-quantity hazardous waste

Small-quantity hazardous waste is produced by, for example, households, small industries, trading activities, farms, educational establishments and research laboratories.

According to estimates for 1986, the European members of OECD produced some 120000 tonnes of small-quantity hazardous waste; a mere dozen products make up 90% of such waste, the most important being motor oils, batteries, paints, medicines, lacquers, solvents, maintenance and cleaning products and glues [4].

Further, small businesses produce an estimated 0.5–1 million tonnes of small-quantity hazardous waste [4]. Some 15 types of activity are concerned, the most important being dental and photographic laboratories, paint and printing workshops and laundries.

In agriculture, pesticides account for some 25 kg of small-quantity hazardous waste per km^2 of cultivated land in the form of waste from the products themselves, and a further 80 kg in the form of packaging [4].

8.2.5 Health care waste

The waste from hospitals and other health care establishments can be categorized as general, pharmaceutical, chemical, radioactive, pathological and infectious waste, and sharps (materials such as needles, instruments and broken glass). The Region is estimated to produce more than 2 million tonnes of health care waste per year. The percentage of hazardous waste is small: about 10% according to WHO [8].

8.3 Waste Management

8.3.1 Collection

In the last two decades, municipal services for solid waste collection have greatly im-

Table 8.2: Distribution of disposal methods for municipal solid waste in 10 countries of the WHO European Region

Country	Percentage share in disposal			
	Incineration	Landfill	Recycling	Other methods
Austria	12	67	16	5
Denmark	54	30	6	10
Finland	2	77	20	1
France	37	47	4	12
Italy	6	89	–	5
Netherlands	33	43	4	20
Spain	5	74	–	21
Sweden	40	44	12	4
Switzerland	75	15	–	10
United Kingdom	12	70	–	18

Source: EUROSTAT (6).

proved. The collection services in most European OECD countries can be assumed to cover virtually the whole population [4]. There are only a few exceptions, such as Finland and Portugal, where no more than 75 % of waste is collected. No statistics are available on the collection of industrial waste.

8.3.2 Disposal

According to data from WHO[a] and OECD [4], 66 % of municipal waste in the Region is estimated to be deposited in landfills, about 20 % is incinerated, 9 % is recycled and 5 % sent for other treatment. As to industrial waste produced in the Region, 70 % of hazardous waste is still estimated to be deposited in landfills, 8 % is incinerated, 10 % is stabilized and about 12 % sent for other treatment (mainly recycling as secondary materials).

Table 8.2 indicates the disposal methods used for municipal waste in selected countries; the category of other options includes composting, methanization, refuse-derived fuel and gasification. In some countries, incineration with the utilization of surplus heat for district heating, electricity production or both is considered to be recycling.

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Sanitary landfills

Disposal in sanitary landfills continues to be the prevailing option for waste disposal in the Region. The difficulties in finding adequate new sites and the increasing concern about the consequences – mainly on groundwater quality – from the disposal of untreated waste (particularly hazardous waste) in landfills, however, are leading to increasing use of other methods.

Countries vary in their definitions of a sanitary landfill, according to local needs and customs. In general, the term means an engineered facility to dispose of waste materials into or on to the land, with a minimum of environmental impact.

In most countries, ever stricter technical specifications are imposed on what are known as controlled landfills; such specifications govern the choice of site, the construction, management and operation of the landfill, and the measures to be taken on and after its closure. Substantial progress has been made in preventing contamination of the surrounding environment by:

- keeping off-site surface water away from the waste and minimizing on-site infiltration of rainwater through use of a well designed final cover;
- leakproofing the bottom and the walls of the landfill with liners of clay and/or flexible membrane or plastic;

- collecting leachate with a drainage net, for ultimate treatment and disposal;
- collecting gases with a venting system, for ultimate treatment or reuse; and
- monitoring the quality of groundwater, surface water and air to detect any kind of contamination both during the operation and after the closure of the landfill.

Incineration

Of the technological options for waste treatment and disposal, incineration plants have probably undergone the most extensive technical evolution in the last fifteen years, owing to concern about the emission of hazardous compounds to the atmosphere.

The primary function of an incinerator is to burn waste to a so-called inert residue. Until the end of the 1970s, the main part of an incineration plant consisted only of the oven and, in a few cases, a dust abatement device. Managing these plants was relatively simple, because there was little concern about the impact of emissions on the environment and public health. Only in the late 1970s and early 1980s did the general public begin to show such concern, possibly as a result of the Seveso accident. The first extensive campaigns to monitor incinerators were carried out, detecting concentrations of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and other hazardous compounds (such as heavy metals) in flue gases and in fly ash from incinerators of municipal solid and hazardous waste.

Since then, efficient new emission standards set by control authorities have resulted in technological innovations to improve combustion control and reduce emission levels. Problems in the disposal of fly ash and solid ashes from incinerators and the disposal of wastewater from gas-cleaning operations can also be handled efficiently. Fly ash from municipal solid waste incineration is usually deposited in sanitary landfills; the heavy metal content of ash from industrial waste may require disposal in special landfills, or inactivation before disposal in standard landfills.

Chemical–physical treatment plants

A fraction of industrial waste is treated in chemical–physical plants before being either recycled or deposited in a landfill. The objective is to remove or substantially reduce the amount and/or mobility of contaminants within refuse by stabilizing waste with chemical agents and solidifying it with cement or other ligands, or oxidizing or neutralizing it. These treatments, if properly managed, do not pose potential health problems for the local population; they are in general confined in closed areas and do not give rise to significant emissions of contaminants outside them.

Composting and sorting plants

As a method of municipal solid waste disposal, composting had a modest role in most countries during the 1970s and 1980s, probably because compost produced from household waste is of low quality and not very useful. Countries such as Austria, Denmark, Germany, the Netherlands and Switzerland, however, have introduced composting of source-selected organic household waste on a national or regional basis.

While composting and sorting plants do not pose potential health hazards to the population, problems may result from poorly managed open-air plants without proper systems for odour abatement.

Application of sewage sludges and compost to land

In theory, sludge from municipal sewage treatment plants and compost from the organic fraction of municipal solid waste are natural by-products of the treatment of wastewater and municipal solid waste. They contain nutrients that are essential to the growth of food plants and forage. The return of sludge and compost to the land thus completes a nutrient cycle.

The contaminants in sludge are derived from domestic sources (containing, for example, insecticides, paints and other products used in house care), small businesses (such as printing and paint workshops, laundries, and dental and photographic laboratories) and from industry. In industrialized areas the main contaminants detected in sludges are heavy metals such as cadmium, lead, zinc, chromium and mercury.

Traces of these elements and compounds are normally present even in sludge from domestic wastewater treatment plants. In spite of the indisputable nutrient content, farmers are often reluctant to apply sludge to arable land; they worry about the long-term consequences, even when the preventive measures mentioned below are practised.

8.3.3 Recovery, recycling and prevention

Various strategies can be used to reduce the amounts of waste produced:

- *reuse*: using a substance or a recovered product for its original or a different purpose;
- *recycling*: returning a recovered substance to the production cycle it came from;
- *energy recovery*: using combustible waste fractions as fuel; and
- *waste prevention*: reduction at the source by substitution of raw material, recycling within the process and introducing clean technology, or modification of the product by analysing its life cycle and using different raw materials.

A growing share of the municipal solid waste produced each year in the Region is recovered at source or undergoes processes leading to material recovery. Data for the whole Region are not yet available, but partial data from European members of OECD show significant differences between countries in recycling rates. There are no comparable data on the recycling of industrial waste, and little information is available on the effect of policies to prevent waste production.

Several attempts (many of them tests) are under way in the Region to reduce waste production. They range from raising public awareness of opportunities for home composting of organic material to promoting clean production technology and introducing incentives for waste prevention. In addition, regulations giving cradle-to-grave responsibility for hazardous waste to the people who produce it are under discussion in some countries.

8.4 Contaminated Sites

For decades, European countries dumped the waste that they generated without taking any precautions at all. By the end of the 1970s, the problem of managing sites had arisen from the contamination of soil and groundwater (with, for example, heavy metals, arsenic, pesticides, halogenated organic compounds and solvents) and the potential health risks to exposed populations. The pollution of groundwater has stopped the use of some sources of drinking-water or precluded the future use of groundwater for drinking.

At present, quantifying the problems is extremely difficult because the exact number of contaminated sites is unknown, and the potential risks from the contaminants present have not yet been assessed. Some countries in the Region have attempted to evaluate the number of problem sites (Table 8.3). Such figures cannot be used to make an intercountry comparison of the problem, however, since some are estimates while others are based on careful investigations. Also, the definition of a problem site varies between countries. Many of these sites are being cleaned up, but the cost of remedial action is extremely high, limiting the rate of intervention.

Similar data for the CCEE and NIS are unavailable, but there is evidence that the problem is just as big or bigger in these countries (see Chapter 17). In addition, many deposits of hazardous chemicals, and possibly

Table 8.3: Surveyed or estimated contaminated sites in some European countries

Country or area	Year	Estimated or surveyed contaminated sites		High priority contaminated sites	
		Total	Type	Total	Type
Austria	1990	7 500	Landfills and abandoned industrial areas	–	–
Belgium (Flanders)	1990	7 672	Landfills (422); abandoned industrial areas (7000); car wrecking areas (250)	–	–
Czech and Slovak Republics	1993	10 000	Landfills	–	–
Denmark	1988	5 000	Landfills, industrial areas	2 000	75% industrial areas
Finland	1990	10 000–20 000	–	500–1 000	–
France	1985	2 373	Landfills, industrial areas	107	Landfills (80); industrial areas (27)
Germany	1991	150 000	–	–	–
Hungary	1993	25 000	HW landfills (4000); hydrocarbon contaminated areas (spills, accidents) (10 000–15 000); military areas; industrial areas; mines	–	–
Ireland	1988	20	Old gasworks	–	–
Italy	1986	5 100	MSW landfills (4500); HW landfills (135); MSW and HW landfills (465)	–	–
Netherlands	1990	525 634	Abandoned gasworks (234); landfills (3300); abandoned industrial areas (400 000); operating industrial areas (120 000); car wrecking areas (2100)	110 634	Abandoned gasworks (234); landfills (3300); abandoned industrial areas (80 000); operating industrial areas (25 000); car wrecking areas (2100)
Portugal	1987	1 800	Industrial waste landfills	69	
Spain (Catalonia)	1991	1 000	MSW and MSW and HW landfills (900); HW landfills (100)	–	–
United Kingdom	1987	12 000–15 000	Landfills	–	–

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

biological agents, from previous military activities are thought to exist (see also Chapter 12).

8.5 Transfrontier Movement of Waste

In itself, the transport of hazardous substances represents a serious risk, and is strictly regulated by EU directives. Nevertheless, the movement of hazardous waste across national borders has reached a significant dimension: more than two million tonnes of hazardous waste or over 10 % of all waste produced by European OECD countries moves across their frontiers [4]. In addition, European market-economy countries send large amounts of waste to eastern European and developing countries.

In some cases, the need to find an adequate and safe disposal site may justify this practice, but in other cases it is used to avoid stricter standards and consequently higher disposal costs in the country of origin. The potential risks to health should be recognized; waste disposal in less well managed or uncontrolled sites may pose environmental hazards to local populations. Further, the waste moved across frontiers is usually the most hazardous.

To control the movement of waste, OECD adopted some principles in 1985 that were later included in the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal [2] and embodied in an EU directive [3]. Not all Member States of the WHO European Region have signed the Basel Convention.

8.6 Waste Management and Health Effects

8.6.1 Methodological problems

The epidemiological literature on the health effects of procedures to collect, dispose of and treat waste is difficult to interpret. For a number of reasons, the exposure of a study population has seldom been assessed. First, waste consists of complex mixtures of chemical, physical and biological agents, and the specific nature of potential types of exposure has seldom been identified. Second, the inherent toxicity of a single agent may vary over time or through environmental degradation. Third, routes of exposure can vary and may modify the toxicological characteristics of a given agent; further, such routes have rarely been established in studies of exposed populations. Fourth, estimates of body burden from residues of relevant agents in human tissues or fluids are seldom secured.

Another problem is the choice of the outcomes to investigate. From a methodological point of view, the main categories are biological markers, clinical diseases and reported symptoms. Research strategies for biological markers have been suggested [10,11]. A tendency to overreport diseases and symptoms has been found in"alerted" populations [12–14]. Seven health conditions have been proposed as priorities for monitoring [15]: birth defects and reproductive disorders, some types of cancer, immune function disorders, kidney dysfunction, liver dysfunction, lung and respiratory diseases, and neurological disorders. Most of the studies reported, however, address public concerns about cancer and adverse reproductive outcomes. In any event, the biological plausibility of a particular effect being caused by exposure to a given agent should be considered. Finally, researchers need to take particular care with the design of epidemiological studies, on which the strength of the evidence for a causal relationship depends.

8.6.2 Sanitary landfills

As mentioned, landfills are the prevailing option for waste disposal in the European Region. Epidemiological investigations on the possible adverse health effects posed by the presence of waste disposal sites have been conducted since the early 1980s, mainly in the United States [16–29]. Many of these studies illustrate the methodological problems described above. In particular, the lack of information about actual exposure to specific agents makes it difficult to establish any direct relationship between exposure and disease. The studies, however, often demonstrate psychological, social or aesthetic effects on wellbeing, which are also environmental health issues.

Biogas

The degradation of organic matter and the vaporization of waste in landfill sites create biogas. Biogas from municipal solid waste consists mainly of methane and carbon dioxide. The gases from hazardous waste vary in composition with the type of waste, but may include toxic substances (such as dichloromethane) or potential carcinogens (such as benzole and vinyl chloride). In addition, mercury can evaporate from landfills.

As long as uncontrolled biogas can escape over the landfill area, mixing with air will prevent acutely toxic concentrations of carbon dioxide from occurring. Nevertheless, acute hazards to health may occur in closed environments within the landfill area, from substantial fissures in the landfill cover, or from shafts or trenches. In addition, the mixing of biogas with air carries a risk of fire and explosion.

There are no reliable data on long-term effects on health from exposure to biogas [30]. The problem lies in evaluating the toxic properties of such a gas mixture, whose composition varies over time and between sites.

Finally, malodorous emissions may create problems, particularly if the landfill site is near residential areas, that are difficult to counter since people can smell many substances at very low concentrations.

Preventive measures

Taking the following measures in designing and operating a sanitary landfill can prevent or minimize the hazards described above.

1. As far as possible, waste delivered to a landfill should not contain hazardous compounds. These can be removed through, for example, incineration, separation at source or product modification measures. Many countries are adopting guidelines that prescribe the treatment of waste before final disposal in a landfill.
2. Biogas must be properly collected by pipelines, and can either be burned off on site or used commercially for heating. All closed landfills must be adequately operated, monitored and ventilated to prevent dangerous emissions of biogas from occurring.
3. Active and passive measures should be used to prevent biogas migration. The soil and buildings in the area surrounding the landfill should be monitored to detect migration and prevent explosions or adverse health effects on the population.
4. The site of the landfill should be carefully chosen and a system for biogas collection should be correctly designed to minimize odorous emissions. Compost cover layers can be used as odour biofilters.

People are exposed to biogas chiefly by its migration through the surface and the subsoil of a landfill. The level of exposure depends mainly on the rate of migration, the composition of the biogas, and the distance to the nearest housing. As a safety measure, most regulations for siting landfills require that a site be at least 1 km from any residential area

8.6.3 Incineration

Only a few studies have examined the possible adverse health effects of exposure to emissions from incinerators. One investigated a cluster of cases of laryngeal and lung cancer near an incinerator of waste solvents at Charnock Richard, United Kingdom (Box 8.2).

Indicators of health effects from exposure to emissions from the incineration of municipal and industrial waste in a village in Isère, France were studied in three groups of people residing within 200 m, 1 km and 2 km from the incinerator [32]. The average number of respiratory drugs per person prescribed in 1980–1981 decreased with distance from the source. Although the authors made no claims of a causal relationship, the results of this study prompted tighter control of emissions from the incinerator.

Preventive measures

Imposing standards and installing pollution abatement devices to ensure compliance can reduce emissions from incinerators to acceptable levels. Most of the industrialized countries in the Region have adopted emission standards for waste incineration. These standards differ widely, both between countries and between the countries and the EU [33]. From the strictest standards proposed by the EU, one can evaluate the aver-

Box 8.2: Incinerators and cancer in Great Britain

After reports of a cluster of cases of laryngeal cancer near the incinerator at Charnock Richard, Lancashire, the Small Area Health Statistics Unit of the London School of Hygiene and Tropical Medicine analysed the incidence of laryngeal and lung cancer near this site, which operated between 1972 and 1980, and around nine other incinerators of waste solvents and oils in Great Britain.

Cancer registration data organized by postcode were available for 1974–1984 in England & Wales and for 1975–1987 in Scotland. Lag periods of 5 and 10 years between the starting of the incinerator and cancer incidence were used in the analysis.

Standardized observed/expected ratios were calculated; expected values were based on national rates (regionally adjusted) with and without stratification by socioeconomic profile of the area (Carstairs' index).

Two sets of circles around each site were selected *a priori* for the analysis: two circles with radii of 3 km and 10 km, and ten circles with radii of 0.5–10 km. Observed/expected ratios were assessed within the first set of circles around each site and aggregated over all sites. Of the second set, data from the first four were used to investigate effects close to the source, and data from the other six were used to give successive bands between circles of approximately equal areas.

The populations living in the two sets of circles were 262 896 and 2 327 651, respectively.

For Charnock Richard, none of the observed/expected ratios, for either cancer or lag period, differed significantly from unity for either the smaller or the larger circles in the first set. The analysis of all 10 sites combined, stratified by Carstairs' index, showed that none of the observed/expected ratios differed significantly from unity for the two types of cancer. There was no evidence of decreasing risk with distance from the sites for either type.

It was concluded that the apparent cluster of cases of cancer of the larynx reported near Charnock Richard was unlikely to be due to its former incinerator.

Source: Elliott, P. et al [31].

age emissions from a modern incinerator of municipal solid waste or hazardous waste. Owing to the differences between countries, however, compliance with national standards does not normally provide a basis for comparison of emissions between countries.

The exposure of populations to flue gases from incinerators is strictly correlated to the emission and immission standards set. It is also associated with the total throughput of gases and with local meteorological and topographical conditions. Studying standards does not therefore permit a general evaluation of exposure. Effective exposure must be evaluated case by case, taking account of the factors mentioned.

In general terms, people living up to 2 km downwind of a plant can be expected to be exposed to the highest concentration of contaminants. The careful siting of incinerators is, therefore, extremely important as a preventive measure. In countries where the surplus heat is used for district heating, however, energy planners prefer (for economic reasons) to locate incinerators as close as justifiable to residential areas. In Sweden, for example, the minimum recommended distance between incinerators and residential areas is 500 m. Nevertheless, compliance with appropriate emission and immission standards can greatly reduce the possibility of adverse health effects.

8.6.4 Application of sewage sludges and compost to land

One of the potential health risks from the application of sludge or compost to the land is the direct or indirect (through the food chain) transmission to humans of infectious microorganisms or toxic chemicals that may be present in such organic waste.

The main pathways for human exposure to microbial and chemical contaminants in sludge applied to land are as follows [34]. Humans may ingest vegetables or animal products contaminated through:

- uptake by plant roots in sludge-treated soil or direct contamination of edible parts of plants by sludge, or by dust or mud after the mixing of sludge with soil; or
- the use of contaminated plants as fodder for animals or direct ingestion of soil and sludge by grazing animals.

In addition, children may ingest sludge-contaminated soil. While these pathways are not equally important, each has been demonstrated. The population potentially exposed therefore includes everyone who eats vegetables or animal food products from areas where sewage sludges are applied. Similar issues arise from the use of wastewater for irrigation (see Chapter 7).

Preventive measures

The EU and other countries in the Region have very strict regulations on the application of sewage sludge or compost to land, based on sludge (or compost) composition and soil characteristics. In addition, countries regulate land use practices, for example by forbidding the use of sludge or compost on areas producing foods that are to be eaten raw. In other cases, a maximum content of microorganisms is allowed in the sludge to be applied to land; in general, only hygienic treatment of the sludge can ensure that this requirement is met.

As application to land is the easiest and cheapest way of disposing of sewage sludge, it is important to enlarge this practice as much as possible by reducing at source the most hazardous contaminants discharged into sewers. This is already a requirement for industry in some countries of the Region. Regulatory approaches and control procedures need to be as uniform as possible to prevent the use of the least controlled countries as dumping sites for others.

8.7 Occupational Exposure to Waste Substances

Occupational studies can provide valuable assessments of exposure–effect relationships, since exposure at work is usually better defined and at higher levels than that in the environment. There are, however, very few investigations of the risks to the health of people who collect, transport or handle waste substances at landfill sites, incinerators, chemical–physical and/or biological treatment plants, or composting and sorting plants.

The mortality in 1951–1985 of a cohort of 176 male workers employed for at least one year during 1920–1985 at a municipal waste incinerator in Stockholm showed an excess of lung cancer and, after a long latency, ischaemic heart disease [35]. Smoking in the cohort was not above the average for Swedish men in cities.

A recent Danish survey [36] showed that the predominant illness of workers in an enclosed sorting plant was asthma, probably related to high emissions of particulate matter containing bacteria and endotoxins derived from the decay of waste. Modifications of the plant (the use of closed conveyors and installation of vacuum cleaning systems) led to significant reductions in airborne bacteria and the nearly complete elimination of endotoxins. Similar and additional measures, such as the use of filters and wearing of protective masks, may be expected to reduce or eliminate occupational health hazards to workers in chemical–physical treatment plants.

Box 8.3: The problem of health care waste

At present, the production of health care waste has been estimated to be more than two million tonnes per year. The proportion of hazardous waste is small: about 10% according to WHO estimates [8]. The first measure to adopt is thus the separation, whenever possible, of the non-infectious from the infectious waste components. The non-infectious waste can be treated in the same way as municipal waste.

Most countries in the Region incinerate hazardous health care waste. They need, however, to ensure proper combustion and the efficient treatment of flue gases. This cannot be done in small hospital incinerators, so most countries are moving gradually towards regional incineration systems. WHO recommends treatment and disposal of infectious health care waste at the regional level to achieve a better level of safety. In future, countries will work to reduce health care waste as much as possible at the source, to minimize any potential health effect for workers and the public.

There is very little published information about the consequences of exposure of workers, patients or the public to health care waste. Domestic personnel, maintenance staff and porters are at risk from sharps in waste. Positive serological tests for hepatitis B were higher among these personnel groups than in nurses and others [38].

Waste collection and transport involve the risk mainly of infections from contact with waste and waste containers, and of accidents. A recent Italian survey [37] showed no significant microbial contamination in municipal solid waste containers in winter, but a possible risk of infection during the hot season. In addition, differences have been reported between waste containers in urban and rural areas; the latter show higher levels of faecal indicators, probably owing to the presence of animal waste.

As to the risks of occupational exposure to health care waste (Box 8.3) concern is felt about sharps injuries, which occur during the collection of waste, particularly hospital waste. This involves the accidental transfer of blood from a contaminated needle, scalpel blade or other sharp object to the worker. A study by Jagger et al. [39] of a teaching hospital in the United States indicated that most sharps injuries occur after the instrument has been used, that is, when it becomes a waste item. Particular fear has arisen over the possible transmission of HIV by this means. Until 1989, only 37 cases of occupationally acquired HIV had been documented worldwide [40]; most were a result of sharps injuries. A more common hazard to health from sharps injury is the transmission of hepatitis B and C viruses (see also Chapter 15). Sharps present a significant occupational hazard to health care workers and waste handlers. Closely following national and other relevant advice on the safe disposal of sharps, however, can control these hazards [8].

Although no adverse occupational health effects have been reported among workers in landfills, the following precautionary measures can be recommended:

- using protective clothing to avoid direct contact with waste;
- fitting dust filters to vehicle cabs, moistening and promptly covering dusty waste, sprinkling dust with water (or in the worst cases wearing dust masks) in order to avoid or minimize dust hazards; and
- controlling vermin.

As to accidents, a survey carried out in Finland showed that the accident rates for the personnel of waste transport vehicles were three times as high as the average for industry [41]. Several deficiencies in safety were found at all stages of this work. The largest number of accidents occurred in handling large waste bins. Several steps can reduce the number and severity of accidents; these include improving the equipment for waste collection and transport, the working methods, the location of waste containers, the instructions given to households, and occupational health services [41].

8.8 Trends

The growing quantity of waste produced worldwide creates problems of disposal due not only to its volume and weight but also to its potential effects on environmental health. In this respect, hazardous waste is of particular concern. In several countries of the Region, governments and industry are taking a more preventive approach to waste management, the main aim being to reduce waste generation from the outset. They promote life-cycle management, by means of which the environmental impact of a product can be reduced at all stages of production, consumption and disposal.

The problem of managing problem sites, the legacy of decades of uncontrolled disposal, is one of the future environmental health challenges for the Region. Its importance arises from the large number of sites and the potential for contamination of soil, surface water and groundwaters, along with possible risks to human health.

While sanitary landfills continue to be the prevailing option for waste disposal in the Region, major technological improvements are increasing the use of other treatment options, particularly incineration. This trend also arises in part from the difficulty of finding adequate new landfill sites in the Region, because of either restrictions on land use or public opposition based on the NIMBY ("not in my back yard") principle. Increasing concern about the disposal of untreated waste (especially hazardous waste) in landfills also plays an important role; the expensive bad experiences with problem sites should not be repeated. Finally, incineration can be considered a way of utilizing the energy content of waste for district heating or electricity production.

Innovative technology provides other options for industrial waste treatment, such as supercritical oxidation and plasma arch incineration. Such technology is becoming an interesting option, particularly for hazardous waste, because of its high destruction efficiency and low emissions.

Some other fairly sophisticated methods – such as pyrolysis, gasification, the production of derived fuels, and anaerobic digestion of municipal solid waste or of selected fractions – are used in some countries of the Region, but not yet to any great extent. The costs remain higher than those of traditional treatment options. Nevertheless, these methods have a promising future; the growing need to reduce the volume of waste and emissions from waste treatment will lead to their wider use, within an integrated framework, for the management of municipal solid waste.

Finally, the countries of the Region will have to make a significant effort to rationalize and control the transfrontier movement of hazardous waste to avoid inadequate or uncontrolled waste treatment and disposal in countries with less strict standards and controls.

8.9 Conclusions

Hazards to health exist where waste collection and disposal services are lacking or inadequate. The primary problem is the contamination of groundwater and soil by leakage from landfills, although the inadequate control of emissions from incinerators may still give rise to potential hazards in some countries. The technical evolution in waste management over the last fifteen years, however, has made it possible substantially to reduce population exposure and potential health effects from most modern plants. Nevertheless the nuisance, particularly from odours, and the anxiety related to living near a waste treatment plant remain. Much of the available data relate to European countries that belong to the EU and/or OECD, but there are good reasons to expect that potential environmental health risks from waste disposal are even greater in the CCEE and NIS.

The public is concerned about the impact of waste disposal on the environment and health. A survey carried out in 1990 by the Department of the Environment in the United Kingdom found that the public was more concerned about the disposal of hazardous waste than any other environmental issues, even pesticides or acid rain. The growing problem of finding acceptable sites for new facilities, away from residential areas, is likely to increase public awareness of this issue.

The few occupational health studies carried out indicate unsatisfactory conditions in the work environment, and that equipment may be inadequate to protect the health of workers. Multicentre studies of employees at different types of waste disposal plant, with proper exposure assessment and control of confounding factors, are warranted.

Few studies of health effects in populations living near waste disposal sites have been carried out in the Region. Many studies were undertaken in North America to address concerns raised by communities and the mass media, but little was known about the composition of the wastes or the environmental pathways and nature of exposure; interpretation of the results is difficult.

While the concern of people living near waste disposal facilities cannot be justified on the grounds of associated harm to physical health, nuisances such as odours and noise are certainly important problems that affect wellbeing. They should therefore be taken seriously.

In addition, the fact that few of the available studies have been able to establish evidence of health effects does not mean that waste disposal sites pose no risks to health. Large populations need to be studied to detect effects on health as a result of long-term, low-dose exposure. Further, the long timescales for changes in groundwater quality and the transport of contaminants imply that current health assessments may underestimate future risks. These considerations and the steady increase in waste production show the need for properly designed epidemiological studies. Studies of workers in waste handling and disposal, however, may prove a more useful way of establishing health effects.

The priority problems in waste disposal are related to old and poorly managed disposal plants, both incinerators and landfills. Important needs include securing the wider adoption of improved technology for waste treatment and improving the control of plants in operation.

Waste management practices vary widely within the Region. Incineration is increasingly used for the disposal of hazardous and municipal waste, but its use varies markedly between countries and the disposal of both hazardous and municipal wastes in the same landfill is still practised. Similarly, effective waste recycling schemes operate in some countries of the Region, while others have no general provisions for separating municipal wastes. Securing improvements requires public education and information.

References

[1] *Environment and health. The European Charter and commentary.* Copenhagen, WHO Regional Office for Europe, 1992 (WHO Regional Publications, European Series, No. 35).

[2] *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.* Paris, United Nations Environment Programme, 1989.

[3] Council Directive of 12 December 1991 on hazardous waste (91/689). *Official journal of the European Communities*, **L377**: 20 (1991).

[4] *The state of the environment.* Paris, Organisation for Economic Co-operation and Development, 1991.

[5] *Environmental data compendium 1991.* Paris, Organisation for Economic Co-operation and Development, 1991.

[6] *Europe's environment 1993. Statistical compendium.* Luxembourg, EUROSTAT, 1993.

[7] PAGE, R.A. & SWIRES-HENNESSY, E. A safe level for lead in soil and dust. *In*: *Proceedings of the 1st International Conference on Contaminated Soil*. Dordrecht, Martinus Nijhoff, 1986.

[8] *Management of waste from hospitals and other health care establishments*. Copenhagen, WHO Regional Office for Europe, 1985 (EURO Reports and Studies No. 97).

[9] DE FRAJA FRANGIPANE, E. ET AL. *Terreni contaminati: identificazione, normative, indagini, trattamento*. Milan, Collana Ambiente, 1994.

[10] *Public health and hazardous waste*. Washington, DC, National Academy Press, 1991.

[11] STALLONES, L. ET AL. Surveillance around hazardous waste sites: geographic information systems and reproductive outcomes. *Environmental research*, **59**: 81–92 (1992).

[12] NEUTRA, R. ET AL. Hypotheses to explain the higher symptom rates observed around hazardous waste sites. *Environmental health perspectives*, **94**: 31–38 (1991).

[13] LIPSCOMB, J.A. ET AL. A study of current residents' knowledge of a former environmental health survey of their community. *Archives of environmental health*, **47**(4): 270–273 (1992).

[14] LIPSCOMB, J.A. ET AL. Reported symptom prevalence rates from comparison populations in community-based environmental studies. *Archives of environmental health*, **47**(4): 263–269 (1992).

[15] Hazardous-waste sites: priority health conditions and research strategies – United States. *Morbidity and mortality weekly report*, **41**(5): 72–74 (1992).

[16] VIANNA, N.J. & POLAN, A.K. Incidence of low birth weight among Love Canal residents. *Science*, **226**: 1217–1219 (1984).

[17] BUDNICK, L.D. ET AL. Cancer and birth defects near the Drake Superfund Site, Pennsylvania. *Archives of environmental health*, **39**: 409–448 (1984).

[18] NAJEM, G.R. ET AL. Clusters of cancer mortality in New Jersey municipalities, with special reference to chemical toxic waste disposal sites and *per capita* income. *International journal of epidemiology*, **14**(4): 528–537 (1985).

[19] WHORTON, M.D. ET AL. Problems associated with collecting drinking water quality data for community studies: a case example, Fresno County, California. *American journal of public health*, **78**(1): 47–51 (1988).

[20] NAJEM, G.R. & GREER, T.W. Female reproductive organs and breast cancer mortality in New Jersey counties and the relationship with certain environmental variables. *Preventive medicine*, **14**: 620–635 (1985).

[21] BAKER, D.B. ET AL. A health study of two communities near the Stringfellow waste disposal site. *Archives of environmental health*, **43**(5): 325–334 (1988).

[22] DUNNE, M.P. ET AL. The health effects of chemical waste in an urban community. *Medical journal of Australia*, **152**: 592–597 (1990).

[23] LIPSCOMB, J.A. ET AL. A follow-up study of the community near the McColl waste disposal site. *Environmental health perspectives*, **94**: 15–24 (1991).

[24] WONG, O. ET AL. An epidemiologic investigation of the relationship between DBCP contamination in drinking-water and birth rates in Fresno County, California. *American journal of public health*, **78**(1): 43–46 (1988).

[25] WONG, O. ET AL. Ecological analyses and case-control studies of gastric cancer and leukemia in relation to DBCP in drinking-water in Fresno County, California. *British journal of industrial medicine*, **46**: 521–528 (1989).

[26] GRIFFITH, J. ET AL. Cancer mortality in U.S. counties with hazardous waste sites and ground water pollution. *Archives of environmental health*, **44**(2): 69–74 (1989).

[27] FAGLIANO, J. ET AL. Drinking-water contamination and the incidence of leukemia: an ecologic study. *American journal of public health*, **80**(10): 1209–1212 (1990).

[28] CLARK, C.S. ET AL. An environmental health survey of drinking-water contamination by leachate from a pesticide waste dump in Hardeman County, Tennessee. *Archives of environmental health*, **37**: 9–18 (1982).

[29] LOGUE, J.N. ET AL. Investigation of potential health effects associated with well water chemical contamination in Londonderry township, Pennsylvania, USA. *Archives of environmental health*, **40**(3): 155–160 (1985).

[30] WILHELM, V. *Safety aspects of the planning, construction and operation of landfill gas plants. Proceedings of the Third International Landfill Symposium, Sardinia, '91. 14–18 October, 1991*. Cagliari, CISA, 1991.

[31] ELLIOTT, P. ET AL. Incidence of cancers of the larynx and lung near incinerators of waste solvents and oils in Great Britain. *Lancet*, **339**: 854–858 (1992).

[32] ZMIROU, D. ET AL. Etude épidémiologique des effets sur la santé des rejets atmosphériques d'une usine d'incinération de déchèts industriels et ménagers. *Revue d'épidemiologie et santé publique*, **32**: 391–397 (1984).

[33] GIUGLIANO, M. & ANDREOTTOLA, G. Emission control and standards proposed by the EC for waste incineration. *In*: *Handbuch der Umwelttechnik 1994. 7. Internationalen Kongress – Messe für Umwelttechnik, Vienna, 19–22 October 1993*. Linz, Kommerz Gesellschaft, 1993.

[34] DEAN, R.B. & SUESS, M.J. The risk to health of

chemicals in sewage sludge applied to land. *Waste management and research*, **3**: 251–278 (1985).

[35] GUSTAVSSON, P. Mortality among workers at a municipal waste incinerator. *American journal of industrial medicine*, **15**: 245–253 (1989).

[36] MALMROS, P. ET AL. Occupational health problems due to garbage sorting. *Waste management and research*, **10**: 227–234 (1992).

[37] VAZZOLER, M. & MARCHI, T. [*Microbiological contamination of urban solid waste containers.*] *Igiene moderna*, **95**: 304–310 (1991).

[38] FERERES, J. *Hospital wastes management: human health. Proceedings of the European Conference on Hospital Waste Management. Copenhagen, 13-15 May 1991.* Copenhagen, DAKOFA, 1991.

[39] JAGGER, J. ET AL. Rates of needlestick injury caused by various devices in a university hospital. *New England journal of medicine*, **15**: 255–265 (1988).

[40] BRITISH MEDICAL ASSOCIATION. *Hazardous waste and human health.* Oxford, Oxford University Press, 1991.

[41] ETTALA, M. ET AL. Work safety in waste collection and transport. *Waste management and research*, **7**: 241–248 (1989).

Chapter 9
Contamination of Food and Drink

9.1 Introduction

It is well known that, in general, food reflects the environmental conditions under which it is produced, handled (processed, packed, shipped, delivered, stored, prepared) and eaten. If at any one of these steps food is exposed to potentially hazardous agents such as pathogenic bacteria or viruses, toxins, chemicals or radionuclides, there exists the possibility of "contamination", with the resulting potential for adverse health effects for consumers. Several factors determine the probability and severity of health effects, including the number and properties of the contaminating agents, the nature of the food and consumption patterns.

9.2 Food Safety Regulations, Services and Information Systems

9.2.1 Current situation

The European Charter on Environment and Health realized the importance of a harmonized approach to preventing possible negative health effects from inadequacies in the production, processing, trade and preparation of food.

In the light of recent political developments in the CCEE and NIS, and in view of the impending removal of all trade barriers between European Union (EU) countries, it is to be expected that a rapid expansion in international trade in food and tourism will result, with increased risks of transboundary foodborne infections and intoxications. There is a need, therefore, to obtain information about the different existing or potential problems. The programmes of the supranational organizations for reporting and assessing such problems, and the chemical contamination of food and drinking-water, will need to be strengthened.

9.2.2 Food safety structure

Food law

In most European countries, basic food laws have now been in operation in different forms for more than a century. A recent survey has revealed a considerable diversity among laws in different European countries.

Food safety services

In most countries, a number of different government departments concerned with health, veterinary medicine, agriculture and fisheries, trade, industry and environmental health are involved in food safety services. The enforcement of food legislation reflects, in general, these departmental divisions at central and local levels. In addition, responsibility is very often shared by two or more departments without formal provision for intersectoral coordination, leaving some areas with ill-defined preventive strategies or ineffective implementation of control measures.

During the last decade, there has been an increased tendency on the part of European countries to tackle food safety issues on an international basis, either within organizations such as the EU or under the aegis of such bodies as the Codex Alimentarius Commission and subsidiary organizations. The EU internal market arrangements, including community legislation on foodstuffs, rely on the recommended food standards of the Codex Alimentarius Commission, if these are available. The EU member states and most other countries of Europe use the Regional Codex Coordinating Committee for Europe as an international forum in which to exchange information on the organization and operation of their national food safety services, and to reach agreement on European food standards.

Food safety personnel

A recent survey conducted to obtain information on the current standard of training provided for food inspectors revealed a very complex situation in Europe. The WHO European Network of National Focal Points on Food Inspection provides information to responsible authorities on all important aspects of food inspection, including guidelines for the training of food safety personnel. Such approaches are especially important for countries outside the EU that export or import food, and that seek to fulfil the requirements of relevant directives.

Food safety information systems

In the health field, international information is used for decision-making at the European level as well as at the national and local levels. National administrations need fast access to comparable and easily interpretable data from other European administrations. In the case of emergencies there is a strong need for an early warning system (rapid alert system) that can be used by all responsible authorities to provide or obtain urgently needed information to or from other sources. In view of the international dimensions of food safety, efficient information systems must be available that allow each responsible authority to retrieve relevant information direct from the source by means of up-to-date telematic communication.

9.3 Microbiological Contamination

Foodborne diseases caused by pathogenic microbial contaminants remain important public health issues. Salmonellosis has increased dramatically in many European countries, and other diseases thought to be eradicated (such as tuberculosis and brucellosis transmitted through raw milk and trichinosis through pork products) may now be regaining importance. A cause for concern is small-scale food trade with countries where traditional zoonotic agents are still of importance.

The increase in foodborne infections caused by bacteria is due to several factors. “Artificial” factors, such as changed or more effective reporting systems for foodborne infections, are likely to be relatively important. Better identification techniques for microbial agents may also be relevant, especially in cases where no causative agent could formerly be found, e.g. the improved detection of newly recognized agents such as *Listeria* spp. and *Escherichia coli.*

Changed consumer and/or eating habits have contributed to the increase. Examples are the increased preference for raw or less processed milk products, and the dependency of a growing proportion of the population on large-scale catering that results in a much higher number of affected people than would arise at the household level.

Improved food technology processes giving food products a longer shelf-life may increase the risk that microorganisms recontaminate food and/or even multiply during storage. Other factors often considered causative are the mishandling of food (especially processed and packaged varieties), improper cooling or freezing conditions at the household level, and the assumption that packaged food is much less sensitive to microbial contamination than fresh food.

All the above reasons have certainly contributed to an increase in foodborne infections but there are other, more important factors. One of these is the international trade in food and also in feedstuffs, which results in a much more extensive spread of potentially dangerous agents. An example is that of the rapid growth since 1985 in the number of outbreaks of foodborne infections due to *Salmonella enteritidis* throughout the WHO European Region. International tourism may contribute in two ways to an increase in foodborne infections. On the one hand there are problems of adaptation by tourists in the host country where they are exposed to “unusual” microbial agents, sometimes under the exacerbating influence of “unusual” food or cooking methods (tourists coming to the Mediterranean area from the rest of Europe or North America are thought to run a 20-fold higher risk of developing diarrhoea than in their home countries; see also Chapter 7). On the other hand, they may be affected by the importation of “unusual” agents into their host countries or into their home countries.

Three of these factors (changes in eating habits, changes in food technology and importation of unusual agents), together with changes in population sensitivity, may also provide some explanation for the emergence of “new” foodborne diseases.

All the reasons mentioned above for an increase in foodborne infections refer mainly to the consumer but the centralization of food production, with a few companies producing a large proportion of a food for whole regions, plays the most important role. This is especially true in the production of food of animal origin, with an enormous concentration of poultry and egg production involving the rearing of millions of animals close together under the same conditions. In some European countries poultry and egg products are the most important carriers of salmonella, contributing to the increased number of outbreaks of especially *S. enteritidis* infection.

Since 1985 there has been a rapid increase in outbreaks of foodborne infection caused by *S. enteritidis*, but very few really effective measures have been undertaken to combat this increase. Application of rigid veterinary epidemic control measures (i.e. killing the whole flock at a production site) is one option for curtailing the spread of an epidemic throughout a region. The cost of such action may be enormous, but the cost of remedying the problem at a later stage, even if possible, would almost certainly be immensely higher. A good example of how effective the policy of salmonella-free flocks can be is the so-called Swedish model, which resulted in a drastic decrease in foodborne infections due to salmonella. This approach is now being adopted elsewhere in the Region. Another tool that could be employed to combat the problem is the consequent application of the Hazard Analysis and Critical Control Point (HACCP) concept at all stages of food production.

9.3.1 Current situation

The WHO Regional Office for Europe requested its Member States to provide data for this report on microbiological contaminants. Only a few countries provided data that could be evaluated in a tabulated form, although all responses reflected similar problems with various groups of foods and their contamination with pathogenic microorganisms.

Bacteria

Salmonella

Contamination of foods with salmonella is the predominant problem that can be traced from farm level to the final product. The bacteria are prevalent in farm animals, and salmonellosis is now considered to be the most important foodborne disease.

Poultry, eggs and egg products in particular are contaminated with *S. enteritidis* PT 4, which is the dominant cause of human salmonellosis in Europe. Cross-contamination,

Table 9.1: Isolation rates of salmonella from various foods in selected European countries

Country	Milk products		Meat products		Poultry		Eggs and egg products	
	No. of samples	Isolation rate (%)	No. of samples	Isolation rate (%)	No. of samples	Isolation rate (%)	No. of samples	Isolation rate (%)
Former Czechoslovakia	–	–	102 618	0.12	17 992	2.7	33 640	0.4
Germany	76 624	0.1	104 919	0.9	6 331	12.7	23 294	1.0
Iceland	17	n.d.[a]	217	1.4	150	23.3	–	–
Israel	–	–	1 034	2.5	1 555	12.3	–	–
Norway	–	–	6 379	1.2	–	–	–	–
Poland	46 450	0.02	19 206	0.3	952	1.9	2 528	3.2

[a] Not detected.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

undercooking and inadequate cooling promote the spread and growth of salmonella during processing and handling, and increase the risk for the consumer.

Table 9.1 was compiled from the data received by WHO and reflects the percentage of positive salmonella samples encountered during food inspection, in six European countries. Several factors make interpretation of such data difficult.

1. Countries may have different sampling and investigation procedures within their national food inspection systems.
2. Different contamination rates of a listed food group may be explained by the fact that food items of the same origin but produced by different technologies are grouped together.
3. Real differences in levels of contamination may exist between countries. Salmonella contamination of indigenous poultry products in Norway and Sweden, for example, is reported to be extremely low, while salmonella-positive samples are frequently reported for imported foods.

Listeria monocytogenes

In recent years *L. monocytogenes* has been recognized as a new foodborne pathogen. It can be detected in a number of foods such as meat, sausages, poultry, milk, milk products, vegetables, prawns and fish products.

This agent can also be isolated from animal feed, silage, soil, sewage, rivers, vegetable matter, insects, and human and other animal tissues. In fact, the wide variety of *L. monocytogenes*-contaminated foods of animal origin is not primarily the result of previous infection of the living animal, but rather the consequence of contamination from the environment of food processing plants. *L. monocytogenes* is extremely well adapted; its high salt tolerance and resistance to nitrites permit its survival in many kinds of processed food, and it is able to multiply at temperatures usually recommended for the storage of perishable food.

L. monocytogenes cannot be eradicated from the environment, and its wide distribution in various foods causes major problems for food inspection authorities. The situation is complicated by the fact that the minimum dose needed to cause infection is not known. Given the wide prevalence of the bacterium in foods but the low incidence of infection, there is reason to assume that a health risk exists only in the presence of high bacterial counts and/or impaired host resistance. On this basis, some countries have established practical control levels to reduce contamination as much as possible; others have focused primarily on education, particularly of those considered to be susceptible to infection such as immunosuppressed people and pregnant women, about avoiding certain foods such as raw foods of animal origin.

Campylobacter

This bacterium is the leading cause of gastrointestinal infection in some European countries. It is widely distributed, particularly in the living environment, and can be isolated from, for example, poultry, fish, fish products and raw milk. The routes of transmission are not yet clearly understood. It does not multiply in food and dies off rapidly in a dry environment.

Most outbreaks have been caused by raw or underpasteurized milk or contaminated water, as well as the consumption of raw or undercooked meat or poultry; recontamination after cooking can occur. The introduction of pasteurisation of raw milk in Scotland in the early 1980s led to the efficient elimination of this pathogen from milk. Elimination of *Campylobacter* spp. from poultry by irradiation has been proposed.

Cholera

The direct or indirect transfer of *Vibrio cholerae* from the faeces of infected people to food and water is recognised as the most important contamination route. The cholera organism may also persist in certain aquatic environments; shellfish and crustaceans, for example, may be persistently or intermittently contaminated even in the absence of recent exposure to human faeces. Refrigeration and frozen storage limit the multiplication of *V. cholerae* but may prolong its survival.

The EU and other countries follow WHO guidance on the control of cholera [1]. To date, *V. cholerae* has not been isolated in Europe from foods imported from cholera affected regions. This confirms an earlier WHO statement that food in international trade has rarely proved significant in the transmission of cholera [2].

Aeromonas

Bacteria of the *Aeromonas* group were chiefly known as causative agents of fish diseases, but in the last fifteen years have been recognised as agents of human infections – affecting wounds and the respiratory and urinary tracts, for example. Gastrointestinal diseases of mild or of cholera-like character have also been reported in patients of all ages, particularly in warm climates.

The bacteria can frequently be found in foods with a high water content, such as seafood, milk, dairy products, meats and vegetables. They can also be detected in freshwater reservoirs, surface water, natural mineral springs, marine water environments, and insufficiently chlorinated domestic water supplies. They can grow at the low temperatures (under 5 °C) that are important for food hygiene. Examination for *Aeromonas* spp. is not yet routinely included in food monitoring.

Escherichia coli O157:H7

Since 1982 this type of *E. coli* has been recognized as an important human pathogen. Effects can range from subclinical infections through mild to severe diarrhoeal disease. Fatal outcomes have been reported. The major food vehicle is probably undercooked beef. Illnesses, however, have also been linked to raw milk and water. Cattle seem to be the most important host for this type of organism and are symptomless carriers; up to 6 % of animals have been found to excrete the agent. As *E. coli* is difficult to identify in raw meats, routine monitoring should concentrate on the screening of farm animals to identify positive herds. Food handlers should be made aware of any potential risk, and consumers be informed about the potential hazards of eating raw or undercooked beef.

Parasites

Cryptosporidium is recognized as an important cause of severe diarrhoeal illness in humans, particularly immunocompromized people, and in animals. Cattle, sheep, goats, pigs and horses are important reservoirs for the parasite. At one stage of the parasite's life cycle oocysts are excreted in the faeces. These are remarkably resistant to common disinfectants and can survive sewage and water treatment (filtration and chlorination). Known routes of transmission are person-to-person, animal-to-person and faecal contamination of the environment, particularly by fertilization of crops with sewage sludge or wastewater irrigation. Waterborne diseases due to *Cryptosporidium* spp. are well documented. Consumption of foods treated with polluted water, or raw foods of animal origin, should be considered as potential sources of infection. Control of cryptosporidiosis depends primarily on breaking the chain, i.e. preventing contamination of surface water and drinking-water by appropriate waste and manure control at the farm. Immunocompromised patients in particular should pay attention to proper heat treatment of meat and must avoid raw milk. The contamination of food by *Cryptosporidium* spp. is currently difficult to detect and monitoring cannot be routinely carried out.

Opisthorchis, a type of trematode or liver fluke, is now recognized as an important foodborne parasite in eastern parts of the Region. It gives rise to mechanical obstruction of the biliary tract with resulting inflammation and infection, and a long-term risk of developing cancer in the liver (cholangiocarcinoma). Mammalian hosts include domestic and wild animals as well as humans.

Two types of intermediate host are involved: the first freshwater snails that take up the eggs excreted in mammalian faeces, and the second freshwater fish, particularly carp, which are host to the larvae. Eradication therefore presents difficulties, but prevention of human infection could be achieved by avoiding consumption of raw or inadequately cooked freshwater fish.

Viruses

Hepatitis

The most frequently reported foodborne viral disease is hepatitis A, formerly called “infectious hepatitis”. The virus is transmitted by the faecal–oral route, with the majority of transmissions occurring by person-to-person contact. Outbreaks of hepatitis A in several areas due to water or, for example, raw milk, shellfish, custard and lettuce, are well documented. Polluted water, sewage and hepatitis-infected individuals serve as the sources of food contamination.

Shellfish grown in contaminated water may accumulate the virus. Strict regulations for monitoring shellfish water quality has proved to be more effective than examining shellfish for viruses.

Bovine spongiform encephalopathy (BSE)

BSE is a disease of cattle with similarities to scrapie in sheep and goats and to certain sporadically occurring human encephalopathies.

The disease was first recognized in the United Kingdom. Its infective principle (virus or infective protein) is still debated. The epidemic occurrence in cattle raised the question of whether food of bovine origin can transmit the disease to man. At present there is no scientific evidence for this. However, regulations have been implemented to protect consumers against such a risk from food of bovine origin, medical instruments used on cattle, or occupational contact with cattle. Further research is needed to elucidate the nature of BSE, its relationship to similar diseases in man and other animals, and its potential transmission through food of animal origin.

Some additional infective agents are discussed, as agents of outbreaks of foodborne disease, on page 251.

9.3.2 Control measures

Primary production

To minimize risks to food safety during food production and processing, as well as at retail outlets, extensive food legislation has been developed at national and international levels (for example by the Codex Alimentarius Commission and the EU). It would be desirable to link food legislation with primary production in order to reduce microbial contamination of food of animal origin at the farm. Harmonization of food legislation and agricultural regulations is therefore required.

Essentially, preventive measures at the farm are related to:

- animal housing
- farm management
- hygienic measures (e.g. feed, manure handling, cleaning and disinfection)
- vaccination where applicable (e.g. against salmonella).

National and international competition in agricultural trade may make it difficult for farmers to institute hygienic measures that have consumer protection in mind rather than cost-effective agricultural production. Some countries such as Sweden, however, have shown that it is possible to reduce substantially the occurrence of salmonella in the food-chain from primary production up to the final product. Apart from specific measures, a substantial component of the control programme is monitoring for salmonella at the farm and throughout the production chain.

The EU has developed a zoonoses directive [3] that links public health aspects and primary production measures. At present it focuses mainly on the control of salmonella in poultry, but it also provides a system for controlling other zoonotic diseases such as brucellosis, tuberculosis and *Campylobacter* infection. Improved cooperation between veterinary and food inspection services is required for its implementation.

Food processing

Growing international trade has resulted in modifications of food control principles, including the responsibility of the producer for systematic inspection during food processing and of food inspection services to check at random the efficiency of the producers' inspection systems.

If certification is to supplement traditional food inspection and food safety precautions during processing, it must necessarily include the HACCP concept. The broad implementation of HACCP will also help small-scale local food industries and retailers to improve food hygiene, while at the same time increasing the efficiency of official food inspection services. The certification of food processing plants will supplement, but not substitute for, official food inspection systems.

Irradiation

Modern food technologies such as irradiation are able to eliminate microorganisms present in foods at the time of treatment. Concern has been expressed that irradiation of an end-product such as raw poultry will reduce the adoption of preventive measures against salmonella or *Campylobacter* in primary production. If farmers were demotivated to combat agents that have no relevance for production, the uncontrolled infection rate in poultry would increase. It can be anticipated that other means of transmission to man would occur in such circumstances. Minimizing the occurrence of pathogenic agents in living animals will remain the most appropriate measure for safeguarding consumers. Irradiation of the end-product, however, can provide additional protection in some circumstances.

Monitoring

Monitoring systems for foods have been established for chemical contaminants such as heavy metals, pesticides and herbicides. A good example of monitoring for biological metabolites (toxins) in foods are the systems for the detection of paralytic shellfish poisoning and diarrhoeal shellfish poisoning. The food component of the Global Environmental Monitoring System (GEMS/Food) considered in 1991 including microbiological contamination of food items in its spectrum; the first feasibility study has been initiated.

With respect to microbiological hazards during food processing, monitoring is an integral part of the HACCP system. Monitoring provides an active control, since it is used to detect problems at early stages in the process and allows corrective action to be taken before a defective end-product results.

Current programmes for end-product examination do not fulfil the requirements of monitoring systems for microbiological contaminants, which should consider (*a*) whether foodborne disease-causing agents are introduced with the raw material or during manufacture and subsequent handling; (*b*) whether, depending on the product and the process, microorganisms multiply, survive or die off; and (*c*) whether transport and storage may permit further microbiological contamination, growth, survival or death. To consider all these aspects, a monitoring system would have to follow extremely complex sampling and examination procedures. Even then, monitoring could only reveal the *status quo*, which could change during the shelf-life of a product.

Until these problems are solved, it seems advisable to promote early warning/alert systems such as the already existing EU system.

9.3.3 Foodborne diseases due to microorganisms

Background

The network of national contact points within the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe has reported a dramatic increase in cases of foodborne disease during the last eight years [4]. The World Health Organization, through its Regional Office for Europe in Copenhagen, initiated this Programme, whose main objectives are:

- to identify the causes of foodborne diseases and to delineate factors contributing to the spread of those diseases;
- to make available and distribute relevant surveillance information;
- to cooperate with national authorities in identifying priorities and using resources to meet both emergency and other needs in the prevention and control of foodborne diseases.

In 1981, eight European countries actively participated in the Programme; by 1991 all 30 Member States of the WHO European Region as it was then were taking part. Some of the new Member States in the CCEE and NIS already contribute actively to the Programme, while others are still in the process of reorganizing their national disease reporting system. The Institute of Veterinary Medicine (Robert von Ostertag-Institut) of the Federal Health Office in Berlin acts as the coordinating centre.

An officially designated central contact point in each country collates and evaluates national data on cases and outbreaks of foodborne diseases and reports these data to the Berlin centre. Here all national data are aggregated in annual reports indicating the foodborne disease situation in Europe [4,5].

Reporting systems

The notification of certain infectious diseases is legally required in all countries. In a few countries (England & Wales, Scotland, Spain) foodborne diseases are included but only information on the number of cases is provided, without details of causative agent, food involved, etc. It is estimated that only 1–10 % of all cases of foodborne disease will be reported. This means that the figures for statutorily notified cases and the calculated incidence rates have to be multiplied by a factor of at least 10 to reach the "true" number of cases and incidence.

Other sources of information are sentinel and community studies. All cases of gastroenteritis that have come to the attention of doctors in a given area for a given period are recorded. The result is then extrapolated to the total population (sentinel study). A community study can demonstrate the number of people reporting each gastrointestinal complaint. By interpolation, the true incidence of gastrointestinal diseases in the total population can be calculated.

More valuable background information in terms of causative agents, foods involved and places where the food was contaminated, acquired or consumed can be obtained from reports of epidemiologically investigated outbreaks. Reports from local or central reference laboratories provide additional information.

Frequency and trends of foodborne diseases

Salmonellosis is still the most important foodborne disease, and cases of salmonellosis are relatively the best notified in most countries. Table 9.2 shows incidence in several European countries since 1985.

There has been a considerable increase of cases of salmonella infection in nearly all countries since 1985. The incidence in many countries has more than doubled, and in some of these it is still on the increase.

The previous predominance of salmonellosis among gastrointestinal infections has currently undergone a change in some countries. In the Netherlands, the number of infections due to *Campylobacter* is about three times higher than those due to salmonella. A

Table 9.2: Incidence of salmonellosis (reported cases per 100 000 inhabitants)

Country	Year		
	1985	1989	1991
Austria	19	62	144
Croatia	67	67	65
Czech Republic	–	–	350
Denmark	27	69	–
Estonia	30	84	160
Finland	89	134	110
Germany	50	103	169
Hungary	87	128	–
Iceland	34	41	–
Israel	68	87	97
Italy	17	21	34 (1990)
Lithuania	16	32	66
Luxembourg	2	8	8
Poland	61	81	81
Romania	20	33	–
Slovakia	118	108	167
Sweden	34	59	64
Switzerland	40	105	69

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

similar situation exists in England & Wales, where in 1989 *Campylobacter* infections rated first with 32 526 cases, followed by salmonellosis with 24 649 cases and rotavirus infections with 13 340 cases. Scotland reported for 1992 a total of 4915 cases of campylobacteriosis compared to 3625 cases in 1990. Single cases or small family outbreaks are typical of *Campylobacter* infections.

Sentinel and community studies

To measure the real incidence and causes of foodborne disease, the National Institute of Public Health in the Netherlands carried out a sentinel study involving 42 general practitioners, 2 local public health services, medical laboratories and the National Institute itself [6]. The 5-year study reported an annual incidence of 15 cases of gastroenteritis per 1000 population in general practice. The total population of the Netherlands is 15 million. By extrapolation, the total number of gastroenteritis cases seen in general practice throughout the country can be calculated as 225 000 yearly. The number of infections due to *Campylobacter* was about three times higher than the number of cases of salmonellosis.

However, because a sentinel study of general practice only reports cases in which a doctor was consulted, no incidence can be obtained for the total number of foodborne diseases in the population. A community study was carried out in 1991 in the Netherlands, in which the number of people suffering from gastroenteritis and the number of patients consulting a doctor for these complaints was documented, and the isolation rates for salmonella and *Campylobacter* in the population and in general practice were compared.

This study of almost 2000 people, over a 4-month period, showed an incidence of 150 cases per 1000 population per year, indicating that more than 2 million people suffer yearly from gastroenteritis in the Netherlands but only some 10 % (250 000) visit a general practitioner. The number consulting a doctor seemed to correspond with the number of cases calculated in the sentinel study. Based on the laboratory results of the sentinel study, it is concluded that at least half of the cases are related to foodborne or waterborne diseases – more than 1 million cases per year in the Netherlands.

Epidemiological investigations

Epidemiological investigations of outbreaks of foodborne disease usually provide details about causative agents, implicated foods, places where the food was contaminated, acquired or eaten, and on factors that may have contributed to the outbreaks. This information is necessary for the implementation of appropriate control measures.

Causative agents

In epidemiologically investigated outbreaks of foodborne diseases, salmonella is still the most commonly implicated organism. *Staphylococcus* and *Clostridium* are the next most important causative agents. *Campylobacter* is not often reported as a causative agent in outbreaks, although in some countries this organism is found in gastrointestinal infections more frequently than salmonella. *Campylobacter* causes illness resembling salmonellosis.

Botulism normally occurs as single cases or small family outbreaks involving only a few people, although it may more frequently be fatal than other gastrointestinal infections. It is mainly due to the consumption of home-made canned meat or vegetable products that have been insufficiently heat treated, or of large pieces of meat such as smoked ham, especially if no nitrite was used during processing to inhibit outgrowth of spores of the microorganism.

Infections with *E. coli 0157:H7* seem to have increased, although only a few data are available at present. In the United States, insufficient cooking of beef probably contributed to the outbreaks. In Canada, milk and cold sandwiches have been associated with outbreaks, and in the United Kingdom turkey rolls were cross-contaminated by raw beef and raw potatoes.

L. monocytogenes has caused few but very severe outbreaks of foodborne disease during recent years. The bacterium is present in a wide range of foods but causes disease in immunosuppressed people that may take the form of septicaemia or meningitis. It also poses a particular hazard to pregnant women and may cause abortion or stillbirth. The fatality rate is about 30%. Outbreaks occurred in Switzerland after consumption of a special brand of cheese produced in a limited area of the country. In the United Kingdom, liver paté was found as the responsible food item. France was hit by a nationwide outbreak in 1992 due to consumption of jellied pork tongue; 275 people were affected, of whom 56 died.

Turkey reports cases of brucellosis to have increased from some 1000 in 1985 to 3000 in 1989. Malta also reports cases of brucellosis, of which the majority are foodborne in origin. Home-made cheese products have been a means of transmission. The major sources of infection are unpasteurized dairy products from infected cattle and goats.

Trichinosis (resulting from infection with the parasite *Trichinella* spp.) occurs in Poland, with some 100–300 cases every year. In Romania, between 300 and 947 cases per year were reported to the health authorities during 1985–1989, and in Bulgaria 8 outbreaks with a total of 206 cases were recorded in 1990/1991. In Lithuania, 498 cases of trichinosis occurred in 1990/1991. The former Yugoslavia reported about 20 cases per year and in Spain 5 outbreaks occurred in 1990/1991. Undercooked pork is the most usual source of infection. In France in 1991, seven cases of trichinosis occurred caused by the consumption of horse meat. The illness may be mild or severe and, in addition to gastrointestinal symptoms, muscular and neurological symptoms may develop. Fatalities have been reported.

About 2 million people in the Russian Federation are estimated to be infected with foodborne trematodes (Sergiev, V.P. et al., unpublished data, 1993). In particular, opisthorchiasis is a public health problem in Kazakhstan, the Russian Federation and Ukraine, with a prevalence of up to 40% in most endemic areas and even higher in certain others (Sergiev, V.P. et al., unpublished data, 1993; Iarotski, L.S. & Be'er, S.A., unpublished data, 1993).

Foods involved in outbreaks

The foods most often involved in outbreaks are meat and meat products, poultry, eggs, egg products and foods prepared with or containing eggs, such as mayonnaise, desserts, cream fillings and certain types of pudding. Eggs and egg-containing dishes are mainly associated with salmonella, which is well adapted to poultry. Cereal products are associated with *Clostridium*. Consumption of raw, frozen, salted, smoked or inadequately cooked freshwater fish is associated with opisthorchiasis.

Place where the food was contaminated, acquired or eaten

Mass catering establishments such as canteens, restaurants, schools, kindergartens, homes for elderly people and hospitals are the main places where outbreaks of foodborne disease arise. The food may be contaminated on site by improper handling, or raw or already prepared food materials may have been previously contaminated elsewhere. Smaller establishments caring for only a limited number of people, including private households, are increasingly important as sites of infection. Training of personnel in food hygiene may be better in larger establishments.

Factors contributing to foodborne disease

The identification of contributing factors, necessary for the introduction of appropriate preventive measures, requires well trained personnel to investigate outbreaks on the spot. From the reports received by WHO, insufficient refrigeration or cooling was the most frequent factor. Other factors mentioned are inadequate heat treatment, cross-contamination, inadequate hygiene of personnel and use of ingredients from unsafe sources.

Social and economic impact of foodborne disease

The information gathered through the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe clearly indicates that foodborne diseases are among the most frequently reported and that their occurrence has increased during recent years in most European countries. Since the course of such disease is normally mild and recovery quite rapid, the consequences of foodborne diseases are often underestimated. Public and official attention results only when there are outbreaks involving a large number of people and when these are fatal cases. Considerable underreporting creates difficulties for the realistic consideration of the social and economic impact of foodborne diseases.

Attempts have been made in Canada [7], England & Wales [8] and the United States [9–11] to estimate the costs of cases and outbreaks of foodborne disease, despite the uncertainties in the available data.

In England & Wales, a national survey by questionnaire was carried out of 1482 cases of salmonellosis officially reported between August 1988 and March 1989. Information was sought about costs imposed upon the public sector, on industry and on individuals and their families, and on the costs to the wider economy in terms of lost production. Costs for the public sector include the health sector, with costs for the direct or indirect care of patients, and for public health and hospital laboratories and environmental health services involved in the investigation of the illnesses. Costs to industry comprise the loss of productivity of sick workers and those who are off work to care for them, and additionally for those who stay away from work in order to avoid transmission of infection. It includes loss of business, productivity and reliability of companies; whole branches of industry may possibly be involved in an outbreak. Individual and family costs are those that arise from limitations in carrying out normal daily activities and from acute and chronic suffering and sometimes

Table 9.3: Costs per case of salmonellosis in the United Kingdom (England & Wales)

	Cost per case (£ sterling)
Local authority investigations	57.78
Laboratory investigations	48.27
General practice costs	29.32
Hospital costs	167.31
Prescribed medicines	6.26
Other costs of illness	66.94
Loss of production	412.98
Total	788.86

Source: Sockett, P.N. & Roberts, J.A. *(8)*.

death. The results of the study, on a cost-per-case basis, are shown in Table 9.3.

The range in costs per case was very wide and was particularly sensitive to the cost of hospitalization and to lost production. Thus, for those admitted to hospital, treatment costs ranged from £119 for a patient admitted for one day to over £4000 for a patient in hospital for 34 days. This had a chain reaction effect, resulting in corresponding increases in travel costs to families and friends visiting the patient. Similarly, for patients in paid employment, the costs of lost productivity ranged widely depending on the number of days off.

Based on the 23 000 reported laboratory confirmed cases of salmonellosis in 1988, public sector costs would have been about £6.8 million, while costs to industry from lost production would have been £9.5 million. These are underestimates of the true costs since they take no account of costs of unreported cases, or of estimates of costs of general discomfort, any longer-term sequelae of infection, or lives lost.

This study did not estimate the cost of salmonellosis to firms that might be involved in an outbreak. Other studies have indicated the enormous sums that have been lost, especially when there was withdrawal of products and closure of factories.

Estimates from the United States, as well as those from the United Kingdom, clearly indicate that foodborne diseases are a tremendous cost factor for society due to the high number of people affected each year. On the basis of the United Kingdom estimates of costs per salmonellosis case and the results of the Netherlands sentinel and community study, it can be estimated that for the Netherlands, with a population of about 15 million, total annual costs are around £790 million. Such a calculation may be debatable, but it is based on figures from serious studies and at least indicates the magnitude of the problem of foodborne diseases in social and economic terms.

The annual economic losses due to foodborne trematode infections in the Russian Federation are estimated to be in excess of US $ 770 million (Sergiev, V.P. et al., unpublished data, 1993).

9.4 Chemical Contamination

Considering the wide range of foods consumed (whether as staples, speciality foods, seasonal foods, or spices and condiments), the number of contaminants and the number of countries within the WHO European Region, thousands of combinations are possible. In some countries, data analysis and time trends are difficult to establish because of the paucity of data.

Data from responses to the Concern for Europe's Tomorrow protocol, the GEMS/Food data bank, national reports, sectoral reports and the scientific literature have been used to prepare the following evaluation. Data related to national foods and imported foods are reported separately where possible. Data interpretation in terms of effects on human health is further complicated in some parts of the Region by the fact that the food supply itself undergoes periodic shortages, with consumption of substandard food, especially by the poor. Even within otherwise affluent sections of Europe, the position of vulnerable and underprivileged groups needs to be specifically evaluated. Changes in political, economic and administrative systems may also affect the extent to which chemically contaminated food may be consumed.

Priority contaminants considered in this report include:

- metals: lead, cadmium, mercury and arsenic
- industrial substances: polychlorinated biphenyls (PCBs)
- nitrates
- mycotoxins: aflatoxins and ochratoxin A
- polychlorinated pesticides: DDT, hexachlorobenzene (HCB), hexachlorocyclohexane (HCH) and aldrin/dieldrin
- organophosphorus pesticides.

Related health effects are discussed in Chapters 10 and 18.

The Food Contamination Monitoring and Assessment Programme (GEMS/Food) is a component of the Global Environment Monitoring System (GEMS) established by the United Nations Environment Programme (UNEP) jointly with WHO and the Food and Agriculture Organization of the United Nations (FAO). The major objectives of the programme are to collect, assess and disseminate information on levels and trends of contaminants in food, the magnitude of dietary exposure, and significance with regard to public health. Such information enables preventive and control measures to be initiated at national level to reduce health impacts. Since the early 1990s, a specific component of GEMS/Food applicable to and developed by the WHO Regional Office for Europe has been established (GEMS/Food-EURO). Its remit is comparable with GEMS/Food but includes mycotoxins other than aflatoxins, nitrates and radionuclides, but not microbial contamination of food. Food safety cannot be guaranteed solely on a national basis; food contamination in one country may affect people in other countries via food exports or imports. International and regional programmes are therefore required to ensure food safety for the consumer.

9.4.1 Current situation

Metals

Cadmium

As food is the main exposure pathway for cadmium, much attention has been given to this element from areas where industrial contamination and the use of cadmium-containing phosphate fertilizers and sewage sludge have been extensively used. Analysis of archived soil samples has shown that cadmium concentrations in topsoil have increased during the last century. Plant uptake of cadmium depends on soil factors such as acidity and on the plant cultivar. The lowest cadmium levels are in milk, eggs, fruit and meat muscle. Levels in potatoes and other vegetables are higher, together with cereals and grains (although considerably higher values have been found in grains grown in areas with high metal emissions in the former German Democratic Republic) [12]. Levels of cadmium in shellfish are appreciably higher than in fish. High levels are also found in animal kidneys.

Lead

Lead is one of the most frequently monitored contaminants in food. Emphasis has been placed on monitoring staple foods such as potatoes, wheat and rice, leaf vegetables, canned foods and shellfish. Monitoring of infant foods is also important, since lead levels are of special health concern at this age. Lead concentrations in food items vary markedly depending on location (crops from urban areas generally contain higher concentrations of lead than those from rural areas), emission sources (surface lead deposition can contaminate leaf vegetables) and processing methods. Levels of lead are generally low in milk, higher in cereals, vegetables and meat muscle, higher again in kidney, liver and fish, and highest in shellfish.

Where vegetables are grown in industrial and mining areas, or close to roads where leaded petrol is used in automobiles, very high levels (around two orders of magnitude greater than normal) can be detected mainly from atmospheric deposition of particulates. Food in lead-soldered cans can contribute substantially to intake, although an increasing number of countries have changed to using non-leaded cans.

Lead in tap water may also add a considerable amount of lead to the dietary intake, where soft (acidic) water is supplied through lead piping.

Arsenic

The highest concentrations of arsenic are found in fish and shellfish, followed by poultry. Values may be high in poultry if they have been fed on fish meal or, in some countries, on arsenic-containing growth-stimulating substances. Foods of vegetable origin and those from other animals generally contain lower concentrations. Most of the arsenic found in food is in organic form. The organic arsenic compounds in seafood are of relatively low toxicity, but health effects in animals have been reported following exposure to arsanilic acid as a feed additive. The different inorganic and organic forms of arsenic have quite different toxicities as a result of different chemical properties and the stability of the compounds formed.

Mercury

Mercury concentrations in food have been extensively studied because of the adverse effects of methylmercury on the central nervous system [13] (see also Chapter 10). Fish and shellfish are the main sources of methylmercury intake by humans.

Polychlorinated biphenyls

Polychlorinated biphenyls are characterized by environmental persistence. As these compounds are fat soluble, they are widely detected in food, milk, human milk and human tissues.

Relatively high concentrations of total PCBs have been routinely reported in a number of food products, especially fish, shellfish, meat and milk, predominantly from industrial countries. Concentrations are elevated in cod liver oil, which is usually not included in consumption or dietary intake studies. The GEMS/Food data bank contains an extensive collection of data illustrating differences in PCB levels among foods and between countries [14].

Production of PCBs only ceased in the former Czechoslovakia in the 1980s. Data from the Czech Republic for 1991[a] show that just over 24 % of more than 20 000 samples tested exceeded the regulatory limits for PCBs. However, concentrations in foodstuffs are decreasing.

Concentrations of PCBs in dairy milk and butter in some countries, such as the Czech Republic, are high and may exceed national limits (Fig. 9.1). Nevertheless, concentrations are decreasing.

Nitrates

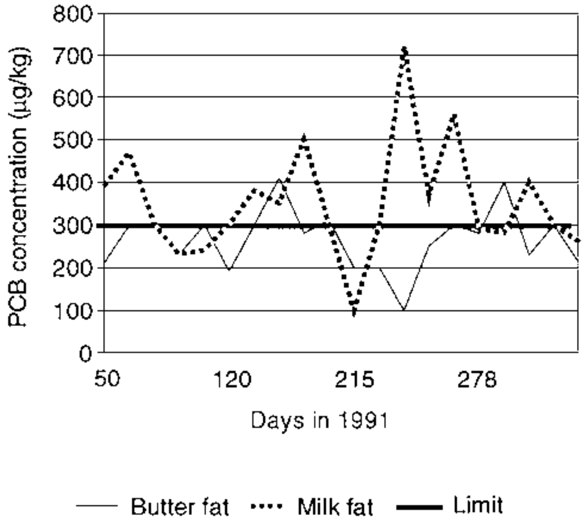
Vegetables and fruit may contain high nitrate concentrations, which are partly influenced by available soil nitrogen, crop variety and growth conditions, including season (nitrate can only be metabolized by plants in the presence of sunlight). Nitrate levels are also high in some meats, and may be comparable to nitrite levels.

Nitrate in drinking-water also adds to the nitrate intake. With the large local, national and regional variations, its significance can be small (where nitrate levels are low) or considerable, exceeding the intake from vegetables when levels are high (exceeding guideline values).

Mycotoxins

In addition to causing food losses, contamination of foods by moulds such as *Aspergillus* spp. can lead to the presence of aflatoxin. The concentration of aflatoxin varies markedly with farming practices, storage conditions, insect damage and climate, as

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.



Source: Ministry of the Environment of the Czech Republic *(15)*.

Fig. 9.1: Concentration of PCBs in milk and butter fat at a location in the Czech Republic, 1991

well as with crop species and cultivar. WHO, FAO and UNEP, either singly or in association, have ongoing programmes dealing with mycotoxin prevention and control in agricultural crops. Consequently, recent data show lower aflatoxin concentrations. Better analytical methods and increasing analytical quality control have also contributed to more accurate and reliable data.

Aflatoxins have been reported in a range of tree nuts and in groundnuts (peanuts), in grains such as rice, millet and maize, and in pulses, spices and figs [16–18]. Peanut butter may contain aflatoxins, and breakfast foods prepared from contaminated grain may, on occasion, contain measurable concentrations. Aflatoxins have also been reported in fermented beverages and even in dried fish.

Data from a number of countries,[a] particularly the CCEE, report a range of aflatoxin concentrations in foodstuffs, including levels considerably in excess of 10 µg/kg. In Lithuania, for example, of 309 domestic cereals sampled 9 were positive with a mean of 135 µg/kg and a range of 0.5–500 µg/kg. In Hungary on the other hand, of 301 cereal samples 34 were positive with a range of 0.02–2 µg/kg. In Romania, 15 % of the 547 domestic cereal samples analysed were found to contain aflatoxins. Some countries reported that up to 50 % of imported groundnuts were contaminated, particularly in the 1980s, but data on aflatoxin contamination more recently refer to materials for animal feeds, thus indicating the successful application of sound control methods designed to reduce aflatoxin exposure of humans.

The mycotoxin ochratoxin A, produced by some *Penicillium* and *Aspergillus* strains, is being increasingly recorded in human food, especially cereals such as rye and wheat, and in imported coffee beans. The fungi are found on growing crops but develop particularly on crops in storage. Toxin production depends on such factors as temperature and humidity, especially during harvest. From a climatological point of view Denmark, Germany, Norway, Sweden and the United Kingdom are at risk, as are also the Danube lowlands, Bulgaria, Romania and the former Yugoslavia. In Denmark during the wet autumn of 1987, higher concentrations of ochratoxin A were reported in grain compared with harvests in other years and with grain imported from drier climates [19]. Ochratoxin A is also found in foods of animal origin, such as those from poultry and pigs that have been fed contaminated feed.

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

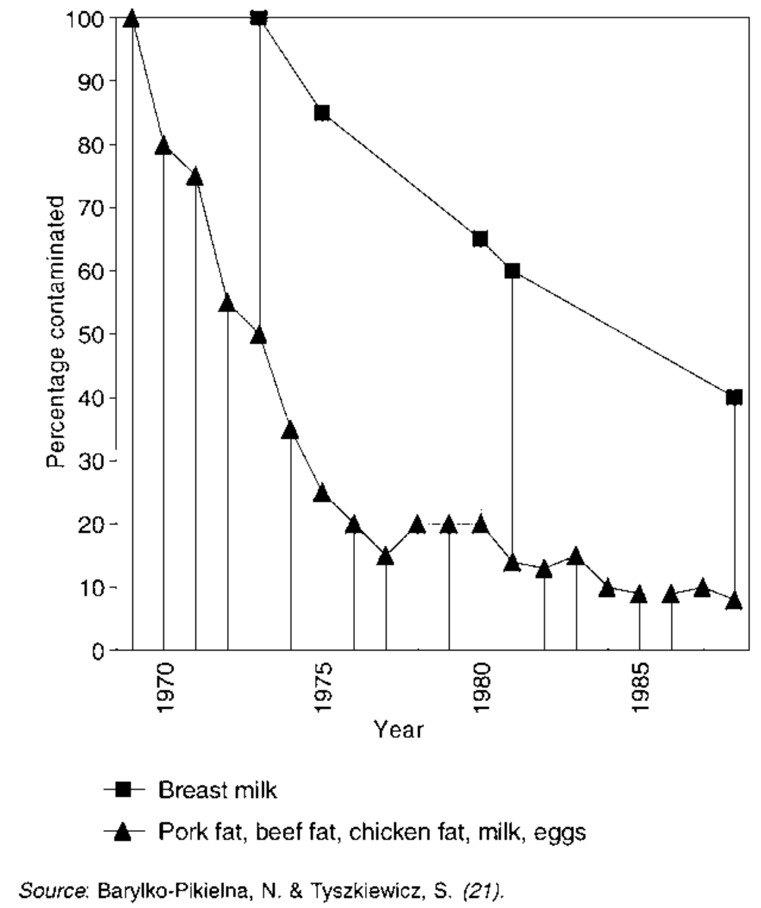


Fig. 9.2: Trend in contamination of human milk and animal proucts by DDT and its derivatives in Poland, 1969–1988

Pesticides

DDT

Of the organochlorine pesticides, DDT has attracted much attention in the past. Interest has declined in recent years, however, especially in western Europe, as concentrations have declined. DDT is fat soluble, and concentrations in pork, beef and chicken fat and in milk and milk products are still reported by some countries. Data from Poland show a decline in the DDT content of animal fats and human milk (Fig. 9.2). Comparable reductions have been shown in Denmark and elsewhere [20].

Hexacholorobenzene

The widespread use of HCB as a fungicide on cereals, coupled with its fat solubility, has led to its widespread occurrence in dairy milk, milk products and human milk. Industrial discharges may also lead to the contamination of seafood products.

Hexachlorocyclohexane

Technical grade HCH consists of a mixture of isomers that have been used as a pesticide in some countries. Gamma-HCH, commonly known as lindane, is the most biologically active isomer and is used more widely. Residues of this and other isomers have been measured in a range of animal fats, dairy milk, fish and vegetables.

Aldrin and dieldrin

Aldrin and its metabolic product dieldrin have been reported in the GEMS/Food programme for a number of years. Low levels of contamination have generally been reported; any contamination present is often below the limit of detection. Concentrations are higher in dairy milk and milk products, as well as in human milk [14].

Organophosphorus and other pesticides

As organophosphorus pesticides are not stable in the environment and are metabolized by animals, residues occur in field crops but not normally in food items or in foods of animal origin.

Analytical data on pesticide residues in a range of dietary staples, fruit and vegetables, cereals and animal products have been produced in a number of countries for 100 or more pesticides, and have been related to national maximum residue levels (MRLs), Codex Alimentarius Commission levels or EU levels. National regulatory monitoring data for Sweden [22] and the United Kingdom [23] show that the majority of the samples contained either no residues or low concentrations. Only a small percentage of samples exceeded the MRL, including some imported food items.

9.4.2 Exposure to chemical contaminants

Estimates of the intake of contaminants require food consumption data as well as knowledge of the concentrations in the relevant foods. Estimates of dietary intake vary both between studies and between countries owing to such variables as differences in type of study, the general nutritional status of the population, the nature of the consumers, differences in diet, and whether drinking-water is included.

Dietary intakes for vegetarians and for infants and small children deserve special attention. Data on human milk as well as cow's milk are given whenever possible. Information about contamination of water used for preparing milk for bottle-fed infants is also important for assessing intake.

Dietary intakes of metals, nitrate, PCBs and pesticides are also discussed in Chapter 10.

Metals

Cadmium

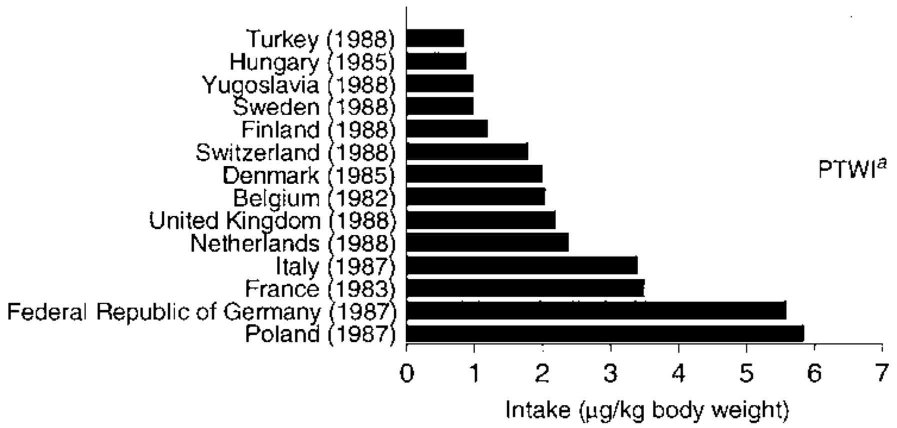
Average adult dietary intakes are shown in Fig. 9.3. None of the mean intakes exceeds the FAO/WHO provisional tolerable weekly intake (PTWI) of 7 μg/kg body weight based on a 50-year exposure period. However, once-a-week consumption of mussels or kidneys, or some species of mushroom that accumulate cadmium, could result in a mean intake that would approximate or exceed the PTWI for those living in previously contaminated areas. Intake of cadmium in potatoes and vegetables normally accounts for around 50–60% of total intake, with bread and cereals next at around 10–30%.

Trends in intake over time are not clear; in some countries they appear to be decreasing while in others no trend is apparent.

Studies on intakes of cadmium in infants and children have also been reported from a number of countries. In general, results show that the mean intakes of infants (12–24 months of age) may be close to or exceed guideline values, while intakes for teenagers are much lower and nearer adult intakes [14,25]. Exceeding the guideline value during infancy is not considered serious as these values apply to regular intakes over a 50-year period. Nevertheless, the intakes of special consumer groups such as vegetarians and infants deserve special attention. Cadmium intakes of breast-fed infants are lower than those of infants fed soya-based formulae.

Lead

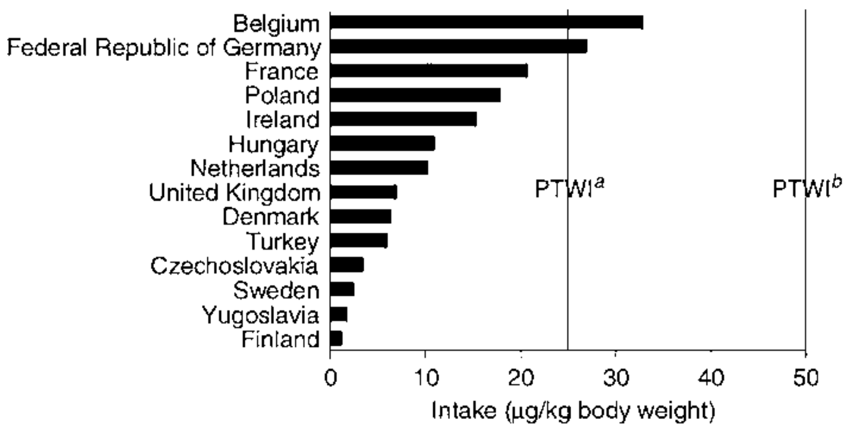
Food, and especially water, are major sources of lead exposure. Average dietary intakes of lead by adults based on GEMS/Food data are shown in Fig. 9.4 and range from 1 to 33 μg/kg body weight per week [26], which can be compared with the new



[a] FAO/WHO provisional tolerable weekly intake.

Source: Jelinek, C.F. *(24)*.

Fig. 9.3: Average weekly dietary intake of cadmium by adults in 14 European countries



FAO/WHO provisional tolerable weekly intake: [a] 25 µg/kg body weight from 1993 *(27)*; [b] 50 µg/kg body weight up to 1993.

Source: Galal-Gorchev, H. *(26)*.

Fig. 9.4: Average weekly dietary intake of lead by adults in 14 European countries, 1980–1988

PTWI of 25 µg/kg [27]. Dietary intake studies more than a decade ago in Scotland showed that around one third of the residents exceeded the PTWI because of high lead levels in the water supply [28]. Lead in canned beverages, drinking-water or alcoholic drinks can account for over 50 % of lead intake. Cereals and fruit contribute the next largest amount of lead to an average diet. Although lead concentrations are high in shellfish and animal products, their contribution to the total dietary intake is small.

As a rough rule-of-thumb, the 95th percentile of food consumers have an intake of lead that is twice the average consumption of the population as a whole [25]. In those countries with an average approaching the PTWI, therefore, a proportion of the population may exceed the PTWI.

Decreases in lead intake over time have been reported for a number of countries, including the United Kingdom, reflecting a decrease in the use of lead-soldered cans, lower plumbosolvency in the water supply and the use of unleaded petrol [27]. In other countries such as the former Czechoslovakia and Hungary, no such trends are apparent.

In Poland, the intake of lead by children living in industrial areas was double that of children living in non-industrial areas. The lowest lead intakes by infants are in those who are breast-fed.

Relatively few countries report the dietary intake of lead by infants and children. The average dietary intake by infants and children up to 12 years of age can exceed the PTWI for lead from all sources. Concentrations of lead in the blood of bottle-fed infants in an area of Scotland show a correlation with lead intake from water [29]. Data from Finland demonstrate that the mean intake for 12–24-month-old infants is 25 μg/kg body weight per week, i.e. the same as the PTWI [24] although intakes among 15-year-old teenagers were much lower. Intakes by infants can be strongly influenced by the lead content of water added to dehydrated infant formulae and cereals and by the lead content of canned infant foods. A shift away from lead-soldered cans markedly reduces lead intake.

How much lead in food contributes to health impairments in children in the CCEE, compared with lead in air or water and ingestion of lead-rich dusts or soils, is uncertain. Nevertheless, a reduction in exposure to lead in food should be a priority for action.

Arsenic

As arsenic in fish occurs in organic forms of relatively low toxicity, it is often not included in intake studies. The provisional maximum tolerable daily intake established in 1989 is 15 μg/kg body weight per day of inorganic arsenic. Data from several countries indicate that intakes from food do not exceed this value.

Daily arsenic intake (from fruit and berries) by infants aged 12–24 months in Finland is close to 2 μg/kg body weight per day, while the intake for 15-year-old teenagers is substantially lower [25].

If drinking-water contains high levels of arsenic, intakes can exceed 1 mg/day.

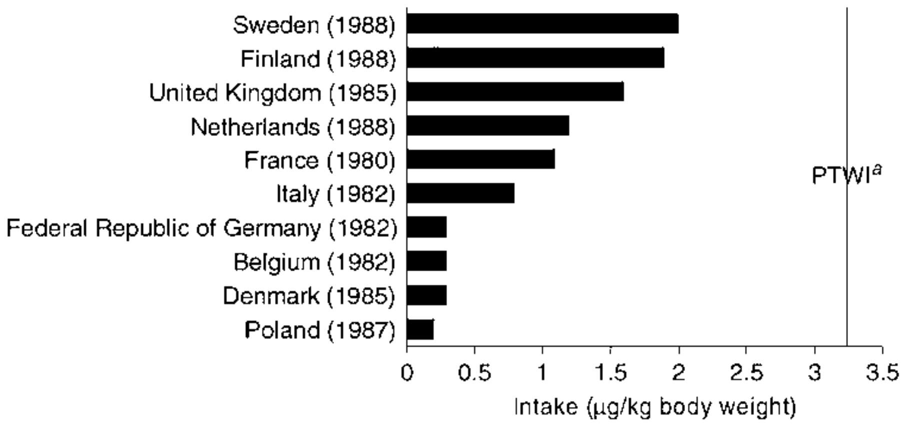
Mercury

A PTWI of 300 μg of total mercury per person has been established, of which no more than 200 μg should be present as methylmercury, i.e. 3.3 μg/kg body weight for the general population. Dietary intakes of mercury for adults from 16 countries for a variety of dates based on GEMS/Food data are shown in Fig. 9.5. Intakes for several countries are around 60% of the PTWI [24]. The main contributory foods in Poland are potatoes and vegetables (nearly 40%), milk and milk products (about 24%), bread and cereals (about 13%) and fish (about 11%) [21]. The monitoring data, therefore, indicate that the risk to the general population is low in most countries. In Poland, contamination of food by mercury can be considered to be moderate, although recent data for average weekly intakes are around 40% of PTWI rather than the earlier 60%.

The fetus and breast-fed babies may be at greater risk of adverse effects from intakes of methylmercury [13]. This is particularly the case when mothers live in coastal and fishing communities and consume large quantities of local fish. Intakes of mercury and methylmercury from human milk have been shown to be within the PTWI. Average levels of 3.1 μg/kg total mercury and 0.6 μg/kg methylmercury were found in the milk of women who consumed fish from Swedish coastal areas of the Baltic Sea [30]. Data from Ludwicki [31] show that the daily intake of mercury in small children (up to 3 years of age) in Poland varied between 0.07 μg and 4.1 μg, and for teenagers aged 14–18 years was around 7 μg depending on location and, hence, source of food.

Polychlorinated biphenyls

As concentrations of PCBs in fish, meat and milk or milk products are high, the total dietary intake of PCBs depends largely on these



[a] FAO/WHO provisional tolerable weekly intake for methylmercury (3.3 µg/kg body weight); the PTWI for total mercury = 5 µg/kg body weight.

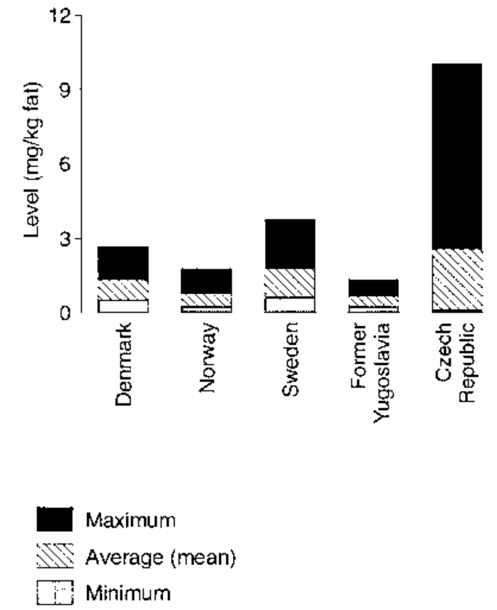
Source: Jelinek, C.F. *(24)*.

Fig. 9.5: Average weekly dietary intake of mercury by adults in 10 European countries

foods. Populations that consume fish as a major part of their diet have a higher total PCB intake than do populations elsewhere. In countries with a high consumption of dairy products, PCB intakes are again relatively high.

In Denmark, the calculated average daily intake was less than 10 µg, corresponding to less than 70 µg/week. There is no PTWI for PCBs. The National Food Agency of Denmark [20] has calculated the guideline tolerable intake as 245 µg/week (3.5 µg/kg body weight per week). The national intake is therefore approximately one third of the guideline tolerable intake. For those taking cod liver oil supplements, the normal weekly consumption of about 150 g, containing 1.6 mg/kg, raises intake to the guideline value. Consumption of eel, a fish with a high lipid content and high PCB concentrations often exceeding 1 mg/kg, also markedly increases the PCB intake. Data from the Czech Republic indicate that some 46% of PCB intake comes from the consumption of meat.

Intakes of PCBs of 0.2–4 µg/kg body weight per day were calculated by Petrik et al. [32] for the general population of Slovakia. These values can be compared with the suggested guideline of the US Food and Drug Administration of 1 µg/kg body weight per day, or the Danish guideline of 0.5 µg/kg body weight per day.



Source: Ministry of the Environment of the Czech Republic *(15)*.

Fig. 9.6: Range and mean levels of PCBs in breast milk in five European countries

Concentrations of PCBs in human milk from mothers living in different areas of the Czech Republic are compared with values from other countries in Fig. 9.6 [15]. These values, of around 2 mg/kg milk fat, are much higher than the 1991 values for Poland of

0.012 mg/kg.[a] Indeed 19 of the 58 samples from Poland were below the detection limit. Data from Lublin, Poland, a decade earlier showed a mean of 0.49 mg/kg milk fat (range 0.17–3.08 mg/kg) [33]. The calculated average intake of PCBs in human milk may therefore exceed the suggested guideline value in these regions.

Data from Norway and Sweden on PCBs in human milk are comparable with those from other countries at around 1 mg/kg milk fat [34–36]. Results also show that the concentrations of PCBs in milk fat are lower during the nursing of the second and third child than during the first lactation period. Levels of PCBs in human milk from other countries are reported by Jensen [37].

Nitrates

Estimates show that, in Denmark, fruit and vegetables provide on average about three quarters of the total nitrate intake [19], other food sources and drinking-water providing the remainder. However, the concentration of nitrate in drinking-water varies so much from place to place that it may be the largest contributor to the daily nitrate intake in some areas.

Analysis of daily intakes of nitrate from vegetables should take into account whether vegetables are boiled or not. Duijvenbooden & Matthijsen [38] report that about 40% of the nitrate is lost with the cooking water.

Comparable intakes, well within the acceptable daily intake of 5 mg/kg body weight, are reported for Denmark, Finland and the United Kingdom – the latter two not including drinking-water [39,40]. In Poland, the daily average intake is 49.5% of the acceptable daily intake (ADI) rising to 255% in extreme cases [20].

Intakes by vegetarians can be expected to be higher, since vegetables provide around 97% of their intake. Estimates range from 185 to 194 mg/day for the United Kingdom [39] which is still within the ADI, although this does not include tap water. Taking the average consumption of water as one litre per day, and the average concentration of nitrate in tap water to be within the range 10–20 mg/1, then the additional contribution to the food intake would only be 10–20 mg/day.

Mycotoxins

Aflatoxin M_1 has been reported in both breast milk and cow's milk. Visconti et al. [41] reported that 72% of samples of cow's milk and milk products from southern Italy were contaminated with aflatoxin M_1. Of 297 cow's milk samples analysed in Bulgaria, 17 were positive with a maximum aflatoxin M_1 concentration of 1.05 μg/l.[a] A reduction of levels of aflatoxin M_1 in animal feed, particularly some imported feeds, has led to a concomitant reduction in levels in cow's milk, as is shown clearly in data from Denmark (Fig. 9.7). Consequently, concentrations of aflatoxin M_1 in infant foods based on milk have also fallen substantially.

Information from several European countries on intakes of ochratoxin A suggests that the PTWI of 112 ng/kg body weight (16 ng/kg body weight per day) [43,44] is not being exceeded, although some intakes have exceeded the tolerable daily intake calculated from carcinogenicity data by Kuiper-Goodman & Scott [45] of 0.2–4.2 ng/kg body weight.

Ochratoxin A has been recorded in 9 out of 50 breast milk samples from Italy within the range 1.7–6.6 ng/ml (limit of detection 0.2 ng/ml) [46].

Ochratoxin A has been determined in some 70% of serum samples from Sweden [47], 50% of samples from Germany [48], approximately 50% from Denmark [49] and 22% from France [50], indicating the widespread exposure to this substance.

Ingestion of ochratoxin A is a risk factor for the development of Balkan endemic nephropathy, which in turn is a risk factor for the development of renal tract tumours [51] (see also Chapter 18).

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

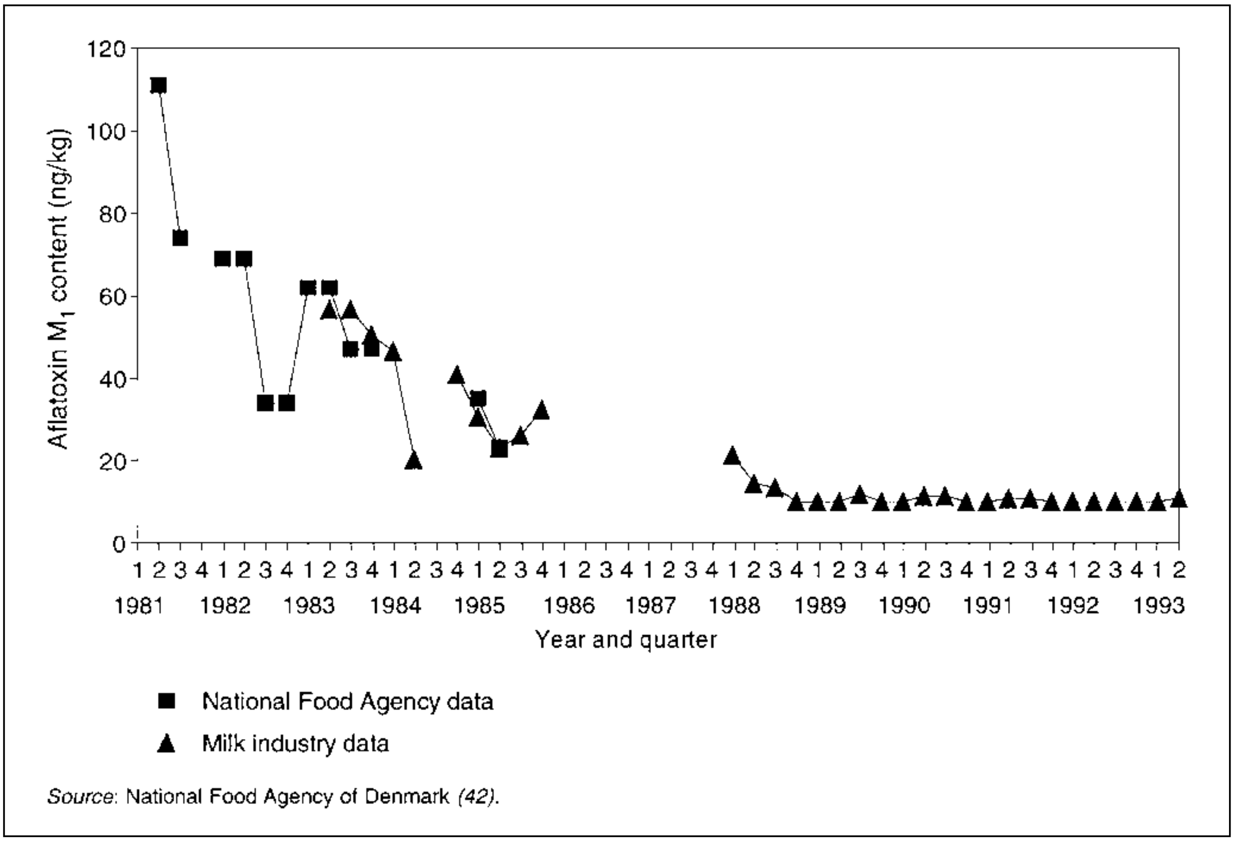


Fig. 9.7: Average content of aflatoxin M_1 in milk in Denmark, 1981–1993

Pesticides

Guidelines for predicting dietary intakes of pesticide residues have been issued by WHO [52]. In general, national data on pesticide residues in the total diet show that calculated intakes are very low, often only 1% of the ADI or less [22,23]. However, as the CCEE and NIS do not have extensive data sets, in spite of the fact that pesticide usage is high, this conclusion may not apply to the European Region as a whole.

Recent data for parts of Romania[a] show that DDT intakes are still high, and may approach or exceed the ADI. A similar situation exists in other CCEE. In general, mean daily intakes of DDT by infants per kg body weight were higher than those of adults.

Several studies over a decade ago showed that the mean daily intake of aldrin/dieldrin by infants from human milk exceeded the ADI [23].

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

9.4.3 Evaluation of food contamination factors as indicated by national focal points

In the Concern for Europe's Tomorrow questionnaire, the national focal points were asked to indicate known or assumed major sources of food contamination in their respective countries. In addition, information from the open literature was used to indicate possible sources of contamination. Countries were also asked to suggest possible remedial action.

The questionnaire referred to the following possible sources of contamination:

- geological conditions
- effects of mining
- industries
- waste and sewage sludge
- agricultural practices
- food harvesting, storage and transport
- food processing and/or packaging.

Of the geological factors, arsenic contamination of groundwater and soil in Hungary and Romania is the most important factor in food contamination and dietary intake of arsenic.

Mining activities, especially metal mining and to a lesser extent coal mining, may lead to local contamination in several CCEE such as the Czech Republic, Poland and Slovakia. In northern parts of Germany, mining activities that took place in the past are still having an effect on contamination of the food-chain by heavy metals.

Waste and wastewater from mines have polluted rivers with metals, leading to increased intakes in Bulgaria, the former Czechoslovakia and Poland.

Metal smelting and the combustion of brown coal are the two most important industrial activities leading to contamination of soil and water and thus of food. Smelter emissions, whether of copper, zinc, cadmium or lead, have caused local contamination of soil and river water and consequently of crops, especially in Bulgaria, the former Czechoslovakia, the former German Democratic Republic, Poland and the former USSR. Of these, the high dietary intake of lead by children is a cause for concern in areas of Bulgaria, the Czech Republic, Poland and Romania. Acidic emissions may lower the pH of the soil, increasing the availability of metals to crops.

High concentrations of cadmium from the application of cadmium-rich phosphate fertilizer and/or sewage sludge to land have contributed to raised intakes of cadmium from vegetables grown in such soils across many areas of Europe.

The industrial production and widespread use of PCBs in open conditions has led to contamination of food in many countries of Europe, although the problem is decreasing following cessation of production and restrictions on their use. In Germany, contamination of binder twine with PCBs led to high levels in food of animal origin.

The use of rodenticides to protect harvested crops from mice or rats has sometimes led to contamination of the final food product.

The processing and packaging of food may contribute to contamination. Food from lead-soldered cans contains around 5–10 times the lead concentration of that from non-soldered cans. The use of cadmium-plated and galvanized equipment in food processing, cadmium-containing enamel and pottery glazes, and cadmium- or lead-based pigments or stabilizers in plastics may also be significant sources of food (or water) contamination. The occurrence of organic contaminants, especially PCBs, in milk from paper containers has been reported, as has the presence of residues of phthalates from plastic films.

Possible remedies

The closure of old industrial plants and the reclamation of contaminated sites will assist in reducing food contamination. Ending the use of cadmium-rich phosphate fertilizers, reducing the use of leaded petrol and installing pollution control devices will reduce soil and water contamination and consequently food contamination. Eliminating lead-soldered cans, cadmium/lead glazes and lead water pipes will reduce exposure substantially.

Improvements in mining and smelting practices and stricter control of waste disposal to prevent further soil pollution are more urgently needed than general soil clean-up programmes. Removal of land from all forms of food production in the neighbourhood of polluting metallurgical industries can be adopted as a measure to reduce hot spot food contamination. Liming of soil to reduce metal availability is another option.

9.5 Radioactive Contamination

9.5.1 Natural radionuclides

All food contains natural radionuclides. In the context of radiation exposure, the most important is potassium-40, a long-lived radionuclide with a half-life of $1.28 \quad 10^9$ years. Throughout the natural environment, radioactive potassium occurs as a constant proportion of the total potassium. Thus the mean potassium-40 activity can be calculated from typical potassium concentrations in foodstuffs. As potassium is an essential element of all organisms, its concentration is subject to self-regulation by plants and animals. The potassium-40 activity therefore lies in a fairly narrow range and results in a dose of about 0.2 mSv/year [53].

The radioactive isotope carbon-14 is created in the upper atmosphere at a constant rate. The activity does not change during assimilation of carbon dioxide in photosynthesis and remains constant throughout the whole food-chain up to man. The total activities of potassium-40 and carbon-14 in humans are comparable, but the dose of carbon-14 is lower at 0.01 mSv/year.

Thorium and natural uranium have only trace activities in food, as they are very immobile elements in soil. Their rate of uptake by plants is low, as is their absorption by the gut. Enhanced activities in food are found in areas with higher soil levels of uranium and thorium, but intakes usually result in doses below 0.01 mSv/year [54,55].

The daughter products, radium-226 and radium-228, are of interest because these isotopes behave much like calcium. Radium is much more mobile in soil and is therefore more available to plants. The activity in Brazil nuts may be up to three orders of magnitude greater than that present in foods such as vegetables, fruit, meat and milk.

While potassium-40, thorium, uranium and radium are for the most part taken up by the roots, the main contamination pathway for polonium-210 and lead-210 is direct deposition. Both are daughter nuclides of the gas radon-222 and aggregate in the air as aerosols, which become deposited on the surface of plants. Higher activities are therefore found in leafy vegetables than in cereals or root vegetables. High activity is found in pork and beef liver and in kidneys, and extreme values have been measured in reindeer as a result of their eating lichen, which accumulates heavy metals such as lead and polonium. The normal annual dose resulting from intake of these radionuclides is estimated to be in the order of 0.13 mSv [56].

Some 30 other natural radionuclides such as tritium and beryllium occur in food, though their activities are so low that the resulting dose is usually negligible.

9.5.2 Weapons fallout

Intensive nuclear test programmes in the atmosphere took place during 1954–1958 and 1961–1963. During this time the radionuclide concentration increased in air, rain and food. Deposition was fairly even worldwide, but as most nuclear tests took place in the northern hemisphere the mean deposition there was about three times that in the southern hemisphere. Carbon-14, iodine-131, strontium-90 and caesium-137, in addition to a number of short-lived radionuclides, were of particular importance [57–59] (Table 9.4).

Systematic measurements of radionuclides in food have been carried out since the end of the 1950s. Strontium-90 and caesium-137 activities in milk in the Netherlands from 1960 to 1990 are shown in Fig. 9.8. The pattern is very similar to deposition patterns during these years, the peak occurring in 1963, the year of the highest deposition rate. Activities were very similar in other countries in the northern hemisphere. In the 1960s direct deposition was the major means of contamination, whereas root uptake later became dominant. Since caesium-137 is strongly adsorbed on clay minerals, its availability for root uptake is low. Strontium-90, however, remains much more mobile and therefore strontium-90 became the more important food contaminant with time. The second peak for caesium-137 between 1986 and 1990 was due to the effects of the Chernobyl accident.

The carbon-14 level in the atmosphere (and hence in food) doubled in 1963 due to its release as a result of nuclear weapons tests. Today the level in the atmosphere and in food is approximately 25 % above the natural level of activity.

9.5.3 Chernobyl

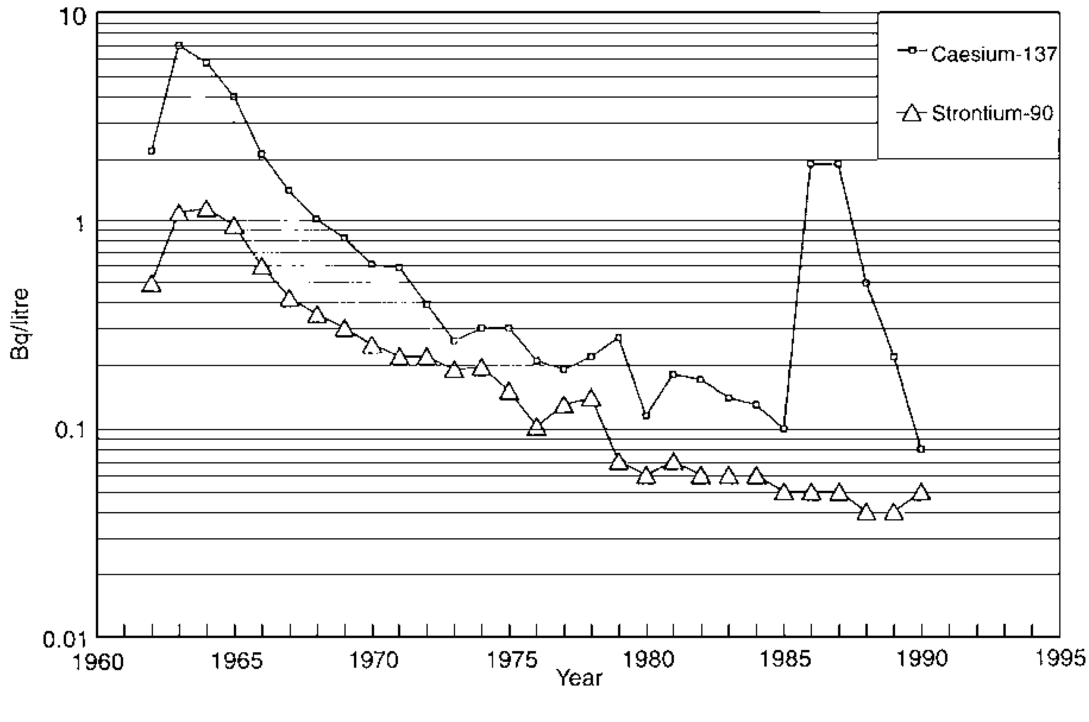
During the Chernobyl accident a great number of radionuclides were released, although the proportion of the less volatile radionuclides such as strontium-90 and plutonium-239 was relatively low. Furthermore, these isotopes were for the most part deposited in the vicinity of the reactor. Many short-lived radionuclides were released, the most important in terms of ingestion by humans being iodine-131 (in the short term), caesium-134 and caesium-137.

According to the weather conditions and especially the amount of rainfall, the deposition pattern was more or less heterogeneous and resulted in similar variations in radionuclide activity in cereals, vegetables, fruit, meat and milk [62–64].

Fig. 9.9 illustrates the decline in caesium activity and intake rates since 1986 for major food groups.

Wild mushrooms, wild berries and game

In contrast to agricultural food products, the caesium-137 activity in wild mushrooms, wild berries and game has remained at a high level in the most exposed areas of Europe. In contrast to agricultural systems, forests are characterized by undisturbed soils with an organic topsoil. In this layer, caesium-137 is not intensively absorbed and is therefore available to plants. As caesium-137 behaves in a manner similar to potassium it is included in the nutrient cycle of forests, and therefore only a slow decline in activity in mushrooms and berries is expected within the next few years. The caesium-137 level in animals grazing in the forests will also decline slowly [65].



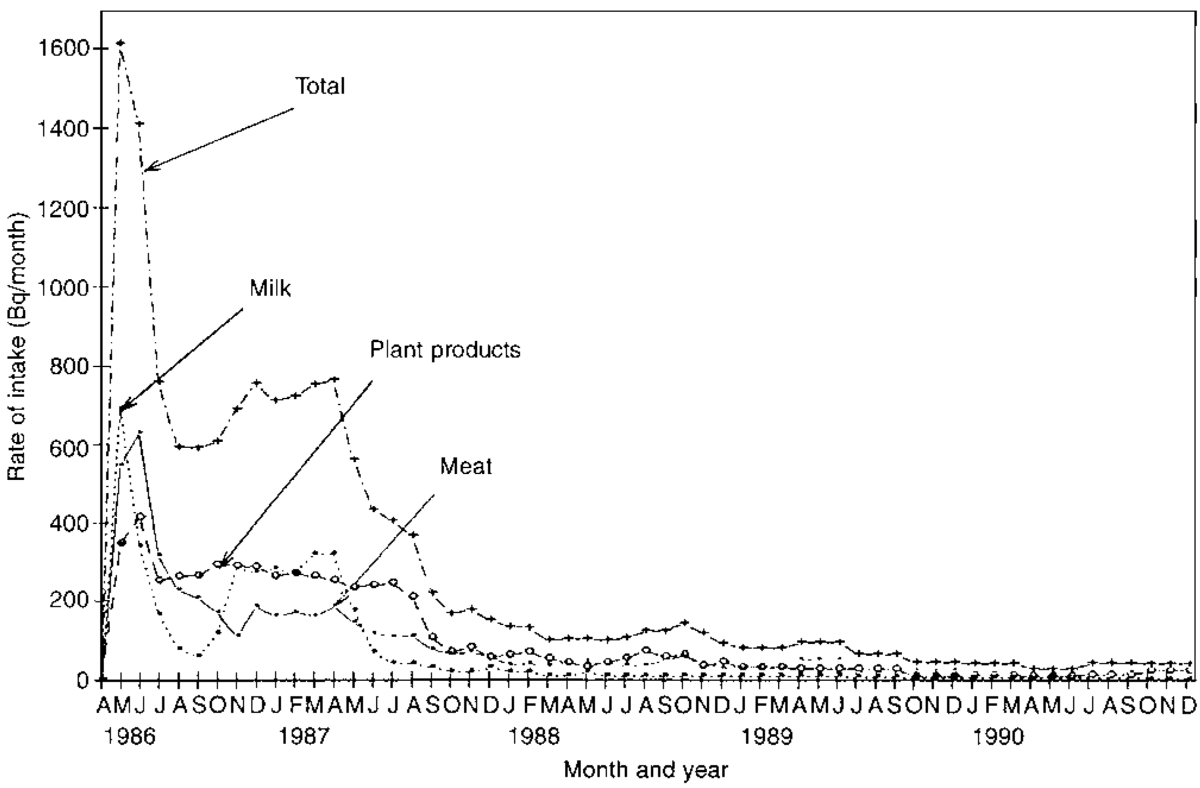
Source: van Kuijen, D.J. *(61)*.

Fig. 9.8: Mean strontium-90 and caesium-137 activities in milk in the Netherlands, 1960–1990

Table 9.4: Effective dose equivalent from ingestion, integrated over 70 years, from atmospheric weapons testing

	Northern hemisphere (μSv)	Southern hemisphere (μSv)
Tritium	83	50
Carbon-14	250	250
Iron-55	14	8.8
Strontium-89	1.6	1.1
Strontium-90	170	110
Iodine-131	49	33
Caesium-137	290	180
Barium-140	0.27	0.2
Plutonium-238	2.8	1.7
Plutonium-240	1.9	1.1
Plutonium-241	0.07	0.04
Americium-241	3.0	1.8
Total	850	650

Source: UNSCEAR *(60).*



Source: Bundesministerium für Umwelt, Natursolutz und Reaktorsicherheit *(57).*

Fig. 9.9: Monthly rate of intake of caesium-134 and caesium-137 with food in the south of the Federal Republic of Germany, 1986–1990

Fish

There was only a small increase of caesium-137 in marine fish, largely because of the degree of dilution by seawater. Significantly higher caesium activities were registered in fish from rivers and streams in 1986, and extremely high values in lake fish [66]. The caesium-137 activity in rivers and streams has decreased with time; the rate of decline in lakes will depend on the rate of outflow.

9.5.4 Radiation dose

The internal dose due to ingestion of natural radionuclides with food is about 0.35 mSv/year [60]. The major part, about 0.2 mSv/year, results from potassium-40. About 0.01 mSv/year is due to carbon-14 and the rest is mainly due to polonium-210, lead-210, radium-226 and radium-228. The contribution from uranium and thorium is generally below 0.01 mSv/year. While the doses from potassium-40 and carbon-14 are fairly constant, exposure from the other radionuclides varies with the natural levels of radionuclides in the soil and with the ecological situation. Food intake on average thus constitutes about 15 % of the total mean natural exposure of about 2.4 mSv/year (range 1.5–5 mSv/year).

Carbon-14, strontium-90 and caesium-137 contribute more than 80 % of the total lifetime dose from fallout from atmospheric weapons testing: 0.85 mSv in the northern hemisphere and 0.65 mSv in the southern hemisphere. Most of these doses were received during the 1950s and 1960s. The present ingested dose from this source is only around 0.01 mSv/year.

The proportion of the average radiation dose from ingestion received in different countries as a result of the Chernobyl accident varied from 25 % to 50 % depending on the agricultural season. The average dose from ingestion of agricultural products, as indicated by whole-body measurements, is less than 0.01 mSv/year even in the more highly contaminated areas. Special population groups, however, such as reindeer herdsmen in Sweden or people who regularly consume wild mushrooms or berries, still show elevated whole-body caesium-137 activity. Measurements of whole-body activity in people living in contaminated areas who eat reindeer meat more than once a week indicated a dose of about 0.7 mSv/year in 1991 [67,68].

In conclusion, the actual doses from contaminated foodstuffs due to weapons fallout and the Chernobyl accident are very low in comparison to natural radiation exposure. The caesium-137 and strontium-90 levels in food will continue to decline in the future, making action with regard to artificial radionuclides in food unnecessary.

9.5.5 Risk

Considerations of risk, especially that of cancer, from the effects of radionuclide activity in food are theoretically relevant. The methodology used for estimating such risk is discussed in Chapter 12.

Given a dose of about 0.35 mSv/year from natural radionuclides in food and the current additional dose of about 0.02 mSv/year due to the Chernobyl accident and weapons fallout, the resulting risk is negligible. Food can thus be considered not to pose any risk to health from the ingestion of radionuclides.

9.6 Safety of Food Produced by Biotechnology

Biotechnology has long been used in food production and processing. It represents a continuum embracing both traditional breeding methods and the latest techniques based on molecular biology. The newer biotechnological techniques, in particular, open up very great possibilities of rapidly improving the quantity and quality of food available. In addition to its direct application to food production and processing, biotechnology has applications in the production of veterinary drugs, pesticides and other products used in agriculture, and also in the development of improved methods of food analysis.

New methods based on molecular biology have aroused considerable interest, because they offer the prospect of more rapid and precisely targeted genetic changes than can be introduced through breeding and selection; organisms can be genetically modified by the introduction of novel genetic material made *in vitro* [69,70].

9.6.1 Fermented foods

Throughout the world, fermented foods form a major part of the human diet. Examples of fermented plant products include alcoholic drinks, tea, coffee, bread and sauerkraut. A wide variety of fermented fish, milk and meat products is also available. Fermentation, which may be brought about by yeasts, moulds or bacteria, can contribute to increasing the palatability, acceptability, nutritional value and shelf-life of foods.

Many fermented foods have been known for hundreds or thousands of years. Initially they were made in the home or in the local community, and the strains of organism used were passed down from generation to generation and were selected for desirable characteristics such as flavour production. Many fermented foods are now produced on an industrial scale, and there is interest in applying genetic modification techniques to the microorganisms that produce them, including those involved in bread and beer production.

9.6.2 Genetic modification

While significant changes can occur as a result of the modification of animal genomes, it would appear, on the basis of the current review of known or suspected hazards, that such transgenic animals should not cause any significant concern from the point of view of food safety. It should be emphasized that, at least in mammals, food derived from a healthy animal should generally be considered safe.

The exact gene product that may result from transgenic modification should be fully characterized as either an existing substance or one that is new to the particular animal species concerned. The safety of gene products in food can be assessed in the same manner as veterinary drug residues and food additives [71–74].

9.6.3 Implications of biotechnology

Biotechnology can potentially result in significant changes in the nutritional quality of food and, in some instances, is specifically intended to alter the composition of food.

Apart from nutritional implications, biotechnological alteration of food may in rare cases present a potential hazard in terms of food intolerances and food allergies, particularly with interspecies modifications or the production of new hybrid proteins. While these possibilities need to be kept in mind, it is highly unlikely that they will be a problem in the overall population. However, current methods for assessing potential allergenicity have serious limitations in predicting a problem in sensitive individuals.

9.7 Data Quality and Comparability

The contributions to this report are based mainly on three different sources of data:

1. The WHO Regional Office for Europe sent questionnaires on all relevant sectors to the national focal points of the Concern for Europe's Tomorrow project, asking for information on the microbiological, chemical and radiological contamination of food and drink. Information on related

items such as quality assurance and data quality was also requested.

2. Relevant data were also made available from two WHO networks that have been in operation for many years, i.e. the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe and the joint UNEP/FAO/WHO Food Contamination Monitoring and Assessment Programme (GEMS/Food).
3. The open literature and other available international data were also consulted.

It is difficult to compare the data received from the different countries and/or from the networks because in most cases an overall quality assurance scheme does not exist. This is particularly true for the microbiological contamination of food and the reporting of outbreaks of foodborne diseases.

9.7.1 National differences in the collection of information and data

One example of the problems of reporting systems and comparability of data can be taken from the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe. Although the definition of foodborne diseases has been agreed on for the purpose of the WHO Surveillance Programme, it is not strictly used in all national reporting systems.

A number of countries officially require all cases of foodborne disease (food poisoning) to be reported, while in the statutory notification requirements of other countries "foodborne disease" or similar terms are unknown. These diseases are covered in their regulations under "gastrointestinal infections" as a common group, or more specifically as "cases of salmonellosis", "campylobacteriosis", "*E. coli* infection", etc. Sometimes the group "infectious enteritis" is subdivided only into "cases of salmonellosis" and those of "other origin".

The following variations exist in national notification and reporting.

- *Notification of cases of foodborne disease (food poisoning; foodborne infections and intoxications).* These are reported without any specification of the causative agent or any other information on epidemiologically important details.
- *Reporting of laboratory-confirmed cases of foodborne disease.* This is based on information from official laboratories who report to a central agency, often a reference laboratory for specific microorganisms such as a national salmonella centre.
- *Reporting of cases of gastrointestinal infection.* Such cases are reported either separately by causative agent, as in cases of salmonellosis, campylobacteriosis or viral and parasitic diseases, or as a group under a common denominator such as "infectious enteritis caused by salmonellae" on the one hand and "infectious enteritis caused by other organisms" on the other. In some countries, these gastrointestinal infections are considered as foodborne whether or not there is any known involvement of food.
- *Notification and reporting of cases of salmonellosis only.* In a number of countries all these cases are considered to be foodborne.

9.7.2 Comparability of national data on outbreaks

These variations alone indicate the impossibility of direct comparison of data from statutory notifications, as well as of incidence or numbers of outbreaks from different countries. In addition to these variations in notification, underreporting is another factor that limits proper comparison between countries.

A high figure for the incidence (number of cases per 100 000 population) or even for the simple number of cases or outbreaks in one country as compared to another could signify that a more severe foodborne disease problem really exists; it could also mean that the reporting system functions much better in one country than in another and thus many more cases or outbreaks are brought to the attention of the official health agencies. The incidence and numerical data given in figures or tables should therefore not be used for direct comparison between countries.

Figures received from such reporting systems, however, are useful when interpreted in a critical manner. On the assumption that the reporting system in a country has not been changed, trends over time can be seen from these figures.

A similar situation also exists with other data made available for this report. In the case of food contamination, differences in sampling methodology and data handling, especially with regard to calculations of detection limits or limits of determination, complicate data analysis and its usefulness for comparative purposes.

Another principal impediment to a sound evaluation of the degree of contamination of food and its health significance lies in the paucity of national dietary intake data and human exposure data for many countries, including that on ethnic differences within diverse geographical regions.

All countries stated that they operated analytical quality assurance and analytical quality control programmes but, in the absence of detailed information, data quality in many countries cannot be evaluated or guaranteed. This matter needs further attention by inviting national institutes to participate in regional and international programmes. Only then can data quality be evaluated.

9.8 Conclusions

9.8.1 Food safety regulations and information systems

International and intersectoral collaboration

Since the health problems associated with food contamination are highly complex but common to all countries, international cooperation and collaboration are essential in achieving the most cost-effective use of resources. This collaboration should concentrate on building up an international network of national focal points for the surveillance, prevention and control of hazards to human health from the biological and chemical contamination of food. The Codex Alimentarius Commission could play a very important role in international collaboration between the countries, particularly in the harmonization of legislation relevant to the food trade. This will be particularly important in view of rapidly growing tourism and trade in food products and the consequences of the removal of trade barriers among the EU member states.

Legal framework

A review of the history of food safety in Europe confirms that if food safety legislation is to be effective, it must be drafted with the circumstances and the problems of each country in mind. However, the increase of international food trade in Europe is leading to an accelerating trend towards the harmonization of national food legislation. The single European market is having a tremendous impact on the harmonization of national food legislation within the EU and elsewhere.

Training of food safety personnel

Dynamic development in food production, distribution and storage, as well as the changes related to the harmonization of food laws in Europe, will require appropriate modifications in the development of national food safety manpower. The food law enforcement officer will have to be adequately trained to (*a*) enforce existing national or international food laws, and (*b*) promote hygienic practices with regard to food by means of health education, including the training of food personnel and management staff in food safety and quality.

Application of the HACCP approach will provide a more effective and cost-effective method of control than end-product inspection.

Food safety information system

Since an information system in an international environment is useful only if it is up to date and covers the whole Region, major efforts are needed to get all European countries actively participating in the existing health-related database initiated by the Council of the European Union. Only regular updating by the participating countries themselves will ensure that the whole system remains current. The information system should also be open to everyone interested in the subject, but especially to intergovernmental and nongovernmental organizations and universities. This could prevent duplication of effort and thus save time and resources. Techniques and equipment are available to improve the speed of information distribution.

9.8.2 Microbiological contamination of food and related foodborne diseases

Based on the information from the WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe and from other sources, it is obvious that foodborne diseases have increased significantly over the last few years in most European countries, in spite of efforts made to improve hygiene in food establishments. In addition, it is generally accepted that microbiologically contaminated food, beverages and drinking-water play the major role in most outbreaks of foodborne disease. Foodborne diseases, but also the loss of food through contamination by microbial agents, present a high cost to society.

As many of the problems arise in primary food production, more attention should be paid to safeguards in animal husbandry rather than to eliminating pathogens solely by food technology.

Although salmonella contamination of food is still of major concern, other microbial agents have also recently been recognized as causes of foodborne illness. Frequently the relevance of and actual risk attributed to these pathogens in food is not always clear, as they can also be found in living organisms and the inanimate environment.

Tourism is an important source of income for many countries, particularly nonindustrialized ones. It is important not to jeopardize this source of national income through outbreaks of foodborne infection and intoxication. Tourists need better information on the special risks associated with the consumption of traditional local food, especially in relation to street vending and to sanitary conditions in rural and camping areas.

In general, consumers are not sufficiently aware of the causes of contamination within the food-chain, and do not understand the mechanisms of bacterial growth in food. This applies to consumers in all European countries but particularly to those in the less developed countries.

9.8.3 Chemical contamination of food and drink

Although substantial data sets of chemical contaminants in food, and dietary intakes, have been reported for many western European countries, data are inadequate for most central and eastern European countries including countries of the former USSR.

Information on those particularly at risk is widely lacking. This includes dietary intakes by infants and children (especially those living near metal industries and mines), lactating women and the elderly. The numbers of people exposed to such conditions, both as totals and percentages of local or district populations, are usually not known.

Studies on the health of populations exposed to contaminated food are currently of limited value or are lacking.

9.8.4 Radioactive contamination of food

The fallout following the accident at Chernobyl caused serious disruption to food production and trade, especially between the highly affected countries and those that were not greatly affected. Generally speaking, the less a country was affected the lower the limits set for radionuclides in food. These disruptions were exacerbated by the lack of uniformity of action on the part of national authorities and the lack of preparedness to respond to such an emergency. In this situation, WHO and FAO established guideline levels for radionuclides in food for use in international trade following accidental nuclear contamination [75]. These levels are in agreement with, for example, the values established by the EU and should be used by all Member States of the WHO European Region.

9.8.5 Biotechnologically produced foods and drinks

The wide range of modifications possible in foods derived from genetically modified plants requires an integrated approach to safety assessment, taking into consideration the proposed use of the food, the potential exposure and the significance of the food in the diet.

In addition to the question of intended use, the safety of foods and food ingredients derived from genetically modified microorganisms depends on all the stages involved – strain development, production, processing and purification. Each case must be evaluated to identify critical points and establish appropriate controls that will ensure safety and quality. Any change in the process should be evaluated in the light of these considerations. The maintenance of good manufacturing practice is of fundamental importance.

References

[1] *Guidance on formulation of national policy on the control of cholera*. Geneva, World Health Organization, 1992 (unpublished document WHO/CDO/SER/92.16 Rev.1).

[2] World Health Organization. *Weekly epidemiological record*, No. 8, 1991, pp. 55–56; No. 9, 1991, pp. 61–63; No 10, 1991, pp. 65–70.

[3] Council Directive 92/117/EEC of 17 December 1992 concerning measures for protection against specified zoonoses and specified zoonotic agents in animals and products of animal origin in order to prevent outbreaks of foodborne infections and intoxications. *Official journal of the European Communities*, **L62**: 38–48 (1993).

[4] Gerigk, K. *WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe. Fifth report 1985–1989*. Berlin, Institute of Veterinary Medicine, Robert von Ostertag-Institut, 1992.

[5] Gerigk, K. *WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe. Sixth report 1990–1991*. Berlin, Institute of Veterinary Medicine, Robert von Ostertag-Institut, 1993.

[6] Hoogenboom Verdegaal, A. Sentinel and community studies as a tool for the surveillance of foodborne disease. *International food safety news*, (9): 73–74 (1992).

[7] Todd, E.C.D. Preliminary estimates of costs of foodborne disease in Canada and costs to reduce salmonellosis. *Journal of food protection,* **52**: 586–594 (1989).

[8] Sockett, P.N. & Roberts, J.A. The social and economic impact of salmonellosis. A report of a national survey in England and Wales of laboratory-confirmed salmonella infections. *Epidemiology and infection*, **107**: 335–347 (1991).

[9] Archer, D.L. & Kvenberg, J.E. Incidence and cost of foodborne diarrhoeal disease in the United States. *Journal of food protection*, **48**: 887–894 (1985).

[10] Roberts, T. Human illness costs of foodborne bacteria. *American journal of agricultural economics*, **71**: 468–477 (1989).

[11] Todd, E.C.D. Preliminary estimates of costs of foodborne disease in Canada and costs to reduce salmonellosis. *Journal of food protection*, **52**: 595–601 (1989).

[12] Auermann, H.G. et al. Studies on heavy metal contents of cereals and potatoes. *Nahrung,* **24**: 925–937 (1980).

[13] *Methylmercury.* Geneva, World Health Organiz-

ation, 1990 (Environmental Health Criteria No. 101).

[14] *Assessment of chemical contaminants in food. Report on the results of the UNEP/FAO/WHO programme on health-related environmental monitoring*. Nairobi, United Nations Environment Programme, 1988.

[15] Ministry of the Environment of the Czech Republic. [*Environment of the Czech Republic.*] Prague, Academia, 1991.

[16] *Health evaluation of aflatoxins in foodstuffs: report from a working group*. Copenhagen, National Food Agency of Denmark, 1989.

[17] [*Aflatoxins B1, B2, G1 and G21 in maize, rice, millet, buckwheat, lentils and beans, etc. 1987-1988.*] Copenhagen, National Food Agency of Denmark, 1990.

[18] [*Aflatoxins in nuts, kernels, etc.*] Copenhagen, National Food Agency of Denmark, 1990.

[19] [*Ochratoxin A in cereals 1986-1989.*] Copenhagen, National Food Agency of Denmark, 1990 (Publication No. 199).

[20] *Food monitoring in Denmark: nutrients and contaminants 1983-1987.* Copenhagen, National Food Agency of Denmark, 1990.

[21] Barylko-Pikielna, N. & Tyszkiewicz, S. [*Daily intake of some chemical contaminants with food - presentation of the approach and summary.*] Warsaw, Polish Academy of Sciences, 1991.

[22] Andersson, A. et al. *Pesticide residues in fruits and vegetables - 1991.* Uppsala, Swedish National Food Administration, 1992 (Report No. 7).

[23] *Annual report of the Working Party on Pesticide Residues: 1991.* London, H.M. Stationery Office, 1992 (Supplement to the Pesticides Register 1992).

[24] Jelinek, C.F. *Assessment of dietary intake of chemical contaminants. Joint UNEP/FAO/WHO Food Contamination Monitoring and Assessment Programme (GEMS/Food).* Geneva, World Health Organization 1992 (document WHO/HPP/FOS/92.6).

[25] Heikkilä, J. *Intake of arsenic, mercury, cadmium and lead from food consumed by children and young people*. Helsinki, National Food Administration of Finland, 1992 (Research Notes 3/1992).

[26] Galal-Gorchev, H. Global overview of dietary lead exposure. *In*: *Symposium on the Bioavailability and Dietary Uptake of Lead, Chapel Hill, 24-27 September 1990* (in press).

[27] *Evaluation of certain food additives and contaminants. Forty-first report of the Joint FAO/WHO Expert Committee on Food Additives*. Geneva, World Health Organization, 1993 (WHO Technical Report Series No. 837).

[28] Ministry of Agriculture, Fisheries and Food. *Lead in food: progress report*. London, H.M. Stationery Office, 1989 (Food Surveillance Paper No. 27).

[29] Sherlock, J.C. Exposure of man to heavy metals from food. *In*: *International Conference on Heavy Metals in the Environment*. Edinburgh, CEP Consultants, 1991.

[30] Skerfving, S. Mercury in women exposed to methylmercury through fish consumption and in their newborn babies and breast milk. *Bulletin of environmental contamination and toxicology*, **41**: 475-482 (1988).

[31] Ludwicki, J.K. [Total mercury intake with daily food ration by certain population groups.] *Roczniki panstwowego zakladu higieny,* **38**: 328-331, 1987.

[32] Petrik, J. et al. The fate of selected organic pollutants in the environment, VIII. PCBs in human adipose tissues from different regions of Slovakia. *Toxicological environmental chemistry review*, **34**: 13-18 (1991).

[33] Juszkiewicz, T. *In*: Ruckebusch, Y. et al., ed. *Veterinary pharmacology and toxicology*. Lancaster, MTP Press, 1983, pp. 641-645.

[34] Yrjänheikki, E.J., ed. *Levels of PCBs, PCDDs, and PCDFs in breast milk*. Copenhagen, FADL, 1989 (Environmental Health Series No. 34).

[35] Skaare, J.U. & Polder, A. Polychlorinated biphenyls and organochlorine pesticides in milk of Norwegian women during lactation. *Archives of environmental contamination and toxicology*, **19**: 640-645 (1990).

[36] Vaz, R. et al. Organochlorine contaminants in Swedish human milk: studies conducted at the National Food Administration 1981-1990. *Food additives and contaminants*, **10**: 407-418 (1993).

[37] Jensen, A.A. Levels and trends of environmental chemicals in human milk. *In*: Jensen, A.A. & Slorach, S.A., ed. *Chemical contaminants in human milk*. Boca Raton, CRC Press, 1991, pp. 45-198.

[38] van Duijvenbooden, W. & Matthijsen, A.J.C.M. *Integrated criteria document - nitrate*. Bilthoven, National Institute of Public Health and Environmental Protection, 1989.

[39] Ministry of Agriculture, Fisheries and Food. *Nitrate, nitrite and N-nitroso compounds in food: second report*. London, H.M. Stationery Office, 1992 (Food Surveillance Report No. 32).

[40] Penttila, P.-L. et al. Nitrate, nitrite and *N*-nitroso compounds in Finnish foods and the estimation of dietary intakes. *Zeitschrift für Lebensmitteluntersuchungen und Forschung*, **190**: 336-340 (1990).

[41] Visconti, A. et al. Aflatoxin M_1 in milk in

southern Italy. *Mycotoxin research*, **1**: 71–75 (1985).

[42] Berg, T. et al. [*Mycotoxins in Danish foodstuffs.*] Copenhagen, National Food Agency of Denmark, 1994 (Publication No. 225).

[43] *Evaluation of certain food additives and contaminants. Thirty-seventh report of the Joint FAO/WHO Expert Committee on Food Additives.* Geneva, World Health Organization, 1991 (WHO Technical Report Series No. 806).

[44] Herman, J.L. Risk evaluation of ochratoxin A by the Joint FAO/WHO Expert Committee on Food Additives. *In*: Bartsch, H. et al., ed. *Methods for detecting DNA damaging agents in humans in applications in cancer epidemiology and prevention*. Lyon, International Agency for Research on Cancer, 1991, pp. 327–329 (Scientific Publications No. 89).

[45] Kuiper-Goodman, T. & Scott, P.M. Risk assessment of the mycotoxin ochratoxin A. *Biomedical and environmental sciences*, **2**: 179–248 (1989).

[46] Micco, C. et al. Contamination of human milk with ochratoxin A. *In*: Castegnaro, M. et al., ed. *Mycotoxins, endemic nephropathy and urinary tract tumours*. Lyon, International Agency for Research on Cancer, 1991, pp. 105–108.

[47] Breitholtz, A. et al. Plasma ochratoxin A levels in three Swedish populations surveyed using an ion-pair HPLC technique. *Food additives and contaminants*, **8**: 183–192 (1991).

[48] Frank, H.K. Food contamination by ochratoxin A in Germany. *In*: Castegnaro, M. et al., ed. *Mycotoxins, endemic nephropathy and urinary tract tumours*. Lyon, International Agency for Research on Cancer, 1991, pp. 77–81.

[49] Hald, B. Ochratoxin A in human blood in European countries. *In*: Castegnaro, M. et al., ed. *Mycotoxins, endemic nephropathy and urinary tract tumours*. Lyon, International Agency for Research on Cancer, 1991, pp. 159–164.

[50] Creppy, E.E. et al. Human ochratoxicosis in France. *In*: Castegnaro, M. et al., ed. *Mycotoxins, endemic nephropathy and urinary tract tumours*. Lyon, International Agency for Research on Cancer, 1991, pp. 145–151.

[51] Castegnaro, M. & Chernozemsky, I. Endemic nephropathy and urinary tract tumours in the Balkans. *Cancer research*, **47**: 3608–3609 (1987).

[52] *Guidelines for predicting dietary intake of pesticide residues*. Geneva, World Health Organization, 1989.

[53] Maul, P.R. & O'Hara, J.P. Background radioactivity in environmental materials. *Journal of environmental radioactivity*, **9**: 265–280 (1989).

[54] Frindik, O. Thorium und Uran in Lebensmitteln Tierischer Herkunft. *Zeitschrift für Lebensmitteluntersuchungen und Forschung*, **194**: 377:380 (1992).

[55] Welford, G.A. & Baird, R. Uranium levels in human diet and biological materials. *Health physics*, **13**: 1321–1324 (1967).

[56] Aurand, K. et al., ed. *Die natürliche Strahlenexposition des Menschen*. Stuttgart, Georg Thieme Verlag, 1974.

[57] *Umweltradioaktivität und Strahlenbelastung*. Bonn, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, 1990.

[58] Morse, R.S. & Welford, G.A. Dietary intake of 210 Pb. *Health physics*, **21**: 53–55 (1971).

[59] Russel, R.S., ed. *Radioactivity and human diet*. Oxford, Pergamon Press, 1966.

[60] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). *Source, effects and risks of ionizing radiation*. New York, United Nations, 1988.

[61] van Kuijen, D.J., ed. Results of measurements of the radioactive contaminants of the biosphere in the Netherlands in 1990. *Annual Report of the Technical Working Group on Radioactivity Measurements, 1991.*

[62] Rantavaara, A. & Hanka, S. *Radioactivity of milk, meat, cereals and other agricultural products in Finland after the Chernobyl accident in 1986*. Helsinki, Finnish Centre for Radiation and Nuclear Safety, 1991.

[63] *Die Auswirkungen des Reaktorunfalls in Tschernobyl auf Österreich*. Vienna, Folgestudie Forschungsbericht, 1989.

[64] Gumprecht, D., ed. *Impact of the Chernobyl nuclear power plant accident in the Federal Republic of Germany*. Stuttgart, Gustav Fischer Verlag, 1988.

[65] Grossklaus, D., ed. *Rückstände in von Tieren Stammenden Lebensmitteln*. Berlin, Hamburg, Parey Verlag, 1989 (Studientext 53).

[66] Camplin, W.C. & Aarkrog, A. *Radioactivity in north European waters. Report of Working Group 2 of CEC Project Marina*. London, Ministry of Agriculture, Fisheries and Food, 1989 (Fisheries Research Data Report No. 20).

[67] Wirth, E. et al. *Assessment of radiation dose commitment in Europe due to the Chernobyl accident*. Neuherberg, Institut für Strahlenhygiene, 1987.

[68] Tveten, W., ed. *Environmental consequences of releases from nuclear accidents*. Nordic Liaison Committee for Atomic Energy, 1990.

[69] Cohen, S.N. et al. Construction of biologically functional bacterial plasmids *in vitro*. *Proceedings of the National Academy of Sciences of the United States of America*, **70**: 3240–3244 (1973).

[70] *Strategies for assessing the safety of foods produced by biotechnology. Report of a joint FAO/*

WHO consultation. Geneva, World Health Organization, 1991.

[71] *Principles for the safety assessment of food additives and contaminants in food.* Geneva, World Health Organization, 1987 (Environmental Health Criteria No. 70).

[72] *Evaluation of certain veterinary drug residues in food. Thirty-second report of the Joint FAO/WHO Expert Committee on Food Additives*. Geneva, World Health Organization, 1987 (WHO Technical Report Series No. 763).

[73] *Evaluation of certain veterinary drug residues in food. Thirty-fourth report of the Joint FAO/WHO Expert Committee on Food Additives*. Geneva, World Health Organization, 1989 (WHO Technical Report Series No. 788).

[74] *Evaluation of certain veterinary drug residues in food. Thirty-sixth report of the Joint FAO/WHO Expert Committee on Food Additives*. Geneva, World Health Organization, 1990 (WHO Technical Report Series No. 799).

[75] *Desired intervention levels of radionuclides in food. Guidelines for application after widespread radioactive contamination resulting from a major radiation accident*. Geneva, World Health Organization, 1988.

Chapter 10
Multimedia Exposure to Selected Chemicals

10.1 Introduction

During the last few decades a large number of chemicals have come on the market with widespread use in various sectors of society, including industrial, agricultural and domestic applications. In fact, chemicals are an integral part of daily life. Currently, some 60–70 thousand are in regular use, of which some 3000 constitute 90 % of the total volume. Some 200 to 1000 "new" chemicals enter the market every year. Owing to industrial and traffic emissions, agricultural use (pesticides and fertilizers) and disposal practices (industrial and domestic) many chemicals are discharged into the environment and may consequently pose potential hazards to human health and environmental integrity.

With existing chemicals, the main problem is often the lack of adequate toxicological data for risk assessment. In this respect, apart from national approaches, there are important activities at the international and intergovernmental level. Scientific evaluations and the collection of relevant data on existing chemicals are being performed by the International Programme on Chemical Safety (IPCS) and the International Register of Potentially Toxic Chemicals (IRPTC) as well as by a number of nongovernmental organizations. Risk evaluation of chemicals is the first objective of IPCS, and in this context some 150 volumes in the Environmental Health Criteria series and some 80 Health and Safety Guides have been published by WHO. In addition, some 1200 International Chemical Safety Cards are available; from Card No. 20 onwards this information is also available on CD-ROM.

In the European Union (EU) control of existing chemicals is ensured through the Council Regulation on Existing Chemicals, which became effective in 1993. This regulation provides a legally binding framework for the collection of relevant data on existing chemicals. The process comprises three steps: (*a*) the establishment of a priority list of existing chemicals requiring evaluation; (*b*) risk evaluation; and (*c*) agreement on adequate abatement and control methods. This will be a major task of the European Bureau of Chemicals of the EU, which is currently being set up in Ispra, Italy.

Within the chemicals programme of the Organisation for Economic Co-operation and Development (OECD) activities are being undertaken to ensure systematic investigation of existing chemicals. The emphasis is placed primarily on high production volume chemicals, i.e. those that are produced in quantities of around 10 000 tonnes per year in one country or 1000 tonnes per year in several countries. The chemicals programme also comprises other elements, including data acquisition and risk reduction measures.

With new chemicals, current legislation in most European countries and at the level of the EU is such that pre-marketing assessment of toxicity (including ecotoxicity) should prevent serious environmental hazards to health in the future. This requirement for pre-marketing hazard assessment covers industrial chemicals, pesticides and household products.

From the point of view of human exposure, chemicals with toxic properties are generally found in several environmental media such as air, water and soil and, consequently, may also be present in food. People may therefore be exposed to pollutants through several routes. The common approach for controlling human exposure is based on knowledge of the concentrations of the substance concerned in different environmental media and food items.

Although risk evaluation is generally based on an estimation of expected health effects at various levels of environmental exposure (exposure–response assessment) it is generally accepted that the total dose of a pollutant that is actually received is the determinant of an effect. The tissue dose, however, may not be directly correlated with the exposure level, and the tissue disposition of a pollutant may change from one exposure level to another. There is therefore a need to distinguish between exposure level in general and the dose to the target tissue, i.e. the tissue in which the major toxic effects of the chemical are likely to occur. Biologically based modelling for the assessment of target tissue dose requires knowledge of a number of variables, including:

- the distribution of the compound in different media including ambient air, water, soil and food, and in certain instances also house dust, paint, indoor air, etc.;
- for agents that tend to accumulate in tissues, knowledge of relevant environmental levels over the whole exposure period (this may include assessments for time spent travelling, and indoors at home and/or at work);
- factors that affect the biological availability of the pollutant, including the age, gender and nutritional and health status of the individual, as well as the chemical and physical properties of the pollutant;
- demographic, socioeconomic and behavioural factors that may have an effect on the exposure, including housing conditions, individual eating and drinking preferences and other social habits.

Thus, to complement the environmental measurements of certain pollutants at point locations in individual media, there is a need to obtain detailed information on individual exposure patterns and biological parameters in order to adopt realistic approaches to estimating the total uptake from all media and the target tissue dose.

Assessment of total intake will rely either on biologically based modelling or on personal monitoring. Modelling requires detailed knowledge of total exposure levels through all media, but needs also to take account of the natural variability in exposure patterns as well as in absorption, distribution, metabolism and excretion. Personal monitoring is based on determining pollutant (or metabolite) concentrations in human tissues, be they the target tissues for toxicity, biological fluids (urine, blood) or sites of accumulation. Again, a number of variables need to be considered, including toxicokinetic factors and exposure periods (especially with chemicals that tend to accumulate).

Knowledge of actual site-specific intake levels of pollutants would permit a more realistic approach to applying and assessing abatement strategies. Intervention based on knowledge about "average" exposure patterns of "average" or "typical" population groups at "average" or "typical" sites will obviously be less effective when compared with abatement strategies based on actual site-specific information. Models based on actual intake data at actual exposure levels would be more reliable tools for selecting appropriate cleanup levels for contamination with any chemical compound.

In this chapter, available data on total exposure to chemicals known to be taken up from different environmental media are reviewed with reference to the relative contribution of different environmental media to total intake. Particular consideration is given to data on arsenic, cadmium, lead, mercury, pesticides, nitrate, benzene, polynuclear aromatic hydrocarbons (PAHs, particularly benzo[*a*]pyrene), polychlorinated biphenyls (PCBs), and polychlorinated dibenzodioxins (PCDDs) and dibenzofurans

(PCDFs). Also, the available data on the concentrations of these agents in human body fluids and tissues are reviewed.

These chemicals are similar to those in the priority list of "harmful chemical substances and processes of global significance" contained in the IRPTC, and were selected as examples to illustrate a wide range of current issues concerning priority multimedia chemicals: their use patterns, toxic properties, persistence in the environment and other factors including the public perception of risk from exposure to them. Thus the chemicals discussed in this chapter are of real or perceived concern to human health.

In the context of the data compiled in this chapter it should be noted that, although monitoring programmes exist for assessing concentrations of chemicals in drinking-water, food and other environmental media, there are no national programmes to monitor human tissue levels of environmental chemicals or to assess individual exposure. The figures given in this chapter cover a small and not necessarily representative portion of the population and, therefore, general conclusions on population exposure should not be drawn, even at national level. At present, estimates of human risk are often derived by extrapolation from animal data, where risk is likely to be expressed in terms of effects at a given applied dose rather than a tissue dose. Even with human data, effects are frequently correlated with intakes rather than tissue levels; in only a few instances will information on tissue levels of a chemical enable health effects to be predicted.

Due to lack of space, individual studies are not cited in this chapter.

10.2 Arsenic

Arsenic is ubiquitous in the biosphere and occurs naturally in both organic and inorganic forms. While arsenic can be found to a small extent in its elemental form, the most important arsenic compounds are inorganic: arsenic trioxide, sodium arsenite, arsenic trichloride (i.e. trivalent forms), arsenic pentoxide, arsenic acid, and arsenates such as lead and calcium arsenates (i.e. pentavalent forms).

10.2.1 Toxic and carcinogenic effects

In general, the trivalent forms of arsenicals are more toxic than the pentavalent forms, and inorganic compounds are more toxic than organic compounds. Factors such as solubility, particle size, rate of absorption, metabolism and excretion can have a significant influence on toxicity [1]. Many of the toxicological effects of arsenic, especially in the trivalent form, are believed to be associated with its reaction with cellular sulfhydryl groups [1].

Long-term exposure to inorganic arsenic has been found to give rise to effects in several organs. Major effects are dermatological (pigmentation, thickening and desquamation with subsequent atrophy and degeneration of the skin), haematological (anaemia, decreased white blood cells) and hepatic (fatty infiltration, necrosis and cirrhosis) [1–3]. Organoarsenicals are considered to be much less toxic [4]. Other adverse effects from exposure to arsenic are related to vascular disturbances such as the so-called "blackfoot disease" (peripheral gangrene) and Raynaud's disease (acrocyanosis).

Lung and skin cancer have been regarded as the critical effects in man from long-term exposure to inorganic arsenic, through inhalation and ingestion respectively [2,3]. The International Agency for Research on Cancer (IARC) has placed inorganic arsenic compounds in Group 1 of its classification as known human carcinogens [5].

10.2.2 Exposure

Sources of arsenic in the environment are mainly industrial, including copper smelting and other metal industries, fuel combustion (particularly brown coal) and the petroleum industry, as well as the production and use of arsenical pesticides, pharmaceuticals and electronic equipment. Arsenic is persistent in the environment and is transported mainly by water. In some countries, such as Hungary and Romania, arsenic levels in water are naturally high; in others, such as Bulgaria, industrial sources are responsible for similar levels.

Arsenic in air is present mainly in particulate form as inorganic arsenic. The intake of arsenic from air, except in industrial areas, is a minor portion of the total intake from all sources and has been estimated at about 0.3–0.4 μg/day [4]. Smoking may also contribute to intake; average arsenic values of 1.5 μg per cigarette are due to the use of arsenical pesticides. The additional contribution of cigarette smoke to total intake, however, is generally low.

The intake of (primarily inorganic) arsenic from water is about 15 μg/day or less for most people [1,2] but can reach about 1 mg/day for those who drink water containing naturally high arsenic levels [4].

Dietary arsenic is the major source of exposure to arsenic for the general population. Daily arsenic intakes are greatly influenced by the amount of seafood in the diet, but the global average is usually under 200 μg/day. Arsenic intakes by those eating large quantities of seafood may be greater than 1 mg/day but virtually all of the arsenic in seafood will be present as organic compounds, which are much less toxic [1,3,4].

The results of eight studies in six European countries between 1978 and 1992 showed average intakes of arsenic, from food and drinking-water combined, of 13–89 μg/day. These studies did not include Bulgaria, Hungary or Romania, where levels in drinking-water are known to be high.

10.2.3 Tissue levels

The total human body content of arsenic has been estimated at 3–4 mg [1]. Arsenic is normally found in higher concentrations in hair and nails than in other parts of the body. Arsenic levels in the hair of unexposed adults are usually below 1 mg/kg body weight [1,3].

The results of 15 studies carried out in 8 countries of the WHO European Region between 1966 and 1992 on arsenic levels in blood, urine, hair and/or nails were reviewed. Mean blood levels are less valuable parameters of exposure owing to the relatively short time that arsenic compounds remain in the blood; the levels observed ranged from 1.9 to 7.9 μg/l. Both the inorganic and the much less toxic organic arsenic compounds are excreted in the urine, and therefore urine levels of between 4 and 73 μg/l do not necessarily reflect exposure to the toxicologically relevant inorganic compounds. Despite the fact that only inorganic (trivalent) arsenic binds to keratin sulfhydryl groups in hair and nails, the levels in these materials are not fully reliable indicators of exposure to these compounds owing to a number of endogenous and exogenous factors that influence analysis. These include gender, age, natural hair colour and the use of hair dyes, shampoos and conditioners. This might explain why mean levels in hair varied widely from 20 to 4000 μg/kg. The highest values were observed in Hungary, in an area with high concentrations of arsenic in drinking-water, followed by the United Kingdom and eastern areas of Germany (the highest mean level observed in a non-affected area was 1220 μg/kg). Only one study of arsenic in nails was found, which reported a mean concentration of 362 μg/kg in the United Kingdom.

10.2.4 Evaluation of observed exposure levels and possible health effects

Although only few data on intake levels of arsenic were found, all lay below the provisional tolerable weekly intake (PTWI) of 0.015 mg inorganic arsenic per kg body weight established by the Joint FAO/WHO

Expert Committee on Food Additives (JECFA) which corresponds to a daily intake by adults of 0.128 mg/day.

It should be noted that inhalation and ingestion have different toxicological effects. Skin cancer has been associated with ingestion of inorganic arsenic compounds, while several epidemiological studies reveal that inhalation may result in cancers of the respiratory tract. Exposure to inorganic arsenic should therefore be reduced to the lowest practicable level. Levels in groundwater in Bulgaria, Hungary and Romania indicate an increased risk of developing skin disorders if such water is drunk. Data from Taiwan suggest an increased lifetime risk of skin cancer with an average daily arsenic intake of 1 mg or more [6].

10.3 Cadmium

Cadmium occurs naturally in the environment at low levels, usually with zinc, lead and copper ore deposits. Current analytical procedures indicate a much lower concentration in the environment than did previous measurements. Although cadmium is easily complexed with some organic compounds, these have not been found in the general environment since they are rapidly broken down [7,8].

10.3.1 Toxic and carcinogenic effects

Metallothionein is an important transport and storage protein for cadmium. The binding of intracellular cadmium to metallothionein in tissues protects against its toxicity [7]. In relation to general population exposure, cumulative chronic toxicity is more relevant than acute toxicity. Much of the information on chronic effects of cadmium has come from occupational exposure; excessive intake in the diet has been limited to only a few localities. Following occupational exposure by inhalation, the kidney is most frequently the critical organ although, under some conditions, the target organ may be the lung. Lung changes are primarily characterized by chronic obstructive airways disease.

After chronic oral exposure, the kidney is the critical target organ. The renal cortex is where the first adverse effects occur, resulting in renal tubular dysfunction that is most often manifested as low-molecular-weight proteinuria. In more severe cases there is a combination of tubular and glomerular effects. In most cases, cadmium-induced proteinuria is irreversible [2,7–9].

There is evidence that long-term occupational exposure to cadmium may contribute to the development of cancer of the lung [8]. Cadmium has been placed in Group 2A of the IARC classification as a probable human carcinogen (limited evidence in humans, sufficient evidence in animals) [10].

10.3.2 Exposure

Emissions of cadmium into the environment are mainly related to industrial activities including zinc refining, electroplating and the production of alkaline batteries, plastics, glass and pigments. Cadmium is primarily released to air, the air concentrations ranging from below 5 ng/m^3 in rural areas to 50 ng/m^3 or higher near industrial sources. Cadmium deposits contribute to soil pollution, and consequently to uptake by crops.

The intake of cadmium from air, excluding industrial areas, is a minor portion of the total intake from all sources. It has been estimated that the daily intake for the general (global) population will be less than 0.5 µg/day [2,8].

Tobacco is an important source of cadmium uptake in smokers. Uptake from heavy smoking may equal the intake from food, and is much higher than that from ambient air [2,8]. Mothers smoking ten cigarettes a day have an increased cadmium level in their milk compared to nonsmoking mothers [11].

For most individuals, cadmium intake from drinking-water will be less than about

1 μg/day, but for certain people cadmium intakes from water (from contaminated wells) can reach values of up to about 20 μg/day [2,7,8].

Food is normally the main source of cadmium exposure for the general population. Most foodstuffs contain traces of cadmium, and crops from polluted areas may contain increased concentrations. The kidneys and livers of animals concentrate cadmium, as do shellfish and fungi. Average global daily intakes from food in most non-polluted areas are 10–40 μg/day (0.2–0.7 μg/kg body weight for an adult) but there may be large variations among individuals depending on age and dietary habits. Weekly consumption of mussels, kidneys or species of mushroom that accumulate cadmium may approximate or even exceed the PTWI. For infants and children, cadmium intakes on a body weight basis are generally higher than those estimated for adults and, in some countries, have been reported to exceed 1 μg/kg. In contaminated areas, cadmium exposure through food may be up to several hundred micrograms per day [2,7,9].

As diet (food and drinking-water) is the main source of cadmium intake, and as total intake levels are not readily available, the results of 33 studies on average dietary intakes in 10 European countries between 1974 and 1992 were analysed. Average daily intakes ranged from 8.6 to 90.4 μg/day, with more than two thirds of the average estimated intake levels being below 20 μg/day. A value of 90.4 μg/day was obtained from one of four Italian studies, the three others giving much lower intake levels.

10.3.3 Tissue levels

Blood levels are usually below 1 μg/l for the nonsmoking general (global) population, with smokers showing levels of 1.4–4.0 μg/l [8]. Results of 36 studies on blood cadmium levels conducted in 14 countries of the WHO European Region between 1972 and 1988 were analysed. Generally, low levels ranging from 0.1 to 5.4 μg/l were found, with no obvious geographical differences. Smokers had higher levels than nonsmokers (see Box

Box 10.1: Decrease in blood cadmium levels over time in Belgium

Owing to emissions from numerous non-ferrous metal industries, environmental cadmium pollution in Belgium was once quite appreciable, reaching a maximum during the 1970s. Considerable improvement was achieved by the introduction of regulations to control industrial emissions into air and water. A study was recently conducted in the polluted urban area of Liège, where most non-ferrous metal industries were closed for economic reasons in 1982. Blood cadmium levels in 31 men not occupationally exposed to cadmium were monitored between 1984 and 1988. A gradual decrease in blood cadmium levels was observed both in nonsmokers (63 % decrease from 1984 to 1988, corresponding to an annual decrease of 16 %) and in smokers (47 % decrease from 1984 to 1988, representing an annual decrease of 12 %). The overall decrease in blood cadmium was 56 % (14 % per year).

In an independent cross-sectional study conducted in 1985 and 1988 in a rural area to verify the results of the Liège study, blood cadmium levels in 1988 were found to be 40 % lower than in 1985, corresponding to an estimated average annual rate of decrease of 13 %: 18 % in male nonsmokers, 7 % in male smokers, 14 % in female nonsmokers and 11 % in female smokers.

These results demonstrate that reducing the emission of cadmium in Belgium was in fact correlated with a decrease in environmental exposure to this metal.

Source: Ducoffre, G. et al. [12].

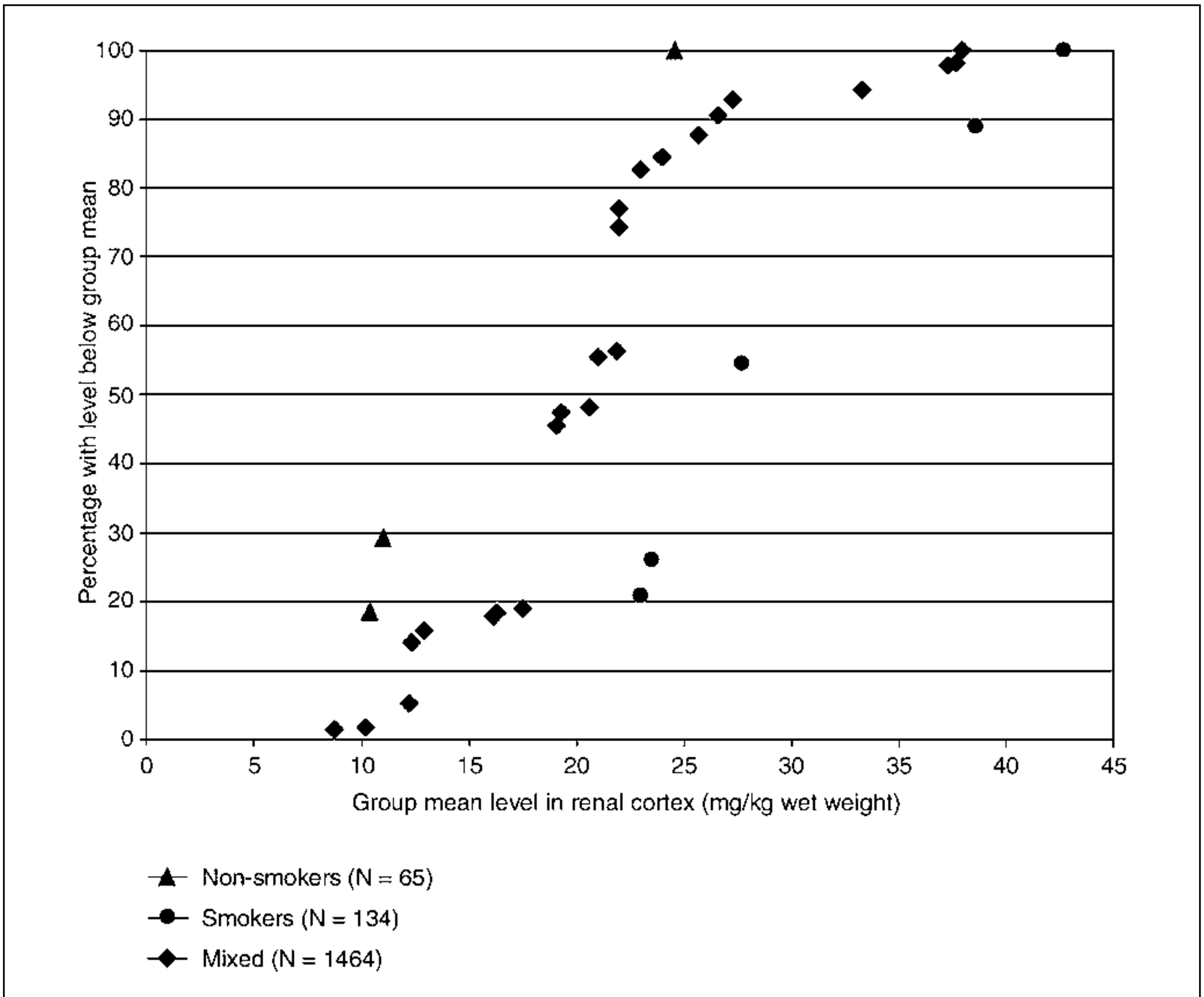


Fig. 10.1: Cadmium levels in the renal cortex of non-occupationally exposed populations

10.1). Urinary cadmium concentrations were evaluated from 13 studies conducted between 1972 and 1988 in 7 European countries. Levels of 0.14–3.0 µg/l were found, with smokers showing higher values than nonsmokers.

The average global cadmium concentration in the renal cortex of a non-occupationally exposed person aged 50 years varies between 11 and 100 mg/kg [7]. The average cadmium concentration is usually 50–100% higher in smokers than in nonsmokers [2].

The cadmium concentration in the renal cortex is a measure of cumulative exposure. Mean levels observed in 23 studies from 11 European countries between 1970 and 1989 ranged from 10 to 57 mg/kg wet weight. Fig. 10.1 depicts the proportional distribution of individuals with group mean cadmium levels in the renal cortex below given concentrations. Mean liver cadmium levels found in 16 studies from 10 European countries between 1976 and 1989 averaged 0.5–3.0 mg/kg wet weight. With both renal cortex and liver the main differences observed were between smokers and nonsmokers, with no obvious differences between different regions of Europe.

10.3.4 Evaluation of observed exposure levels and possible health effects

Both the intake estimates and the tissue levels of cadmium analysed in this chapter are the results of limited studies and do not permit extrapolation to the general population in the Region; nor do they provide information on population groups exposed to higher than average levels of cadmium. Average intakes and tissue levels of cadmium may suggest that the health risk from exposure to cadmium in Europe is low, but it should be noted that variations are large and that higher levels may be encountered in individuals. The tissue concentration at which renal injury occurs varies, but a level of 200 mg/kg renal cortex (wet weight) was taken as the level at which kidney dysfunction may occur. Mean levels found in studies from the European Region were below this critical value. The PTWI was set by the JECFA at 7 µg/kg body weight, corresponding to a daily intake of 60 µg/day for adults on the assumption that this long-term level of intake would lead to a maximum renal concentration of 50 mg/kg. Average daily intakes from the available European studies were generally below 60 µg/day. A recent study revealed that dietary cadmium intake by the general adult population in Belgium averaged 13.2 µg/day (95th percentile 36 µg/day) [13]. Thus the estimated average intakes in Europe do not exceed the PTWI. The situation will be different for population groups living in heavily polluted areas, but more specific data are needed to assess the actual risk.

Evidence from Japan indicates that dietary intakes may greatly exceed the PTWI in populations living in polluted areas. Intakes of 160–400 µg/day have been estimated in polluted areas, with as high as 600–2000 µg/day in heavily polluted regions [8] sufficient to cause adverse effects on health (Itai-itai-like disease). Recent evidence suggests that the risk of renal effects is low when the urinary excretion of cadmium is below 2 µg/day, corresponding to a concentration in the renal cortex of about 50 mg/kg. According to the data presented above, average values in some parts of Europe reach and sometimes exceed these levels, indicating that there is a risk of mild toxic effects on the kidney. No clear-cut definition of geographical locations with populations at risk can be made from the available data, however, and data were not available on occupationally exposed groups.

Population groups at specific risk comprise smokers (smoking 20 cigarettes a day results in an additional uptake of 1–2 µg/day), occupationally exposed individuals (the additional uptake may typically amount to 25–125 µg/day) and population groups with extremely high consumption of fish (in particular shellfish) or mushrooms, although the bioavailability of cadmium in shellfish may be relatively low [8].

The mean intakes of infants (12–24 months of age) may be close to or even exceed guideline values. This is not considered a serious problem, however, since the guideline value applies to long-term regular intakes and the exceeding of that value in infancy is of limited duration.

Trends in intake over time are not clear. In some countries they appear to be decreasing while in others no trend is apparent.

10.4 Lead

Lead occurs naturally in the earth's crust at an average concentration of about 13 mg/kg and is the most common of the heavy elements. It is present in a number of minerals, the principal ore being galena (lead sulfide). Lead in the environment exists almost entirely in the inorganic form [8,14].

10.4.1 Toxic and carcinogenic effects

Lead is a cumulative general poison, with pregnant women, the fetus, infants and children up to six years of age being the most susceptible to adverse health effects. The toxicity of lead may to some extent be explained by its inactivation of certain enzyme systems, by binding to protein sulfhydryl groups or by displacing other essential metal ions. For this reason, almost all organs and organ systems may be considered as potential targets, and a wide range of biological effects of lead have been documented. These include anaemia and effects on the nervous, reproductive and immune systems, and cardiovascular, hepatic, renal, endocrinal and gastrointestinal effects. Under conditions of low-level and long-term lead exposure such as are found in the general population, the most critical effects are those on the developing nervous system [2]. Lead causes a continuum of nervous system effects in children ranging from small decrements in cognitive ability to mental retardation, with slowed nerve conduction and behavioural changes. Effects on the nervous system develop in children at lower blood lead levels than in adults [2,15]. There is evidence that cognitive ability may be affected down to levels as low as 100–150 µg/l; the existence of a threshold for effects of lead on neuropsychological development is uncertain [16] and exposure of young children should therefore be reduced to the lowest possible level.

Lead has been placed in Group 2B of the IARC classification as a possible human carcinogen (evidence inadequate in humans, sufficient in animals) [17].

10.4.2 Exposure

Major sources of lead in the environment include lead-based indoor paint in older dwellings and atmospheric emissions due to the combustion of lead-containing petrol or to industrial activity. Lead persists in the environment, air being generally the principal medium affected.

Inhaled lead contributes little to the background body burden compared to intake from food, water, beverages and dust [15]. The daily intake of lead from air for an urban dweller will be in the order of 6–8 µg [9].

The major source of lead in drinking-water is the lead piping in some distribution systems. The daily intake from water varies from 10–20 µg up to 1 mg or more [9] depending on the plumbosolvency of the water.

In general, the major source of ingested lead is food. Lead is present in a wide variety of foodstuffs. No specific category of food has been identified as having particularly high levels of lead, other than foods and beverages that are stored in lead-soldered cans or lead-glazed pottery. Because of large differences in individual diets, precise calculations of lead intake are not possible. Estimates of typical daily intakes range from less than 100 µg to over 500 µg. The worldwide average intake for adults is about 200 µg/day [2,9,14]. For young children, estimates of total daily intakes are about one half the figures for adults [2]. Recent data suggest that levels of lead in the diet appear to have been falling in the last few years [15].

In addition to exposure from general environmental sources, some infants and young children receive high doses of lead through mouthing or swallowing non-food items such as soil, dust or flakes of lead-based paint [15].

Thirty-one studies carried out between 1979 and 1992 to estimate the mean daily dietary intakes of lead (including drinking-water) in 12 European countries were reviewed. Mean intakes ranged from 15 to 312 µg/day, the lowest value being found in Croatia and the highest in Romania. The majority of mean intakes were between 30 and 150 µg/day. Intake levels in some of the countries have shown a clear tendency to fall in recent years, in parallel with the reduction of emissions to air (see Chapter 5).

10.4.3 Tissue levels

The total body burden of an adult has been estimated to be 100–400 mg [18], the largest amounts being stored in bone. Blood lead levels reflect total recent exposure. The majority of occupationally unexposed adults have blood lead levels below 250 µg/l [9,18,19].

Mean concentrations of lead in blood measured in 64 different studies from 18 European countries between 1977 and 1992 were evaluated. Mean blood levels ranged from 8 to 277 µg/l, with few studies (on few subjects) revealing mean levels higher than 500 µg/l. In general, higher values were observed in industrial areas, in particular in the eastern and southern parts of the continent (see Box 10.2). Children generally had higher blood levels than did adults from the same geographical area. As with intake levels, there has been a tendency for blood lead levels to decrease in recent years. The proportional distribution of individuals with group mean blood lead levels below given concentrations is shown in Fig. 10.2.

Five studies in 5 countries between 1983 and 1992 provided data on urinary lead levels, which lay between 2.6 and 41 µg/l. Lead levels in teeth and bone may be indicative of longer-term exposure. The results of 15 studies in 5 countries between 1983 and 1991 revealed mean lead concentrations in teeth and bone of between 0.3 and 13.2 µg/g, with levels being higher in urban or polluted areas.

10.4.4 Evaluation of observed exposure levels and possible health effects

According to the studies reviewed, estimated daily intakes of lead in European countries are below the PTWI level set by the JECFA [21] for adults and children. For children, however, the PTWI of 25 µg/kg body weight may be exceeded, but only a few specific studies in children were available. Data from Finland indicate that the lead intake of infants (12–24 months of age) approximates to the PTWI level. The lowest intakes of lead by infants are when they are breast-fed. In Poland, the intake of lead by children living in industrial areas was double that of children living in non-industrial areas (Box 10.3). Considerable additional amounts of lead may be taken up from soft water if lead piping is used in the drinking-water supply, a problem encountered mainly in the CCEE and in the United Kingdom.

Lead in blood is used as an indicator of recent exposure and to evaluate the likelihood of health effects. For adults, the mean values found in blood are below the threshold levels for haematological or neurological effects (500 µg/l). The data indicate that, in general, blood lead concentrations are lower in rural than in urban areas. In a number of countries, blood lead levels have fallen following reductions in the use of lead additives in petrol while in other countries, mainly the

Box 10.2: Biomonitoring of lead in a metal-polluted Romanian town

Blood lead levels were measured in different population groups living in the city of Baia Mare ("big mine") in Romania, which has two outdated lead and copper smelters. Many of the 170 000 inhabitants of the town were concerned about the large emissions of smoke, gases and metals. Mean blood lead levels in a group of workers at the lead smelter were found to be 774 µg/l, exceeding by far the WHO recommended upper limit for male workers of 400 µg/l, while in workers at the copper smelter the average blood lead value was below the limit. In adults living near the lead smelter blood lead averaged 523 µg/l, the value recommended by WHO for the general population being 200 µg/l. In children living near the lead smelter, mean blood lead levels of 633 µg/l were measured, a value much higher than the 100–150 µg/l now thought likely to be associated with detectable impairment of cognitive ability. Control children had normal mean values for a non-industrial urban environment of 118 µg/l. The exposure of the population in Baia Mare to lead proved to be among the highest ever reported. Detrimental effects on neuropsychological development and performance in children are to be expected, but health studies were not carried out. Considerable efforts are needed to clean up both the occupational and the general environment.

Source: Verberk, M.M. et al. [20].

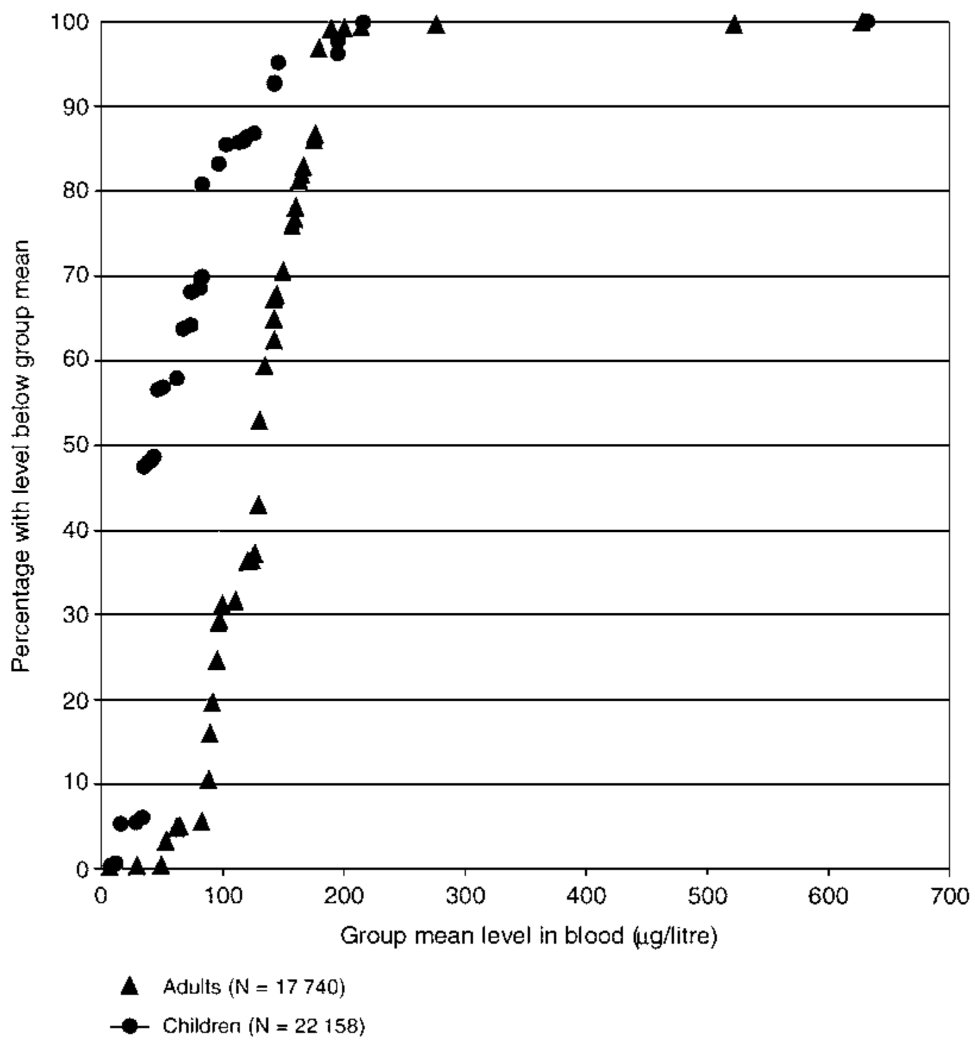


Fig. 10.2: Lead levels in the blood of non-occupationally exposed people by age, 1971–1992

CCEE, no such decrease has been seen. Higher mean blood lead levels were found in populations living near smelters or industrial plants.

In children, mean blood lead levels were generally below 150 µg/l. Higher mean values were found in some countries, particularly in one study from Hungary (248 µg/l) and two from Romania (196 and 633 µg/l) (see Box 10.2). With such mean values, some children must be exposed to lead at levels that will have severe effects on neuropsychological development and intelligence.

Lead levels in teeth and bone are possible indicators of longer-term exposure. Too few data were available to permit generalizations, but some studies from Germany clearly demonstrate the tendency for lead levels in teeth to decrease in recent years, while most studies show higher levels in urban than in rural populations.

10.5 Mercury

Mercury is a naturally occurring heavy metal. The major source of mercury in the biosphere is the natural degassing of the Earth's crust emanating from land areas, river beds and ocean floors [22]. Apart from the elementary, metallic form, inorganic mercury exists in the mercurous (monovalent) and mercuric (divalent) states. Mercury can form organometallic compounds, some of which have found industrial and agricultural uses [23]. Among these, methylmercury is produced in nature as a result of microbial activity [2,24]. Mercury is present in the environment as a result of its numerous uses: in chloralkali plants, paints, electrical switching equipment and batteries, measuring and control equipment, the production of lamps and explosives, copper and silver amalgams (tooth filling materials) and agricultural fungicides. In addition, the burning of fossil fuels, the smelting of various metals, the manufacture of cement and the disposal of wastewater may contribute significantly to mercury releases into the environment [2].

10.5.1 Toxic and carcinogenic effects

Different chemical forms of mercury have different toxic properties, the most toxic species being methylmercury. With metallic mercury, exposure is mainly via vapour inhalation. Acute effects are predominantly respiratory including, in some cases, interstitial pneumonitis that may prove fatal. The

Box 10.3: Assessment of the lead hazard in Poland: an example of national risk assessment of a multimedia pollutant

A group of 12 Polish experts evaluated data on sources of emission and environmental levels of lead, as well as data on intake levels and body doses in children and adults, from both reference and contaminated areas in Poland. The report states that the total emission of lead has decreased since 1987. The main sources of emission were found to be motor traffic, industry (mainly non-ferrous metal processing) and industrial waste disposal. Total lead emissions in Poland are comparable with those in other European countries. Levels of lead in ambient air in most Polish cities do not exceed the WHO guideline level of 0.5 $\mu g/m^3$. This does not apply, however, to some Silesian cities (Katowice, Tarnowskie, Gçry and Zawiercie) where the levels slightly exceeded 1 $\mu g/m^3$ in 1991, having decreased considerably over the previous few years. Air lead levels in other Silesian cities were below 0.5 $\mu g/m^3$. Soil levels observed in Poland are generally low except in Silesia, where soil concentrations may reach several thousand mg/kg, particularly in the neighbourhood of metal processing plants.

Intake of lead from food in Poland was found to be below the PTWI for adults. Median intake levels in children were also below the PTWI of 0.025 mg/kg body weight. In both cases, however, the data were from the early 1980s. Additional data on blood lead levels in non-occupationally exposed adults between 1988 and 1992 indicated that geometric means were below 90 µg/l for males and 60 µg/l for females in non-polluted areas. In polluted areas of Upper Silesia and Legnica-Glogow, geometric means of between 100 and 210 µg/l were observed, with some as high as 400 µg/l (in men) in highly contaminated areas of Silesia. In children, high levels of blood lead were found in certain areas of Silesia as well as in Legnica-Glogow, indicating the need for remedial action. The geometric means were 70–156 µg/l, showing a marked decrease from around 260 µg/l (98th percentile at 480 µg/l) in 1982–1985. In occupationally exposed individuals, blood lead levels frequently exceeded 600 ug/l, the level adopted as the threshold limit in Poland.

The group concluded that the lead hazard in Poland does not concern the whole population, but is associated with point sources of emission. Measures related to assessment, emission control and prevention of exposure were recommended.

Source: Pietrowski, J., personal communication, 1993.

main target organ for long-term effects of metallic mercury is the nervous system, symptoms including tremor and behavioural effects such as deficits in short-term memory and social withdrawal. Effects on motor function are also observed, but these are generally reversible. The kidney may also be affected, with responses ranging from mild proteinuria to the nephrotic syndrome [23].

Less information is available on the effects of long-term exposure to divalent inorganic mercury compounds. Ingestion of mercuric salts has been reported to cause ulcerative gastroenteritis and renal tubular necrosis [23]. Occupational exposure to mercuric oxide has resulted in damage to the peripheral nervous system [2].

The target organ for methylmercury is the nervous system. In adults, areas of the brain concerned with sensory and coordination functions are mainly affected [2,24]. Accidental intoxications have occurred, such as the Minimata and Niigata incidents in Japan and the Iraqi outbreak in 1971–1972 (following the consumption of grain dressed with alkylmercury fungicides) which were accompanied by a range of neurological effects. Prenatal exposure to methylmercury is associated with a substantially higher level of risk. The fetal nervous system, in particular the brain, is especially vulnerable. Prenatal exposure to levels yielding 10–30 μg mercury per gram of maternal hair may result in mild effects in the offspring such as psychomotor retardation [2,24].

There is no evidence that inorganic mercury is carcinogenic [23]. Some experimental feeding studies with methylmercury have shown that renal carcinoma may occur at high doses, but no evidence exists that it is carcinogenic in humans [24]. Mercury has not been evaluated by IARC.

10.5.2 Exposure

The total global release of mercury into the atmosphere due to human activity is estimated at 2000–3000 tonnes per year. Emitted mercury vapour is converted to soluble forms and deposited by rain on to soil and water. Methylation results in mercury entering the food chain and binding tightly to protein, leading to its possible bioaccumulation, particularly in fish [23].

Intake of mercury from air is largely as mercury vapour, with inorganic mercury compounds and methylmercury contributing 5 % and 20 % of total intake by inhalation, respectively. Total average intake of mercury from air has been estimated to be around 0.04 μg/day [24] to 0.2 μg/day [2] for the general (global) adult population.

Mercury intake from drinking-water is assumed to be generally less than 0.05 μg/day [2,24], the prevailing form being its inorganic salts.

The major source of exposure to mercury in the general environment is food. Average intakes of inorganic mercury from food (excluding fish) have been estimated to be around 3.6 μg/day, with fish contributing on average an additional daily intake of 0.6 μg. Methylmercury intake is generally due to fish consumption and averages globally around 2.4 μg/day for adults [24]. With high fish consumption dietary intakes may be substantially greater, particularly where waters are affected by acid deposition and/or industrial pollution.

An additional source of possible exposure to elemental mercury is the amalgam in dental fillings. It is, however, difficult to make accurate quantitative estimates of its release and uptake from this source [23].

Data on total intake levels are not readily available. Diet accounts for most of the mercury intake in humans, and the results of 13 studies and surveys in 11 European countries between 1980 and 1992 were reviewed. Average daily intakes ranged from 1.1 to 22 μg mercury per person.

10.5.3 Tissue levels

Results of 35 studies on blood mercury levels in 12 countries of the European Region conducted between 1973 and 1991 were analysed. In population groups with normal levels of fish consumption mean values ranging from 0.7 to 12 µg/l whole blood were observed, with two studies from Italy showing average levels of 17 and 25 µg/l and a study from Glasgow, United Kingdom, revealing a mean blood mercury concentration of 27.2 µg/l. In population groups with high levels of fish consumption (four or more fish meals per week) averages of 47.5–165 µg/l whole blood were observed. In all these studies, variations among individuals were large. No differentiation could be made between organic and inorganic mercury. In a recent review of normal concentrations of mercury in blood [25], analysis of available data for all regions of the world substantiated the strong correlation between mercury blood level and fish consumption. (These studies were mostly carried out in Canada, Finland, Sweden, the United Kingdom, the United States and the former Yugoslavia.)

In six studies in five countries of the European Region between 1988 and 1991, mean mercury levels in urine ranged from 0.9 to 2.8 µg/l. Again, however, individual variations were large with peak levels up to 54.4 µg/l.

Three studies in two countries revealed average concentrations in hair of 0.25–3.2 µg/g in non-exposed and 7.6 µg/g in exposed populations. Within the framework of the Long-term Programme of Pollution Monitoring and Research in the Mediterranean Sea, data on levels of total mercury in the hair of 880 individuals living in Greece, Italy and the former Yugoslavia were collected [26]. Values for total mercury ranged from 0.08 to 66.9 µg/g, with 4% of the samples exceeding 10 µg/g. In a subgroup of 146 subjects, methylmercury levels were also measured and ranged from 0.19 to 52.2 µg/g, with 22% of the samples exceeding 10 µg/g.

Levels of mercury in human milk indicate that intakes by breast-fed infants will not exceed tolerable levels. In a study from Sweden, levels of 3.1 µg/kg total mercury and 0.6 µg/kg methylmercury were found in the milk of women consuming fish from Swedish coastal areas of the Baltic Sea.

10.5.4 Evaluation of observed exposure levels and possible health effects

The intake estimates and tissue levels of mercury in European countries reported in this chapter are the result of studies limited to a small number of individuals and do not permit extrapolation to the general population. Moreover, the reported averages do not reflect the possibly large variations that might lead to higher levels in some groups of the population. The daily dietary intakes reported here are well below the PTWI for total mercury of 5 µg/kg body weight per week, equivalent to 43 µg/day (or 300 µg/person per week). Of this value, no more than 200 µg should be present as methylmercury [27,28]. No data were available, however, on the contribution of methylmercury to total dietary intake. Only average intakes are reported, although the risk for some population groups such as those consuming large quantities of fish is certainly higher.

No PTWI for methylmercury could be set for pregnant women and nursing mothers, as insufficient data were available on the magnitude of additional risk to the developing nervous system of the fetus and infant [28].

Urinary levels of mercury associated with mild proteinuria have been estimated to be around 50 µg/l [2] or 30–100 µg/g creatinine [23]. The average levels observed in the few studies reviewed in this chapter are much lower, though this does not exclude risk since the peak values observed are of concern.

The blood levels reported indicate that populations consuming large quantities of fish may attain blood levels of mercury associated with a risk of neurological damage to adults (5% risk at 200 µg methylmercury per litre whole blood) [2,24]. A blood level of 200 µg/l methylmercury was the lowest associated with neurological effects following the accidental exposures in Iraq and Japan. The risk to the fetus cannot be assessed, but it is certainly increased when pregnant women consume large amounts of fish.

The risk becomes more evident in data from studies on human hair. The incidence of motor retardation of children may rise over background levels when mercury in maternal hair reaches levels of 10–20 μg/g [24]. Mercury levels in hair above 10 μg/g were observed in 4% of the subjects in the WHO survey in three Mediterranean countries [26]. Thus there is a reason to be concerned about possible effects on the developing nervous system in some areas of Europe. The risk of adverse effects of mercury is low, however, for the larger part of the European population consuming moderate quantities of fish.

10.6 Pesticides

Pesticides comprise four major classes: insecticides, fungicides, herbicides and miscellaneous substances (rodenticides, nematocides, plant growth regulators, pheromones, etc.). The world market in pesticides in 1990 was about US $26400 million. Europe, which accounts for approximately 40% of the market, is the continent making the greatest use of these substances – more than 1 million tonnes are applied every year. Herbicides (38%) and fungicides (33%) represent the most widely used types of pesticide in European countries (Agrofarma,[a] unpublished data, 1992).

10.6.1 Toxic and carcinogenic effects

The pesticides currently in use include a wide variety of chemicals with great differences in their mode of action on, uptake by, biotransformation in and elimination from the body. The resulting toxicity to humans therefore varies greatly with different compounds and depends on the chemicophysical structure of the molecules.

Several pesticides possess high or moderate acute toxicity. Acute intoxication may result from accidental or inadvertent exposure when proper handling procedures are not followed, or from attempted suicide. Table 10.1 shows some organs and systems of the human body that may be affected after acute exposure to compounds of the main pesticide classes.

The real incidence of acute pesticide poisoning is not known. Published reports are based on hospital admissions, which include only the most serious cases, or are derived from the official reports to health authorities, which are known to greatly underestimate the extent of the problem. However, estimates based on hospital admission data and population surveys suggest that the world total for the number of cases of unintentional acute poisoning with severe manifestations probably exceeds 1 million per year, with a case fatality rate of 0.4–1.9%; it has been estimated that occupational exposures account for 70% of these cases. It has also been estimated that there are an additional 2 million cases of intentional poisoning (mainly attempted suicide) [30].

The incidence of acute pesticide poisoning in the European Region is not known, but is thought to vary substantially among countries. National statistics based on official reporting to health authorities in western European countries give an annual rate of about three cases per million population.

Besides acute effects from high-dose exposures, a large body of data from animal experiments supports the possibility of long-term health effects following prolonged exposure to low doses of pesticides. However, the relevance of these data to humans is limited, and epidemiological confirmation is available only for some effects.

Most of the published epidemiological studies on long-term health effects relate to the occurrence of cancer, while non-cancer health effects have been less frequently investigated. Well established evidence of associ-

[a] Italian association of industries manufacturing and formulating products for agriculture.

Table 10.1: Main sites of toxicity following acute exposure to compounds of selected pesticide classes

Site of toxicity	Pesticide class									
	Organo-phosphates	Organo-chlorines	Carbamates	Dithio-carbamates	Pyrethroids	Quaternary ammonium compounds	Substituted ureas	Organo-metallic compounds	Anti-coagulants	Phenoxy-acetates
Central nervous system	*	*	*	*	*		*	*		*
Peripheral nervous system	*		*		*					
Skin						*	*	*		*
Respiratory tract						*	*			
Kidney				*		*		*		*
Liver		*				*		*		*
Endocrine system				*			*			
Blood coagulation									*	

Source: Tordoir, W.F. et al. *(29)*.

Table 10.2: Non-cancer health effects in humans from prolonged exposure to selected pesticides

Pesticide	Evidence well established	Evidence requires further confirmation
Phenoxyherbicides		
2,4,5-T, 2,4-D, 2-methyl-4-chlorophenoxyacetic acid and related compounds (trichlorophenol, tetra-chlorodibenzodioxin)	Chloracne (tetrachlorodibenzodioxin)	Teratogenesis
Other herbicides		
Arsenicals	Liver disease	
Halogenated hydrocarbons		
Pentachlorophenol		Aplastic anaemia
Dibromochloropropane	Spermatogenesis suppression	
Methylbromide		Mild neurotoxic effects
Ethylene dibromide	Sperm abnormalities	
Carbamates		
Carbaril		Chromosome aberrations Sperm abnormalities
Organochlorine insecticides		
Hexachlorobenzene	Porphyria	
Dichlorodiphenyltrichloroethane (DDT)	Chloracne	Chromosome aberrations High cholesterol and triglyceride levels Tremors, muscular weakness Neurotoxic effects
Synthetic pyrethroids	Reversible paraesthesia ("skin sensations")	
Organophosphorus esters	Delayed neuropathy[a]	Chromosome aberrations Central nervous system alterations
Copper sulfate		Liver disease

[a] Some compounds only; after subacute or acute exposure only.

Source: Maroni, M. & Fait, A. *(31).*

ation between prolonged exposure to pesticides and chronic diseases is summarized in Table 10.2 [31]. Moreover, allergic dermatoses have been related to a number of pesticides.

A large number of epidemiological studies have investigated the possible association between exposure to pesticides and specific cancers. Table 10.3 lists the types of cancer studied and the classes of pesticide that may possibly be associated with them. It should be noted that a firm association between exposure and cancer has been established only for arsenical pesticides and the occurrence of lung neoplasia [32]. In all other cases, the epidemiological studies provide inconclusive evidence of association. Exposure assessment, in particular, is a critical factor limiting interpretation of these studies; direct measurements of exposure (ambient concentrations and biological monitoring) were not available in most epidemiological investigations.

The EU standards for pesticide residues in drinking-water are 0.1 μg/l for each active ingredient and 0.5 μg/l for the sum of pesticides. These standards are lower than the health-based guidelines prepared by the

Table 10.3: Specific cancers investigated in association with long-term exposure to pesticides

Type of cancer	Pesticides investigated
Soft-tissue sarcomas	Phenoxyherbicides (tricresylphosphate? tetrachlorodibenzodioxin?)
Myelolymphoproliferative disorders	Phenoxyherbicides Dichloropropene Chlordane/heptachlor Organophosphorus compounds
Brain	Chlordane/heptachlor
Lung[a]	Inorganic arsenicals
Gonads	Triazines
Liver	Inorganic arsenicals Hexachlorobenzene
Digestive system	Phenoxyherbicides
Urinary tract	Phenoxyherbicides

[a] A firm association has been established only for arsenical pesticides and occurrence of lung cancer.

Source: Maroni, M. & Fait, A. *(31)*.

Table 10.4: Groups occupationally exposed to pesticides in the European Union

Occupational group	Estimated number (millions)
Manufacturers of pesticides	0.2–0.5
Those formulating pesticides	1–2
Those applying pesticides in agriculture	8–14
Those applying pesticides in public health	0.5–2
Others[a]	1–2
Total	11–20

[a] Includes workers using pesticides in specific industrial processes such as tanning, paper milling and wood treatment.

Source: Maroni, M. *(33)*.

World Health Organization [9] as they are not based on toxicological considerations but rather with the objective of setting a "high purity" standard just above the analytical detection level. It should be noted that those countries that have adopted such low levels have reported great difficulty in compliance, due to current agricultural practice.

The International Agency for Research on Cancer has also evaluated a number of pesticides for their carcinogenic risk in exposed populations and/or in experimental animals [32].

10.6.2 Exposure

Exposure to pesticides concerns several groups of workers engaged in different occupations, and also the general population. Table 10.4 shows the estimated number of people in the EU occupationally exposed to pesticides.

Industrial workers are usually exposed to a limited number of pesticides in the form of concentrated substances mixed with intermediates of production and other chemicals. The exposure is continuous or intermittent.

Exposure takes place indoors, inhalation being an important route of absorption, and the level of exposure is rather stable and predictable.

By contrast, agricultural workers use many different pesticides, with diluted ingredients and for limited periods of time. Duration of exposure in agriculture may typically range from a few days to one month per year, with the exception of professional applicators whose length of exposure can approach that found in industrial workers. Exposure intensity in agriculture is extremely variable, depending on a number of factors related to field size, type of crop, mode of application, operator skill, climatic conditions and the use of personal protection. All these factors make the prediction of exposure levels difficult and strongly linked to individual and local determinants. Skin exposure, which may be easier to control in industry, has proved to be the most important route of exposure in agriculture.

The general population may be exposed to pesticides in several ways. For example, residents living in farming areas may be exposed to pesticide sprays in the air, depending on their proximity to the crops being treated. However, ingestion of pesticide residues via food and drinking-water as a result of their extensive use in agriculture represents the main route of exposure for the general population.

Using mathematical models to estimate the environmental fate of pesticides, it has recently been calculated [34] that in 65% of the EU's agricultural land the established drinking-water standard for the sum of pesticides will be exceeded. In approximately 25% of that area, the standard will be exceeded by more than tenfold.

The definition of standards for pesticide residues in food is made regularly by the Joint FAO/WHO Meeting on Pesticide Residues, which formulates recommendations on acceptable daily intakes (ADIs) and maximum residue limits (MRLs). These are accepted as national standards in most countries.

In evaluating the exposure to pesticides via food, several elements must be considered. Different kinds of food involve different pesticides in their production, different kinds of food are eaten in different amounts by the general adult population of a particular country and in different countries, and the proportion may vary widely for infants or other special groups [35].

Few data are available on the levels of dietary intake of pesticides by the European population. Tables 10.5 and 10.6 show the results of some studies carried out in Italy and the United Kingdom [36,37]. In all these studies the estimated daily intake for each of the investigated compounds was lower than the respective ADI.

This is also true for other available national data on pesticide residues in total diet studies. These show that, in general, calculated intakes of pesticides are often only 1% or less of the ADI [38,39]. In the CCEE and NIS, however, available data are insufficient to allow the conclusion that this assumption applies to the whole Region, particularly in view of the fact that in the CCEE and NIS pesticide use is high. Recent data from Romania[a] indicate that DDT intakes are still high in certain parts of the country, and may approach or exceed the ADI. A similar situation may exist in some other European countries, for children or other population groups whose diet differs significantly from the national average.

Official reports of monitoring programmes on pesticide residues in drinking-water and food in Europe are rather limited. In many cases data are available at the local level but are not centrally evaluated. For this reason a comprehensive evaluation of pesticide exposure levels is not possible.

10.6.3 Tissue levels

Some persistent and non-persistent pesticides can be detected in blood, serum, urine and adipose tissue, both in occupationally

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 10.5: Dietary intake of pesticide residues in Italy (1986–1987)

Active compound	ADI (μg/kg/day)	EDI[a] (μg/kg/day)	EDI/ADI (%)
Azinphos-methyl	2.5	0.160	6.4
Benomyl	20	0.495	2.5
Carbaril	10	0.04	0.4
Carbophenothion	0.5	0.015	3.0
Chloropyrifos	10	0.014	0.1
Chloropyrifos-methyl	10	0.009	0.09
Diazinon	2	0.004	0.2
Dicofol	25	0.612	2.4
DDT	20	0.026	0.1
Dimethoate	10	0.144	1.4
Endosulfan	6	0.024	0.4
Ethion	6	0.008	0.1
Fenitrothion	5	0.012	0.2
Heptachlor	0.5	0.003	0.6
Iprodione	300	0.014	0.005
Isophenphos	1	0.0001	0.01
Lindane	10	0.031	0.3
Malathion	20	0.150	0.8
Mancozeb	50	4.03	8.1
Methidathion	5	0.004	0.08
Parathion	5	0.025	0.5
Parathion-methyl	20	0.006	0.03
Phosalone	6	0.078	1.3
Pirimiphos-methyl	10	0.134	1.3
Procymidone	100	1.362	1.4
Thiabendazole	300	0.507	0.2
Vinclozolin	70	1.206	1.7

[a] EDI = estimated daily intake.

Source: Camoni, I. et al. *(36).*

Table 10.6: Dietary intake of organochlorine residues in the United Kingdom

Compound	Dietary intake		
	ADI (μg/kg/day)	1975–1977 (μg/kg/day)	1979–1980 (μg/kg/day)
Lindane	10	0.056	0.043
Dieldrin	0.1	0.033	0.023
DDT	20	0.085	0.046

Source: Ministry of Agriculture, Fisheries and Food *(37).*

exposed subjects and in the general population.

Occupationally exposed workers may have relatively high pesticide tissue levels as a result of recent exposure; these are closely related to the intensity and pattern of exposure. Pesticides that can be detected in the general population are those that show a strong tendency to accumulate in the body. Organochlorine pesticides are the substances most investigated since their high liposolubility facilitates their bioaccumulation through the food-chain [40]. The residues most frequently found in adipose tissue were DDT, hexachlorocylohexane, dieldrin and heptachlor epoxide, and in human milk

DDT and its main metabolite DDE, hexachlorobenzene, hexachlorocyclohexane, dieldrin and heptachlor epoxide [30].

10.6.4 Evaluation of observed exposure levels and possible health effects

Pesticides may represent a risk to human health. However, knowledge of their adverse effects is mostly confined to acute effects from high-dose exposure, while their role in the development of adverse effects from prolonged exposure to low doses, as occurs in both workers and the general population, is still controversial. The available data do not suggest that, in general, dietary pesticide intakes exceed the ADI levels.

A number of studies have attempted to evaluate the patterns of morbidity and mortality of populations living in particular geographical areas where, as a result of their extensive use, pesticides may have contaminated drinking-water and food. Increased frequencies of certain types of cancer have been observed (e.g. stomach cancer or lymphoma in rural areas) but any association with pesticide exposure remains ill-defined and difficult to establish [31].

10.7 Nitrate

Nitrates are present naturally in soil, water, plants and meat [9,41]. They are also present in low concentrations in air. In the natural environment, nitrifying bacteria convert ammonium ions into nitrites and nitrates. Nitrate levels in soil and water may be increased through human activity including the use of nitrogenous fertilizers [41].

10.7.1 Toxic and carcinogenic effects

The effects of nitrate on health are generally a consequence of its ready conversion to nitrite in the body [9]. Nitrite reacts with haemoglobin to produce methaemoglobin (a form of the pigment that is incapable of transporting oxygen). In adults, this is rapidly reduced back to oxyhaemoglobin. In infants up to three months of age, however, the relevant enzyme system is incompletely developed and the methaemoglobin formed may build up, resulting in the potentially fatal clinical condition known as methaemoglobinaemia [9,41].

The conversion of ingested nitrates into nitrites occurs in the mouth or elsewhere in the body where the acidity is relatively low. Under certain conditions, nitrites may react with secondary and tertiary amines and amides (derived from food and beverages) to form nitrosamines or amides.

There are no appropriate data from animal studies to demonstrate the carcinogenicity of nitrate via the formation of nitrosamines [9] but tests in many animal species have shown that a number of nitrosamines are carcinogenic. There is no direct evidence of their carcinogenicity in humans. Several epidemiological studies have been carried out to investigate the possible carcinogenic effect in humans of nitrate in drinking-water, but the evidence remains inconclusive.

10.7.2 Exposure

Accumulation of nitrate in the environment is a result of the extensive use of nitrogen-based fertilizers in agriculture, the increase of nitrogenous wastes from livestock and poultry production, and urban sewage treatment. The primary media affected are soil and water.

Inorganic and organic forms of nitrate also occur in small concentrations in air. It has been estimated, for areas with high levels of nitrogen compounds in the air, that if all these compounds were absorbed by an adult it would amount to an intake of approximately 0.1 mg nitrate-N per day [9,41].

The concentrations of nitrate in water vary widely depending on the water source. Typically the intake is below 20 mg nitrate-N per day, but in rare circumstances it could be more than five times this value [9]. The WHO drinking-water quality guideline level is 50 mg/l.

In general, the major source of nitrates is food. Certain vegetables, including cabbage, celery, lettuce, potatoes, several root vegetables and spinach, contain relatively high levels of nitrate. The quantities of nitrates ingested from the diet range from about 120 mg to 230–300 mg of nitrate per day, but may be substantially higher. A daily intake from food alone for a two-month-old infant has been estimated to be approximately 25 mg nitrate-N [9]. Because of the relatively large fluid intake of infants compared to adults, intakes from drinking-water may comprise a large proportion of the total in this age group.

The results of 21 studies yielding estimates of intake levels by ingestion in 11 countries of the WHO European Region between 1976 and 1992 were reviewed. Average values ranged from 32 to 245 mg nitrate per day, with nitrite intake averaging 0.3–4.5 mg/day. Most average intake levels lay between 50 and 160 mg/day, with a low of 32 mg/day from Romania and the highest level of 245 mg/day being one of three estimates from Italy.

10.7.3 Tissue levels

Few studies from the European Region were available for review. Mean nitrate excretion levels in urine of 32–96 mg/day were observed in two studies carried out between 1985 and 1989. Levels in saliva measured in two further studies in 1990 and 1991 ranged from 3.6 to 23.4 mg/l, while in gastric juice one study revealed a concentration of 17.8 mg/l. In a Dutch study [42] the level of nitrate in saliva clearly correlated with that in drinking-water; validation of this may prove useful as an indicator of nitrate intake from this source. Urinary excretion of some nitrosation products has also been suggested as an estimate of exposure, but the correlation with nitrate intake is generally poor.

10.7.4 Evaluation of observed exposure levels and possible health effects

Average daily intakes of nitrate estimated in studies from different European countries were all below the ADI for adults established by the JECFA of 0–300 mg/day [43]. Estimates from the United Kingdom range from 185 to 194 mg/day, which is still within the ADI although the estimates do not include tap water. Vegetarians can be expected to have higher intakes, as vegetables make up around 97 % of their diet. No specific studies of daily intakes by infants and small children were available.

The levels in human body fluids do not permit any clear-cut conclusions.

Although average nitrate intakes in Europe reviewed in this chapter are below levels of concern this does not imply a lack of risk, particularly in the case of infants and small children. In certain areas where extensive use is made of nitrogen fertilizers and/or there is high production of animal wastes, intake of nitrate through drinking-water and food may be higher than the estimated average. Nitrate levels in some samples of drinking-water were shown to exceed 100 mg/l in Bulgaria and Romania (100 mg/ml is the level above which infant methaemoglobinaemia may occur). Infant deaths due to methaemoglobinaemia have been reported in the CCEE.

10.8 Benzene

Benzene is a monocyclic aromatic compound, present in the environment as a result of both natural processes and human activities. Natural sources, which include volcanoes and forest fires, account for a small proportion of the total. Benzene is also a natural constituent of crude oil. Motor vehicle emissions (of both natural and combustion products) and industrial processes are the main sources of benzene in the ambient environment and in the interior of motor vehicles; in all indoor environments, tobacco smoke contributes significantly to benzene exposure [2].

10.8.1 Toxic and carcinogenic effects

Acute exposure to high concentrations of benzene results in central nervous system depression [9]. The chronic toxicity of benzene is presumed to be due to several metabolites. Persistent exposure to toxic levels of benzene can damage bone marrow, the early manifestations being anaemia with low counts of white blood cells and platelets. In severe cases, fatal aplastic anaemia develops [2].

A large number of cases of myeloblastic and erythroblastic leukaemia associated with occupational exposure to benzene have been reported. Some cases of chronic myeloid and lymphoid leukaemia, and of related malignant lymphoproliferative diseases, have also been reported in connection with known benzene exposures [2]. Benzene has been placed in Group 1 of the IARC classification as a known human carcinogen [44].

10.8.2 Exposure

Sources of benzene emissions are petrol (including production during combustion) and the petrochemical industry. Also, benzene is used as a solvent in a number of industrial processes. It is relatively unstable in air or soil, but more persistent in groundwater.

Air is the primary source of benzene exposure for the general population. The daily (global) average intake for an adult at typical ambient benzene levels has been estimated to be about 160 μg/day [2]. Air inside motor vehicles may contain higher levels. Intake via environmental tobacco smoke may be quite considerable. Tobacco represents an important source of exposure for smokers, estimates of uptake ranging from 10 to 30 μg per cigarette [2].

The intake of benzene from drinking-water is minimal compared with intake from food and air [9]. No estimates of total daily intake were found. There are few data on levels of benzene in foods, although there are indications that benzene occurs naturally in some fruits, fish, vegetables, nuts, dairy products, beverages and eggs [9]. The daily (global) average dietary intake of benzene has been estimated to be in the order of 100–250 μg/day. Conventional cooking may increase the benzene content of food [2].

Eight studies from six European countries on estimated average intakes of benzene via inhalation between 1981 and 1992 were reviewed. Values ranged from 0.7 to 504 μg/day, the average intake in urban areas being around 150 μg/day with much lower intakes in rural and clean air areas. Mean intake levels from food were found to be less than 180 μg/day in the Netherlands.

10.8.3 Tissue levels

Different possibilities exist for the assessment of exposure and body burden. Measurement of benzene levels in exhaled air is a highly sensitive method, but to date only a few studies on occupational and/or voluntary exposure have been performed. Owing to the rapid exhalation and metabolism of benzene, toxicokinetic parameters must be considered. Blood levels of benzene have rarely been measured, and no data were found on populations in Europe exposed to benzene in the general environment.

The most sensitive means of assessing exposure to benzene by urine analysis is to measure phenol excretion, as benzene yields substantial amounts of phenol metabolites. The results of six studies from five European countries conducted between 1955 and 1991 showed mean urinary phenol levels of 1.8–17.8 mg/l. It should be noted, however, that the excretion of phenol may also stem from the metabolism of alimentary and endogenous amino acids. Measurement of a more specific benzene metabolite in urine might be more useful.

10.8.4 Evaluation of observed exposure levels and possible health effects

Only limited data on exposure to benzene are available. In general, however, exposure is higher in urban than in rural areas. Benzene is a carcinogen and exposure of the population should be reduced to the lowest possible level, though it cannot be totally avoided. The estimated cancer risk is 4 10^{-6} for exposure to 1 µg/m^3 over a lifetime.

Other sources of benzene include the indoor environment, with time spent travelling (especially in motor vehicles) contributing significantly to total exposure. Environmental tobacco smoke also contributes to total exposure. In addition, pollution of the soil with petrol or with chemical waste may incidentally contribute to increased concentrations of benzene in the air.

Smokers constitute the main population group at special risk, as smoking is a large contributor to benzene intake. Smoking 20 cigarettes a day may provide an additional daily intake of 200–600 µg benzene, exceeding by far the intake from the general environment. Environmental exposures are approximately 5–10 times below the occupational levels that may be associated with haematological effects.

10.9 Polynuclear Aromatic Hydrocarbons

Polynuclear (or polycyclic) aromatic hydrocarbons (PAHs) are organic compounds consisting of two or more benzene rings. PAHs are present in the environment from both natural and man-made sources, mainly as a result of pyrolytic processes (incomplete combustion of organic compounds). PAHs are widely distributed in the environment, having been detected in animal and plant tissues, sediments, soil, air and various water sources. There are several hundred PAHs, the best known being benzo[*a*]pyrene (BaP) which usually constitutes less than 5 % of the total. The relationship between the amount of BaP and some other PAHs is termed the "PAH profile" [2,9,45].

10.9.1 Toxic and carcinogenic effects

Little information is available on the acute or chronic toxicity of PAHs after ingestion. On the basis of experimental results, carcinogenic effects are expected to be the most important.

There is a lack of adequate population studies on the relationship between exposure to PAHs and lung or other cancers. But PAHs have been shown to be carcinogenic in a number of animal experiments, and several studies of workers have shown an increased risk of skin and scrotal cancer after exposure to soots, tars and mineral oils, and of lung cancer after exposure to coal gas and coke-oven emissions [2,9,46]. Little research has been conducted on the carcinogenic effect of ingested PAHs, even though the oral intake may be much higher than the inhaled intake in the general population [2]. Long-term feeding studies with PAHs are currently under way.

As a group, PAHs have not been evaluated for carcinogenicity by IARC. BaP has been placed in Group 2A of the IARC classification as a probable human carcinogen (limited evidence in humans, sufficient evidence in animals) [47].

10.9.2 Exposure

The major source of PAHs in the environment is the combustion of fossil fuels for energy and transportation, besides emissions from the petrochemical, iron and steel, non-ferrous metal, rubber and wood industries. The primary environmental medium is air. Lifestyle factors, such as tobacco smoking and some types of food preparation (barbecuing and smoking) contribute significantly to total exposures to PAHs. Smoking ten cigarettes a day may result in an estimated additional intake of 0.1–0.2 µg BaP per day.

The daily (global) average intake of BaP by inhalation of polluted ambient air has been estimated to be 0.4 µg. However, the BaP intake in clean rural areas may be no more than 1 % of this amount [2]. PAH concentrations may be quite considerable in the indoor environment owing to the combustion of fossil fuels for heating and cooking and/or to environmental tobacco smoke.

It has been estimated that the typical daily intake of PAHs from drinking-water is only 0.1 % of the total daily oral intake [9].

Polynuclear aromatic hydrocarbons are detected in a wide range of meat, fish, vegetables and fruits and are found in substantial quantities in some prepared foods, depending on the method of cooking, preservation or storage. Estimates of total intake of PAHs from food range from 1.6 to 16–27 µg/day [2,9,45]. Various estimates of the average (global) dietary intake of BaP have been made: 1.0–3.3 µg/day, 0.16–1.6 µg/day and 0.25 µg/day (total PAHs 3.7 µg/day) [45].

The results of eight studies conducted in different European countries between 1977 and 1992 on estimated dietary intakes of BaP revealed average levels ranging from 0.05 to 0.25 µg/day. In four of these studies total intake of 9–16 different PAHs was also estimated, with values ranging from 2.1 to 6.8 µg/day.

10.9.3 Tissue levels

There have been several attempts to determine the levels of PAHs in both normal human tissues and tumours.

In one study, samples were taken at autopsy from people ranging in age from birth to the fifth decade. The overall average in tissue (liver, spleen, kidney, heart and skeletal muscle) was 0.32 µg/100 g dry weight. In lungs and in tissues with high cellular proliferative activity such as secreting glands and bone marrow, the average was 0.2 µg/100 g. In other studies, average tissue levels of BaP were found to be 3.5 µg/g (carcinoma) and 0.09 µg/g (tumour-free) [46].

One of the methods used to assess exposure to PAHs is the measurement of urinary excretion of 1-hydroxypyrene, a major PAH metabolite in humans. In occupational studies, control values ranged from 0.46 to 0.98 µg/g creatinine. In workers who smoke heavily, this value rose to 1.2 µg/g creatinine. The method suffers from a lack of sensitivity (only large variations in exposure can be detected) and the fact that the relationship between exposure to PAHs and excretion of the metabolite is far from linear.

Measurement of DNA adducts derived from PAHs in white blood cells has been employed to assess exposure to PAHs, mainly in the occupational environment, in smokers and in individuals living in highly polluted areas. In any population, the mean level of DNA adducts seems to reflect group exposure, but there is a wide variation in adduct concentration among individuals with the same estimated exposure (Box 10.4). This wide range of individual variability is probably due to a number of factors, including inter-individual differences in metabolism [48].

10.9.4 Evaluation of observed exposure levels and possible health effects

Levels of intake of BaP and other PAHs reviewed here are not representative and vary widely. To assess the extent of exposure of the general population to PAHs, more accurate and sensitive methods need to be developed, validated and used. Owing to the carcinogenic nature of this group of compounds, exposure should be reduced to the lowest possible level. The cancer risk associated with lifetime exposure to 1 $\mu g/m^3$ is estimated to be 9 10^{-2}. Exposure cannot be totally avoided, however, as PAHs are ubiquitously present in the environment. For example, BaP may be present in unpolluted

Box 10.4: Biomarkers of exposure to PAHs and of genetic damage in a polluted area in Poland

In the highly industrialized Silesian region of Poland, severe environmental pollution is encountered that has been associated with increased risk of cancer and adverse effects on reproduction. Polycyclic aromatic hydrocarbons produced by industrial and domestic combustion of coal are among the most prevalent carcinogenic and mutagenic air pollutants in Silesia. In recent studies, atmospheric concentrations of benzo[*a*]pyrene (BaP) in the town of Gliwice, for example, were 57 ng/m^3 in winter and 15 ng/m^3 in summer, the difference resulting from the extensive burning of coal for heating.

In a study conducted in 1990 in 39 males from Gliwice and 49 controls from the rural province of Biala Podlaska, BaP-DNA adducts were analysed both in winter and in summer and compared to biological markers of genetic damage. DNA adducts in both the exposed group and the control group were higher in winter than in summer. They were also significantly higher in exposed winter samples than in control winter samples, as were some markers of genetic damage. Large inter-individual variations were observed, however, and biomarkers of exposure (adducts) were not significantly correlated with those of effects (genetic damage).

Source: Perera, F.P. et al. [49].

urban air at concentrations of 1–5 ng/m^3, and occupational exposures may be three orders of magnitude greater. Since individual exposure to PAHs is to a large extent related to lifestyle, particularly smoking, it can be significantly reduced through individual choice.

10.10 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are synthetic compounds, and have been used as heat transfer fluids, organic diluents, plasticizers, lubricant inks, fire retardants, paint additives, sealing liquids, immersion oils, adhesives, and dielectric fluids for capacitors and transformers. In total, there are 209 possible PCB isomers, and the composition of commercial PCB products is therefore highly complex. The relative number of congeners and their concentrations in the products depend on the degree of chlorination of the mixture [50]. Some of the congeners exhibit biochemical and toxicological effects similar to those produced by polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDDs and PCDFs, see below). Lipophilicity is an important property of this group of compounds.

10.10.1 Toxic and carcinogenic effects

The evaluation of toxicity studies is difficult since the various commercial PCB mixtures are not well defined and many are contaminated with PCDFs and other related chlorinated compounds. The presence of these contaminants is thought to be at least partly responsible for a number of effects observed [50,51] with PCBs (see below).

Information on the effects of PCBs in humans were obtained following a large-scale incident in Yusho, Japan, in which over 1000 people showed signs of poisoning from the ingestion of rice oil contaminated with PCBs from a heat transfer liquid. The most striking effects were hypersecretion in the eyes, pigmentation and acneiform eruptions of the skin, and disturbances of the respiratory system [52]. Symptoms similar to those of Yusho patients have been observed in workers in a Japanese condenser factory, including pigmentation of the fingers and nails and acneiform eruptions on the jaw, back and thighs. It was thought that these effects arose from local contact with PCBs [52]. An accident involving PCBs and dioxins occurred in Yu-cheng, Taiwan in 1979 [53]. Again, the most obvious effects were on the skin, including chloracne, but effects on liver enzymes, the immune system and the nervous system have also been reported.

Hyperactivity and impaired learning ability have been reported for rhesus monkey infants exposed to different PCBs *in utero* and during lactation [54]. Behavioural effects similar to those seen in monkeys have also been reported for human infants whose mothers were exposed to PCBs through eating contaminated fish [55]. The effects recorded in those infants were slight, but should still be regarded as adverse. The causal relationship between PCB exposure and these behavioural effects could not be proven, but such a relationship is plausible [56].

Information on the possible carcinogenic risk from human exposure to PCBs comes from studies of occupational groups and of populations accidentally exposed to the compounds. The available studies are inconclusive but suggest an association between (liver) cancer and exposure. Almost without exception, PCBs contain various levels of PCDFs as contaminants, and it is uncertain if and to what extent PCDFs play a role in the observed carcinogenic effects of PCBs [50,52,57]. PCBs have been placed in Group 2A of the IARC classification as probable human carcinogens (limited evidence in humans, sufficient evidence in animals) [57]. It is likely that these compounds act by a nongenotoxic mechanism, and that carcinogenesis is threshold-dependent.

10.10.2 Exposure

Polychlorinated biphenyls are exceptionally persistent in the environment, a fact that explains the continued exposure to them despite major efforts to restrict and eventually eliminate their release. This group of compounds is widespread in soil and water.

From the PCB levels encountered in air and drinking-water, the daily intake from each of these sources is likely to be less than 1 μg/day [52].

The majority of people are exposed to PCBs via the diet. The main foods in which contamination with PCBs is possible are those with a high fat content: fish, milk and other dairy products, and meat [50–52]. The average dietary intake of PCBs by various populations has been estimated to range from 0.005 to 0.2 μg/kg body weight per day. In the case of breast-fed infants, PCB intake has been calculated to range from 2 to 12 μg/kg body weight per day [51]. It is expected that levels of PCBs in the environment and food, and consequently in breast milk, will decrease with time [51].

Only a few recent studies on dietary intakes of PCBs in different European countries are available. The results of three studies conducted in the Netherlands from 1985 to 1988 and in Finland in 1986 revealed average daily dietary intakes of 2–14 μg total PCBs/day. Average intakes in Scandinavian countries have been estimated to range from 0.12 to 2.6 μg/day in populations with low fish consumption and from 0.48 to 39 μg/day in populations with high fish consumption [56], particularly of fish with a high lipid content such as eel. The same is true for people taking cod liver oil supplements; a normal weekly consumption of about 150 g (which contains, on average, 1.6 mg/kg) leads to an intake of PCBs that approximates the possible tolerable intake.

Occupational exposure may result in higher uptake, mainly by inhalation. Acute high-dose exposures may take place as a result of accidental releases caused, for example, by fires or short-circuits in electrical devices. Also, overheating of transformers may lead to contamination of buildings.

10.10.3 Tissue levels

Surveys on human adipose tissue in several countries have shown that most samples contained levels of PCBs in the region of 1–2 μg/g or less. Higher values, 2.5 μg/g on

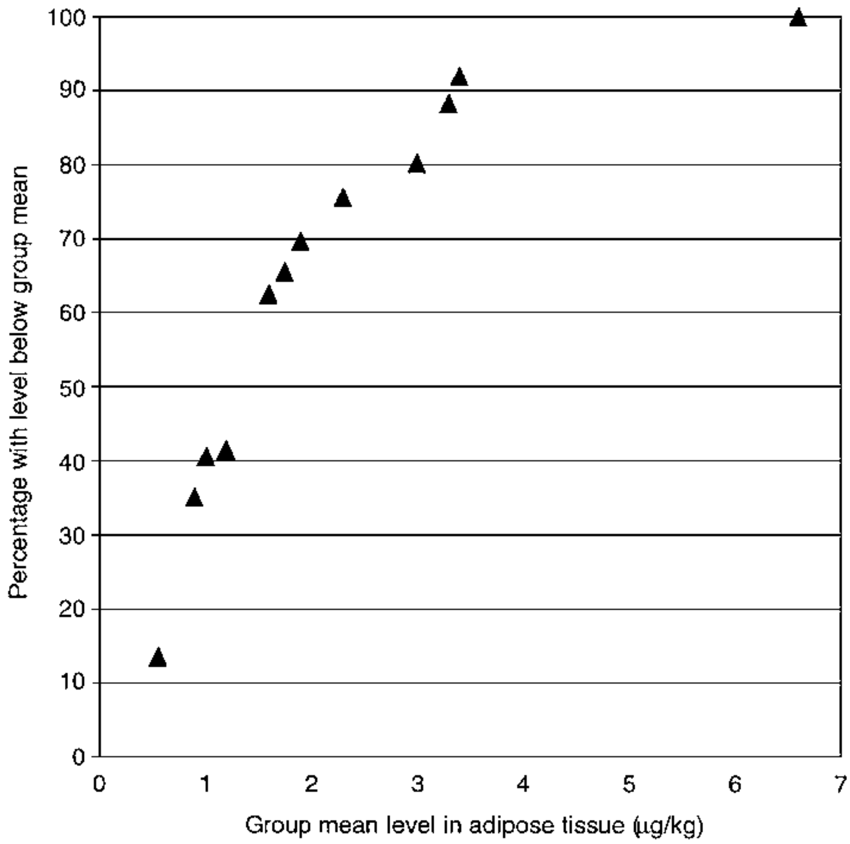


Fig. 10.3: PCB levels in adipose tissue of non-occupationally exposed people (N = 871)

average, were reported in patients 1–3 years after accidental exposure to PCBs in the diet. Much higher values of up to 700 µg/g have been found in occupationally exposed people [50,52]. The results of 13 studies conducted between 1969 and 1990 in 8 European countries were reviewed. Average levels of 0.6–6.6 µg PCBs/g fat were determined. Recent German studies reveal lower levels than those found earlier, indicating a tendency for the concentration of PCBs in adipose tissue to fall in recent years. Fig. 10.3 shows the proportion of individuals with group mean adipose tissue PCB levels below a given level for the total population.

Several national surveys have shown PCB concentrations in the blood in the region of 3 µg/l. The mean blood level in people accidentally consuming PCBs was 6–7 µg/l five years after exposure. Levels approaching 20 µg/l have been measured in occupationally exposed individuals [52,56]. PCBs could also be detected in both male and female reproductive fluids, the concentrations being around 10 µg/l. Mean values for liver and brain were reported to be 0.15 and 0.12 µg/g, respectively [50].

Most surveys on human milk have shown PCB concentrations in the region of 20–30 µg/kg, although concentrations up to 100 µg/kg have been recorded. The results of 43 studies conducted in 14 countries of the European Region between 1971 and 1992 were reviewed. Mean levels observed ranged from 9 to 90 µg/kg whole milk (with one study from Spain yielding an average value of 250 µg/kg); average PCB levels of 0.32–3.2 µg/kg milk fat were reported. The proportional distribution of individuals with group mean milk PCB levels below given concentrations is shown in Fig. 10.4. In general, there has been a tendency for PCB levels in breast milk to decrease in the course of the last few years.

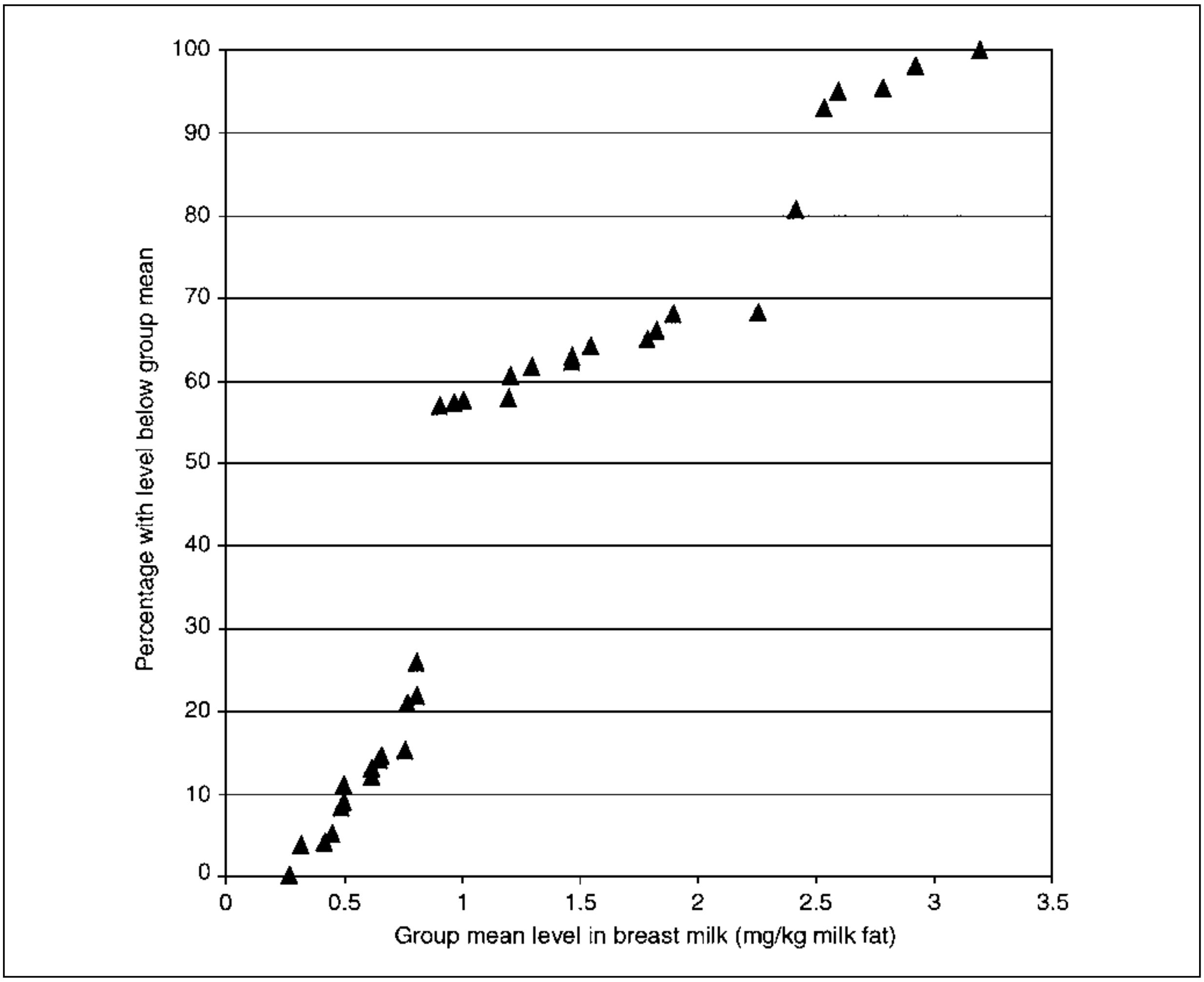


Fig. 10.4: PCB levels in the milk fat of non-occupationally exposed women (N = 4945)

10.10.4 Evaluation of observed exposure levels and possible health effects

The assessment of dietary intakes and tissue levels measured in terms of their possible effect on health is difficult, as the available human data do not permit the establishment of a proper dose–response relationship. In addition, risk assessment is complicated by the fact that older toxicological data are based on commercial mixtures of PCBs that are different from those encountered in the environment today. The exposure levels observed are of possible concern with regard to the neurobehavioural effects of PCBs [54–56].

The JECFA concluded that it was impossible to establish a precise value for tolerable intakes for humans, but considered there was no reason to suppose that humans would be more sensitive than monkeys to the effects of PCBs (a no observed effect level (NOEL) of 0.04 mg/kg body weight per day).

Breast-fed infants are exposed to higher levels of PCBs than adults and bottle-fed babies. A daily intake of 3–11 μg/kg body weight per day has been estimated for breast-fed babies as compared to 0.12–0.3 μg/kg body weight per day for bottle-fed infants. Breast-fed infants of women who have consumed large quantities of fish may have even higher intakes of PCBs.

The lowest observed effect level (LOEL) for mild neurotoxic effects in infants of exposed mothers is estimated to be in the range 0.014–0.9 μg/kg body weight per day [56]. On this basis, both breast-fed and bottle-fed infants are at risk of experiencing such effects from current intake levels, with breast-fed (particularly first-born) infants at higher risk. Intensive efforts to reduce exposure to PCBs in the general environment should therefore continue, especially in view of the low biodegradability and the long persistence of these compounds.

Blood levels of 80–100 µg/l have been associated with dermatological effects in occupationally exposed individuals.

10.11 Polychlorinated Dibenzo-*p*-Dioxins and Dibenzofurans

Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are two series of tricyclic aromatic compounds with similar chemical and physical (including lipophilic) properties. They are ubiquitous in the environment. They do not occur naturally, nor are they intentionally produced, but are formed as trace amounts of impurities in the manufacture of other chemicals such as chlorinated phenols and their derivatives, chlorinated diphenyl ethers and polychlorinated biphenyls. They have also been detected in effluents and wastes from the pulp and paper industry and from magnesium production, as well as in fly ash and gas from municipal incinerators. There are 75 positional isomers of PCDDs and 135 isomers of PCDFs. The most well known and well described isomer of the PCDDs is TCDD (2,3,7,8-tetrachlorodibenzo-*p*-dioxin).

10.11.1 Toxic and carcinogenic effects

In laboratory animals, a number of adverse effects including hepatotoxicity, reproductive toxicity/teratogenicity, immunotoxicity and dermal toxicity have been attributed to PCDDs and PCDFs. Human data do not support the occurrence of these effects at the exposure levels observed. Occupational and accidental exposure to PCDDs and PCDFs, with clinical and follow-up studies, have provided no evidence of systemic effects other than chloracne [53]. Chloracne is a sign of exposure to several chlorinated cyclic organic compounds, the most potent being TCDD.

The only well documented intoxications with PCDFs in humans are two instances of contamination of rice oil with PCDFs and PCBs, i.e. at Yusho in Japan in 1968 and Yucheng in Taiwan in 1979. In total, several thousand people were acutely poisoned (see page 303).

Epidemiological findings suggest that long-term exposure to TCDD is associated with depressed cell-mediated immunity [58].

In laboratory animals cancers of the liver, thyroid and nasal and mouth cavities have been observed.

An increased incidence of cancer at different sites has been claimed in some epidemiological studies of subjects occupationally exposed to a mixture of PCDDs, PCDFs and other chemicals. Several factors limit the interpretation of these studies, however [58].

A number of cases of cancer have been reported in workers exposed to TCDD, but no adequate epidemiological studies were available when IARC performed its evaluation in 1987 [59]. TCDD has been placed in Group 2B of the IARC classification as a possible human carcinogen (evidence inadequate in humans, sufficient in animals) while PCDFs have not been classified by IARC [59]. Recent studies do indicate, however, that TCDD is a nongenotoxic human carcinogen at high doses, and appears to act as a potent and persistent hormone agonist [60,61].

Because PCDDs and PCDFs are normally encountered as complex mixtures, the concept of TCDD equivalents has been introduced to simplify risk assessment and regulatory control. The actual concentration of each constitutent is multiplied by a “toxic equivalency factor” (TEF) and summed to produce a “TCDD-equivalent” (TEQ) con-

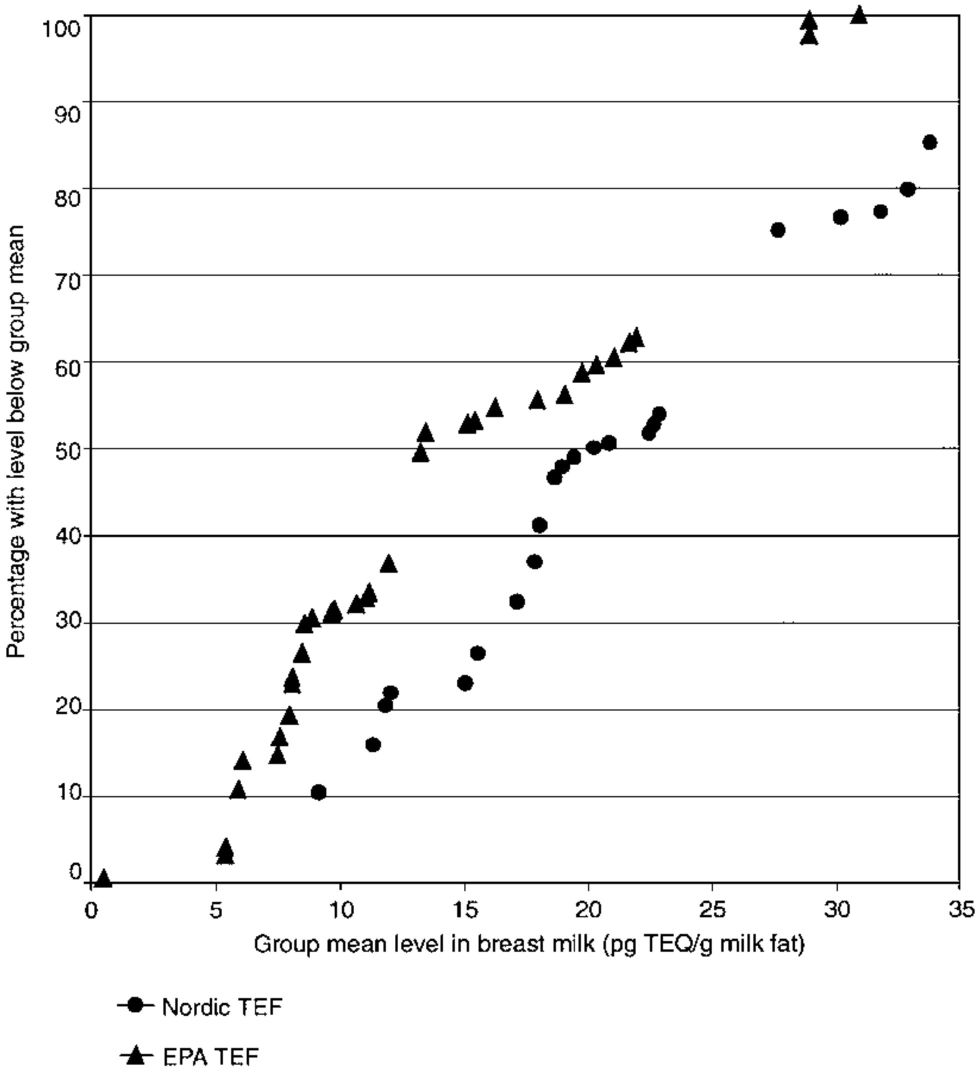


Fig. 10.5: PCDD/PCDF levels in the milk fat of non-occupationally exposed women (N = 1512)

centration. The approach assumes that synergistic and antagonistic effects do not exist. Although a number of different schemes of TEF values have been developed (based on available biochemical and toxicological data) the US Environmental Protection Agency (US-EPA), international TEF (i-TEF) and Nordic models are the most widely used, the latter two differing very little from each other. Data collected by the Regional Office [62] is presented in this report in terms of both the Nordic and the US-EPA TEQs. Data on daily intakes were available in terms of either i-TEQs or Nordic TEQs. Certain PCBs show TCDD-like activity and can also be assigned TEFs.

10.11.2 Exposure

Major sources of PCDD/PCDF emissions include incineration, the pulp and paper industry and pesticide production. This group of compounds is persistent in the environment and has a tendency to bioaccumulate.

Occupational exposure in, for example, the chemical and paper industries can be expected to make a considerable contribution to total intake. Those who spray herbicides may also be exposed to higher amounts of PCDDs/PCDFs. Accidental releases due to fires or explosions may result in high acute exposures.

The limited data available indicate very low levels of PCDDs and PCDFs in ambient air and in water. The intake of PCDDs and PCDFs from air and water is likely to be a minor portion of the total intake from all sources, but air plays a significant role as a transport medium [58]. The exposure levels in population groups living in the vicinity of incinerators or relevant industrial plants is a hotly debated issue, but scientific data on actual exposures are scarce. The application of new control technologies, however, results in a considerable reduction in emissions. Thus, the additional exposure from such sources can be regarded as negligible, provided that modern technologies are applied.

Exposure to PCDDs and PCDFs in the general population probably occurs mainly through food (90–95% of total intake). Data on contamination of commercial foods are very limited. PCDDs and PCDFs have been detected in fish, especially in fatty or bottom-feeding fish [58]. Average (global) dietary intake levels range from 20 to 150 pg i-TEQ/day.

Estimates of average daily dietary intakes of PCDDs/PCDFs from seven European countries over the period 1988–1992 were reviewed. Intakes ranged from 29 to 480 pg Nordic or i-TEQ per day, with the lowest value of 29 pg Nordic TEQ/day estimated in Sweden and the highest value of 480 pg i-TEQ/day in Italy.

10.11.3 Tissue levels

In human fat, levels of TCDD up to 20 ng/kg have been found in the general population with no known specific exposure. Average tissue levels of TCDD tend to increase with age [58].

Levels of PCDDs and PCDFs in blood and breast milk were measured in a number of European countries in a survey coordinated by the Regional Office. Levels in breast milk ranged from 15.5 to 40.2 pg Nordic TEQ/g fat [62]. Results of 14 studies conducted in 13 European countries between 1986 and 1988 on PCDD/PCDF levels in breast milk were reviewed. Mean levels observed ranged from 5.4 to 21.0 pg EPA TEQ/g fat, corresponding to levels of 9.1–40.2 pg Nordic TEQ/g fat. Fig. 10.5 depicts the proportional distribution of individuals with group mean TEQ values of PCDDs/PCDFs in breast milk below given concentrations, with respect to both the EPA and the Nordic TEFs. Average blood levels found in five studies from three countries of the European Region from 1980 to 1992 lay between 17 and 43 pg EPA TEQ/g fat.

10.11.4 Evaluation of observed exposure levels and possible health effects

Although the data reported are results of single studies and do not permit conclusions as to the exposure of the population in general, dietary intakes in European countries do not seem to exceed the WHO guideline value of 10 pg/kg body weight per day [63]. If the dioxin-like PCBs are also considered, however, dietary intakes would be higher in terms of TCDD toxic equivalents.

Infants are at special risk owing to the fact that both cows' milk and breast milk contain PCDDs/PCDFs, with levels in breast milk being 10–100 times higher than those in cows' milk. Thus, intake for breast-fed infants might be as high as 100 pg/kg body weight per day, and higher if dioxin-like PCBs are also considered. However, considering the advantages of breast-feeding and its short duration, the fear of exposing their children to dioxins should not prevent mothers from breast-feeding them.

Demonstration of a carcinogenic effect from environmental exposure to TCDD is not to be expected at the low daily intakes of the general population [64].

Owing to the uncertainties related to the actual doses received by humans, and the difficulties associated with assessing toxic effects, exposure to PCDDs/PCDFs should in general be reduced to the lowest practicable levels.

10.12 Conclusions

Exposure of the general population to potentially toxic chemicals is restricted to those chemicals that are produced commercially and those that are released to the environment by industrial processes, fuel combustion or agricultural practices. The risk to human health from exposure to these chemicals depends on both the toxicological characteristics of the substance and the exposure level. Thus, it is essential to increase knowledge about both aspects to arrive at rational policies on chemical control, bearing in mind the importance of chemicals for economic development in various sectors.

Risks to health from exposure to chemicals may emanate from those that are ubiquitous and persistent, and that have the capacity to cause adverse effects following long-term exposure to low levels, but also – on a more restricted geographical scale – from those that are released at higher concentrations by point sources (including industrial emissions and accidental releases) and that may, thus, also cause acute effects.

With existing chemicals, the main problem is often the lack of adequate toxicological data for risk assessment. In this respect, apart from national approaches, important activities at the international/intergovernmental level are being carried out. Collection of relevant data on and the scientific evaluation of existing chemicals are being performed by IPCS, while the IRPTC makes the information readily accessible on a worldwide basis. At the level of the EU, control of existing chemicals is ensured through the Council Regulation on Existing Chemicals. Within the chemicals programme of OECD, activities are being undertaken to ensure systematic investigation of existing chemicals.

For new chemicals, current legislation in most European countries and at the level of the EU are such that pre-marketing assessment of toxicity should prevent serious environmental hazards to health in the future.

Despite continuing efforts at both the scientific and the legislative level, problems with environmental chemicals are still encountered. One such problem is that of persistent chemicals such as PCBs and DDT which, despite being banned from use in Europe, are still present in the environment and in the human body. Furthermore, chemicals that are persistent and subject to long-range transport processes can be found in countries that have banned them, if they are released in other countries and distributed on a global scale.

In defining strategies for the future to deal with environmental chemicals and to protect the European population from potential adverse effects, there is a need to develop harmonized mechanisms for the assessment and control of existing and new chemicals for the WHO European Region as a whole. Activities coordinated by IPCS and OECD are already under way within the context of chapter 19 of Agenda 21, adopted at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Apart from this, assistance to the CCEE and NIS in establishing national strategies to control chemicals may be needed. These activities should be accompanied by adequate monitoring and by inspection and control mechanisms throughout the European Region.

For the chemicals discussed in this chapter, information on intake and on tissue levels were evaluated in the context of exposure via environmental media. In general, the information available proved to be restricted to individual studies, allowing no generally valid conclusions on the exposure to hazardous chemicals in the Region as a whole. Also, no comparison could be made between the exposure levels of the general population in different geographical locations in the Region, so as to identify areas of specially high exposures to certain chemicals. Some studies permitted the identification of population groups at specific risk and/or the determination of additional sources of intake of certain pollutants. In view of these limitations, the following conclusions may be drawn.

- Monitoring of general population exposure to chemicals, and the integration of exposure assessment into risk evaluation procedures, should form the basis for setting guidelines and establishing legislation aimed at reducing such exposure. Defining the contribution of different environmental media to total exposure is necessary for setting media-based guidelines, while identification of sources is essential for prevention, i.e. pollution control at source. Exposure monitoring will, in addition, permit assessment of the effectiveness of mitigation measures.
- In view of the problems encountered in comparing results from different studies on exposure assessment, there is a need to harmonize methodologies for sampling and analysis and the design of human studies aimed at assessing total exposure to selected chemicals, in order to cover representative population groups at different locations in the Region.
- Identification of areas of high exposure to certain hazardous chemicals, and of population groups at special risk, are priority issues in exposure assessment.
- In view of the large segment of the population potentially exposed to pesticide residues in drinking-water and food, monitoring and surveillance programmes need to be (further) developed. The systematic collection of such data is necessary for risk assessment as a basis for the development of public health policy.
- Evaluation of the risk to human health from pesticides is particularly concerned with the question of low-dose exposures and the causation of chronic diseases. In this respect epidemiological studies on well defined exposed populations such as occupational groups with higher and more readily ascertainable doses than the general population may be particularly useful.
- Models aimed at calculating total intake and/or target organ doses, based on environmental levels in all media, need to be further developed and validated. This will provide the potential to predict future trends for different scenarios, and to assess the results of various intervention measures.
- In situations where exposures have been demonstrated or are likely to give rise to intakes significantly in excess of recommended levels, but where no adequate data exist on possible health effects, appropriate studies should be undertaken. Where possible these should provide information on the correlation between exposure, tissue levels and effects.

It appears that for the general population exposure to these selected chemicals does not pose an appreciable risk. However, for certain subgroups of the population exposure levels may be higher, resulting in only a small or no margin of safety. For example, exposure to lead among children living near some industries, and/or exposed to vehicle emissions from the combustion of leaded petrol may be expected to affect neuropsychological development.

In view of the paucity of the data on exposure, more attention should be paid to human exposure assessment in order to make better estimates of possible risks to health.

Finally, it must be recognized that accurate assessment of total population exposure to environmental chemicals is an essential prerequisite for an “environmentally sound management of chemicals” as requested by Agenda 21 of the 1992 Rio Conference.

References

[1] World Health Organization. Arsenic. *In*: *Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1983 (WHO Food Additives Series No. 18) , pp. 176–202.

[2] *Air quality guidelines for Europe*. Copenhagen, WHO Regional Office for Europe, 1987 (WHO Regional Publications, European Series No. 23).

[3] *Arsenic*. Geneva, World Health Organization, 1981 (Environmental Health Criteria No. 18).

[4] World Health Organization. Arsenic. *In*: *Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1989 (WHO Food Additives Series No. 24), pp. 155–162.

[5] Arsenic and arsenic compounds. *In*: *Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 100–106.

[6] Tseng, W.P. Effects and dose–response relationships of skin cancer and Blackfoot disease with arsenic. *Environmental health perspectives*, **19**: 109–119 (1977).

[7] World Health Organization. Cadmium. *In*: *Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1989 (WHO Food Additives Series No. 24), pp. 163–219.

[8] *Cadmium*. Geneva, World Health Organization, 1992 (Environmental Health Criteria No. 134).

[9] *Guidelines for drinking-water quality*. Geneva, World Health Organization, 1984.

[10] Cadmium and cadmium compounds. *In*: *Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 139–142.

[11] Radisch, B. et al. Cadmium concentrations in milk and blood of smoking mothers. *Toxicology letters*, **36**: 147–152 (1987).

[12] Ducoffre, G. et al. Decrease in blood cadmium levels over time in Belgium. *Archives of environmental health,* **47**: 354–356 (1992).

[13] Budet, J.P. et al. Renal effects of cadmium body burden of the general population. *Lancet*, **336**: 699–702 (1990).

[14] *Lead*. Geneva, World Health Organization, 1977 (Environmental Health Criteria No. 3).

[15] World Health Organization. Lead. *In: Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1986 (WHO Food Additives Series No. 21), pp. 223–255.

[16] Beck, B.D. An update on exposure and effects of lead. *Fundamental and applied toxicology*, **18**: 1–16 (1992).

[17] Lead and lead compounds. *In: Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 230–232.

[18] Krause, C. et al. *Umwelt-Survey Band I. Studienbeschreibung und humanbiologisches Monitoring.* Berlin, Institut für Wasser-, Boden- und Lufthygiene des Bundesgesundheitsamtes, 1989 (WaBoLu-Hefte 5/1989).

[19] Lead and lead compounds. *In: Some metals and metallic compounds.* Lyon, International Agency for Research on Cancer, 1980 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 23), pp. 325–415.

[20] Verberk, M.M. et al. Biomonitoring of lead in a metal-polluted Romanian town. *Lancet*, **340**: 1221 (1992).

[21] *Evaluation of certain food additives and contaminants*. Geneva, World Health Organization, 1993 (WHO Technical Report Series No. 837).

[22] Bhamra, R.K. & Costa, M. Trace elements aluminum, arsenic, cadmium, mercury and nickel. *In:* Lipmann, M., ed. *Environmental toxicants: human health exposures and their health effects.* New York, Van Nostrand Reinhold, 1992, pp. 577–632.

[23] *Inorganic mercury.* Geneva, World Health Organization, 1991 (Environmental Health Criteria No. 118).

[24] *Methylmercury.* Geneva, World Health Organization, 1990 (Environmental Health Criteria No. 101).

[25] Brune, D. et al. Normal concentrations of mercury in human blood. *Science of the total environment,* **100**: 235–282 (1991).

[26] *Mediterranean health-related environmental quality criteria*. Report on a joint WHO/FAO/UNEP meeting. Copenhagen, WHO Regional Office for Europe, 1989 (document EUR/ICP/CEH 059).

[27] *Evaluation of certain food additives and contaminants: mercury, lead and cadmium.* Geneva, World Health Organization, 1972 (WHO Technical Report Series No. 505).

[28] World Health Organization. Methylmercury. *In: Toxicological evaluation of certain food additives and contaminants.* Cambridge, Cambridge University Press, 1989 (WHO Food Additives Series No. 24), pp. 295–328.

[29] Tordoir, W.F. et al. Health surveillance of pesticide workers. A manual for occupational health professionals. *Toxicology,* **90**: 1–115 (1994).

[30] *Public health impact of pesticides used in agriculture*. Geneva, World Health Organization, 1990.

[31] MARONI, M. & FAIT, A. Health effects in man from long-term exposure to pesticides. A review of the 1975–1991 literature. *Toxicology*, **78**: 1–180 (1993).

[32] *Occupational exposures in insecticide application and some pesticides.* Lyon, International Agency for Research on Cancer, 1991 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 53).

[33] MARONI, M. Strategies for preventing health effects in use and handling of pesticides at work. *In: Current topics in occupational health*. Copenhagen, National Directorate of Labour Inspection, 1994.

[34] *Sustainable use of groundwater. Problems and threats in the European Communities*. The Hague, National Institute of Public Health and Environmental Protection (RIVM), 1991 (Report No. 600025001).

[35] SPEAR, R. Recognized and possible exposure to pesticides. *In:* Hayes, W.J. & Laws, E.R., ed. *Handbook of pesticide toxicology,* Vol. 1. Orlando, Academic Press, 1991.

[36] CAMONI, I. ET AL. Evaluation of dietary intake of pesticide residues from Italian survey data for 1986–1987 period. *Rivista della Società Italiana di Scienza delle Alimentazione*, **20**(3): 1–77 (1991).

[37] *Report of the Working Party on Pesticide Residues* [1977–1981]. London, Ministry of Agriculture, Fisheries and Food, 1981 (Food Surveillance Paper No. 9).

[38] *Annual report of the Working Party on Pesticide Residues: 1991.* London, H.M. Stationery Office, 1992 (Supplement to the Pesticides Register 1992).

[39] JELINEK, C.F. *Assessment of dietary intake of chemical contaminants.* Nairobi, United Nations Environment Programme, 1992.

[40] MUIR, D.C.G. ET AL. Organochlorine contaminants in Arctic marine food chain: accumulation of specific polychlorinated biphenyls and chlordane-related compounds. *Environmental science and technology*, **22**: 1071 (1988).

[41] *Nitrates, nitrites and N-nitroso compounds.* Geneva, World Health Organization, 1978 (Environmental Health Criteria No. 5).

[42] KLEINJANS, J.C.S. ET AL. Nitrate contamination of drinking-water. Evaluation of genotoxic risk in human populations. *Environmental health perspectives,* **94**: 189–193 (1991).

[43] WORLD HEALTH ORGANIZATION. Nitrate, potassium and sodium salts. *In: Toxicological evaluation of certain food additives and contaminants*. Cambridge, Cambridge University Press, 1974 (WHO Food Additives Series No. 5), pp. 92–95.

[44] Benzene. *In: Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 120–122.

[45] WORLD HEALTH ORGANIZATION. Benzo[*a*]pyrene. *In: Toxicological evaluation of certain food additives and contaminants.* Cambridge, Cambridge University Press, 1991 (WHO Food Additives Series No. 28), pp. 301–363.

[46] *Polynuclear aromatic compounds, Part 1. Chemical, environmental and experimental data.* Lyon, International Agency for Research on Cancer, 1983 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 32), pp. 33–91.

[47] Polynuclear aromatic compounds. *In: Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42.* Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), p. 58.

[48] DELL'OMO, M. & LAUWERYS, R.R. Adducts to macromolecules in the biological monitoring of workers exposed to polycyclic aromatic hydrocarbons. *Critical reviews in toxicology,* **23**: 111–126 (1993).

[49] PERERA, F.P. ET AL. Molecular and genetic damage in humans from environmental pollution in Poland. *Nature*, **360**: 256–258 (1992).

[50] Polychlorinated biphenyls. *In: Polychlorinated biphenyls and polybrominated biphenyls.* Lyon, International Agency for Research on Cancer, 1978 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 18), pp. 43–103.

[51] Polychlorinated biphenyls (PCBs). *In: Evaluation of certain food additives and contaminants.* Geneva, World Health Organization, 1990 (WHO Technical Report Series No. 789), pp. 30–33.

[52] *Polychlorinated biphenyls and terphenyls*, 2nd ed. Geneva, World Health Organization, 1993 (Environmental Health Criteria No. 140).

[53] HSU, S.T. ET AL. Discovery and epidemiology of PCB poisoning in Taiwan: a four-year follow-up. *Environmental health perspectives*, **59**: 5–10 (1985).

[54] BOWMAN, R.E. ET AL. Correlation of PCB body burden with behavioural toxicology in monkeys. *Pharmacology, biochemistry and behavior*, **9**: 49–56 (1978).

[55] JACOBSON, J.L. ET AL. Effects of *in utero* exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. *Journal of pediatrics*, **116**: 38–45 (1990).

[56] NORDIC COUNCIL OF MINISTERS. *Risk assess-*

ment of polychlorinated biphenyls (PCBs). Århus, Aka-Print, 1992.

[57] Polychlorinated biphenyls. *In: Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 322–326.

[58] *Polychlorinated dibenzo-para-dioxins and dibenzofurans.* Geneva, World Health Organization, 1989 (Environmental Health Criteria No. 88).

[59] 2,3,7,8-Tetrachlorodibenzo-*para*-dioxin (TCDD). *In: Overall evaluations of carcinogenicity: an updating of IARC Monographs Volumes 1–42*. Lyon, International Agency for Research on Cancer, 1987 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Suppl. 7), pp. 350–354.

[60] Fingerhut, M.A. Cancer mortality in workers exposed to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. *New England journal of medicine,* **324**: 212–218 (1991).

[61] Lucier, G.W. et al. Receptor mechanisms and dose–response models for the effects of dioxins. *Environmental health perspectives,* **101**: 36–44 (1993).

[62] Yrjönheikki, E.J., ed. *Levels of PCBs, PCDDs and PCDFs in breast milk*. Copenhagen, FADL, 1989 (Environmental Health Series No. 34).

[63] Ahlborg, U.G. et al, ed. Tolerable daily intake of PCDDs and PCDFs. *Toxic substances journal,* **12**: 101–332 (1992).

[64] Falk, H. Non-occupational exposure: U.S.A. *In: Current views on the impact of dioxins and furans on human health and the environment. Proceedings of the Toxicology Forum Meeting, Berlin, 1992*. Washington, DC, Toxicology Forum, 1993, pp. 228–232.

Chapter 11
Nonionizing Radiation

11.1 Introduction

Because types of nonionizing radiation are disparate, this chapter has been divided into two parts, dealing (*a*) with light, and ultraviolet (UV) radiation in particular, and (*b*) with electric and magnetic fields. The two categories have very different types of possible environmental exposure, mechanisms of interaction with human tissue and effects on health. UV radiation and low-frequency electric and magnetic fields, particularly under power transmission lines, are judged to be of concern to health.

Other types of nonionizing radiation, including high-frequency fields, ultrasound and laser light, can also affect health [1]. Medical applications have clear diagnostic or therapeutic benefits for the people exposed, and exposure may be important in an occupational context but of little significance in the environment. As a result, they are not discussed in detail in this chapter.

The evidence that exposure to UV radiation can be damaging is all but irrefutable. Much of the exposure and potential damage, however, has less to do with the environment than with lifestyle: tanning the skin in sunlight or with artificial sources.

Electric and magnetic fields pose a more complex problem. In the case of ionizing radiation, knowledge of the variations in natural background radiation, exposure to which is unavoidable, can be used to provide a perspective on the possible significance of additional (man-made) sources of environmental exposure, where these are comparable in quality. Further, there is some understanding of the mechanisms through which ionizing radiation affects health. Natural, time-varying electric and magnetic fields exist and, in general, have much lower electric field strengths and magnetic flux densities than those arising from man-made sources. These fields interact with the body to induce currents in the tissues. However, naturally flowing currents in the body generated, for example, by electrical events in the brain and heart are generally greater than those induced by most man-made sources. Some epidemiological evidence, however, suggests that health effects may be associated with certain man-made sources of exposure. Experimental data have indicated effects at the cellular level, but there is no clear evidence that these are important to health and no understanding of possible biological mechanisms to account for the epidemiological observations.

11.2 Ultraviolet Radiation

All human beings are exposed to solar radiation, which is essentially electromagnetic radiation of wavelengths longer than 200 nm, extending from the UV into the infrared region. Although the sun also emits both ionizing and radiofrequency radiation, these are much less significant for human health.

Largely for practical rather than scientific reasons it is considered convenient to subdivide UV radiation into three wavebands, namely UVA (315–400 nm), UVB (280–315 nm) and UVC (<280 nm). The range of visible light is 400–780 nm. UV radiation is energetic enough to rupture chemical bonds or energize molecules into excited states, and so can initiate a variety of chemical and biological processes. Some of these can ultimately prove harmful in biological systems.

The solar radiation that reaches the surface of the earth is modified; some of its components are absorbed by atmospheric constituents that have varied over geological time. All life forms ultimately depend on solar radiation and have adapted themselves to exist in balance with conditions on the planet. Some of the past changes in solar emissions and the atmosphere, such as the great ice ages, led to enormous effects on life on earth.

Human activities are changing the composition of the atmosphere. These man-made effects include the depletion of the ozone layer in the stratosphere as a result of the action of chlorofluorocarbons (CFCs) and similar compounds. Since this layer normally filters out the more harmful components of UV radiation, its depletion is potentially significant for human health. The possible effects of an increase in UV radiation, as a result of ozone depletion, should also be considered in the context of greenhouse gases and global warming (see Chapter 5), although the extent of the changes in climate that could result from a combination of these two effects is not clear.

The exposure of the skin to sunlight, with absorption of UV radiation, is essential for vitamin D production, but a relatively recent change in human behaviour – the intentional exposure of the skin to intense sunlight – has profound adverse effects on health. In particular, the incidence of skin cancer has risen markedly.

New technology has introduced sources of UV radiation and visible light that can harm people's health. According to a recent survey, up to 10% of the population in western countries habitually use sunlamps or sunbeds. A significant proportion of the working population is exposed to light from fluorescent and high-intensity tungsten–halogen lamps over long periods. In addition, industry has more uses for UV radiation than commonly assumed, including photopolymerization, disinfection and sterilization, welding, and work with lasers.

11.2.1 Solar radiation

About 5% of solar terrestrial radiation is in the UV region, and is the main source of human exposure to UV radiation. At sea level, about 95% of this radiation is UVA and 5% UVB; oxygen and ozone in the atmosphere largely cut off the low level of UVC in extraterrestrial radiation. The amount of solar UVB energy reaching the earth's surface depends on the angle of the sun (time of day, season and latitude), the weather (cloud, mist, fog, etc.) and altitude; that falling on the human skin depends on the extent of reflection from such different surfaces as grass (low), sand, water and snow (high). A less evident influence is the effect of stratospheric ozone, which absorbs UVB. This layer of ozone is formed in the higher levels of the stratosphere by the action of short-wavelength UV radiation (<242 nm) on oxygen molecules. The absorption of UV radiation up to about 320 nm (that is, including UVB) converts the ozone back to oxygen. This process both prevents radiation with wavelengths of less than 290 nm reaching the earth's surface and absorbs most of the UVB. The terrestrial radiation levels arising from these processes have developed over evolutionary time, and human and other forms of life have adapted to them.

Over the last 20 years it has been established that CFCs and other man-made pollutants containing chlorine or bromine can lead to depletion of the stratospheric ozone layer [2,3] with an expected increase in terrestrial levels of UV radiation, particularly UVB. CFCs are extremely stable and their inertness makes them convenient for use as refrigerants and aerosol propellants, for example. When released, they eventually reach the stratosphere by slow diffusion where, after photodissociation, they generate chlorine and chlorine oxides; these are capable of removing ozone through a sequence of reactions. Other compounds containing chlorine (and bromine) such as carbon tetrachloride and methylchloroform (cleaning solvents) also have this effect, as do hydrochlorofluorocarbons (HCFCs) which are used as substitutes for CFCs. HCFCs are certainly less persistent than CFCs and have considerably less potential to deplete ozone [4]. Volcanic activity can also introduce chlorine into the atmosphere; this is particularly true of large eruptions such as that of Mt Pinatubo in the Philippines. Studies on the hole in the ozone layer that develops over Antarctica during the winter have shown that other reactions occurring on the surface of aerosol particles, at the extremely low temperatures that prevail, remove ozone in the stratosphere. The oxidation of a variety of sulfur-containing compounds coming from the earth forms a sulfate aerosol layer. In addition to pollution arising from combustion, other sources of sulfate aerosols are volcanic eruptions and biological processes [5].

Measurements of ozone levels and UV radiation

Levels of ozone in the atmosphere can be measured by meters, either on satellites or on the ground. Although there is no evidence to date of a hole above the Arctic, satellite measurements have demonstrated that stratospheric ozone is also being depleted in the northern hemisphere, albeit at a slower rate: between 30°N and 50°N the average decrease in the winter is 6–7% per decade [6]. The fact that depletion has resulted in a hole above the Antarctic is thought to be due to the unique distribution of land and sea and the lower atmospheric temperatures, in which aerosol formation further enhances ozone depletion.

Table 11.1 gives an example of results from ground-based meters in the United Kingdom. The data were cited in a written answer to a question asked in Parliament, and provide evidence of a decrease in the average level of stratospheric ozone of about 11% in the past 10 years [7].

Measurements of solar UV radiation have been made over some years throughout the world [8]. The equipment most commonly used provides continuous, broad-based information from which trends in UV radiation, but not changes in the UVB component, can be detected. Tracing changes in UVB requires considerably more expensive equipment that can provide information on irradiance at different wavelengths. Its use is relatively limited at present and continuous monitoring data cannot yet be obtained. In addition, problems are associated with the design and calibration of the instruments.

Despite predictions of a 2% increase in UVB for every 1% decrease in stratospheric ozone, monitoring has established few such correlations [8,9]. The reason may be the considerable natural variations in cloud cover or pollution. If variation in pollution is associated with an increase in the absorption of UVB by ozone in the troposphere it may be an important factor, particularly when UV radiation has a longer path through the troposphere than through the stratosphere.

Table 11.1: Total stratospheric ozone at Camborne and Lerwick, United Kingdom, 5–7 March, 1980–1993

Year	Total ozone (Dobson units)[a]					
	Camborne			Lerwick		
	5 March	6 March	7 March	5 March	6 March	7 March
1993	262	240	261	297	250	291
1992	351	327	345	341	320	323
1991	384			429		
1990	358	308			314	
1989		333	382	384	354	499
1988	411	420	352	375	436	340
1987				354		389
1986	301	373	383		389	400
1985	392	351	320			345
1984		287	301		293	328
1983	359			279		
1982	392	362	416	393		427
1981	361	399		441		444
1980	378			436		

[a] Dobson unit: total amount of ozone in a vertical column expressed as the thickness (in μm) of an ozone layer converted to normal temperature and pressure.

Note: Blanks indicate days when weather conditions prohibited measurements. Recent data are subject to final corrections. The average ozone measurements for March 1993 are 335 Dobson units at Camborne and 347 Dobson units at Lerwick. These values are, respectively, 12.6% and 10.4% below the average for the last 10 years.

Source: Hansard (7).

Interactions between UV radiation and nitrogen oxides (pollutants largely derived from petrol combustion) increase the level of tropospheric ozone. In heavily polluted areas, the absorption of UV radiation by ozone in the troposphere may partially counteract the effect of the depletion of ozone in the stratosphere [10].

Recent results from Toronto, however, show that levels of UVB in winter increased by more than 5% every year from 1989 to 1993 [11]. Allowance was made for factors (such as clouds, aerosols, pollutants and ground reflectance) affecting the intensity of UVB radiation at sea level. This study provides the most reliable analyses to date of the situation in the northern hemisphere. There may, of course, be regional effects due to atmospheric movements and temperature variations and these findings are the subject of debate [12,13]. Further research is needed.

11.2.2 Artificial sources of UV radiation

Various forms of artificial lighting and the use of sunlamps and sunbeds for cosmetic reasons increase human exposure to UV radiation. In addition, industry makes increasing use of visible and UV light [14].

Sunlamps and sunbeds

Before the mid-1970s, unfiltered medium- and high-pressure mercury lamps were used as sunlamps. They generate high levels of UVC and UVB and, for safety, irradiation times needed to be short. Nevertheless, skin damage readily occurred. In the late 1970s and early 1980s fluorescent lamps, which generate UVA and visible light almost exclusively, have been used for such cosmetic purposes. The spectral outputs of these lamps vary with the filters used, spatial arrangements and other factors.

Limited studies have not provided any clear evidence correlating the use of sunlamps and sunbeds with the incidence of skin cancer. The widespread and uncontrolled use of artificial tanning procedures, however, causes some concern [15]. Improperly used, these could give rise to large doses of UVA and/or UVB; such exposure is not without risk, particularly for people who do not readily tan.

It should be noted that defining a "safe" level of exposure is impossible; the risk increases with use, particularly when solarium sessions are combined with sunbathing.

Other sources

Fluorescent lights are widely used in working environments and consist of low-pressure mercury vapour lamps that generate a strong emission at 254 nm. This excites a phosphor coating on the inside of the glass envelope. Depending on the nature of the phosphor, radiation in the UV region may be generated.

Low-pressure mercury vapour lamps may also be used for the disinfection and sterilization of drinking-water, water for swimming pools and sewage. The studies made to define risk from exposure give inconsistent results and draw attention to the difficulties in monitoring the doses of UV radiation that could have been received. No convincing evidence of adverse effects has been produced, but more investigations are needed before a firm conclusion can be drawn [16,17].

Tungsten–halogen lamps generate appreciable amounts of UV radiation. Glass jackets should ensure the removal of the UVC and much of the UVB generated, but some radiation may still be received. High-intensity lamps (several kW) may be used to induce polymerization in the production of, for example, protective coatings or printed circuit boards. In addition, large xenon arc lamps, which produce UV radiation, are used in weathering studies and the intense illumination of wide areas.

Electrical welding gives rise to UV radiation, and at least two studies from North America show significant positive associations between welding and melanoma of the eye and cataracts [18]. Protective measures can be taken, however.

Finally, lasers and other high-power sources of visible radiation are used in the chemical and electronic industries and in clinical medicine. Only technically qualified staff, who know the potential risks and appropriate safety procedures, should operate them. The high intensities used involve not only the risk of immediate injury (burns) but also risks from stray and scattered light from these sources.

In addition, some effects are peculiar to lasers [19], such as the stimulation of growth observed in cell cultures at low intensities [20]. The mechanisms for this effect are not understood. The coherence of the radiation allows more absorption by molecules such as DNA than is possible with solar and other sources of UV or visible radiation. Laser radiation has been suggested to induce transmembrane effects in mitochondria; the release of calcium ions [21] and interaction with oxygen may be involved. Reliable experimental data are needed to settle these issues.

11.2.3 Biological effects

A comparison of the action spectra for killing of bacterial cells with the absorption spectra shows that the bactericidal effect involves nucleic acids. DNA synthesis shows the most sensitive response to UV radiation. The UVC and UVB regions are both absorbed by DNA, but wavelengths longer than 320 nm are not.

Damage to DNA in skin cells *in vivo* follows exposure to UV radiation in doses comparable to those in people exposed to sunlight. The extent of the damage depends on a combination of the biological efficiency of the different wavelengths and the extent of absorption by the outer layers of the skin. Most of the damage is repaired within 24 hours.

Chromosomal aberration, gene mutation,

sister chromatid exchange and cell transformation are biological effects that have been studied under various exposure conditions with cultures of human cells. A publication of the International Agency for Research on Cancer (IARC) fully discusses the implications of these observations for carcinogenicity in human beings [17]. Studies using human skin fibroblasts exposed to simulated sunlight give results consistent with the supposition that lesions induced by sunlight represent a mixture of DNA damage, cellular responses and repair mechanisms. Mutations resulting from errors in repair may predispose to cancer.

Further, the absorption of UV radiation and visible light may initiate reactions involving lipids and proteins. Lipid membranes are structures particularly susceptible to attack by oxidizing species, giving rise to various adverse biological effects.

Extensive studies of relative biological effectiveness on a range of materials – such as purified DNA, bacteria, plant and human cells in tissue culture, and the human skin and eye *in vivo* – show that light with a wavelength of 290 nm (UVB) is 1000–10 000 times as effective in damaging DNA, killing cells, producing skin erythema (sunburn) and inducing skin cancer in mice than that with wavelengths longer than 300 nm (UVA). The action spectra for erythema in human beings and skin carcinogenesis in animals [22,23] both show a very marked decrease in biological effectiveness with increasing wavelength (from 290 to 330 nm).

11.2.4 Effects on health

Skin cancer

According to IARC there is sufficient evidence for solar radiation as the cause of malignant melanoma and other types of skin cancer in human beings [17]. The separate UVA, UVB and UVC regions are carcinogenic in laboratory animals, and probably in humans. UV radiation from the sun evidently induces the three common forms of skin cancer: basal-cell carcinoma, squamous-cell carcinoma and cutaneous malignant melanoma. The risk of a person developing any of these is considered, on the basis of a large number of reports, to be related to the cumulative dose received. In malignant melanoma, short intermittent exposure to intense sunlight, as on a Mediterranean holiday, and exposure to sunlight in early childhood are also important factors.

Basal-cell carcinoma and squamous-cell carcinoma are the most common forms of skin cancer, and exceed the total of all other neoplasms in many sunny countries, particularly among outdoor workers [24]. The incidence of the former is always greater than that of the latter, varying with increasing latitude from 10:1 to 2.5:1.

The incidence of these types of skin cancer is at present increasing by 2–3 % per year. The incidence of skin cancer is higher in fair-skinned northern Europeans who have migrated to an area of intense sunlight but not in more darkly pigmented immigrants. Specifically, a Celtic ancestry notably increases the risk of skin cancer. Many studies on immigrants to Australia have clearly established these effects [25].

Squamous-cell carcinoma and basal-cell carcinoma are similar in characteristics such as the high incidence on the face or exposed surface of the head or neck, and the increase in incidence with age and with decreasing latitude. In the European context, an analysis of sunlight-induced non-melanoma skin cancer in Norway, using data on the incidence of basal-cell carcinoma and squamous-cell carcinoma in six regions of Norway over the years 1976–1985, is of interest [26]. It was estimated that depletion of atmospheric ozone by 1 % may cause increases in the incidence of basal-cell carcinoma by 1.6–2.1 % and of squamous-cell carcinoma by 1.3–1.7 %. Estimates for men and women were the same. Sunlight is the main cause of these forms of skin cancer even at the northernmost latitudes in Norway.

Other factors than changes in the ozone layer, however, are more significant at present. Diffey [27] has pointed out that an annual two-week holiday in a sunny climate can increase the risk of basal-cell and squamous-cell carcinoma fivefold in northern European indoor workers by the age of 70 years, because of a doubling of the annual biologically effective UVB dose. An equivalent change in exposure in northern Europe would require a decrease in the ozone layer of about 50 %.

The incidence of cutaneous malignant melanoma has risen markedly in the last few decades [28]; for example, it rose by 50 % in England between 1980 and 1986. Although this form of skin cancer is rarer than the others, it has a high fatality rate of 30–50 %. Epidemiological data obtained in Australia and the United States have established the connection with UV sunlight, and similar trends have been reported for Scandinavia and Israel [29,30]. The Scottish Melanoma Group [31] made a comprehensive study of the incidence of cutaneous malignant melanoma in Scotland in 1979–1989. Table 11.2 shows the incidence data, and Table 11.3 the

Table 11.2: Incidence of malignant melanoma in Scotland, 1979–1989

Year	Males			Females		
	No.	Age-standardized rate[a]	World standardized rate[b]	No.	Age-standardized rate[a]	World standardized rate[b]
1979	81	3.4	2.8	176	6.6	4.7
1980	83	3.4	2.8	183	6.9	4.8
1981	86	3.5	2.8	165	6.2	4.3
1982	90	3.6	2.9	191	7.1	5.1
1983	106	4.2	3.3	212	7.9	5.9
1984	115	4.6	3.7	224	8.3	6.1
1985	150	5.9	4.8	266	9.8	7.7
1986	137	5.4	4.4	297	10.9	7.8
1987	131	5.4	4.4	256	9.3	6.9
1988	183	7.1	5.7	294	10.8	8.3
1989	189	7.1	5.9	285	10.4	7.9

[a] Per 100 000 in Scotland in 1981.
[b] Per 100 000.

Source: Mackie, R. et al. *(31)*.

Table 11.3: Site-specific incidence of malignant melanoma in Scotland, 1979–1989

Site	Males		Females	
	Percentage	No.	Percentage	No.
Face	16.5	221	17.1	433
Other head/neck	9.0	121	2.6	65
Trunk	37.4	502	13.4	339
Arm	8.4	113	12.8	324
Leg	14.9	200	41.8	1057
Foot	5.6	75	5.4	136
Hand	1.0	14	1.4	36
Mucosa	2.5	33	2.8	72
Nail bed	3.7	50	2.5	64
Other	0.9	12	0.2	5

Source: Mackie, R. et al. *(31)*.

site-specific differences between the sexes. The rates of increase are greatest on the parts of the body where melanoma is most common: the trunk in men and the legs in women.

The rates of melanoma development per unit area of skin are higher on skin that is not regularly exposed to the sun [32]. Major studies made in the northern hemisphere seem to show that irradiation in early life is especially important; the unnecessary exposure of children to the sun should therefore be avoided. Short bursts of intermittent exposure also increase incidence [33]. In contrast, regular outdoor exposure decreases the risk, probably as a result of the development of pigmentation, although Australian studies do not show such a clear distinction. The relationship between the risk of melanoma and sun exposure is complex [17].

The influences on the risk of developing cutaneous malignant melanoma include individual characteristics, as well as the intensity and duration of sun exposure and clothing and tanning practices in different countries. This makes estimating the consequences of ozone layer depletion far more difficult than in the case of other types of skin cancer. Since intermittent exposure and exposure causing severe erythema both increase the risk, the effects of small changes (about 10%) in the ozone layer may well not be important [34].

Effects on the immune system

In animals, exposure to UVB causes changes in the immune system (mainly by suppressing normal immune responses [35]) that are important in the development of cancer and the course of infectious disease. No detailed or adequate investigations have been made in humans, and the available evidence is drawn from experiments with light containing UVC and UVA as well as UVB. The exposure of human skin to UV radiation impairs the function of antigen-presenting cells normally resident in the epidermis. These cells are capable of activating T-lymphocytes, which may be involved in preventing the development of contact dermatitis and in the immune surveillance of certain types of skin cancer. UV irradiation of human T-cells before viral transmission significantly shortens the viral growth cycles, implying that UV-induced cellular stress is conducive to viral replication and growth. In particular, sunlight activates HIV gene expression [36]. A recent study has shown that T-cells are particularly sensitive to UV radiation [37]. If stratospheric ozone depletion results in significant increases in terrestrial levels of UVB, these could have an important effect on the human immune response to certain allergens or infectious agents, as well as on the development of some types of cancer.

Biological effects on the eye

Ultraviolet radiation is probably a major cause of cataracts, which are more common in tropical or sunny climates than in temperate regions. The mechanism of the damage involves the initial absorption of UVB by the protein of the ocular lens. In 1988, it was reported that more than 17 million people worldwide had cataracts, a figure that could rise with exposure to elevated UVB levels. A 1% decrease in the ozone layer has been estimated to result in a 1–2% increase in the incidence of cortical cataracts. To diminish the risk of cataract, it is prudent to reduce unnecessary exposure and wear a wide-brimmed hat or properly designed sunglasses when outdoors. Taylor [38] has assessed possible protective measures.

The association between UVB exposure and photokeratitis (snow blindness) is well established. Less is known about the association between UVB exposure and retinal damage.

Photosensitization

As mentioned, some biological substances absorb UV radiation and visible light and generate chemically active forms, which then react with and damage, for example, DNA and cell membranes [39]. Oxygen is frequently involved in these reactions. No specific mechanism is involved in photosensitization. Natural chromophores that are present in biological systems and strongly absorb UVA and visible light include flavins, steroids and porphyrins. Some photosensitizing agents present in the diet or administered as drugs, such as phenothiazine and chlorpromazine, can accumulate in the skin and have adverse biological effects after activation by solar radiation.

Increased UVB exposure will enhance such effects whatever the nature and origin of the photosensitizer. Apart from solar radiation, sunbed use could exacerbate these effects.

11.2.5 Effects on the ecosystem

Aquatic ecosystems

Modelling studies indicate that UV radiation can penetrate water to a sufficient depth (up to 50 m) for ecological effects to occur. UVB damages phytoplankton in the laboratory and probably in the marine environment. UVB not only affects DNA but also impairs cell metabolism and motility. Increased UVB intensity causes irreversible damage and/or death to zooplankton: this is an important effect, as plankton is the essential food for krill, which in turn is essential to the nutrition of all higher forms of marine life. Marine organisms in the upper layers of the sea, including the eggs and larvae of fish, are sensitive to UV radiation and would be affected by any increase in radiation resulting from the depletion of stratospheric ozone [40].

Studies in progress on the effects of ozone depletion on the southern ocean marine ecosystem are providing further information. A small but statistically significant reduction (5%) in photosynthesis in phytoplankton has been claimed [41] but more evidence is required to confirm this effect.

Any increase in UVB would harm marine food production. In addition, marine phytoplankton produces at least as much biomass as all the terrestrial ecosystems combined, and is important in the uptake of the greenhouse gas carbon dioxide.

Terrestrial plants

The influence of UVB on plants varies between both species and cultivars of a species [42]. Plant responses include photorepair, accumulation of UV-absorbing pigments and growth delay. Many important crops, including soybean and cereals such as barley, rye, oats and maize, are particularly sensitive to UV radiation. The mechanism for these effects is not well understood but they are due, at least in part, to the impairment of photosynthesis. The proteins and RNA involved in the conversion of carbon dioxide to oxygen are affected. If terrestrial levels of UV radiation increased, differences in susceptibility could lead to an increase in the growth of weeds to the detriment of more valuable forms of plant life.

Animals

In general, skin pigmentation and fur protect animals from solar radiation but some, such as cattle and sheep, are susceptible to ocular cancers to an extent that appears to be directly related to the level of exposure to UV radiation [43]. Any significant increase in UVB could significantly affect animals used for food; the effects would be relatively greater at higher latitudes.

Materials

Photochemical degradation, especially by UV radiation, adversely affects wood, plastics, paints and textiles. Any increase in UVB could have significant economic consequences because of the need for more frequent repair and renovation.

11.2.6 Conclusions

Clear experimental data from animals and convincing epidemiological evidence from human beings support a direct causal relationship between exposure to UV radiation and basal-cell and squamous-cell skin cancer. The data linking exposure to sunlight and melanoma are also compelling, but the relationship is more complex. The very rapid recent increase in the number of cases of skin cancer is clearly connected to social behaviour, including recreational pursuits, and may also be associated with migration from cooler to sunnier countries. Topical sunscreens and sunblocks attenuate solar radiation incident on the skin by absorption and reflection or scattering. Sunblocks, such as the pigments zinc oxide and titanium dioxide, reflect or scatter UV radiation. Chemical sunscreens contain one or more colourless UV-absorbing compounds, which in general absorb UVB more strongly than UVA [17]. Such agents are effective in preventing erythema, but an undesirable result of their use is that it may encourage longer exposure to wavelengths of UV radiation not absorbed by the sunscreen [44]. The effectiveness of many commercial sunscreens on preventing skin cancer has therefore been questioned.

Public awareness of the hazards of UV exposure, particularly for people of certain skin types and for young children, should be increased through national campaigns. Health education on UV radiation has already successfully modified behaviour in some countries, but further efforts are needed. In Australia, where the increase in skin cancer has been most severe, the publicity has been intense. The government issues forceful propaganda for the use of sunscreens and the wearing of shirts and hats on beaches, provides on-site inspection of moles by dermatologists, and subsidizes high-factor sunscreens.

Similar measures need to be considered for implementation in the European Region. A campaign has been organized in Scotland to increase public awareness and encourage earlier referral and treatment of malignant melanoma [45]. It has been successful for women but less so for men. The achievements, however, show the value of such methods.

To date there is little evidence in Europe that depletion of the stratospheric ozone layer has resulted in changes in terrestrial levels of UV radiation that exceed the considerable normal variations occurring in UVB. The recent claims from Canada [11] of an increase in UVB, associated with a decrease in ozone levels in the northern hemisphere, makes imperative the setting up of a worldwide monitoring system capable of scanning the entire UV spectrum.

The most important factor in the current increases in skin cancer is undoubtedly lifestyle: the cult of the suntan and the pursuit of holidays in the sun. Health education about these risks needs to include information on the possible hazards of the excessive or uncontrolled use of sunlamps or sunbeds.

The consequences of any increase in terrestrial UV radiation from ozone depletion are potentially serious, with possible direct and indirect effects on human health. The need to prevent further depletion of stratospheric ozone is clear. International action to limit it is discussed in Chapter 5.

11.3 Electric and Magnetic Fields

Because an electric field at or close to the surface of an object in the field is generally strongly perturbed, the value of the unperturbed electric field (that is, the field that would exist if all objects were removed) is used to characterize exposure conditions. Whereas electric fields are associated with the mere presence of electric charge, magnetic fields result solely from the physical movement of electric charge (electric current) [46,47].

Natural electric and magnetic fields consist of a static component from the earth and several other small components that have different characteristics and are related to such influences as solar activity and atmospheric events. The time-varying fields originating from man-made sources generally have much higher intensities than naturally occurring fields. This is particularly true for sources operating at a power frequency of 50 Hz, such as home appliances. The principal man-made sources of electric and magnetic fields are high-voltage transmission lines, and all devices and appliances in industry and in the home that operate at a power frequency of 50 Hz in most countries (60 Hz in North America). Other man-made sources are found in research and in industrial and medical procedures. Table 11.4 gives some typical data on exposure levels.

11.3.1 Interaction mechanisms

Electric and magnetic fields and living organisms can interact directly or indirectly. As to direct interaction, electric fields induce a surface charge on an exposed body. This results in a current distribution inside the body depending on exposure conditions

Table 11.4: Typical levels of exposure from sources of electric and magnetic fields

Field sources	Frequency (Hz)	Magnetic flux density: Average	Magnetic flux density: Peak	Electric field strength
Earth	0	50 μT		130 V/m 3-20 kV/m (thunderstorms)
	50 and 60 5–1000	10^{-6} μT 10^{-5}–10^{-8} μT		10^{-4} –0.5 V/m (atmospheric fields)
Office and households	50 and 60	0.03–1 μT 0.6-12 μT (residences with electric heating)	1–40 μT (at 30 cm distance from various appliances)	2–500 V/m at (30 cm distance from various appliances)
	0			1–20 kV/m (electrostatic charge)
30 cm from a visual display unit	50	0,8 μT	5–18 μT	30–1500 V/m
High-voltage AC power transmission				
Overhead transmission line (380 and 756 kV)	50 and 60	10–30 μT	400 μT (during failure)	3–10 kV/m
25 m from midspan (380 kV)	50	6–8 μT		1–2 kV/m
Railway transmission line (110 kV)	16.7	12–25 μT		2–5 kV/m
Generating stations	50 and 60	20–40 μT	270 μT	5–16 kV/m
Industry				
Electrolytic processes	0 and 50	1–10 mT	50 mT	
Welding machines	0 and 50		130 mT	
Electric furnaces	1–1000		25 mT	
Induction heating	50–10 000	1–6 mT	25 mT	
Medicine				
Nuclear magnetic resonance imager	0	1–5 mT (operator)	2T, 20T/s (gradient field) (patient) 30–250 mT (operator, outside magnet)	
Therapeutic equipment	12,15,20,50,75	1–16 mT (patient)		

Source: World Health Organization *(46,47)*.

and the size, shape and position of the exposed body in the field. Biological effects can include the vibration of body hair, stimulation of sensory receptors and cellular interactions. Magnetic fields induce electric fields and currents in the body that depend on exposure conditions and body dimensions.

As to indirect interaction, electric and magnetic fields coupling to conducting objects may cause electric currents to pass through people in contact with the objects. The magnitude and spatial distribution of such a current depend on frequency, the quality of field coupling, the size, age and sex of the person, and the area of contact.

Transient discharges (sparks) can occur when people come into close proximity with conducting objects exposed to strong fields. The fields can interfere with medical implants such as cardiac pacemakers and cause them to malfunction. In general, the sensitivity of medical implants to electromagnetic interference is not known.

11.3.2 Biological effects

During the last 10–15 years, more systematic studies on the biological effects of electric and magnetic fields have examined the mechanisms of interaction [47,48]. The appropriate dosimetric quantity, which is closely linked to biological effects, is the induced electric field strength at the cellular level in living tissue or, connected with the specific conductivity of the medium, the induced current density. For frequencies between 3 Hz and about 300 Hz, current densities of about 1–10 mA/m^2 correspond with the average values for current densities that flow naturally in the body owing to the electric events in the brain and heart. On a microscopic level, however, the naturally occurring current densities are likely to be considerably greater than the average values. It is assumed that no effects occur below about 1 mA/m^2 that could be explained by the naturally occurring current densities. Biological effects are well documented for the range 10–100 mA/m^2 (Table 11.5) Current densities of more than 100 mA/m^2 exceed the stimulation thresholds for nerve and muscle cells and are likely to pose an acute threat to health. Definite health hazards via extrasystoles and ventricular fibrillation result from a current density in the cardiac region over 1000 mA/m^2. The health consequences of long-term exposure to field strengths corresponding to current densities of 1–10 mA/m^2 are not known.

On the other hand, laboratory studies on the biological effects of fields of extremely low frequency (ELF) cannot be ignored. Although there is today little direct evidence about ELF fields and cancer, more focused experiments are necessary. Some data challenge the conventional assumption that the magnitude of an effect grows with increasing exposure.

Effects at the cellular level

In general, no mutagenic effects of ELF electric and magnetic fields have been seen. The lack of effect on chromosomes and DNA has suggested that if electrical and magnetic fields play any role in carcinogenesis they are more likely to promote than to initiate, enhancing the proliferation of genetically altered cells rather than causing the initial lesion. Some studies report that ELF fields may alter RNA and protein synthesis. A change in protein synthesis would be interesting in the light of emerging evidence that a complex interplay of different factors, including ELF fields, regulates the cell cycle.

Since the 1970s, it has been known that electric and magnetic fields might disrupt the calcium balance in cells. The disruption seems to depend on frequency and amplitude ("window effects"). In cells, calcium acts as an intracellular messenger both for the activation of genes and in intercellular communication. Further, calcium homoeostasis helps protect cells from oxidative stress. If disruptions of calcium balance induced by ELF fields are sufficient to raise free radical levels, they could inhibit a cell's ability to protect itself from another oxidative insult,

Table 11.5: Biological effects of electric and magnetic fields (with induced electric field strength or current densities in the extracellular medium) between 3 and 300 Hz

Electric field strength	Current density	Effects
5–50 V/m	1 – 10 A/m^2	Possible extrasystoles and ventricular fibrillation
0.–5 V/m	0.1 – 1 A/m^2	Changes in central nervous system excitability
50–500 mV/m	10 – 100 mA/m^2	Visual (magnetophosphenes) and possible nervous system effects Reported facilitation of reunion of fractured bone Enhanced DNA synthesis Change in transcription of DNA into mRNA Changes in molecular weight distribution during protein synthesis Delay of the mitotic cell cycle Blocking of the action of the parathyroid hormone at the site of its plasma membrane receptor Inhibition of the cytotoxicity of T-lymphocytes Transient increase of the activity of ornithine decarboxylase
3–50 mV/m	1 – 10 mA/m^2	Minor biological effects reported, some being observed at distinct frequencies and field strengths Changes in several transcription processes Calcium efflux from preparations of brain tissue following exposure to 16-Hz electric or magnetic fields Modified calcium uptake of lymphocytes following magnetic field exposure Inhibition of melatonin synthesis by the pineal gland

Source: World Health Organization *(47)*.

such as a toxic chemical or ionizing radiation.

Effects on animals

A number of investigators have reported that electric and magnetic fields can reduce or suppress melatonin production by the pineal gland in laboratory animals under some circumstances. The pineal is a neuro-endocrine agent that provides a hormonal signal synchronized to the daily cycle of light and darkness. Melatonin, the principal pineal hormone, exerts a generally suppressive action on other endocrine glands. Because light perceived by the retina suppresses melatonin production, circulating melatonin levels are lower during the day than at night. Electric and magnetic fields can suppress melatonin production; this may influence the risk of developing certain types of cancer, particularly cancer of the breast and prostate. Two known biological effects of melatonin may influence cancer risk, and account for the experimental observation that melatonin inhibits chemically induced breast cancer in rats: melatonin stops the growth of hormone-dependent cancer cells, and suppresses estrogen and testosterone production.

In addition, light at night suppresses melatonin production. Thus, two products of electric power, electric and magnetic fields and light at night, may reduce melatonin in humans and influence the risk of breast and prostate cancer – although it has to be noted that the physiological role of melatonin in humans is uncertain.

Even if the extrapolation of results from animal experiments to human beings remains controversial, owing to differences in field strengths and current distributions as well as biological differences, the largest number of studies on electric fields has been performed on animals. Many of the published accounts of animal experiments, however, show that insufficient care was taken to avoid the influence of secondary effects, such as perceptible electrification or vibration of body hair. Up to field strengths of 30 kV/m the observed changes in, for example, white blood cells, blood sugar, serum proteins, calcium concentration and urine remained, as a rule, within the normal range.

In general, the interacting effects of magnetic fields on mammals have not received as much study as the influence of electric fields. For static magnetic fields with flux densities of less than 2 T, however, numerous data indicate the absence of irreversible effects on growth, development, behaviour and physiological parameters.

For time-varying ELF magnetic fields, very few systematic animal experiments have been done to define thresholds for changes in biological functions. Some studies report effects depending on the pulse shape of the magnetic fields. The latest investigations, however, reveal that the densities of currents induced by magnetic fields must exceed 10 mA/m^2 in tissue and in extracellular fluids to effect significant changes in the development, physiology and behaviour of higher organisms.

Effects on human beings

For electric fields, results are available from extensive laboratory tests on volunteers, whereby the exposure conditions and control groups seem to be well defined in comparison to epidemiological studies but the exposure time is limited [46]. The laboratory tests include field exposure times of from 3 hours to 1 week and field strengths of up to 20 kV/m. The variables examined were reaction time to optic and acoustic stimulation, psychological factors, electroencephalogram, electrocardiogram, blood pressure, pulse frequency, body temperature, blood status, biochemical parameters of blood and urine, enzymes and metabolic factors. No significant changes were found [49].

For magnetic fields, the examinations performed on human beings can be divided into two groups: those substantiated by many independent experiments on visual flicker manifestations caused by the magnetic field (magnetophosphenes) and the remaining studies with non-uniform test conditions and a multitude of examined parameters [47].

The maximum sensitivity of visual phenomena occurs with frequencies of about 20 Hz; the lowest sensitivity thresholds for magnetophosphenes are about 2 mT at 20 Hz and about 5 mT at 50 Hz. Examinations such as electroencephalogram, electrocardiogram and measurements of pulse, blood pressure, reaction time and diverse blood and biochemical parameters showed no changes beyond the normal range. The strongest magnetic flux density used in these studies with human volunteers was one of a 5-mT, 50-Hz field to which subjects were exposed for 4 hours.

11.3.3 Epidemiological studies

Some reports on epidemiological studies and laboratory research have raised questions about the adequacy of existing guidelines for limiting exposure to electric and magnetic fields. Several epidemiological investigations report an increased incidence of cancer in children, adults and occupationally exposed workers after exposure to ELF magnetic fields (50/60 Hz) [50]. The reports of an excess of cancer in children, estimated to have been exposed to average levels of approximately 0.1–0.4 μT by virtue of their place of residence, have caused the most concern. Several studies have been reported since the appearance of the first in 1979 [50]. All are case–control studies, in which comparisons have been made between the proximity of various sources of electromagnetic fields to the places of residence of children who had or had not developed cancer. Most of the studies have been criticized because of inadequate dosimetry and borderline statistical significance due to their low case numbers.

Further epidemiological studies have been reported on residential [51,52] and occupational [51,53] exposures to electromagnetic fields. There is some evidence from the residential studies for a possible link between exposure and childhood leukaemia.

A recent study from Sweden [54,55], which included exposure assessment based on measurements, found an increased risk of childhood leukaemia related to estimated exposure to electric and magnetic fields. It also indicated that the effect was insignificant from a public health point of view; less than one extra case of childhood leukaemia per year in Sweden (population 9 million) was associated with living near high-voltage power lines.

As to the occupational studies, there is some evidence that increased exposures to electromagnetic fields may be associated with an increased risk of developing leukaemia (of different types); no dose–response relationship has been demonstrated.

Present knowledge does not permit the suggestion of a biological mechanism to account for the occurrence of malignant tumours as a result of exposure to electric and magnetic fields. It should be noted that the currents induced in the body by the magnetic fields in question are more than two orders of magnitude lower than those occurring naturally in the body.

Experimental findings are not helpful [56]. One cannot conclude either that electric and magnetic fields have no effects on the physiology of cells, or that they produce effects that would be regarded as suggestive of potential carcinogenicity. The weight of available experimental evidence is against electromagnetic fields acting directly to damage DNA, implying that these fields may not be capable of initiating cancer in a way similar to that of ionizing radiation or many chemical agents. The results of some studies suggest the possibility that electromagnetic fields act as co-carcinogens or tumour promoters, but the data are inconclusive.

The International Commission on Nonionizing Radiation Protection (ICNIRP) reviewed the data on the possible carcinogenicity of power frequency magnetic fields related to power lines at its annual meeting in May 1993. All scientific data were considered that had been published or publicly presented since the 1990 publication of the interim guidelines [57] by the International Nonionizing Radiation Committee (INIRC) of the International Radiation Protection Association (IRPA) – the predecessor of ICNIRP. The most recent data reflect some improvements in the methodology of laboratory and epidemiological studies of occupational and general populations. After careful consideration of this evidence, the ICNIRP concluded that the data related to cancer do not provide a basis for the assessment of the health risks of human exposure to power frequency fields, and the Commission confirmed the interim guidelines.

In summary, although the epidemiological findings reviewed provide no conclusive evidence of a carcinogenic hazard from exposure to ELF fields, the findings justify the proposal of a programme for further research.

11.3.4 Exposure limits and protective measures

Given the inadequacy of the available data on carcinogenicity, exposure limits for electric and magnetic fields are currently based on well established mechanisms and experimental findings related to acute effects. The published guidelines [57] are based on the limitation of electric fields or current densities induced in the body by exposure to electric or magnetic fields. Current densities (well below thermal effects) should be no more than about 10 mA/m^2 and continuous occupational exposure should be limited to a current density of 4 mA/m^2; a further safety factor is incorporated for exposure of the general public (2 mA/m^2). From these basic limits, limits for exposure to electric and magnetic field strengths have been derived that can be monitored by dose meters. Table 11.6 summarizes these derived exposure limits.

Experience has demonstrated different thresholds for direct and indirect effects [58]. Secondary short-term effects must be

Table 11.6: Limits of exposure to 50/60-Hz electric and magnetic fields

Exposure characteristics	Effective electric field strength (kV/m)	Effective magnetic flux density (mT)
Occupational exposure		
Whole working day	10	0.5
Short term	30	5
Limbs	–	25
Exposure of the general public		
Up to 24 hours per day	5	0.1
Few hours per day	10	1

Source: International Radiation Protection Association *(57)*.

considered when evaluating health risks resulting from exposure to electric or magnetic fields. The thresholds for some indirect effects are lower than those for biological effects, owing to the direct influence of electric and magnetic fields. Contact currents enter a person through electrical conductors in contact with the skin; spark discharges introduce transient currents into the body through an arc gap when the electrical breakdown potential of air is exceeded; and electric or magnetic fields interfere with the performance of cardiac pacemakers. These effects may occur in the range between the exposure limits for the general public (5 kV/m, 100 μT) and the limit for short-term occupational exposure.

The responsibility for the protection of workers against the potentially adverse effects of exposure to electric and magnetic fields should therefore be clearly assigned. The competent authorities should consider developing and adopting exposure limits and implementing a programme to ensure compliance. In addition to the requirement of observing the exposure limits and developing standardized measurement procedures and survey techniques, some special issues need consideration.

Occupational exposure

Strong electric fields in the workplace induce currents in conducting objects, which may then pass through grounded people in contact with the objects. Field strengths greater than about 5–7 kV/m can produce a wide variety of hazards, such as startle reactions associated with spark discharges and contact currents from ungrounded conductors in the field. Care should be taken either to eliminate or ground such conductors, or to ensure that people wear insulated gloves when ungrounded objects must be handled. Caution dictates the use of protective devices (such as suits, gloves and insulation) in all fields exceeding 15 kV/m.

Safety hazards associated with combustion, the ignition of flammable materials and electric explosive devices may exist in the presence of a high-intensity electric field.

Exposure of the general public

The limit of 5 kV/m for continuous exposure of the general public provides substantial protection from annoyance caused by steady-state contact currents or transient discharges. This limit, however, cannot completely eliminate the perception of the effects of an electric field, since the perception threshold for some people is below 5 kV/m. In such cases, additional technical measures (such as grounding) may be instituted to avoid indirect coupling effects arising from touching charged, ungrounded objects.

People with cardiac pacemakers and other electrically active medical implants should not have access to areas where the electric field strength exceeds 5 kV/m or the magnetic flux density exceeds 0.1 mT (50/60-Hz fields).

11.3.5 Conclusions

More people will be exposed to fields of 50 Hz and higher frequencies as increased electrification accompanies socioeconomic development, and modern communication systems are adopted. If long-term exposure to weak electric and magnetic fields poses any hazard to health, more people will be at risk.

Although the public is concerned about exposure to electric and magnetic fields, the epidemiological evidence on which these concerns are based is inconclusive. In addition to further epidemiological research, experimental research is needed on the mechanism of the action of ELF fields at the cellular level, the biological significance of window effects, and the relevance of some observed effects for long-term exposure. While measures and limits have been proposed for the protection of workers from established acute effects and measures to protect the general public have been suggested, the situation should be reviewed in a few years when the results of new research are available.

References

[1] Suess, M.J. & Benwell-Morison, D.A., ed. *Nonionizing radiation protection*, 2nd ed. Copenhagen, WHO Regional Office for Europe, 1989 (WHO Regional Publications, European Series, No. 25).

[2] Molina, M.J. & Rowlands, F.S. Stratospheric sink for chloromethanes: chlorocatalyzed distinction of ozone. *Nature*, **249**: 810–812 (1974).

[3] Environmental effects of ozone depletion: 1991 update. Panel report pursuant to Article 6 of the Montreal Protocol on Substances that Deplete the Ozone Layer under the auspices of the UNEP. *Journal of photochemistry and photobiology. B. Biology*, **13**: 187–190 (1992).

[4] McCulloch, A. Atmospheric chlorine loading and trends in intensity of solar UV radiation at ground level. *Journal of photochemistry and photobiology. B. Biology*, **10**: 171–174 (1991).

[5] *Stratospheric ozone. Stratospheric Ozone Review Group Report, 1993.* London, H.M. Stationery Office, 1993.

[6] Frederick, J.E. Yearly review. Ultraviolet sunlight reaching the Earth's surface: a review of recent research. *Photochemistry and photobiology*, **57**: 175–178 (1993).

[7] *Hansard*, 26 April 1993, pp. 322–323.

[8] Frederick, J.E. et al. Solar ultraviolet radiation at the Earth's surface. *Photochemistry and photobiology*, **50**: 443–450 (1989).

[9] Jokela, K. et al. Effects of Arctic ozone depletion and snow on UV exposure in Finland. *Photochemistry and photobiology,* **58**: 559–566 (1993).

[10] Brühl, C. & Crutzen, P.J. On the disproportionate role of tropospheric ozone as a filter against UVB radiation. *Geophysical research letters,* **16**: 703–706 (1989).

[11] Kerr, J.B. & McElroy, C.T. Evidence for large upward trends of ultraviolet-B radiation linked to ozone depletion. *Science*, **262**: 1032–1035 (1993).

[12] Michaels, P.J. et al. Analyzing ultra-violet B radiation: is there a trend? *Science,* **264**: 1341–1342 (1994).

[13] Kerr, B. & McElroy, C.T. *Science,* **264**: 1342–1343 (1994).

[14] Moseley, H. *Nonionizing radiation: microwaves, ultraviolet and laser radiation*. Bristol, Adam Hilger, 1988 (Medical Physics Handbook 18).

[15] Moan, J. & Johnsen, B. What kind of radiation is efficient in solaria, UVA or UVB? *Journal of photochemistry and photobiology. B. Biology,* **22**: 77–79 (1994).

[16] Walter, S.D. et al. The association of cutaneous malignant melanoma and fluorescent light exposure. *American journal of epidemiology*, **135**: 749–761 (1992).

[17] *Solar and ultraviolet radiation*. Lyon, International Agency for Research on Cancer, 1992, p. 221 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans No. 55).

[18] Mariutti, G. & Matzeu, M. Measurement of ultraviolet radiation in welding processes and hazard evaluation. *In*: Passchier, W.F. & Bosnjakovic, B.F.M., ed. *Human exposure to ultraviolet radiation: risks and regulations*. Amsterdam, Elsevier, 1987, pp. 387–390.

[19] Friedmann, H. et al. A possible explanation of laser-induced stimulation and damage of cell cultures. *Journal of photochemistry and photobiology. B. Biology*, **11**: 7–91 (1991).

[20] BOULTON, M. & MARSHALL, J. He-Ne laser stimulation of human fibroblasts proliferation *in vitro*. *Lasers in the life sciences*, **1**: 125–134 (1986).

[21] KARU, I. Molecular mechanism of therapeutic effects of low intensity laser radiation. *Lasers in the life sciences*, **2**: 53–74 (1988).

[22] MOAN, J. ET AL. Ozone depletion and its consequences for the fluence of carcinogenic sunlight. *Cancer research*, **49**: 4247–4250 (1989).

[23] MCKINLEY, A.F. & DIFFEY, B.J. A reference action spectrum for ultraviolet induced erythema in human skin. *In*: Passchier, W.F. & Bosnjakovic, B.F.M., ed. *Human exposure to ultraviolet radiation: risks and regulations*. Amsterdam, Elsevier, 1987, pp. 83–86.

[24] URBACH, F. Potential effects of altered solar ultraviolet radiation on human skin cancer. *Photochemistry and photobiology*, **50**: 507–513 (1988).

[25] KRICKER, A. ET AL. Pigmenting and cutaneous risk factors for nonmelanocytic skin cancer. A case control study. *International journal of cancer*, **48**: 650–662 (1991).

[26] MOAN, J. ET AL. Biological amplification factor for sunlight-induced nonmelanoma skin cancer at high latitudes. *Cancer research*, **49**: 5207–5212 (1989).

[27] DIFFEY, B.L. Analysis of the risk of skin cancer from sunlight and solaria in subjects living in northern Europe. *Photodermatology*, **4**: 118–126 (1987).

[28] KOH, H.K. ET AL. Yearly review. Sunlight and cutaneous malignant melanoma: evidence for and against causation. *Photochemistry and photobiology*, **51**: 765–779 (1990).

[29] LEE, J.A.H. The relationship between malignant melanoma of skin and exposure to sunlight. *Photochemistry and photobiology*, **50**: 93–496 (1989).

[30] MOVSHOVITZ, M. & MODAN, B. Role of sun exposure in the etiology of malignant melanoma: epidemiologic inference. *Journal of the National Cancer Institute,* **51**: 777–779 (1973).

[31] MACKIE, R. ET AL. Cutaneous malignant melanoma, Scotland 1979–89. *Lancet*, **339**: 971–975 (1992).

[32] CASCINELLI, C. & MARCHESINI, R. Increasing incidence of cutaneous melanoma, ultraviolet radiation and the clinician. *Photochemistry and photobiology*, **50**: 497–505 (1989).

[33] MOAN, J. Ozone holes and biological consequences. *Journal of photochemistry and photobiology. B. Biology*, **9**: 244–247 (1991).

[34] MAGNUS, K. The Nordic profile of skin cancer incidence. A comparative epidemiological study of the three main types of skin cancer. *International journal of cancer*, **47**: 12–19 (1991).

[35] MORISON, W.L. Effects of ultraviolet radiation on the immune system in humans. *Photochemistry and photobiology*, **50**: 515–524 (1989).

[36] VALERIE, K. ET AL. Activation of human immunodeficiency virus type 1 by DNA damage in human cells. *Nature*, **333**: 78–81 (1988).

[37] ARLETT, C.F. Hypersensitivity of human lymphocytes to UVB and solar irradiation. *Cancer research*, **53**: 1–6 (1993).

[38] TAYLOR, H.R. The biological effects of UVB on the eye. *Photochemistry and photobiology*, **50**: 489–492 (1989).

[39] BEIJERSBERGEN VAN HENEGOUWEN, G.M.J. (Systemic) phototoxicity of drugs and other xenobiotics. *Journal of photochemistry and photobiology. B. Biology*, **10**: 83–210 (1991).

[40] SMITH, R.C. Ozone, middle ultraviolet radiation and the aquatic environment. *Photochemistry and photobiology*, **50**: 459–468 (1989).

[41] RYAN, K.G. UV radiation and photosynthetic production in Antarctic Sea ice microalgae. *Journal of photochemistry and photobiology. B. Biology*, **13**: 235–240 (1992).

[42] TEVINI, M. & TERAMURA, A.H. UVB effects on terrestrial plants. *Photochemistry and photobiology*, **50**: 479–487 (1989).

[43] KOPECKY, K.E. Ozone depletion: implications for the veterinarian. *Journal of the American Medical Association*, **173**: 729–733 (1978).

[44] MOAN, J. UVA radiation, melanoma induction, sunscreens, solaria and ozone reduction. *Journal of photochemistry and photobiology. B. Biology*, **24**: 201–203 (1994).

[45] MACKIE, R.M. & HOLE, D. Audit of public education campaign to encourage earlier detection of malignant melanoma. *British medical journal*, **304**: 1012–1015 (1992).

[46] *Extremely low frequency (ELF) fields*. Geneva, World Health Organization, 1984 (Environmental Health Criteria No. 35).

[47] *Magnetic fields*. Geneva, World Health Organization, 1987 (Environmental Health Criteria No. 69).

[48] SIENKIEWICZ, Z.J. ET AL. *Biological effects of exposure to nonionizing electromagnetic fields and radiation. II. Extremely low frequency electric and magnetic fields*. London, H.M. Stationery Office, 1991 (NRPB-R239).

[49] SANDER, R. ET AL. Laboratory studies on animals and human beings exposed to 50 Hz electric and magnetic fields. *In: Proceedings of the International Conference on Large High Voltage Electric Systems. Paris, 1–9 September 1982.*

[50] *Electromagnetic fields and the risk of cancer. Report of an Advisory Group on Nonionising Radiation*. Chilton, National Radiological Protection Board, 1992 (document NRPB **3**, No. 1, pp. 1–138).

[51] *Electromagnetic fields and the risk of cancer. Summary of the views of the Advisory Group on Nonionising Radiation on epidemiological studies published since its 1992 Report.* Chilton, National Radiation Protection Board, 1993 (document NRPB **4**, No. 5, pp. 65–69.

[52] Verkasalo, P.K. et al. Risk of cancer in Finnish children living close to power lines. *British medical journal*, **307**: 895–899 (1993).

[53] Thériault, G. et al. Cancer risks associated with occupational exposure to magnetic fields among electric utility workers in Ontario and Quebec, Canada, and France, 1970–1989. *American journal of epidemiology,* **139**: 550–572 (1994).

[54] Feychting M. & Ahlbom A. Cancer och magnetfält hos boende nära högspänningsledningar i Sverige. [Cancer and magnetic fields in people living near high-voltage power lines in Sweden.] *Läkartidningen,* **89**: 4371–4374 (1992).

[55] Feychting M. & Ahlbom A. Magnetic fields and cancer in children residing near Swedish high-voltage power lines. *American journal of epidemiology,* **138**: 467–481 (1993).

[56] Saunders, R.D. & Kowalczuk, C.I. Weak electromagnetic field interactions and cancer. *Radiological protection bulletin*, No. 148, pp. 38–40 (1993).

[57] International Radiation Protection Association. Interim guidelines on limits of exposure to 50/60 Hz electric and magnetic fields. *Health physics*, **58**: 113–122 (1990).

[58] Bernhardt, J.H. The establishment of frequency dependent limits for electric and magnetic fields and evaluation of indirect effects. *Radiation and environmental biophysics,* **27**:1–27 (1988).

Chapter 12
Ionizing Radiation

12.1 Sources

Ionizing radiation is a natural part of the environment. Life has been exposed to radiation since it first appeared on earth. The principal sources of ionizing radiation originate in the terrestrial environment, i.e. the radioactive substances in the soil, rocks, water and air, and from cosmic sources (Table 12.1).

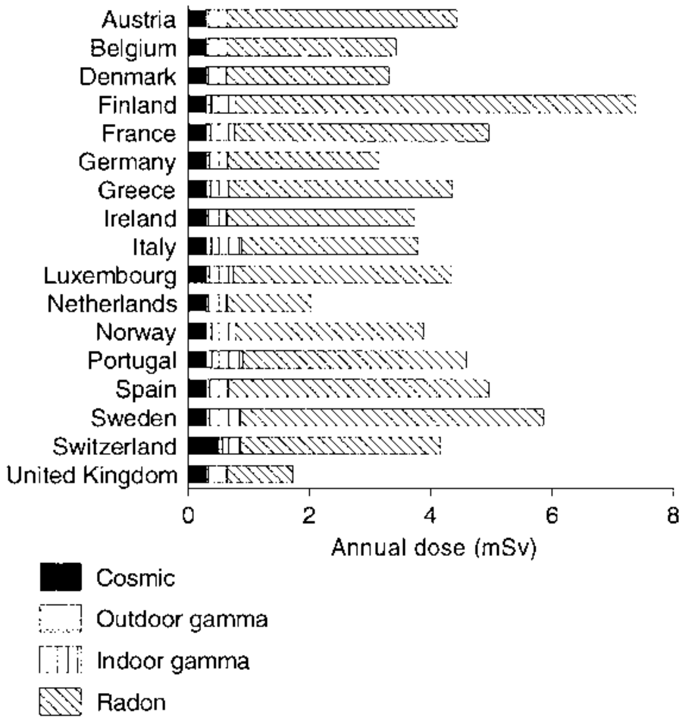
Natural radiation varies significantly from one part of the earth to another, depending principally on factors such as the latitude and geological make-up of an area [1]. With one exception, all natural sources provide an essentially unvarying exposure in any given geographical location. The exception is the radioactive gas radon, which is released to the atmosphere from uranium-bearing rock. The emission of this gas, apart from diurnal and seasonal variations, does not vary over time, except when the terrestrial structure is disturbed by, for example, mining or earthquakes. Over the past few decades, however, buildings over such radon-releasing rock have tended to acquire higher concentrations of radon as a result of reductions in the ventilation rate designed to conserve energy [3]. It is therefore useful, in considering the natural radiation background environment, to distinguish between radon and other sources of ionizing radiation to which life has been exposed at an almost constant rate over eons. While variations in exposure to radon may vary by over several orders of magnitude from one geographical location to another, exposure to other sources commonly varies by a factor of two to three and, exceptionally, by an order of magnitude. Fig. 12.1 shows typical values for the relative contributions of radon and other sources to the average annual dose from natural sources of radiation for several European countries [4].

Human beings have increased exposure to radiation from the environment through a number of activities, including mining, using products with high natural radioactivity (such as phosphate fertilizers), burning fos-

Table 12.1: Annual effective doses to adults from natural sources of ionizing radiation

Source of exposure	Annual effective dose (mSV)
Cosmic radiation	0.38
Terrestrial radiation	0.46
Radionuclides in the body (except radon)	0.23
Radon and its decay products	1.28
Total	2.4

Source: UNSCEAR *(1,2)*.



Source: National Radiological Protection Board *(4)*.

Fig. 12.1: Average annual doses from natural sources of radiation in 17 European countries

sil fuels and extracting water from deep wells, as well as testing nuclear weapons, generating nuclear power and using radiation and radioactive materials in medicine, industry and research. In general, the extent of the increased environmental exposure from all these activities is within the range of geographical variation commonly found in exposure to the non-radon sources of natural background radiation [1] and as such can be regarded as unexceptional in terms of the risk of extra disease that might occur. Some exceptions, however, need careful consideration. These arise primarily from sources for which no analogous exposure occurs in the natural environment (particularly certain radionuclides that are either extremely rare or nonexistent naturally) and that concentrate in parts of the human body or are located in especially sensitive organs. This chapter emphasizes environmental exposure to radiation from man-made sources. It gives no further consideration to exposure that can be seen to be both analogous to non-radon natural background exposure and insufficient to exceed, on an annual basis, the natural variations in background radiation exposure, or to medical exposures in diagnostic or therapeutic procedures.

12.2 Biological Effects

12.2.1 Nature and quality of ionizing radiation

The generation of ionizing radiation can result from technical processes or the natural radioactive decay of certain substances. Such radiation interacts with matter, including biological materials, by transferring energy that may break the bonds that hold a molecule together. In biological materials, such chemical changes can have consequences that may be recognized immediately, or after several decades or even generations.

The different kinds of ionizing radiation can produce similar biological effects. They may differ, however, in their quality; this reflects primarily the efficiency with which they deposit energy and induce biological effects. Biological effects are traditionally related to the absorbed dose: the amount of energy imparted per unit mass of tissue. Some types of radiation, such as alpha particles, lose their energy to relatively small tissue masses and thus create high energy densities. Others, such as gamma rays, impart their energy more sparsely. In general, the latter are less effective than the former at producing biologically relevant damage per unit dose [5].

12.2.2 Effects on health

Ionizing radiation brings about biological effects through the processes of molecular break-up and rearrangement. As most kinds of molecule exist in large numbers within the cell, their loss or alteration in a few cells is of little consequence. Danger arises when a rare molecule, critical to the functioning of the cell, is damaged. The most important of these is DNA. Damage to DNA may either modify or prevent reproduction of the cell, resulting in the death of the cell progeny. Unless many cells are killed this usually does not affect the functional capability of the tissues and organs, because of their very substantial redundancy. There is evidence, however, that the modification of DNA underlies the mutagenic and carcinogenic effects of radiation.

Ionizing radiation causes two kinds of biological effect: deterministic and stochastic [5]. Deterministic effects result from a loss of biological function; normally these become apparent shortly after exposure (within weeks), increase in severity with increasing dose, and are either insignificant or absent below a threshold of dose (about 0.5 Sv). Stochastic effects result from changes in the genetic make-up of cells. These may take several years to become clinically apparent in the exposed person, and may affect his or her progeny. The probability of an effect is related to dose; there is assumed to be no threshold below which this probability is zero.

Owing to the threshold, limiting doses can usually prevent deterministic effects. Examples of deterministic effects are the depression of the blood-forming tissues, skin damage, and the induction of opacities in the lens of the eye (cataract). Only in very exceptional cases, such as accidents, do deterministic effects occur as a result of exposure to environmental sources of ionizing radiation. Even in such circumstances, very few people are likely to receive doses high enough to exceed the threshold for effects. For this reason, deterministic effects are not further discussed here.

With the assumption of no threshold, limiting doses cannot eliminate stochastic effects but the probability of an effect occurring can be kept at tolerable or acceptable levels. At low doses, stochastic effects are assumed to be induced in direct proportion to dose. The principal risk is of cancer. Radiation can induce a wide range of types of cancer and the following generalizations can be made.

- In general, radiation-induced cancer occurs only in the tissues exposed to radiation.
- Radiation-induced cancer is currently in-

distinguishable in its histopathology from the spontaneously occurring disease.
- The latency periods for the occurrence of cancer range from 2 years for leukaemia to more than 40 years.
- Sensitivity varies from tissue to tissue and with age, sex and genetic constitution.

In addition, it is recognized that irradiation of the germ cells may lead to hereditary disease in future generations. Studies on the populations exposed to the atomic bombs in Hiroshima and Nagasaki have not identified statistically higher frequencies of genetic disorders, although experimental studies on plants and animals have indicated that such effects can occur. Gardner et al. [6] reported an increased risk of leukaemia in the offspring of certain radiation workers, but whether there is a causal relationship is still unclear.

12.2.3 Assessment of risk

People exposed to ionizing radiation from environmental sources are thus primarily at risk of cancer, which has to be seen against a relatively high spontaneous incidence; cancer accounts for 20–25 % of all deaths. It is assumed that exposure to natural background radiation may cause a proportion (5–10 %) of these deaths [1]. An important consequence of this is that one cannot definitively attribute any one case of disease to exposure to radiation; it is only possible to estimate the probability that this is so. Risk is usually expressed in terms of the cases of cancer expected in a specified number of people exposed to a unit of dose, in addition to the naturally occurring cases. In addition to such absolute risk one can assess relative risk, which indicates the excess risk from radiation relative to the baseline risk.

Since few studies examine an exposed population throughout life, the lifetime risk is usually obtained by projecting the frequency of cancer induction obtained for the period of observation to the lifetime of the exposed population. Since the spontaneous cancer rate increases with age, a projection in terms of constant relative risk will yield higher risk estimates than a projection in terms of constant absolute risk, which is independent of the spontaneous rate [5].

12.3 Control of Exposure

12.3.1 Converting exposure to dose

The two basic quantities in the assessment of radiation levels and effects are the activity of a radionuclide and the radiation dose. The conversion of the amount of radionuclides incorporated into the human body into dose depends on the transfer of the relevant radionuclides to different human tissues and organs, the decay of the radionuclides, and the energy of radiation accompanying the radioactive decay.

The physical, chemical and biological properties of a radioactive substance determine the extent to which it may pose a health hazard. The factors that increase the hazard are the ease with which a radionuclide reaches the blood after ingestion or inhalation, the tenacity with which it is retained in the body and the sensitivity of the tissues it can irradiate. Inhaled radionuclides, such as radon, primarily irradiate the lungs. Tritium may become chemically combined as water or a constituent of biological substances, and its tissue distribution will vary accordingly. Caesium behaves like potassium and is widely distributed in the body. An important radionuclide in sudden accidental releases is iodine-131, because it concentrates in the thyroid gland. Plutonium and strontium are deposited in bone.

12.3.2 Alpha emitters

The short range of the alpha particle means that the radionuclides must be located near the cells that are likely targets for adverse effects. A single alpha particle can only traverse a few cells, but can deposit relatively large amounts of energy in each. Indeed, sufficiently high doses can be imparted to the nucleus of a single cell to create a high probability of killing the cell. Cells surviving such a passage carry substantial damage and may give rise to cancer or genetic defects [3].

At high enough exposure rates, therefore, a cell killing effect may prevail and fewer added cases of cancer may be caused per unit dose with increasing exposure rate. Studies of lung cancer in miners exposed to radon have shown such an effect. Several studies of risk from domestic exposure are under way [7]. Two studies reported from Sweden indicate a risk factor in line with that derived from the data on miners, but without the complication of fewer cases of cancer per unit dose with increasing exposure rate [8,9].

Other sources of alpha radiation are the transuranic elements that constitute nuclear fuels. The manufacture and processing of nuclear fuels and the disposal of the associated wastes are an important source of radioactivity in the environment. In general, these nuclides are avidly retained in the body and may irradiate critical cells in various tissues. Their behaviour in the environment is comparatively poorly understood and their bioavailability may vary from one set of circumstances to another. Estimates of their effectiveness in causing harm have to be derived from limited data sources, often not strictly comparable. Once released into the environment, however, they are difficult and expensive to remove.

Transuranic elements find their way into many tissues of the body following inhalation or ingestion. Of principal concern to health are the internal "interfaces" of the body with the outside world, such as the lung and tracheobronchial lymph nodes. Lymphatic tissues are exposed as part of the immune response system and are thus at risk of irradiation by particulate radionuclides. Baverstock & Thorne [10] have extensively reviewed this topic. They conclude that, in spite of the inevitable doses received by lymphatic cells, especially those in the tracheobronchial lymph nodes where particulate material cleared from the lung may remain for very long periods, there is no evidence of a risk to the lymphatic system. Of course, lung cancer is known to result from irradiation of the lung by alpha radiation, and transuranic elements may be expected to carry risks, in proportion to dose, of the same magnitude as those from radon.

Alpha emitters that irradiate bone are known to carry a risk of bone cancer. The experience of radium chemists, dial painters in the United States and patients treated in Germany with the short-lived radium-224 provides evidence of the ability of radium to induce bone cancer. There is little or no human evidence at the much lower doses that might be expected from environmental exposure to transuranic elements; some interpretations of the data on dial painters suggest a lower risk per unit dose at low levels of radium. The inner surfaces of bone form the lining of marrow cavities, and bone marrow damage leading to leukaemia might therefore be expected to occur. In fact, the radium studies give no evidence of a risk of leukaemia, in contrast to a marked risk in patients treated with the X-ray contrast agent thorotrast, which is an insoluble colloid of thorium oxide that becomes distributed in the bone marrow. It may therefore be tentatively concluded that environmental exposure to bone-seeking transuranic elements, including plutonium, does not present a significant risk of either bone cancer or leukaemia.

Finally, small amounts of transuranic elements entering the body become located in the gonads, where in the male they can irradiate the spermatogonial stem cells. There are no human data to indicate whether such exposure entails a risk. Evidence from studies in mice and in mouse bone marrow cells in culture suggests that the passage of a single alpha particle through a cell can, if it does not kill it, lead to rather generalized late chromosomal damage. This phenomenon is not at all well understood and the risks of gonadal exposure to transuranic alpha radiation cannot be assessed, but cannot be dismissed.

12.3.3 Recommendations on radiation protection

The International Commission on Radiological Protection (ICRP) has recommended that the lifetime dose for the public from planned activities should not exceed 70 mSv, with a maximum of 5 mSv in any one year [5]. The average dose for five years should be less than 1 mSv/year. This recommendation does not apply to natural background radiation, medical exposures or already existing conditions, such as those that have resulted from a major accident.

Exposure is largely controlled by controlling releases of radioactivity to the environment in such a way that these are as low as is reasonably achievable, and in any case do not give rise to exposure that would result in the dose limit being exceeded. This process involves a complex framework of "pathway modelling" to determine the extent of exposure. This essentially predictive process is based on extensive studies of the properties and behaviour of radionuclides in the environment, in the food-chain and in human beings. Inevitably, such models cannot accurately reflect the exposure of individuals, since assumptions have to be made about such factors as the transfer of radionuclides and diets. A margin of safety must be incorporated, to ensure that the exposure of particular groups does not exceed the limit.

12.4 Priorities in Environmental Exposure

On the basis of these arguments, all planned activities involving the controlled release of radioactivity to the environment should not contribute a dose larger than 1 mSv/year to the general population. This is well within the variation of the natural background exposure (without radon) between geographical locations. Some facilities, especially in the CCEE and NIS, may not conform to these standards. The added exposure of people living in the vicinity of most present-day nuclear facilities such as power plants, however, is far less than the levels of exposure to natural radiation.

Concern focuses on sources that may result in radiation exposure above the variation in natural radiation (1–3 mSv/year) such as radiation accidents, nuclear weapons testing, waste disposal, radon in regions with uranium-bearing rock, and occupational exposure.

12.4.1 Radiation accidents

Accidents fall into two categories: large-scale accidents in nuclear facilities, resulting in the breaching of containment and major structural damage to the affected facility, and unplanned releases from intact facilities. Accidents in the second category often go undetected or unreported, and their impact is in general considered small in both absolute terms and in comparison to those in the first category. It has only recently become known [11] that the Chelyabinsk region of the RSFSR[a] suffered large-scale contamination from 1949 to 1956, both from accidents and from routine releases of radioactive waste from the Mayak atomic weapons complex (Box 12.1).

The European Region has experienced three accidents that fall into the first category: the Windscale accident in the United Kingdom in 1957, the Kyshtym accident in the USSR in 1957, and the Chernobyl accident in the USSR in 1986 [12]. The accident at the Windscale reactor was a fire in the graphite core. The main substances released were isotopes of xenon, caesium, polonium and, most important, iodine. A ban on milk supplies had the effect of reducing radioactive iodine intake through milk. Maximum absorbed doses to the thyroids of people close to the Windscale site were estimated to be of the order of 10 mGy for adults and

[a] The Russian Soviet Federal Socialist Republic, now the Russian Federation.

Box 12.1: Radioactive contamination in the southern Ural mountains

In May 1946, during the initial phase of the nuclear arms race, the USSR began constructing a facility named Mayak "beacon" in a region of the southern Ural mountains between Chelyabinsk and Sverdlovsk, to breed and separate plutonium for atomic bombs. In June 1948 the first uranium–graphite reactor began operation, and in December 1948 a radiochemical separation plant was started. Serious problems ensued with radioactive contamination and the exposure of workers and of the population.

Radiation exposure of the workers was extremely high during the first years of operation. Particularly in the chemical plant, workers not infrequently received doses of several Sv per year – up to a hundred times the dose that was later specified as the limit for radiation workers. Numerous cases of acute radiation sickness occurred, and even more cases of lasting changes in blood count, which were classified as chronic radiation sickness. Between 1948 and 1953 about 2400 workers were exposed to average annual doses of 0.7 Sv. Some 1600 workers in the reactor received doses that were, on average, about half as high. The follow-up for late radiation effects has shown significant increases in leukaemia and solid cancers in people who had started work in the early years of the plant. The excess incidence of leukaemia per unit dose appears to be somewhat less than that among the survivors of atomic bombs, who were subject to high exposure of shorter duration.

An even larger problem resulted from the release of 80 10^{9} litres and 10^{17} Bq of liquid waste into the river Techa in the period 1949–1956. A large number of people in the villages on the river were exposed without their knowledge, due to incorporated strontium and to gamma rays from external contamination, predominantly by caesium isotopes. In subsequent years, over 7000 people residing in villages close to Mayak were evacuated and the villages were destroyed. In the remaining villages, the river and flood lands were fenced off and the use of river water was forbidden, although these regulations were neither explained nor effectively enforced. Hundreds of people received doses of several Sv per year, and cases of acute and chronic radiation sickness were not infrequent. Even the average doses in some of the villages were over 1 Sv. A follow-up study is under way of about 40 000 people who were subject to significant exposure. The epidemiological follow-up has shown an increased incidence of leukaemia and an excess of solid cancers. The river Techa is still largely fenced off, although the remaining radioactive contamination is substantially reduced and protective regulations are widely disregarded.

When the routine releases into the river Techa had already been greatly reduced, a dramatic accident happened at Mayak's separation plant near the village of Kyshtym. In September 1957 a liquid waste storage tank with 740 PBq – predominantly strontium-90 – exploded and spread its activity in a plume extending several hundred kilometres to the north-east. About 270 000 people lived in the wider region of contamination. Somewhat more than 10 000 were evacuated within days and weeks after the accident. In three villages, a total of about 1000 inhabitants received doses of roughly 0.6 Sv. The relatively small number of people in the more highly exposed groups makes it unlikely that radiation-induced excess rates of cancer can be detected. The so-called South Ural Track is still fenced off and access to this area, which still has strontium contamination of up to 55.5 TBq/km^2, is strictly controlled.

A further problem in the same territory, although on a smaller scale, occurred in the spring of 1967 when heavy storms resuspended radioactivity from the dried shoreline of a small lake, Lake Karachay, that Mayak continues to use to store high-level waste. The re-

Box 12.1: Radioactive contamination in the southern Ural mountains

sulting contamination affected part of the terrain that had already been affected by the Kyshtym accident. This incident shows the lasting danger still represented by Lake Karachay; it remains the largest and the worst site of radioactive waste accumulation on earth. A system of storage ponds along the river Techa has less specific activity but it, too, presents most difficult problems with regard to the protection of water, soil and air.

Source: Burkart, W. & Kellerer, A.M. [11].

100 mGy for children. Several million people living in the south-east of the United Kingdom received very small doses from iodine contamination of their milk supplies.

The accident at Kyshtym, adjacent to Chelyabinsk, was a chemical explosion in a storage tank of high-level waste fission products. The products released were isotopes of cerium, zirconium, nobium and, most important, strontium. The exposure of the population was due to incorporated strontium and external radioactive contamination. The accident affected a very large number of people in the Chelyabinsk, Sverdlovsk and Tyumen areas (Box 12.1).

The Chernobyl accident (Box 12.2) was a reactor explosion and subsequent graphite fire, which released a substantial fraction of the reactor core. It is the worst accident in the history of energy generation. It led to the widepread distribution of radioactive material over much of the European Region. Outside the former USSR, estimated whole-body doses ranged up to 1 mSv in the first year (Fig. 12.2). Part of this exposure included that from isotopes of iodine. The resulting average doses to the thyroid of infants ranged up to 25 mSv in some countries (Fig. 12.3); doses to some individuals could have been substantially larger. In contrast to the whole-body doses, which on average fall within the variations of natural background doses, the doses to the thyroid cannot be ignored. Calculation of the risk is uncertain, however, because there is no direct experience of the effects of iodine-131 on infants and children, risk estimates being based on data from X-ray exposure. If iodine-131 is as effective as external radiation in inducing thyroid cancer, then a dose of about 90 mSv can be expected to treble the spontaneous risk [13], which is of the order of a few in a million.

Within the more immediate environment of the accident, doses were much higher. In the 30-km zone around the reactor, from which about 135 000 people were evacuated, doses would have been 0.5 Sv or more in the first year if locally produced food had been eaten. Substantial doses were received at greater distances. In an assessment of doses to selected settlements outside the 30-km radius, the International Atomic Energy Agency (IAEA) reports total average doses ranging up to 160 mSv between 1986 and 1989 [14]. The individual risks of leukaemia and other types of cancer may be expected to increase. A dose of 1 Sv delivered at low dose rates might be expected to double the spontaneous risk of leukaemia (a rare disease) in adults and adolescents. In children, who have a much lower spontaneous incidence, such a dose may increase the risk by up to tenfold, although the resulting absolute excess risk may be similar to that of adults. For all other types of cancer taken together, the relative increase will be considerably smaller, but the spontaneous risks are much larger and therefore the number of deaths may be greater.

The dose to the thyroid from iodine isotopes gives rise to particular concern. The IAEA estimate of the average thyroid dose to children is up to 2 Sv in the heavily contaminated settlements near the 30-km zone around the reactor; individual doses may be up to five or more times this, particularly in infants. In Belarus, an increase in childhood

Box. 12.2: Radiation effects of the Chernobyl accident

The explosion and the subsequent fires at the Chernobyl reactor in April 1986 led to the discharge of radioactive material, which was carried further than expected by air streams. The material precipitated with rain not only over the territory of the USSR but also over many other countries in the European Region, and in trace amounts throughout the northern hemisphere. An appreciable fallout of radioactive caesium-137 and caesium-134 was observed in such countries as Austria, Bulgaria, Finland, the German Democratic Republic, the Federal Republic of Germany, Italy, Norway, Poland, Romania and Sweden. No one had anticipated that an accident could affect such an extensive area.

The main components of the radioactive releases were caesium-137, caesium-134 and, to a much lesser extent, strontium-90. The highest level of soil deposition of caesium reported outside the USSR was of the order of several tens of kBq per m^2. Because of its short half-life, iodine-131 was detected as an air contaminant in certain parts of the RSFSR and the Ukrainian and Byelorussian SSRs and the Baltic states only immediately after the accident. Children in these regions were particularly affected by the radioactive iodine, which could concentrate in the thyroid gland.

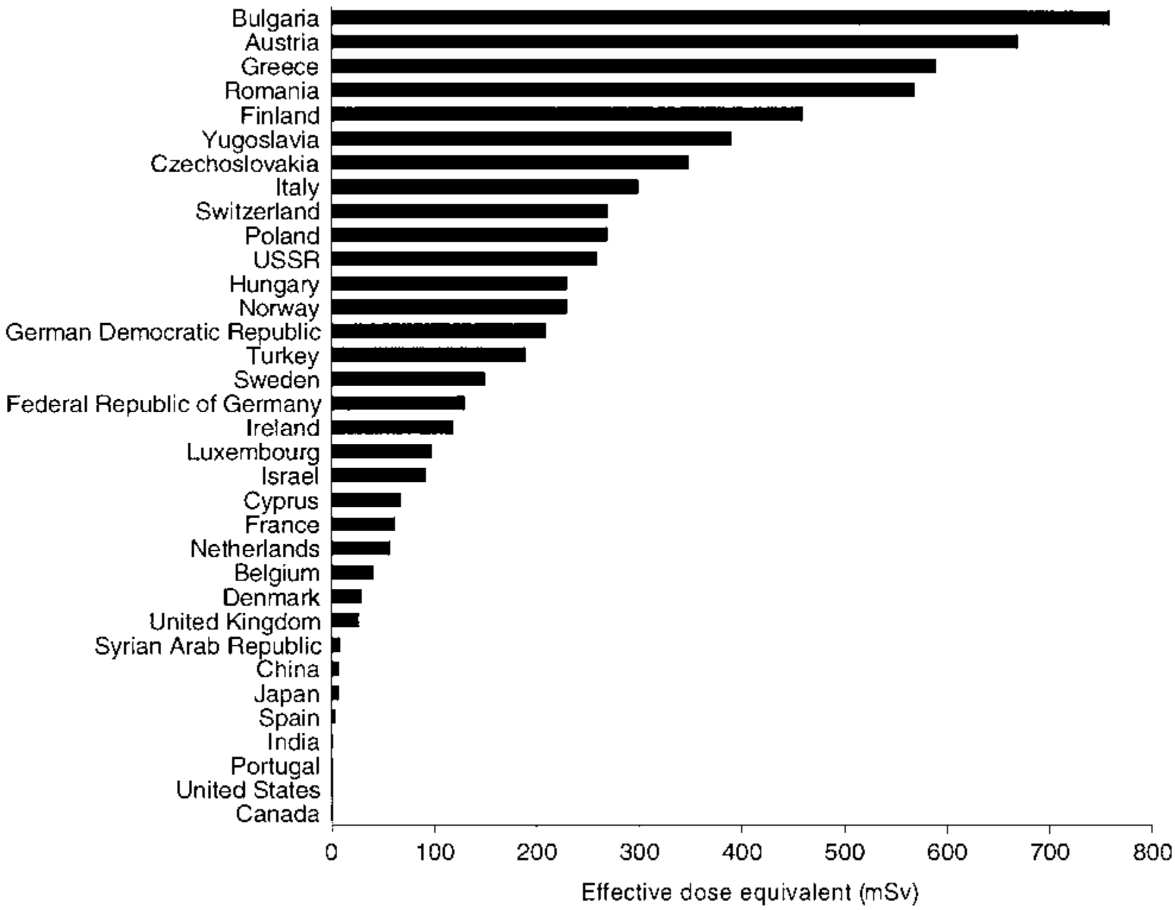
Immediately after the accident, the population was evacuated from a 30-km zone around the Chernobyl power station. In other areas, people had to leave only if the annual dose expected was higher than 100 mSv (50 mSv external and 50 mSv internal exposure). The Ministry of Health of the USSR subsequently introduced an upper lifetime limit of 350 mSv as a criterion for evacuation. If the lifetime dose was expected to be less than 350 mSv, evacuation could still be considered for social, economic or other reasons. In the first year, the populations of 186 settlements in the RSFSR and the Ukrainian and Byelorussian SSRs – about 120 000 people – were evacuated. In about 640 settlements (with about 230 000 inhabitants) an increased level of radiation was observed that still requires strict monitoring, especially of food.

Measurements since the accident have shown that iodine-131, caesium-134 and caesium-137 are the radioactive substances that have contributed significantly to doses, mainly by external exposure from deposited material and by ingestion of contaminated food. An unexpectedly high accumulation of caesium-137 was observed in mushrooms, reindeer, game and some freshwater fish (see Chapter 9).

Direct casualties occurred among reactor workers and firefighters, 30 of whom died from radiation exposure and burns incurred during the initial phase of the accident. Initial estimates about later health effects varied widely. Predictions of the number of deaths from radiation-induced cancer depend on the territory covered, estimated exposure and the number of affected people. Although the full health consequences of the accident are unlikely to be known precisely, some unexpected effects have emerged. Five years after exposure to radioiodine, a sharp increase in the incidence of thyroid cancer among children has been observed in Belarus, with the annual number of new cases rising from 2 in 1986 to 55 in 1991.

To date there is no proof of an increase in the incidence of any other type of radiation-inducible cancer. The accident had substantial psychological impact; this indirect adverse effect on health may possibly be more important than the direct effects due to radiation.

thyroid cancer has already been observed; although it is not unequivocally related to the exposure from Chernobyl, iodine isotopes appear to be the most likely cause. The ICRP estimates the risk of thyroid cancer for all ages to be 0.8 % per Sv, but for children the

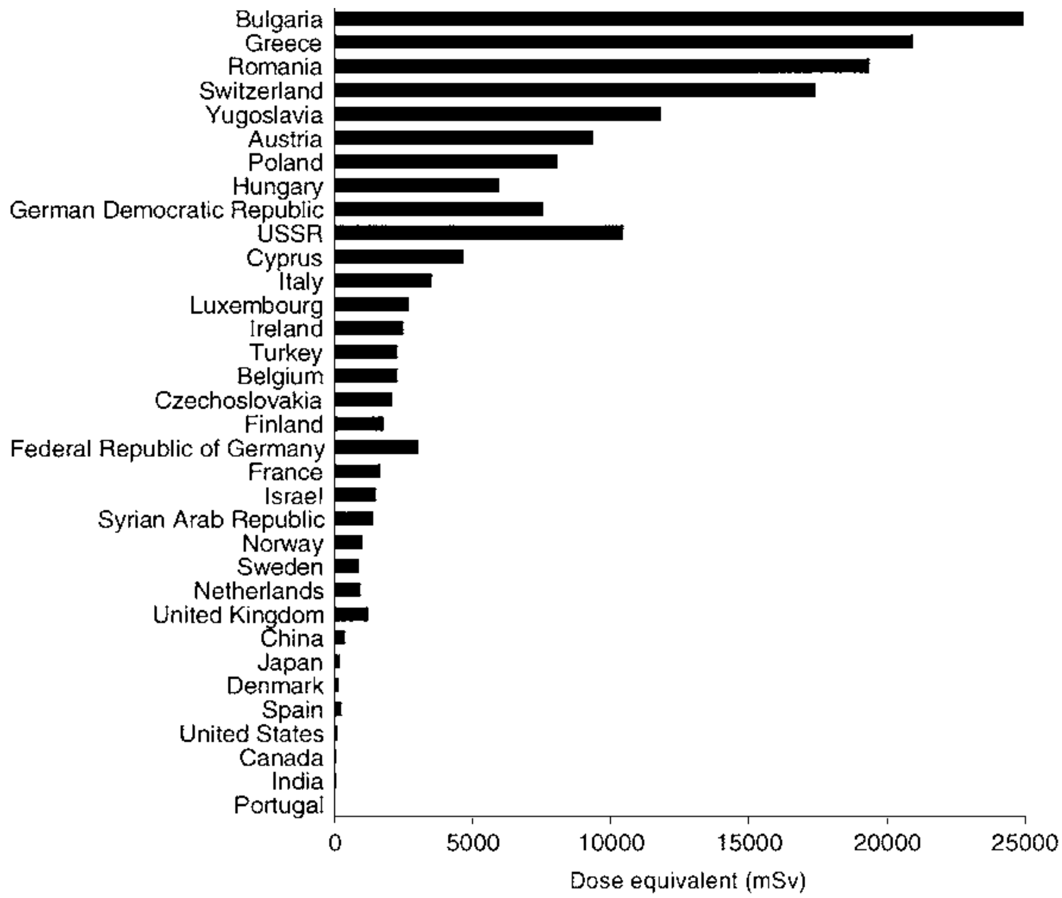


Source: United Nations *(1)*.

Fig. 12.2: Average first-year committed effective dose equivalents from the Chernobyl accident

relative risk given above implies increases of up to 100 times the spontaneous risk. This represents a serious potential public health problem. As indicated above, however, the estimate is based on the assumption that iodine-131 is as carcinogenic as external radiation in children; this underlines the urgent need for a better understanding of the risks associated with exposure to iodine isotopes.

At present, there is no firm evidence of an increased incidence of any other type of radiation-inducible cancer as a result of the Chernobyl accident. The relative absence of baseline data on cancer incidence and mortality in these regions may make it difficult for epidemiological studies to detect increases. Nevertheless, the accident had substantial negative psychological consequences: anxiety and stress due to the continuing high levels of uncertainty. The direct impact of stress and the changes in lifestyle (such as increased drinking and smoking) that were its indirect results may well have had effects on health and wellbeing that far exceeded the direct effects of the radiation exposure. The perception of the risk of exposure to radiation, rather than the exposure itself, has produced what has been called an epidemic of stress-related diseases. Information is still fragmentary and mainly circumstantial, but there is no doubt that the fear of exposure to radiation has caused psychosomatic illness and that considerable social disruption has resulted (a negative effect on wellbeing). A less noticed health consequence of the Chernobyl accident is the sharp increase in abortions in southern Europe because of fear of birth defects [15].



Source: United Nations *(1)*.

Fig. 12.3: Average first-year infant thyroid dose equivalents from the Chernobyl accident

12.4.2 Safety of nuclear power plants

A nuclear power plant in operation normally releases negligible amounts of radioactivity into the environment. Under normal conditions, exposure is far less than that from natural background sources, such as radionuclides in the soil and cosmic rays. The safety of a nuclear power plant is governed by the likelihood of a significant release to the environment of radioactive material in the event of a malfunction or accident. The risk of such an incident depends on several factors, including the design of the plant (with or without multiple physical barriers or containments), its maintenance and the level of staff training.

Several lines of physical barrier should be used in nuclear power plants:

- a fuel matrix consisting of pellets that bind the fission products;
- a cladding on the fuel rods that seals the pellets in the rods;
- a primary coolant circuit, which is composed of pressure vessel, valves, pipes and other components and circulates coolant to prevent heat damage to the fuel rods; and
- a containment that comprises a hermetically sealed building and confines radioactive materials within the plant.

Redundancy, diversity and spatial separation of the safety components dominate the design principles. Safety measures should be taken at several levels.

1. Plants should be designed and operated with conservative margins of safety using, for example, strict quality requirements for construction materials.

2. Operating systems should be designed to counter abnormal events through inherently safe design, additional equipment such as back-up electricity generators in case of loss of power, and high-sited water reservoirs for emergency cooling.
3. Safety systems should respond automatically to prevent events from escalating into a severe accident; for example, the control rods should move into the core by gravity alone.
4. Special design features should be used (such as a core catcher to prevent radioactivity contaminating groundwater, vents to release pressure and sand filters to retain gaseous radioactivity) to preserve the integrity of the containment structure and minimize releases to the environment.

In addition to proper design, an adequate number of qualified and motivated staff is necessary to operate and service the plant. Regular and scheduled preventive maintenance and surveillance ensure that the structural components and systems continue to operate at the intended level of safety.

Not all the nuclear power plants in the European Region meet these stringent standards. RMBK reactors, which lack both an inherently safe design and appropriate containment, are an obvious cause for concern in some of the CCEE and NIS. In other countries of the Region, the operation of aging reactors may be a potential problem. To reduce the risk of an accidental release of radioactivity to the environment, countries with more advanced technology should assist others in improving their safety standards. The Chernobyl accident has shown that the release of radioactivity is not confined to the immediate vicinity of the accident scene, but may also affect places thousands of miles away.

A different type of potential problem may exist where nuclear power dominates energy policy. In such a situation, the adjustments necessary for safety may require the reduction of electricity production to levels uncomfortable for the consumer; plants may therefore be kept operating to suboptimal safety standards. Ideally, the principle of diversity should be maintained not only in the design of safe nuclear power plants but also in the supply of electricity by different sources.

Finally, the safety of nuclear technology and control of its radioactive inventory requires a certain stability in society and may be threatened by war or other major social upheavals.

12.4.3 Weapons testing

The extensive programmes for testing nuclear weapons during the 1950s and part of the 1960s released enormous quantities of radioactivity; after injection into the upper atmosphere, this was distributed over the entire northern hemisphere. It created a fallout that continues to provide a component of environmental radiation exposure, particularly in areas with heavy rainfall. Annual doses are now very small in comparison with the variations in natural background radiation.

12.4.4 Disposal of radioactive waste

The various forms of waste can be categorized by their level of radioactivity, heat content and potential hazard. Radioactive waste may thus be divided into low-, intermediate- and high-level waste. Low-level waste includes slightly contaminated material such as industrial trash and hospital waste. This can normally be handled without special shielding. Intermediate-level waste may include solidified chemical sludges, as well as pieces of equipment or metal fragments, and might require some shielding. Low-level waste is usually deposited in near-surface structures or shallow burials. With the exception of sea dumping, which relied upon dilution and dispersion in the environment and is now suspended, all disposal concepts for low- and intermediate-level waste rely on isolation from the biosphere until radioactive decay has made subsequent releases to the environment compatible with radiation protection criteria.

High-level waste generates much heat and penetrating radiation for centuries. There are four kinds of such waste:

- spent fuel, consisting of the uranium remains contaminated with fission products;
- actinides formed from uranium nuclei, including long-lived alpha particle emitters such as plutonium-239;
- concentrated fission products arising from the reprocessing of spent nuclear fuels; and
- by-products of weapons programmes.

At present, no country has a high-level waste repository; IAEA predicts that the first will be operational in 2010 [16]. Compared with the spent fuel of nuclear reactors, the mass of waste generated from military applications of nuclear technology is enormous. Waste from civilian nuclear plants, however, contains more radioactivity and is increasing more rapidly than waste from military programmes.

Most countries using nuclear power plants, except the NIS, have programmes for the safe disposal of spent fuel. One of the major problems arises from the very long half-lives of some of the radionuclides present in the waste; it is impossible to provide absolute proof of safe repository performance over such long periods. In most countries, spent fuel and solidified high-level waste will be stored for about 20–100 years before disposal. The problem of what to do with worn-out nuclear power plants has developed an important new dimension, with evidence that some reactor components may remain radioactive for thousands of years. Of major concern are the very long-lived isotopes of nickel and niobium, which are added in traces to some steels to inhibit cracking.

While most radioactive material and waste are stored under secure conditions, the unauthorized sale of radionuclides or sources of radioactivity (including those used in radiotherapy) has alarmed some European authorities, especially those in countries sharing borders with the CCEE and NIS.

Table 12.2: Percentage of the population exposed to radon equilibrium equivalent concentrations[a] in various countries of the European Region

Country	Year reported	Percentage exposed to:					
		<50 Bq/m^3	50–100 Bq/m^3	100–200 Bq/m^3	200–400 Bq/m^3	400–1000 Bq/m^3	>1000 Bq/m^3
Czechoslovakia[b]	n.a.[c]	72	16	7.3	3.0	1.3	0.3
Denmark	1988	88	10	2	<0.2		
Germany	1985	89	6	3	1	0.6	0.2
Finland	1987	67	21	8.5	2.5	0.7	0.3
Hungary	1985	95	5				
Italy	1992	79	15.9	3.7	1.2	0.1	0.01
Luxembourg	1988	83.8	11.2	3.5	1.3	0.2	
Netherlands	1984	99.0	1.0				
Norway	1988	83.0	12.0	5.0			
Romania	n.a.	87.1	9.6	2.3	0.5	0.3	0.1
Sweden	1984	70.6	18.5	6.9	2.3	1.5	0.1
United Kingdom	1987	98.0	1.6	0.4	0.1	0.01	

[a] The equilibrium equivalent concentration is the activity concentration of radon in radioactive equilibrium with its short-lived progeny that has the same potential alpha energy concentration as the actual non-equilibrium mixture. The ratio of the equilibrium equivalent concentration to the activity concentration of radon is given by the equilibrium factor F, which is about 0.7 in open air and about 0.4 in dwellings.

[b] These data refer to percentages of dwellings.

[c] n.a. = not available.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

The proliferation of radioactive materials such as plutonium or enriched uranium, which can be used to produce nuclear weapons, is a problem of global importance.

12.4.5 Radon

Radon and its decay products contribute most to the average annual exposure of the general population from almost all sources, both natural and man-made, and are the principal source of exposure to alpha radiation. The highest radon concentrations are found in underground uranium mines but other mines, natural caves, tunnels and water supply systems also have raised radon levels.

Domestic exposure to radon decay products depends on local geology and housing construction, including insulation. Table 12.2 shows the percentage of the population exposed to different levels of radon equilibrium equivalent concentrations in different countries. In certain regions of the Czech Republic, Finland and Sweden, the average level of exposure might be ten times higher than that for most of the population; in even smaller areas, concentrations several orders of magnitude higher are observed. Typical annual radiation doses in European dwellings are 1–3 mSv but a small percentage of the population, particularly in Nordic countries, receives more than 20 mSv per year as a result of exposure to radon.

Health effects other than lung cancer have been mentioned. Data are sparse, associations weak and the results of different studies inconsistent, however. Risk estimates for lung cancer due to radon exposure have been derived principally from the experience of uranium miners, who are exposed to high levels, often in very dusty atmospheres (Box 12.3). Such exposure is not typical of the domestic environment and may thus not be a reliable basis for extrapolation [17].

The lung cancer risk from domestic exposure to radon is at present uncertain. The most recent and extensive study, from Sweden [8], indicates a risk similar to that observed in miners [3]. This implies an average lifetime risk of fatal lung cancer of 1 in 80 from lifetime exposure to 200 Bq/m^3 (radon gas), assuming that risk increases linearly with exposure. However, the lung cancer risk in this study [8] is expressed primarily in the highest exposure groups, and predominantly in smokers; the risk in nonsmokers was about 1 in 3500. People sleeping close to an open window incur no lung cancer risk from radon, whether smokers or nonsmokers.

These risk factors are taken into account in making decisions on policies to reduce risks from exposure to radon in dwellings. ICRP, however, has drawn attention to the fact that the same action level for remedial work is unlikely to be appropriate in all countries [5]. It will be important to avoid setting the action level too low, and thus defining an unmanageable number of houses, and to concentrate first on effective remedial action in those where radon risks are highest. Table 12.3 illustrates this principle, showing the levels at which action is recommended or

Box 12.3: Uranium mining in the German Democratic Republic

In the middle of one of Europe's most densely populated regions, the *Länder* of Saxony and Thuringia in Germany have a large-scale uranium mining industry. Since the twelfth century, mining has been a tradition in the Erzgebirge "Ore Mountain" region in south-eastern Germany. Silver, nickel, bismuth and cobalt were mined at first. After 1945 and under the misleading name of Wismut (bismuth), uranium was produced under Soviet leadership. The Soviet–German mining company SDAG Wismut became the third largest producer of uranium after the United States and Canada.

From 1946 to 1954, mining conditions were primitive. Ore was drilled underground

Box 12.3: Uranium mining in the German Democratic Republic

without damping down the dust. There was no forced ventilation to reduce the high concentrations of radioactive radon gas that accompanied the uranium ore. In some shafts, radon gas concentrations as high as 300 kBq/m^3 were later assessed. It was estimated that miners received effective doses of up to 3 Sv per year at that time. After 1954, radiation protection in the mines was improved as a result of the introduction of forced ventilation and drills that damped the dust down. Thereafter, miners' radiation doses dropped to 15 mSv per year.

In the early 1950s, the peak years of the mining operation, the workforce comprised 150 000 people, including forced labour. After 1954, however, the number of miners steadily decreased to about 30 000. Exact figures on the workforce are not available because uranium was mined under paramilitary conditions, and in absolute secrecy, until 1989. Mining was discontinued at the end of 1990. In the final years, 3200 tonnes of uranium were produced annually, in contrast to 8000 tonnes in the peak years. The Wismut company now belongs to the German Federal Ministry of Economics.

Until 1990, about 5200 cases of lung cancer and about 15 000 cases of silicosis were officially recognized as occupational diseases. The total number of lung cancer cases is thought to be up to three times higher, since there is evidence that many miners moved to other parts of Germany and their deaths from lung cancer may not have been recognized as being connected with their earlier occupation. The size and exposure of the population of German uranium miners are much higher than all other known uranium miner cohorts, as is the known number of lung cancer cases. Initial investigations indicate that the miner data are of a quality similar to or higher than that of data from other epidemiological studies on the risk of lung cancer due to radon. Epidemiological studies, sponsored by the German Government and using Wismut miners' records, could lead to better estimates of the cancer risk from radon exposure. There is some evidence that the Wismut files also contain data on many women working underground. The evaluation of these data could provide useful information on possible gender differences in cancer risk.

There is some concern that people living in this region have a higher health risk than the general population in Germany, owing to the massive uranium mining and processing activities. The radioactive content of thousands of dumps of waste rock and several tailing ponds is an environmental health hazard. The ponds are contaminated not only by radioactive material but also by heavy metals and toxic chemicals such as sulfuric acid and arsenic. Some homes are known to be built from materials with radioactive contamination, and some are located on top of old mineshafts. Indoor radon concentrations in such situations are among the highest in the world. In Schneeberg, radon gas concentrations in about half the buildings exceed 250 Bq/m^3; the average value is 300 Bq/m^3 and, on the basis of short-term measurements, 1.2 % of buildings have concentrations above 15 kBq/m^3 (the maximum being more than 100 kBq/m^3).

The lung cancer risk to uranium miners leads to an expectation of increased mortality from lung cancer among inhabitants of the mining region. Investigations to date, however, have shown that neither general nor cancer mortality is higher in the region than elsewhere in eastern Germany. There are some indications of an increased lung cancer rate among both men and women in certain mining communities. More extensive studies are under way, the results of which may indicate whether synergistic effects (from, for example, the dusts to which miners, but not house occupants, are exposed) are important factors in determining lung cancer risks from radon inhalation.

Table 12.3: Levels of the annual average radon gas concentration in air in dwellings at which action is recommended or required

Country	Action level: radon gas (Bq/m³)	
	Existing dwellings	Future dwellings
Sweden[a]	400	200
Finland[a]	400	200
Norway	400	200
Germany	250	250
Ireland	200	200
United Kingdom	200	200
Czech Republic	200	100

[a] At these levels, action is compulsory.

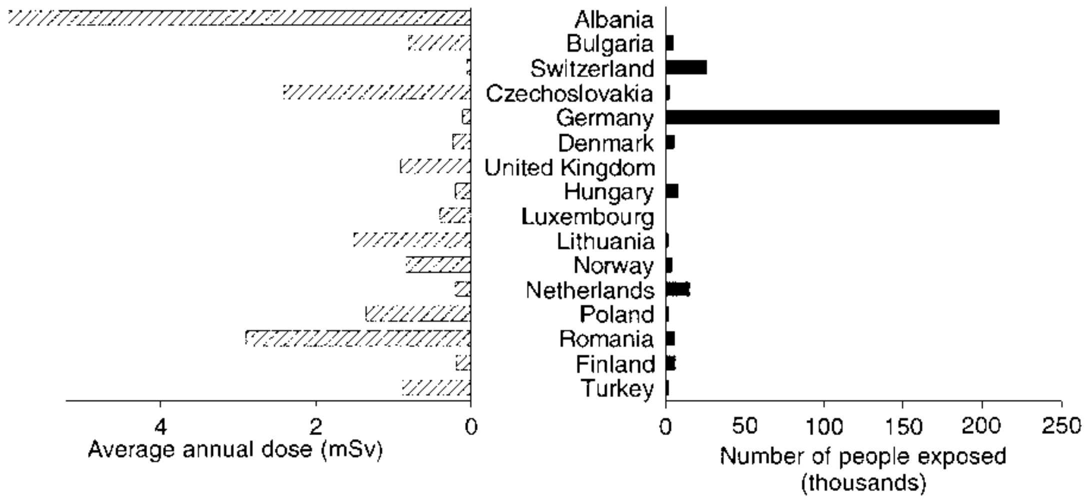
Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

required in different countries. ICRP [18] estimates that an action level for radon gas of 200 Bq/m^3 would correspond to an annual effective dose of 3 mSv. Given a lung cancer risk factor of 7.3 10^{-5} per mSv, the approximate lifetime cancer risk at 200 Bq/m^3 is 1 in 2000.

The technical procedure for remedial work needs to be adopted from the outset; the procedure selected should be the one that is most likely to keep the radon level to a value well below the action level. Intervention needs to begin soon after the discovery of elevated concentrations, particularly if they are substantially above the action level. For preventive work, construction codes and building guides need to be devised to achieve low radon concentrations in new buildings.

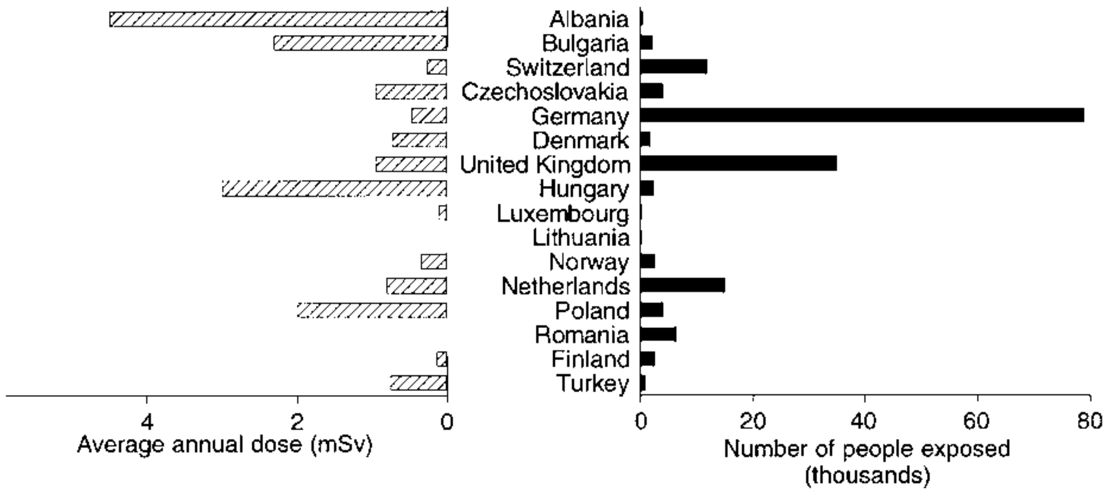
12.4.6 Occupational exposure

Occupational exposure to radiation is divided into the following categories: medical care, research and industry, and nuclear power. The average annual dose for each category varies between countries, and the dose in any one country varies between categories (Fig. 12.4–12.6). With the exception of some of the CCEE and NIS, the average annual doses to monitored workers have decreased steadily in recent years and are now of the same order as the total dose from natural radiation. A large variation for the same category between countries should stimulate activities to improve radiation protection, although the differences in methods of personnel monitoring, dose assessment and record keeping in each country have to be considered. More detailed comparisons would probably reveal that each country could learn and perhaps improve its own procedures for dose assessment by more carefully studying how other countries deal with personnel monitoring.



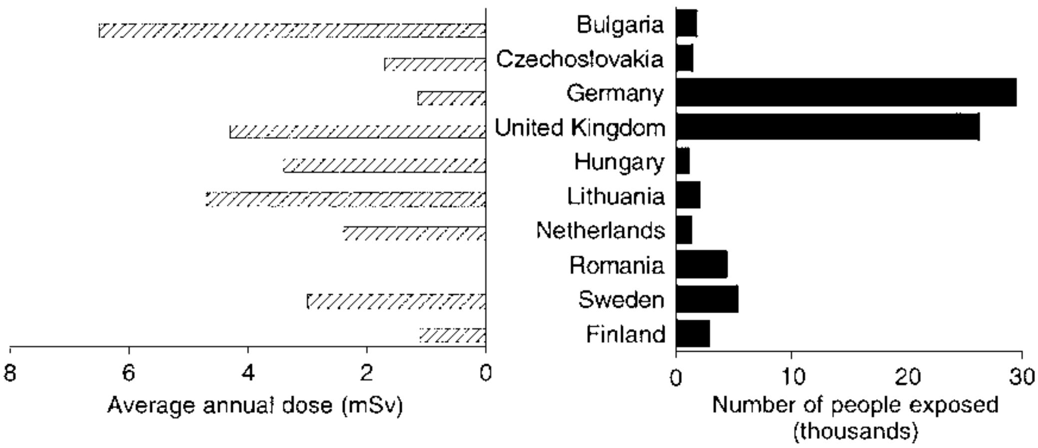
Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 12.4: Occupational exposure to ionizing radiation: medical care



Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 12.5: Occupational exposure to ionizing radiation: research and industry



Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 12.6: Occupational exposure to ionizing radiation: nuclear power

Only a few data are available for exposure from the mining and milling of uranium; the current number of and radiation doses to uranium miners in the Region are difficult to establish. The occupational exposure of such miners is expected to be higher than that of workers in other categories; estimates are up to 10 mSv per year on average. Other miners may also be exposed to increased levels of radon, depending on the geological characteristics of the area being mined. In general, non-coal miners receive higher doses than coal miners, with a likely average annual dose of the order of 5 mSv.

The ICRP recently recommended that air crews be considered as occupationally exposed persons whose exposure should be controlled [5]. There are only a few estimates of the exposure of flight personnel; the average is 5 mSv per year from 600 hours of flight time [19].

A direct assessment of the carcinogenic effects of long-term, low-level radiation on human beings has been made from studies of cancer risk among workers in the nuclear industry. Observations of 131 000 radiation workers in the United Kingdom and the United States provide estimates of the lifetime risks of leukaemia and other cancers that are close to those (obtained by extrapolation from high-dose and high-dose-rate exposure) on which current radiation protection is based [20].

12.5 Conclusions

Human beings can be exposed to ionizing radiation from cosmic sources or the soil, from man-made sources such as nuclear power, and from environments with increased radiation exposure from technical processes such as mining. Exposure to cosmic rays and terrestrial gamma rays is a fact of life. Natural background radiation contributes most to the average human exposure, and on average half of this contribution comes from lung irradiation by radon and its decay products. Individual doses from radon, however, may be much higher. Other sources or practices, such as nuclear power production and the use of radioactive material in industry and research, contribute doses to the general population that are on average several orders of magnitude lower than total doses from natural sources. The exception is some population groups that are exposed to significant doses as a result of nuclear accidents, particularly through internal exposure.

Current or potential problem areas include the safety of nuclear power facilities, the proliferation of nuclear material, and the safe disposal or storage of nuclear waste.

In all nuclear plants, safety standards need to be implemented using the best available technology. Nuclear power safety is one of the most important issues in radiation protection. An international consensus is needed to provide technical help to countries with less secure power plants.

The proliferation of radioactive material that could be used for the construction of nuclear weapons is a threat of global importance. The problems entailed in the decommissioning of nuclear power plants and the destruction of atomic weapons have not yet been solved. The residual radioactive material needs safe disposal. Meanwhile, no country yet operates a repository for high-level radioactive waste.

In addition to these more global problems, the higher exposure of special population groups needs attention. These include:

- workers carrying out "dirty" jobs that are associated with higher than average doses or involve exposure to actinides such as plutonium;
- people exposed to higher than average levels of natural radiation, including those living in areas with high levels of radon, miners and air crews.

References

[1] United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources, effects and risks of ionizing radiation*. New York, United Nations, 1988.

[2] United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources and effects of ionizing radiation*. New York, United Nations, 1993.

[3] Committee on the Biological Effects of Ionizing Radiation. *Health risks of radon and other internally deposited alpha-emitters.* Washington, DC, National Academy Press, 1988.

[4] National Radiological Protection Board, United Kingdom. *Radiation atlas. Natural sources of ionising radiation in Europe*. Luxembourg, Office for Official Publications of the European Communities, 1993 (EUR 14470).

[5] *Recommendations of the International Commission on Radiological Protection, 1990*. Oxford, Pergamon Press, 1991 (ICRP Report No. 60).

[6] Gardner, M.J. et al. Results of a case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. *British medical journal*, **300**: 423–429 (1990).

[7] Neuberger, J.S. Residential radon exposure and lung cancer: an overview of ongoing studies. *Health physics*, **63**: 503–509 (1992).

[8] Pershagen, G. et al. Residential radon exposure and lung cancer in Sweden. *New England journal of medicine*, **330**: 159–164 (1994).

[9] Pershagen, G. et al. Residential radon exposure and lung cancer in Swedish women. *Health physics*, **63**: 179–186 (1992).

[10] Baverstock, K.F. & Thorne, M.C. Radiological protection and the lymphatic system: the induction of leukaemia consequent upon the internal irradiation of the tracheobronchial lymph nodes and the gastrointestinal tract wall. *International journal of radiation biology*, **55**(1): 129–140 (1989).

[11] Burkart, W. & Kellerer, A.M., ed. A first assessment of radiation doses and health effects in workers and communities exposed since 1948 in the southern Urals. *Science of the total environment*, **142**: 1–2 (1994).

[12] *Nuclear power and health. The implications for health of nuclear power production*. Copenhagen, WHO Regional Office for Europe, 1994 (WHO Regional Publications, European Series, No. 51).

[13] Baverstock, K.F. A preliminary assessment of the consequences for inhabitants of the UK of the Chernobyl accident. *International journal of radiation biology*, **50**(1): 3–13 (1986).

[14] *The international Chernobyl project*. Vienna, International Atomic Energy Agency, 1992.

[15] Spinelli, A. & Osborn, J.F. The effects of the Chernobyl explosion on induced abortion in Italy. *Biomedicine and pharmacotherapy*, **45**(6): 243–247 (1991).

[16] *IAEA bulletin*, **34**(3) (1992).

[17] Doll, R. Risks from radon. *Radiation protection dosimetry*, **42**: 149–153 (1992).

[18] *Protection against radon-222 at home and at work*. Oxford, Pergamon Press, 1994 (ICRP Report No. 65).

[19] Regulla, D. et al. Radiation exposure of civil air crew. *Kerntechnik*, **58**(5): 299–303 (1993).

[20] Doll, R. Epidemiological evidence of effects of small doses of ionising radiation, with a note on the causation of clusters of childhood leukaemia. *Journal of radiological protection*, **13**(4): 233–241 (1993).

Chapter 13
Residential Noise

13.1 What is Residential Noise?

Noise has been called "an insidious poison" [1]; it is an external factor with a negative influence on the environment but without direct physiological harm to exposed human beings. This is particularly true of residential noise, which people encounter in their homes and similar environments such as hospitals, schools and hotels. The main negative effects of such noise on people are disturbances of communication, rest and sleep, and general annoyance. Over long periods of time these effects have a detrimental influence on wellbeing and perceived quality of life.

While the reaction to noise varies from one person to another, negative effects increase with noise level. A level has been identified (65 dBA) above which considerable annoyance occurs in the large majority of people. The Organisation for Economic Co-operation and Development (OECD) [2] reported that, in the early 1980s, more than 130 million people in its member countries were exposed to noise above this level. The WHO Regional Office for Europe collected data on noise from Member States of the European Region[a] that confirm this scale of population exposure. In this chapter, these and other available data comprise background for a survey of residential noise in most of the 23 Member States that responded to the WHO questionnaire.

In contrast to the nonspecific health effects of residential noise, exposure to high levels of noise at work over extended periods may result in irreversible and disabling impairment of hearing (see Chapter 15). This chapter does not address these problems, or those related to infrasound generated by machinery and heavy traffic.

This chapter defines residential noise – which is also called community, environmental or domestic noise – as noise experienced in closed rooms of dwellings as a result of the operation of one or more noise

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

sources not related to the dwelling (see Box 13.1). For acoustic reasons, residential noise is measured outside, at the facade of the dwelling. Noise levels inside the dwelling may be estimated from outside levels if the sound insulation of the facade is known. Most countries have regulations on residential noise from road, rail and air traffic and industrial enterprises, and on the acoustic properties of buildings.

Neighbourhood noise comes from sources in or close to residential areas. Typical sources are premises and installations related to the catering trade (such as restaurants, cafeterias and discotheques), live or recorded music, sports events and playgrounds, car parks, and domestic animals (such as barking dogs). Registers of complaints from the public show that neighbourhood noise is an important cause of nuisance to many people. Few countries, however, have regulations on this class of noise, probably owing to the present lack of methods to define and measure it, and the difficulty of controlling it.

Many dwellings are exposed to noise from more than one source. In the Netherlands, 44 % of exposed dwellings receive noise from two or more sources [3]. Very few countries have regulations for such situations. Noise from installations inside dwellings (such as elevators, heating and ventilating systems and refrigerators), however, is often covered by local or national building codes.

13.2 Magnitude of Problems

While levels of indoor noise capable of causing hearing impairment range from 85–90 dBA to 120–130 dBA, depending on the duration of exposure, levels of residential noise of 50–60 dBA lead to annoyance and sleep disturbance. Levels of 60–65 dBA considerably increase annoyance, and those above about 65 dBA seriously harm the perceived quality of life, as they lead to constraints on behaviour patterns. These figures apply to noise from unspecified sources. The acceptability of noise from particular sources depends on their type. For the same degree of annoyance, noise levels from rail traffic may be 4–5 dBA higher than those from air and road traffic [2].

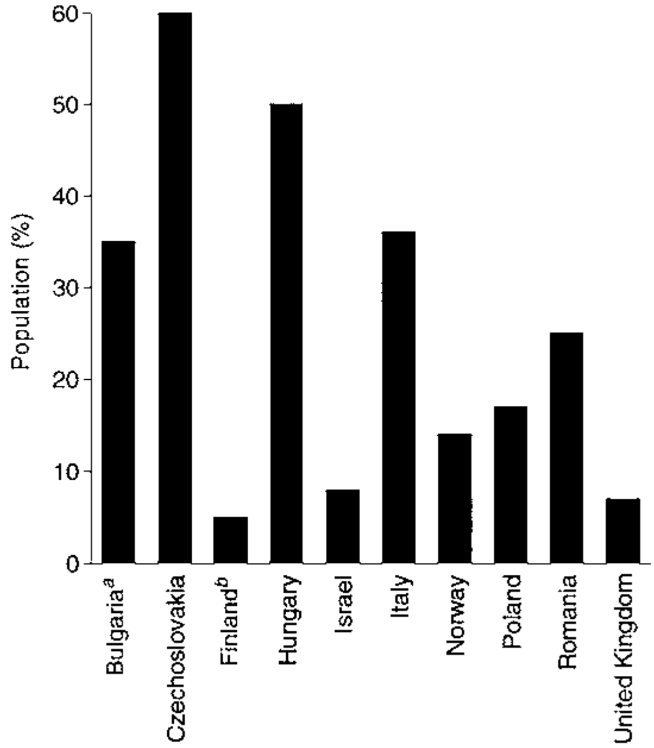
Box 13.1: What is noise and how is it measured?

Noise is usually defined as unwanted sound. The perception of sound and noise depends on three factors: loudness, pitch and duration. Sound level – a logarithmic measure of excess pressure in the atmosphere caused by sound waves – is taken as an expression of loudness. Pitch is a subjective measure of the frequency of sound waves.

Residential noise is measured with a standardized sound level meter placed in front of the facade of the exposed building. The result is expressed as: A-weighted sound pressure level (L_A) or equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$). $L_{Aeq,T}$ is used to describe the total noise exposure over a specified period, such as 24 hours. Both levels are expressed in dbA.[a] A-weighting takes account of the varying sensitivity of human hearing to high- and low-frequency components of noise.

For aircraft noise and other types of fluctuating noise, some countries apply a system that adds 10 dBA to the values of noise occurring at night (22.00–07.00 hours). The outcome is termed day–night level (L_{dn}) in dBA. As a rule of thumb, a L_{dn} is often about 3.4 dB higher than a $L_{Aeq, 24h}$. A variant of L_{dn} is the day–evening–night level (L_{den}), in which a further penalty of 5 dBA is applied to noise occurring in the evening.

[a] dB is a logarithmic quantity corresponding to human perception; a difference in level of 10 dB corresponds to a factor of two in loudness.



[a] Urban areas only.

[b] Traffic noise only.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 13.1: Percentages of populations exposed to residential noise at outdoor levels above 65 dBA (equivalent continuous A-weighted level over 24 hours)

Countries have reported on the estimated number of their citizens currently exposed to levels of noise from unspecified external sources above 65 dBA (Fig. 13.1). Such levels affect about 26 % of the total population of the responding countries, in contrast to the 15 % reported by OECD around 1980 [2]. Table 13.1 shows the proportion of the population exposed to levels over 55 dBA for each of the most important noise sources: road, rail and air traffic and industrial activity. Road traffic is the dominant source of residential noise.

A comparison of data from OECD [2] and WHO on exposure to noise levels above 65 dBA reveals a surprisingly similar tendency, given the different traffic structures prevailing in the responding countries. OECD data include Australia and Japan; WHO data are from certain countries of the European Region.[a] Both organizations give about 20 % as the proportion of the population exposed to residential noise levels over 65 dBA from road traffic. The figures for rail and air traffic differ more, with OECD giving respectively 3 % and 0.7 % as the shares of population affected, and WHO giving 0.2 % and 1.7 %. The difference in railway noise may be related to the fact that the OECD data include Switzerland, where railway noise is an important problem. Fig. 13.2 displays the WHO data on road traffic noise. Considering the serious nuisance of residential noise levels above 65 dBA, the number of people exposed to them justifies efficient legal and technical action to reduce or at least to limit exposure.

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 13.1: Percentage of the population exposed to various levels of residential noise from road, rail and air traffic and industry (equivalent continuous A-weighted levels over 24 hours)

Source and levels	Czecho-slovakia	Denmark	France[a]	Germany[a]	Hungary[a]	Israel	Italy[a,b]	Netherlands[c]	Norway	Sweden
Road traffic										
>55 dBA	–	30	54.5	45.0	30	–	97	29.0	30	16
>65 dBA	35	10	16.5	12.5	10	–	72	8.7	14	4
>75 dBA	–	–	0.6	–	2	–	27	0.03	0.7	–
Rail traffic										
>55 dBA	–	–	1.2	18	10	–	–	19.7	0.5	3
>65 dBA	1.5[a]	0	0.4	3	3	–	–	3.6	0.1	0.3
>75 dBA	–	–	–	0	1	–	–	0.9	–	–
Air traffic										
>55 dBA	–	1[b]	1.2	–	5	35[b]	–	23	4	0.7
>65 dBA	3[a]	0[b]	0.4	–	0.5	12[b]	–	2	0.5	0.002
>75 dBA	–	0[b]	–	–	–	–	–	–	–	–
Industry										
>55 dBA	–	–	–	–	5	20[a]	–	–	2	–
>65 dBA	0.5[a]	–	–	–	0.5	2[a]	–	0.1	–	–
>75 dBA	–	–	–	–	–	–	–	–	–	–

[a] Daytime only.
[b] Urban areas only.
[c] Levels in L_{dn}.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

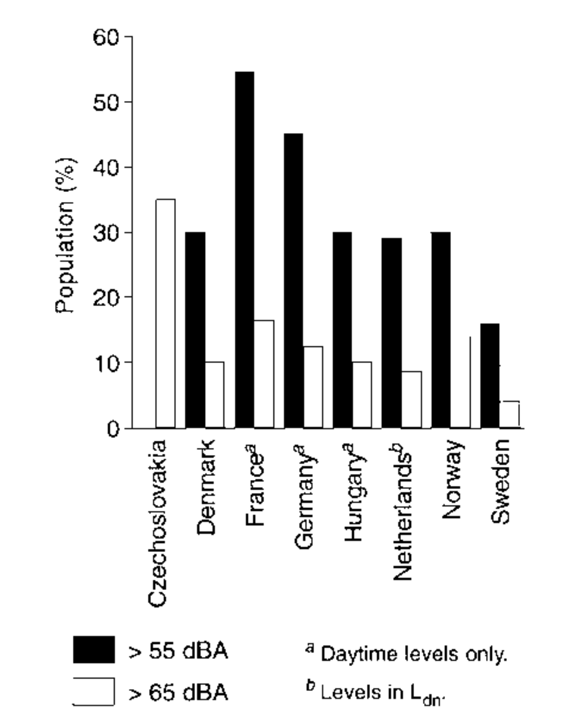


Fig. 13.2: Percentages of populations exposed to residential noise from road traffic levels outdoors above 55 dBA and 65 dBA (equivalent continuous A-weighted level over 24 hours)

13.3 Annoyance

In general, noise levels encountered in private life do not cause hearing impairment but have indirect effects on health, such as those related to sleep deprivation. Morbidity data related to residential noise exposure are scarce.

Concern is increasing about self-inflicted or leisure noise as a source of permanent hearing impairment. This noise includes loud music heard through the headphones of personal stereo equipment or in discotheques, often at levels above 90 dBA. While the results of investigations to date are not always consistent [4,5] current research may resolve the uncertainties. Other sources of high-level, non-occupational noise include some types of public transport. Sound levels in the passenger compartments of some underground trains may exceed 90 dBA. Such noise may have unknown long-term effects on hearing, perhaps in combination with the normal, age-related deterioration of hearing acuity.

Much lower levels, however, such as those found in residential areas, may induce widespread general annoyance. This may be limited to feelings of displeasure evoked by noise [6] or result in an unwanted change in lifestyle and habits. Tolerances vary enormously; even at noise levels to which the average response is no annoyance, 10% of exposed people feel highly annoyed [4]. The time structure of the intrusive noise is also important. Most people find noise pulses more annoying than a steady noise at the same level.

Unlike hearing impairment, noise-induced annoyance cannot be quantified directly from medical and acoustic examinations. The relationship between noise level and the annoyance of people in a residential area can be quantified in the laboratory or in the field. In the laboratory, a number of test subjects representative of the population of the area are invited to an acoustic laboratory and placed in a room furnished as a living room. There they are exposed to recordings of noise and interviewed on their annoyance under defined conditions. Social surveys are performed in the field. Trained interviewers visit inhabitants of an area in their homes, and ask for their responses to a set of standardized questions, some of which are related to noise from outdoor sources.

Both approaches have advantages and disadvantages. Laboratory conditions provide excellent control over the acoustic stimuli, but the environmental conditions are far from a homelike atmosphere. This may create a strong, unpredictable bias in the subjects. While field studies provide a homelike atmosphere for subjects, there is little control over the acoustics, particularly because acoustic properties (including local background noise) vary appreciably between furnished dwellings in an area. These and other factors result in a comparatively large spread in the results. It is very important to keep in mind that, because of psychological and statistical implications, all results obtained by the two methods must be considered group responses. They cannot be used to predict or evaluate the responses of individuals.

Numerous investigations on annoyance from various noise sources have been reported. Most were concerned with problems caused by heavy traffic on motorways and at civilian and military airports.

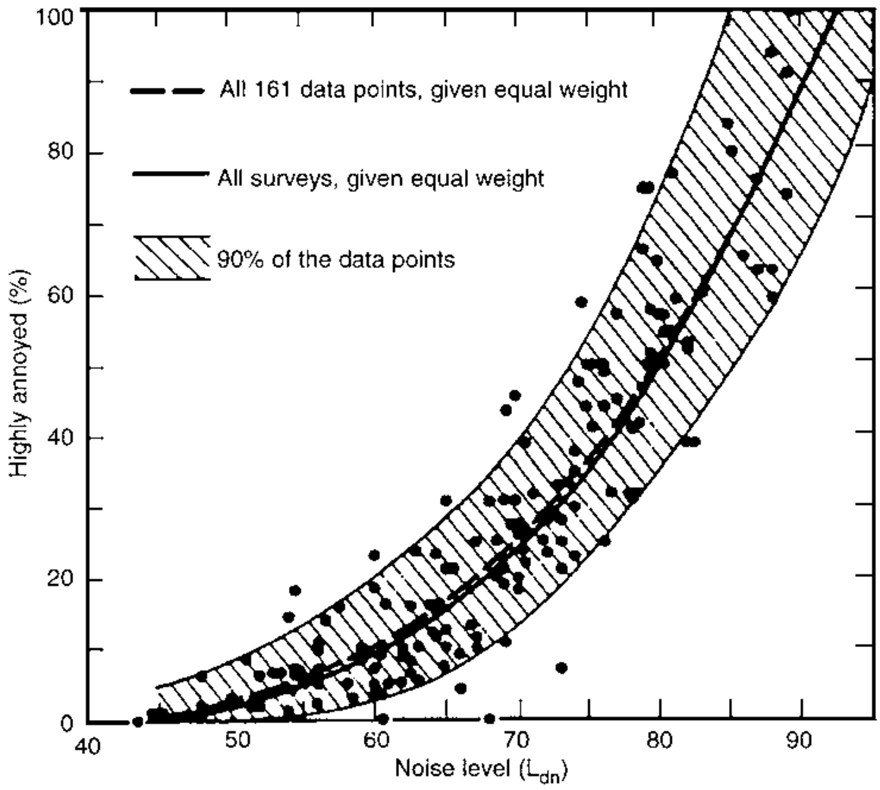
The results of a large number of studies (Fig. 13.3) show a general increase in perceived annoyance with increasing noise level [7]. The inherent spread makes it impossible to establish a simple, universally applicable relationship between noise levels and different classes of annoyance. The spread is usually attributed to the influence of non-acoustic factors and the differences in subjects' interpretation of the word "annoyance", as used in interviews and questionnaires. The practice has developed of using the percentage of highly annoyed people as an indicator of the magnitude of nuisance, because they are probably less affected by non-acoustic stimuli.

Of the non-acoustic components of annoyance, the people exposed to noise most frequently report a perception of lack of control of or benefit from the operation of the source [8]. For aircraft noise, the fear induced by frequent, low-altitude flyovers adds to the perceived annoyance. Informal investigations seem to indicate national and local differences in tolerance for noise from certain sources, particularly motor vehicle horns and military aircraft.

The key indicators of the magnitude of total noise nuisance are disturbances of sleep, rest and communication [9,10].

13.3.1 Disturbance of sleep

Disturbances of the normal sleep pattern – either difficulties in falling asleep or sudden awakening – are undoubtedly the most important negative effects of residential noise. Sleep is affected by lower sound levels than any other human activity. In general, levels below 45 dBA (measured outdoors) seem to be without ill effects, but personal sensitivity



Note: Reproduced by permission of Applied Science Publishers Ltd, United Kingdom.

Source: Schultz, T.J. *(7)*.

Fig. 13.3: Relationship between noise level and annoyance as shown by a summary of 161 data points from 11 surveys, 1961–1974

varies considerably. Children, for example, are in general less sensitive than adults by about 10 dBA. In addition, bursts of noise (from traffic, for example) are more intrusive than a continuous noise of the same level. Levels above 50–60 dBA greatly increase the time taken to fall asleep.

For many years, research has investigated the underlying mechanisms of and the thresholds for noise-induced sleep disturbance. Neurophysiological methods – including the monitoring of electroencephalograms of subjects sleeping in quiet and noise – have produced some important results [4,9]. Reliable studies, however, are extremely difficult to design, manage and interpret. Whether in the laboratory or in their own homes, the people used as test subjects have highly individual living habits and sleep patterns, which are very vulnerable to unusual influences such as the presence of recording instruments. Further, disturbances of sleep can be related to factors other than noise; 20% of the people living in Greater London are subject to such disturbances [4].

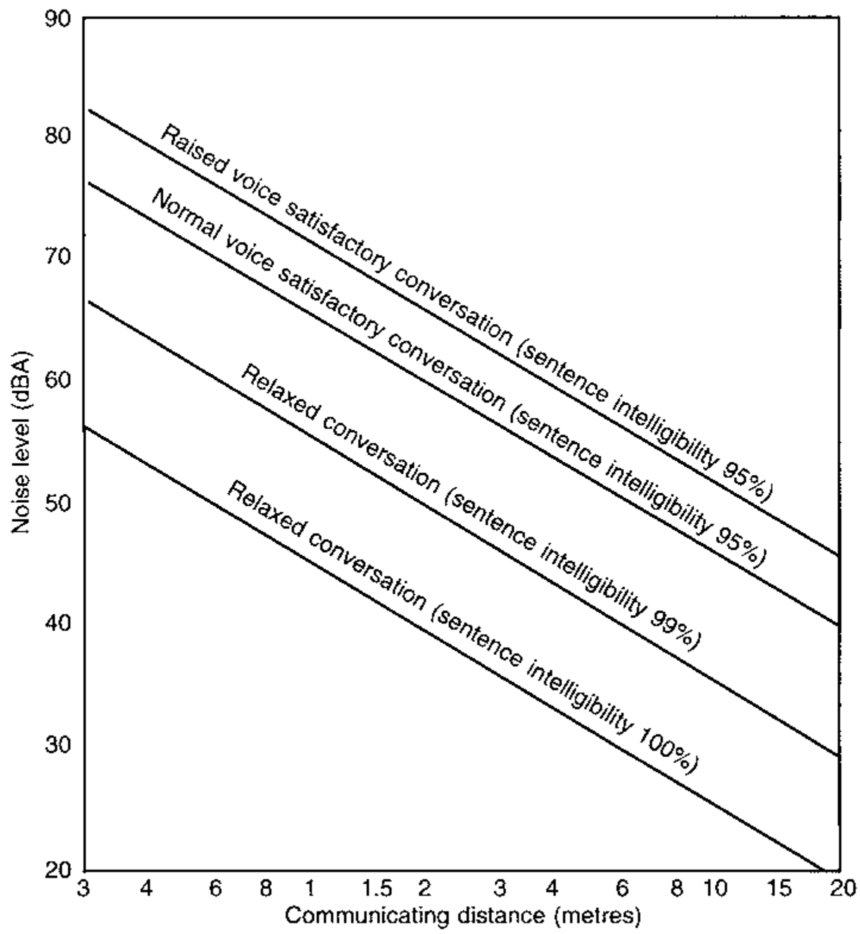
The effects of sleep disturbances are well known to most people, regardless of the reason for the disturbance. They include mood change and reduced performance at intellectual and mechanical tasks. The main difference between people exposed to noise and others is that the latter experience such effects only occasionally. A population exposed to noise may encounter sleep disturbances night after night, perhaps over many years. Although such people may become more or less accustomed to nocturnal noise, complete physiological habituation to sleep-disturbing noise does not seem to occur, even after several years of exposure [11]. While no conclusions can be reached about effects on health over several years of observation, despite large-scale research [12], there are indications that long-term nocturnal exposure to noise may be a health risk [9].

13.3.2 Communication disturbances

The term communication disturbance must be interpreted in the broadest sense. In addition to speech – in direct conversation, over the telephone, and from radio and television – music and natural sound should be considered communication signals that should be unaffected by noise from external sources.

In contrast to sleep disturbances, communication problems are primarily associated with daytime activities both in rooms of the dwelling and outdoors. Many complaints of communication disturbances are related to the limitation or prevention of the pleasurable use of gardens, parks, terraces or balconies, because noise masks conversation and natural sounds. Typical complaints are also concerned with the need to keep windows closed to suppress external noise during activities such as conversation, telephoning and watching television. Such problems impose particular strains in the summer months, when the number of complaints about noise increases steeply.

The acoustics of rooms of normal dwellings vary because of differences in size and furnishing. As a result, there is no simple rule for predicting the relationship between noise levels outdoors and communication disturbances indoors. In outdoor conditions, the relation between noise level and distance



Source: World Health Organization *(6)*.

Fig. 13.4: Maximum distances for satisfactory conversation in the presence of noise

between the speaker and listener for the satisfactory intelligibility of sentences is simpler and easier to trace (Fig.13.4) [6].

13.3.3 Stress and fatigue

Research shows that moderate and high levels of noise can elicit stress and physiological changes usually associated with stress and fatigue [11]. The long-term effects of these changes are not well known, mainly owing to the difficulties in conducting full-scale, long-term field studies.

13.4 Effects on Health

The general effects of noise on health have been intensively studied for as long as reliable medical and acoustic instrumentation and methods have been available. Laboratory and field studies of these effects are complex and difficult, involving psychological, physiological, medical and acoustic factors.

The effects of noise on, for example, psychomotor performance, the positioning of the hand in space, cardiorespiratory parameters (blood pressure and heart and respiratory rates) and the dilation of the pupils of the eyes have been experimentally demonstrated [6,13,14]. Laboratory experiments using recorded aircraft noise (at 90 dBA), road traffic noise (at 80 dBA) and factory noise (at 95 dBA) indicate some physiological effects of noise [14]. The importance of such effects for people exposed to noise for a long time is not clear [4,13]. Settling this question requires long-term, large-scale field studies.

Research is in progress in several countries. The results to date from studies in Germany and the United Kingdom suggest that exposure to high levels of traffic noise (above 66–70 dBA) may be associated with a small increase in relative risk of ischaemic heart disease [15]. Owing to the large number of exposed people in the population, however, even a small increase in relative risk may affect public health.

Much research has addressed questions related to the direct influence of noise on mental health, as indicated by such factors as the taking of tranquillizers and admission to mental hospitals. Despite such research, it is difficult to draw overall conclusions of practical value. It is believed that noise may be a factor in aggravating rather than causing mental illness [4].

Further work is needed to establish limits above which long-term exposure to residential noise is causally related to non-specific health effects. It is generally recognized, however, that exposure to such noise over long periods reduces the quality of life. Residential noise is thus an environmental health problem [11]. On the basis of numerous social surveys in the United States, the National Academy of Sciences issued human noise exposure criteria [16]. These suggest that residential day–night noise levels below 55 dBA (corresponding to about 52 dBA over 24 hours) do not in general have permanent adverse effects on public health and welfare.

13.5 Economic and Other Consequences

13.5.1 Depreciation

A measure of the nuisance of residential noise is the depreciation of housing in areas where noise is so annoying that many people do not consider them desirable places to live. Studies in Canada, the United Kingdom and the United States of relations between aircraft noise and housing values pointed to depreciation factors of 0.75% per dBA for low- and medium-priced houses, and 1.0% per dBA for high-priced houses. These factors apply to noise levels of about 60–80 dBA [17].

Such negative effects obviously motivate citizens to exert pressure on authorities to take steps to reduce the noise or to provide adequate compensation by, for example, taking over the property at a reasonable price as a last resort.

13.5.2 Complaints

In a modern society, people subjected to noise annoyance and the owners or operators of noise sources usually do not communicate directly. A more useful strategy may be to apply to the authorities responsible for the environment in question.

Many countries have established national, regional or local systems to register and process the complaints of citizens annoyed by noise. Such systems may efficiently identify noise sources and solve specific and general problems; they must be easily accessible and visible to the general public. Maintaining confidence in a system requires that each case be handled expertly and with a minimum of delay and bureaucracy.

Fourteen European countries have reported to WHO[a] that they maintain systems to collect, process and report public complaints on nuisance created by residential noise; eight countries reported on the contents of their annual reports. In about half, complaints of neighbourhood noise are the most frequently recorded. Table 13.2 shows the number of yearly complaints registered in eight countries of the European Region, and Table 13.3 indicates the distribution of complaints by source of noise. It is important to recognize that the number of complaints only faintly reflects the size of the problem. Only 15–25 % of people highly annoyed by noise are estimated to complain [10]; in general, better educated people show the highest tendency to complain. In addition, the number of inhabitants in a community exposed to noise affects the number of complaints, and probably the importance attached to them by the authorities.

These factors make it difficult to compare the reported number of complaints with the reported data for noise exposure and noise regulations. In addition, the organization and activities of complaint systems, the character of predominant noise sources, and differences in climate and lifestyle are likely to influence differences between countries in

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 13.2: Reported annual number of complaints of nuisance from residential noise per 100 000 inhabitants

Country	Number of complaints
Bulgaria	4
Czechoslovakia	11
Finland	55
France	33
Hungary	1.6
Israel	7.1
Poland	3.2
United Kingdom	7.3

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 13.3: Percentage of complaints about various sources of residential noise

Source	Czechoslovakia	Hungary	Italy	Netherlands[a]	United Kingdom[b]
Industry	50	34	–	4	23
Road traffic	20	–	34	20	–
Neighbourhood	–	35	25	26	50

[a] Data from *Concern for tomorrow* (*3*).
[b] Data do not include complaints to the highway authorities and the Department of Transport.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

the number of complaints. Further complications arise from the fact that, in some countries, different authorities (such as the highway and airport authorities and the police) register complaints about noise so that no complete national reports exist.

13.6 Regulations

Many countries have noise regulations that apply at either a local, regional or national level. They usually aim at reducing exposure to noise in such places as homes, schools and hospitals. An efficient and reliable system for noise reduction through statutory regulations must rely on a few important conditions. First, limits must be clearly specified in practical terms so that they can be complied with through the application of existing technology. Second, qualified personnel and instruments and methods to monitor and control noise conditions must be available throughout the country. Third, enforcement must be quick and efficient and the results should be published to increase professional and public interest in and understanding of noise problems.

The most efficient way of reducing a noise problem is to control the source. Most industrialized nations recognize this and have made regulations on noise emission from aircraft and road vehicles. The results are most spectacular for aircraft noise; the use of some types of aircraft has been reduced or stopped, and supersonic aircraft have not found widespread use in commercial traffic. For road traffic noise, the increase in traffic density has largely masked improvements resulting from the reduction of noise from individual motor vehicles.

Nevertheless, regulations for the emission of noise from specific sources are not sufficient to control noise received in residential areas. Additional measures – such as traffic restrictions, noise-screening walls and barriers along roads and railway lines, and improvements in the sound insulation of facades and windows – are frequently required.

Limits for residential noise are usually specified as levels in front of facades, either as an average over 24 hours, as a day–night average (L_{dn}) or for day and night separately. Standardized methods and instruments to monitor compliance with existing regulations are commercially available [18–22]. A number of countries reported to WHO their limits on noise levels at the facades of dwellings. Usually, separate sets of limits apply to noise from road, rail and air traffic and from industry; few limits on neighbourhood noise have been reported.

In general, regulations to control residential noise from external sources include the following:

- limits for noise from specific external sources that are enforced by environmental and traffic authorities;
- minimum requirements for the acoustic properties of dwellings, such as specifications for the sound insulation of facades, roofs and windows (often as part of a national building code that also applies to schools and hospitals); and
- limits for noise in dwellings from unspecified external sources (usually as part of the national building code).

The noise limits for specified external sources, as reported to WHO and summarized in Table 13.4, show a remarkable similarity in the structure of regulations in different countries. Bearing in mind the number of registered complaints of annoyance from neighbourhood noise (25–50 % of the total) it is striking that very few countries reported the existence of statutory regulations for such noise.

Despite the existence of limits on residential noise, some people are exposed to levels that exceed them. For example, 45 % of German citizens are exposed to such levels from road traffic, and 18 % from rail traffic [12]. In the Netherlands, 16 % of dwellings are exposed to levels of noise from road traffic that exceed national levels; the figures for rail and air traffic and industry are 1 %, 11 % and 4 %,

Table 13.4: Limits on residential noise in rural and urban areas (equivalent continuous A-weighted sound level for day and night)

Source, area and time	Limits (dBA)													
	Austria	Bulgaria	Czecho-slovakia	Denmark	Finland	France	Germany	Hungary	Israel	Lithuania	Netherlands	Norway	Russian Federation	Sweden
Road traffic														
Rural areas														
Day	65	65	60	55	–	–	59	–	–	–	50	55	45	45
Night	55	60	50	–	–	–	49	–	–	–	40	55	35	45
Urban areas														
Day	65	65	65	55	55	65	64	–	–	–	50	55	55	55
Night	55	60	55	–	45	–	54	–	–	–	40	55	45	55
Rail traffic														
Rural areas														
Day	–	–	60	55	–	–	59	60	–	–	57	55	45	–
Night	–	–	50	–	–	–	49	50	–	–	47	55	35	–
Urban areas														
Day	–	–	65	55	–	–	64	65	–	–	57	55	55	–
Night	–	–	55	–	–	–	54	55	–	–	47	55	45	–
Air traffic														
Rural areas														
Day	–	–	65	45–55[a]	–	–	67	60	65[b]	85	63	55	45	–
Night	–	–	55	45–55[a]	–	–	67	50	65[b]	75	63	55	35	–
Urban areas														
Day	–	–	65	45–55[a]	–	–	67	65	65[b]	85	63	55	55	–
Night	–	–	55	45–55[a]	–	–	67	55	65[b]	75	63	55	45	–
Industry														
Rural areas														
Day	–	–	50	45	–	45	–	50	50	70	50	50	45	50
Night	–	–	40	35	–	35	–	40	40	–	40	40	35	40
Urban areas														
Day	–	–	50	55	–	–	–	55	–	–	–	55	55	40
Night	–	–	40	40	–	–	–	45	–	–	–	45	45	35

[a] Levels in L_{den}.
[b] Levels in L_{dn}.
Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

respectively [3]. The corresponding figures for dwellings in Denmark are 28 % from road traffic, 2 % from rail traffic and 2 % from air traffic [23].

The similarity in noise limits for living rooms and bedrooms in different countries (30–40 dBA) reflects the general observations on levels of noise that affect sleep and rest. Limits for kitchens are slightly higher (30–45 dBA).

Obviously, countries differ widely in their general requirements for the sound insulation of dwellings. The large variations in requirements for external elements of the dwelling – facades (18–50 dB), roofs (25–50 dB) and windows (20–45 dB) – are probably related to local climatic conditions and construction traditions. Thus, if windows are usually left open for much of the year to increase ventilation, very strict acoustic requirements for insulation of windows and facades are superfluous. The requirements for the sound insulation of floors (39–52 dB) and partitions (48–55 dB) are more strict and vary less from country to country. These building elements form important "borders" between adjacent rooms and dwellings. If the insulation is insufficient, the inhabitants lose control over important aspects of the quality of their lives.

Reports to WHO[a] on the extent of compliance with regulations for the sound insulation of dwellings give a range of 30–90 %, with an average of 70 %. In many countries, the acoustic properties of dwellings are not subject to control.

13.7 Conclusions

13.7.1 Land-use planning

In the long term, the most efficient way of reducing noise problems is to apply the concept of land-use planning to prevent new problems. A national or local system of noise zones can be established; the authorities will specify and control the uses to which land in each zone may be put so that compliance with noise regulations can be ensured. Noise zoning will frequently be based on predictive models. Useful information on procedures for such assessments of likely acoustic situations in use by European countries has been published by WHO [24]. International standards for the measurement and description of noise for land-use planning have been established [18–20].

An efficient zoning system may be a useful instrument for determining the allocation of grants to solve large environmental noise problems. For example, the Danish Government has set aside 1 % of its annual national construction budget until 2010 to reduce residential noise by means that include the building of screens along noisy roads and railway lines and the sound insulation of exposed facades and windows [23].

13.7.2 Health studies on exposed populations

Eleven countries of the European Region submitted information to WHO on a total of about 60 studies of noise-related health problems that had recently been published or were in progress; 28 % of the studies are related to residential noise problems, 25 % to road traffic as a noise source, and 7 % to air traffic. The rest address a variety of other noise sources and health problems (including those linked to occupation). Establishing a European system for the exchange of information on planned and completed research and the documentation of noise-related health problems would be useful.

13.7.3 Concern for the future

Twelve European countries stated to WHO[a] their environmental health concerns related to noise problems for the next five to ten years. Residential noise and traffic noise

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

problems dominate. Other concerns focus on the health effects related to loud music from personal stereo systems and discotheques, and exposure to noise in transport (e.g. in underground railways) and noise from open-air factories (e.g. stone crushing).

An example of the prediction of trends in noise problems comes from the analysis of noise nuisance for the years 1985–2010 conducted by the National Institute of Public Health and Environmental Protection in the Netherlands [3]. The Institute predicts a decline in nuisance by road traffic; 30% of the population will be affected by the year 2010 in contrast to 60% in 1990. These estimates reflect a balance between an increase in traffic volume and a reduction of noise emission by single vehicles. The total noise nuisance from rail traffic is predicted to show a slight increase and stabilize at 4% of the Dutch population by the year 2010.

The prediction of noise nuisance from civil aviation based on an assumed traffic increase of 50–60% suggests that more than 40% of the population will be affected by 2010. It is assumed, however, that strict regulations imposed on noise emission from aircraft from 1995 and the limitation of night flying from 1993 may reduce nuisance from civil aviation to a negligible figure by 2010. Noise from low-flying military aircraft may, however, still cause nuisance to a substantial part of the population by the year 2010.

The total nuisance of noise from industry is predicted to affect 15% of the Dutch population. Neighbourhood noise affects 14% of the population at present; because of the diversity of sources in this group, prediction is extremely difficult.

The Swedish Board of Transport predicts an average decrease of 5 dBA for traffic noise in about 20 years. This will be far from sufficient, however, to eliminate problems related to traffic noise. For the general population, it is not sufficient to obtain a moderate reduction in noise from specific sources. The increasing public interest in physical and mental wellbeing and nature will stress the importance of establishing and maintaining silent areas in rural and urban environments and parks. This will require careful planning and control by national and local authorities.

References

[1] Pedersen, O.J. Noise and people. *Noise control engineering journal*, **32**: 74–78 (1989).

[2] *Fighting noise in the 1990s*. Paris, Organisation for Economic Co-operation and Development, 1991.

[3] *Concern for tomorrow. A national environmental survey 1985–2010.* Bilthoven, National Institute of Public Health and Environmental Protection, 1986.

[4] Godlee, F. Noise: breaking the silence. *British medical journal*, **304**: 110–113 (1992).

[5] Axelson, A. Leisure noise exposure in adolescents and young adults. *Journal of sound and vibration*, **151**: 447–453 (1991).

[6] *Noise.* Geneva, World Health Organization, 1980 (Environmental Health Criteria No. 12).

[7] Schultz, T.J. *Community noise rating,* 2nd ed. London and New York, Applied Science Publishers, 1982.

[8] Dunn, B.E. The noise environment of man. *In*: *Noise in the human environment*. Edmonton, Canada, Environment Council of Alberta, 1979.

[9] Ising, H. & Kruppa, B., ed. *Noise and disease.* Stuttgart, Gustav Fischer, 1993.

[10] Bastenier, H. et al. Damage and annoyance caused by noise. *In: Environment and quality of life*. Luxembourg, Commission of the European Communities, 1975.

[11] Suter, A.H. Noise sources and effects – a new look. *Sound and vibration*, **25**: 18–36 (1992).

[12] Griefahn, B. Noise pollution during the night – a possible risk factor for health. *In*: Lara Sáenz, A. & Stephens, R.W.B., ed. *Noise pollution.* London, J. Wiley & Sons, 1986.

[13] Molitor, L. *Noise abatement. A public health problem*. Strasbourg, Council of Europe, 1964.

[14] Mosskov, J.I. *Experimentelle Untersuchungen über Lärmwirkungen auf den Menschen.* Amsterdam, Coronel Laboratorium, 1976.

[15] Babisch, W. et al. Road traffic noise and heart disease risk: results of the epidemiological studies in Caerphilly, Speedwell and Berlin. *In*: Vallet, M., ed. *Noise as a public health problem. Proceedings of the 6th International Congress "Noise and Man 1993".* Arcueil, Institut National de Recherche sur les Transports et la Securité, 1993.

[16] Committee on Hearing Bioacoustics and Biomechanics. *Guidelines for preparing environmental impact statement on noise*. Washington, DC, National Academy of Sciences, 1977.

[17] Kryter, K.D. *The effects of noise on man,* 2nd ed. Orlando, FL, Academic Press, 1985.

[18] *International Standard 1996-1. Acoustics - description and measurement of environmental noise. Part 1. Basic quantities and procedures*. Geneva, International Organization for Standardization, 1982.

[19] *International Standard 1996-2. Acoustics - description and measurement of environmental noise. Part 2. Acquisition of data pertinent to land use*. Geneva, International Organization for Standardization, 1987.

[20] *International Standard 1996-3. Acoustics - description and measurement of environmental noise. Part 3. Application to noise limits*. Geneva, International Organization for Standardization, 1987.

[21] *International Standard 651. Sound level meters*. Geneva, International Electrotechnical Committee, 1979.

[22] *International Standard 804. Integrating-averaging sound level meters.* Geneva, International Electrotechnical Committee, 1985.

[23] Danmarks Statistik. [Traffic noise exposure of dwellings.] *Statistiske efterretninger*, **1**: 1–8 (1993).

[24] Lang, J. *Assessment of noise impact on the urban environment - a study on noise prediction models.* Copenhagen, WHO Regional Office for Europe, 1986 (Environmental Health Series No. 9).

Chapter 14
Housing and the Indoor and Urban Environments

14.1 Introduction

In its very first report in 1961 [1] the WHO Expert Committee on the Public Health Aspects of Housing recognized that housing implies more than the physical structure providing shelter. The immediate surroundings of the shelter are also important. It considered a more appropriate term therefore to be the "residential (or housing) environment":

> The scope of the public health aspects of housing involves town and country planning, the design and arrangement of the dwelling unit, the materials and method of construction, the use of space by the occupants, the maintenance of the structures and dwelling areas, the availability of community facilities and services including those for circulation and transport.

In June 1991, the Third International Conference on Health Promotion in Sweden [2] advocated "the building-up of physical and social environments supportive to health". Thus consideration of housing and health should include both physical and social environments and their interactions.

14.1.1 Interaction of housing, other conditions and health status

More than 20 years ago a WHO Expert Committee on Housing and Health [3] stated that:

> It has been shown that people who live in bad housing and poor environmental conditions experience higher mortality rates and are generally less healthy

than those who live in districts where the housing is good.

It is difficult to put forward convincing epidemiological evidence that the house itself is directly responsible for ill health. Many factors associated with living conditions and housing are strongly interrelated. Thus social class, occupational status, unemployment, poverty, mental capacity, general ability and the social status and health education of parents are not strictly covered by the term "environment", yet each may contribute to the circumstances that cause a family to find itself in a particular environment.

It is difficult to establish the precise nature and extent of the relationship between the housing environment and health for two main reasons. First, there is no unified measurement of the hygienic quality of the housing environment; second, poor housing conditions are often accompanied by other social and economic factors that may influence health status, such as poverty, ignorance, poor nutrition, detrimental lifestyles, harmful atmospheric and occupational environments, and lack of medical care. The result of the complex interaction of these factors is an impact on health that may be further influenced by the inherent characteristics of the people affected, such as age, sex and genetic make-up.

14.1.2 Housing factors affecting health

As long ago as 1978 a Regional Office report on the environmental health aspects of human settlements [4] identified the following issues:

- Space and population density
- Indoor microclimate and air quality
- Illumination and natural sunlight
- Building structure and fittings and environmental safety
- Immediate natural environment and nearby recreational and leisure facilities
- Communication and transport in residential areas
- Energy conservation in buildings and its impact
- Legal incentives to improve housing
- Slum problems of city centres
- Shantytowns and mobile homes
- Risk groups: mothers and children, the elderly, the handicapped and migrants
- Mental health and psychosocial problems associated with housing
- Air pollution and community noise.

The World Health Organization subsequently identified features of the housing environment of importance in determining direct or indirect effects on the occupants' physical and/or mental health [5]. These include factors in addition to those listed above that are relevant to the present situation in the European Region:

- the extent to which the provision of water is adequate, from both a qualitative and a quantitative point of view, including access to an indoor toilet and washing/bathing facilities;
- the effectiveness of provision for sewage and solid waste disposal;
- food safety, including the extent to which there is adequate provision for storing food to protect it against spoilage and contamination; and
- the home as a workplace – where occupational health questions such as the use and storage of toxic or hazardous chemicals, and the health and safety aspects of equipment used, need consideration.

The nature of the risk of disease arising from specific housing defects [6] may be summarized as set out in Table 14.1.

In summary, the housing environment may affect health adversely by facilitating the transmission of communicable diseases, predisposing to injury through faulty planning, design, construction or use, and causing physiological or psychological stress.

14.1.3 Current housing and health issues in the European Region

Many of the issues listed above remain today as important housing-related public health

Table 14.1: Risks to health arising from specific housing defects

Housing defect	Health risk
Inadequate heating	Bronchitis, pneumonia, stroke, heart disease, hypothermia, accidents
Damp, mites and mould growth	Respiratory and other allergies
Inadequate ventilation	Respiratory complaints, carbon monoxide poisoning
Formaldehyde and other chemicals	Irritation of eye and respiratory tract
Lack of hygiene	Infections
Inadequate kitchen facilities	Accidents, food poisoning
Disrepair (and poor technical quality of electrical, heating, cooking and lighting systems)	Accidents, fire
Structural inadequacy	Accidents
Inadequate lighting	Accidents
Hazardous materials (e.g. asbestos)	Cancer
Radon infiltration	Cancer
Overcrowding	Infections, stress
Inadequate means of escape	Injury or death from fire

Source: Smith, S.J. *(6)*.

problems. For example, too many areas in the Region, particularly in the CCEE and NIS, still have homes that lack a supply of safe drinking-water (see Chapter 6) and basic sanitation (see Chapter 7).

New priorities have emerged: homelessness is an increasing problem, not only because of the economic recession and rising unemployment but also as a result of armed hostilities; and tuberculosis is reappearing as a public health problem, partly in relation to population migration but also to the AIDS pandemic and drug addiction, in addition to the accompanying and underlying problem of poor socioeconomic conditions.

More recognition is currently being given to psychosocial stress, particularly for vulnerable groups, as a consequence of overcrowding, high-rise buildings, urban noise and congestion, and lack of amenities (including public transport). And, although the impact of energy conservation in buildings was mentioned as early as 1978, the need to achieve a better balance between energy conservation and the adverse effects on indoor climate and air quality of low rates of air exchange has only recently been widely recognized. The health consequences may be particularly marked in the context of exposures to radon and, in the case of children, to environmental tobacco smoke or allergens.

14.1.4 European health for all targets related to housing

The original title of the WHO European Region's health for all target 24 was "Healthy homes". This was subsequently broadened to "Human ecology and settlements", in part to reflect the interrelationship of housing with other aspects of the physical and social environment.

In 1991, the reformulation of the targets and revision of the associated indicators were approved by the forty-first session of the WHO Regional Committee for Europe. Further revisions of the indicators take into account the practical constraints on obtaining data and on the quality of data. The selection of a small number of relevant indicators for which reliable information can be obtained is considerably more useful than a scheme that aims to be comprehensive.

Target 24, which states that by the year 2000 cities, towns and rural communities throughout the Region should offer physical and social environments supportive to the health of their inhabitants, will be reviewed in 1995/1996. The review will include a quantitative assessment of housing quality, in particular of those living in houses with a water supply, toilet, bathroom, separate kitchen and central heating, a description of programmes for the construction of healthy houses and the improvement of housing standards, and an assessment of measures to meet the needs of special groups such as young families, the old and the disabled.

The key statistical indicators will be (*a*) the proportion of the population who are homeless and the proportion living in substandard accommodation, according to the relevant national standards; and (*b*) the average number of people per room in occupied housing units and distribution by density, number and percentage.

Other targets relate directly or indirectly to the housing environment. For example, target 20 states that all people should have access to adequate supplies of safe drinking-water and that the pollution of groundwater sources, rivers, lakes and seas should no longer pose a threat to health. The statistical indicators needed to monitor progress towards this target include the percentage of the population (or of dwellings) connected at home to a water supply system throughout the year, and the percentage having access to a sewage system, septic tank or other hygienic means of sewage disposal.

14.1.5 Urbanization

According to the report *Europe's environment* [7] more than 70% of the population of Europe live in cities. Growth is notable in the southern and eastern European countries, where pressure on housing reserves and the urban environment in general is most acute. In some situations, unplanned urban developments lacking basic public health services have resulted. Nevertheless, the proportion of people living in urban areas in those countries remains in most cases below that in northern countries. Very few Member States still have a predominantly rural population, but these include Albania and Portugal (Fig. 14.1).

Nearly all the Member States whose urban population was below 60% in 1982 showed an increase by 1991, whereas very little further change occurred in those countries that had reached 80% or more by 1982 (see Fig. 14.1).

In the compact urban situation, the quality of the housing in part reflects the quality of the urban environment in general. For example, in some circumstances the quality of air inside buildings may reflect the atmospheric conditions around the buildings. Similarly, noise disturbance may result from the juxtaposition of housing areas and transport routes or industrial sites (see Chapter 13). On the other hand, industrial areas may lose the functions for which they were designed, and the associated housing gradually reaches the bottom of the housing market and may become derelict. Inhabitants of urban dwellings may suffer stress if their children cannot be allowed out to play unsupervised because of a lack of safe play areas away from traffic. On the other hand, poor access to public transport suitable for mothers with small children, the elderly and the disabled may also be an undesirable feature of some urban developments. Spatial relationships between land use for housing, recreation, industry/commerce and transport may, in some situations, be stronger determinants of certain health outcomes, such as psychiatric morbidity or injury rates, than the internal features of the dwelling.

The *Europe's environment* report [7] indicates that our knowledge of the European urban environment is incomplete. Very limited comparable data exist to allow the impact of urban activities on Europe's environment to be charted. In some cities, systematic environmental monitoring has only recently commenced. The report identifies factors related to housing that directly affect the state of the urban environment and human health, such as design, layout and types of building material.

14.1.6 Current problems in European urban development

An interesting source of information on the social aspects of the European urban environment are the reports published by the

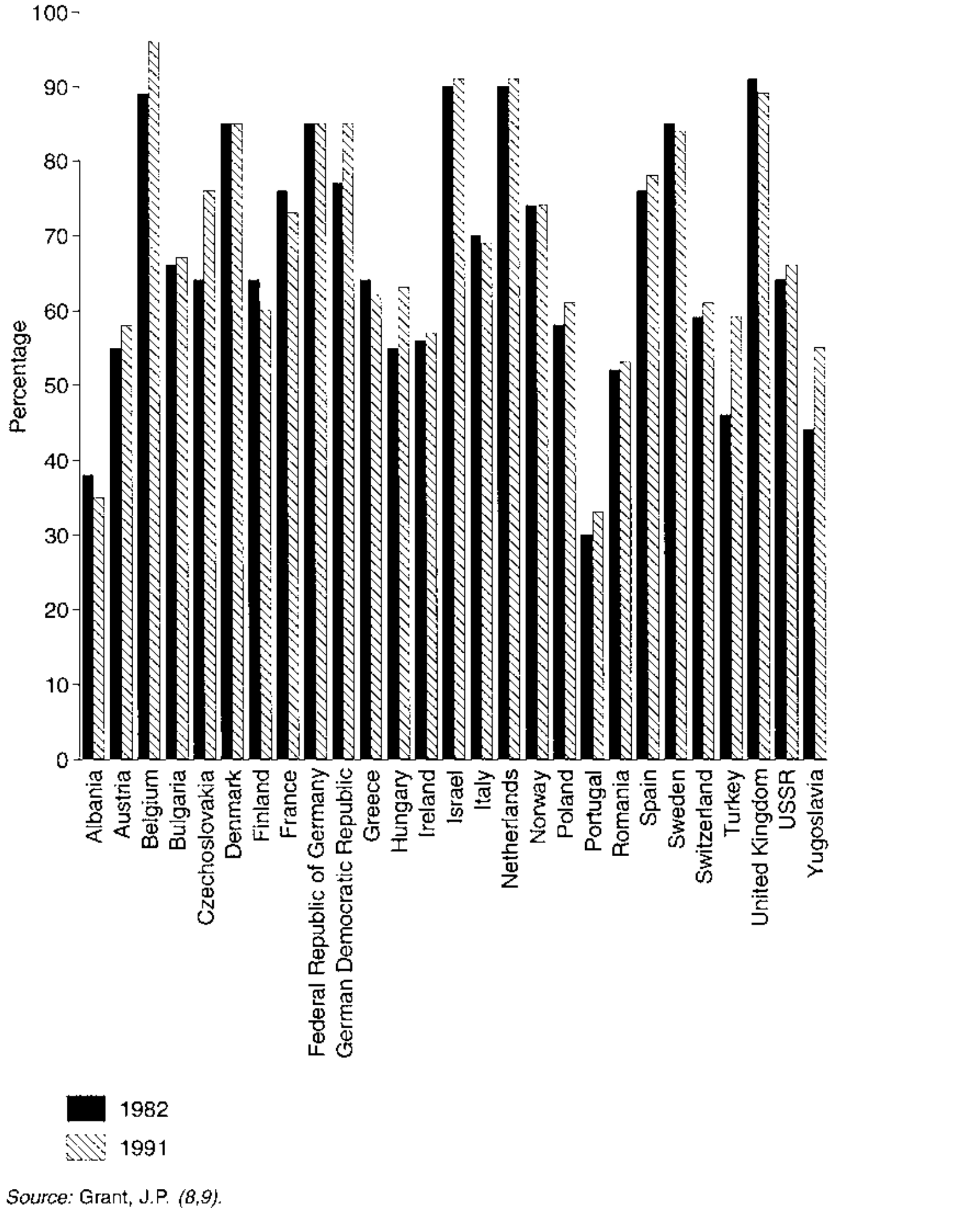


Fig. 14.1: Urban population as a percentage of total population for 27 countries of the WHO European Region, 1982 and 1991

European Foundation for the Improvement of Living and Working Conditions [10], which draw attention to the growth of homelessness as well as the special problems of risk groups such as young and elderly people, single parent families, migrants and ethnic minorities. However, it covers only the member states of the European Union (EU).

There is a lack of comparable data on the urban and housing situation for many countries in the WHO European Region, and this is particularly marked for countries east of the Ural Mountains or south of the Caucasus. Nevertheless, there is evidence that slum conditions persist, for example in cities with very old housing that escaped destruction by bombing during the Second World War, in rural areas where primitive types of housing have survived, and in unplanned and often illegal urban developments of rapidly growing cities, especially in newly industrialized countries. Finally, there are new slums resulting from poorly planned, low-cost housing schemes.

Two opposite urban development patterns coexist in the Region. In the more affluent countries, high-income groups tend to move into suburban areas, leaving the inner city with low-income inhabitants. This pattern of urban development concentrates slum conditions and social problems in the inner city.

In other countries and cities the reverse pattern is evident. City amenities are concentrated in the downtown area and developing suburbs may lack adequate transport, recreation and shopping facilities, job opportunities and even adequate access to schools and medical care. This pattern leads to a situation where high-income groups rebuild or rehabilitate the housing stock in the inner city areas. The resulting price increases make these areas inaccessible to low-income groups, who are progressively pushed out to suburbs. Thus slum conditions and social problems become concentrated in this low-cost suburban “social” housing.

To deal with the shortage of urban dwellings, numerous governments in both western and eastern Europe adopted a policy of building large housing schemes with the objective of producing the maximum number of dwelling units at the minimum cost. They failed, however, to consider sufficiently the sustainability of life in these new buildings, their appropriateness to the culture of their inhabitants, the quality of the surroundings and the need for urban amenities. These concentrations of fast deteriorating, high-rise apartment blocks have now become a major cost to local government and a stressful, depressing physical and social environment for the inhabitants.

A second major inadequacy in post-war urban planning, especially in southern Europe, is the lack of development of efficient and accessible public transport. Pre-war public transport systems are still operating without improvement or rehabilitation, and too much dependence is placed on private cars. This has created endemic traffic congestion, excessive expense in building urban highways and car parks, increasing noise and air pollution and traffic accidents, while at the same time making the cities inaccessible to groups such as mothers and young children, the disabled and the elderly.

The deteriorating quality of urban life is associated with psychosocial disorders, unhealthy lifestyles and criminality. Many governments have recognized that they face urban crises and have created specific ministerial departments to cope with them.

WHO has promoted the Healthy Cities movement with a view to motivating the efforts of enlightened local governments to concentrate their resources on finding a positive solution to the most acute urban problems and improving the quality of life of local populations so that everybody may enjoy “a socially and economically productive life” in an “urban environment making easy the choice of a healthy lifestyle”. Healthy cities in Europe have devoted a lot of effort to the physical and social rehabilitation of underprivileged city centres or poorly planned suburbs, and have often achieved visible improvements.

14.1.7 Housing policies

Historically, different countries have shown variations in the distribution of responsibilities for housing development between the public and private sectors and between different levels of administration. The major observable change in pattern in recent years has been the decentralization of planning responsibility and the withdrawal of subsidies for housing in the eastern European countries. The World Bank, as a major donor in the field of settlement development, is encouraging borrowing member governments to adopt policies that enable housing markets to work, and to move away from producing, financing and maintaining housing [11]. At the same time the Bank seeks greater government commitment to the improved collection and analysis of housing data, in order to assess housing sector performance and improve the process of policy formulation and implementation. Meanwhile, the baseline data from various sources indicate that the populations of the CCEE and NIS are, on average, less favourably housed than their western European counterparts.

It is generally accepted that the priority role of the public sector is to make plots available to those who wish to build dwellings. Local government in particular has a responsibility to select land appropriate for new development and to plan such development with its necessary infrastructures, public services and urban amenities. The public sector should then recover its investment by selling building plots to whatever public or private agency or individual wishes to build.

Poor quality dwellings will become slums in a few years. Urban development and building should therefore be designed for at least 50 years of life without major refurbishment.

Existing building regulations should be updated regularly, including technical regulations regarding electrical, heating, cooking, lighting and plumbing systems, to cope with technological developments and to avoid creating risks of domestic accidents. This would also ensure safety clearance of new building materials prior to licensing.

14.2 Studying Housing and Health

14.2.1 Sources of information: housing

The majority of countries in the European Region (a notable exception being the Netherlands) periodically conduct a national census of their population and usually of its social and economic circumstances. These censuses usually include data on housing arrangements, such as the number of people per household or housing unit, tenure, and the facilities available in occupied housing units.

Household surveys may be carried out ad hoc or systematically. The annual general household survey in the United Kingdom, based on interviews with 12 000 households and covering 30 000 inhabitants, is an example. Socioeconomic in coverage, it provides between-census estimates of demographic, social and economic circumstances, including housing characteristics.

Periodic compendia draw largely on national census data augmented by special surveys. The best established of these is the *United Nations statistical yearbook*. This annual source presents data by country on population, number of households, size of dwellings, tenure, occupancy and facilities. The data, being largely based on censuses, may be up to ten years old when published.

The *Eurostat statistical yearbook* has a wider socioeconomic framework. In its chapter on living standards there are statistical descriptions of the stock of housing in EU countries, and of the household equipment available in these houses. This source includes data from national censuses and from housing surveys such as the English House Condition Survey, an approximately 3–5-year survey of the fabric of a sample of English dwellings. The *Annual bulletin of housing and building statistics for Europe and North America*, published by the United Nations Economic Commission for Europe (ECE) [12] is concerned largely with newly completed buildings. It is useful, therefore, for assessing how rapidly adverse housing conditions are being improved.

The *United Nations compendium of human settlement statistics* is an occasional publication last published in 1985. Compiled by the United Nations Statistical Division in New York, it obtains data from national statistical offices. The next edition, now being compiled, will also contain data on a wide range of social indicators for the four largest cities in each country. The housing section covers types of living accommodation, number of rooms and household tenure, duration of residence and facilities in occupied housing units.

In spite of much effort to coordinate and harmonize international statistics on housing, the comparability and reliability of data are still low owing to differences in definitions, validity and methods of measurement, and reference year. This is especially true of data supplied by national focal points in ad hoc surveys. Because of this, the comparisons drawn in this chapter must be viewed with caution; they are only broadly indicative of the relative situation in individual countries. The position is likely to improve considerably with the forthcoming introduction of a standardized programme of current housing and building statistics for countries in the ECE region agreed in 1993.

14.2.2 Sources of information: housing-related health status

The problems of relating housing conditions to health in such a way that complicating factors such as socioeconomic status are adequately taken into account, are considerable and virtually insurmountable. The main health statistical sources are mortality data, based on the International Form of the Certification of Cause of Death, and morbidity data that describe the incidence or prevalence of a disease or condition.

However, not all the incidence and prevalence of diseases presumed to relate to housing conditions can be measured accurately. For non-fatal conditions, encounters with health care services are needed before the conditions can be identified and recorded. This, in turn, depends on the availability and accessibility of the relevant services.

For fatal conditions, accurate determination depends on the thoroughness of the diagnostic process (including autopsy), on the diagnostic choice of the doctor certifying the cause of death (for example, asthma or chronic obstructive airways disease) and local interpretation of the international disease coding conventions.

The main source of information on vital statistics in Member States of the WHO European Region and the world in general is the *World health statistics quarterly*, published by the World Health Organization. This source lists mortality rates from the most important clinical conditions and from accidents, poisoning and violence.

Certain conditions may be important indicators of the quality of the indoor environment, for example the incidence of asthma in relation to allergenic characteristics of the environment such as the presence of house mites or various moulds. More emphatic, however, are statistics on the incidence of and mortality from communicable diseases such as pulmonary tuberculosis or enteric diseases. These are likely to be more fully ascertained and may be associated with an index of overcrowding such as, for example, the smallness of room area per inhabitant. Postneonatal infant mortality rates are generally accepted as an index of social conditions; in most European countries 80–90% of infant mortality due to infections and parasitic diseases occurs after the first month of life.

The health effects of trauma at home are more easily measured. The more serious trauma incidents are likely to prove fatal or to require hospital treatment. Several of the EU member countries provide data from systematic samples of records of hospital attendances for injuries received in the home. Preliminary work is under way to harmonize the definitions and interpretations adopted in the various member countries. Meanwhile certain countries, such as the United Kingdom, have produced annual reports from the local system for over a decade. While a broad idea may be obtained of the injury patterns sustained in various domestic circumstances, precise estimates of the burden of trauma are less reliable because the hospitals sampled may receive only a selection of cases and hence of types of injury. For example, severe burns cases may be taken to a regional burns centre, by-passing the hospital concerned.

Despite the deficiencies of these sources, data from some of them have been used in this chapter alongside housing descriptions, in order to illustrate the possible effects of inadequate housing in some Member States.

14.2.3 Housing stock

In virtually all the European Member States for which information is available, the majority of dwellings have been constructed since the Second World War, particularly in urban areas. This reflects the renewal of antiquated stock and addition to it to cope with migration from rural areas. It implies that much of Europe's existing stock was planned and built to modern standards of hygiene. Rural housing stock is generally older (Table 14.2).

By far the greatest proportion of dwellings in the Region are constructed from durable, impenetrable materials such as stone, brick or concrete. The exceptions are in Scandinavia, where in some countries wood is the principal building material.

Where space is scarce or ready access to a large workforce is needed, dwellings have been built as apartment blocks. The proportions of apartment dwellings range widely among Member States (Table 14.3). Space and the unsuitability of much of the terrain dictate that high proportions of dwellings are apartments in some countries such as Israel and Switzerland. Definitions of what comprise apartment blocks vary. For example, in Iceland a large detached house may include five separate dwellings (flats) without being designated an apartment block.

Among the more difficult and challenging dwelling situations are those high-rise dwellings that lack elevator access to the higher levels. Most countries now require the installation of elevators in new residential buildings with more than four or five levels. The proportion of dwellings on the upper levels

Table 14.2: Percentage of housing built since the Second World War in 27 European countries

Country	Total	Urban	Rural
Albania	86	67	90
Austria	60	59	63
Bulgaria	75		
Croatia	77		
Cyprus	85		
Former Czechoslovakia	60		
Denmark	62	67	30
Estonia	88		
Finland	88		
France	62	63	48
Germany[a]	67		
Hungary	67	68	65
Iceland	84		
Israel	91		
Italy		73	
Latvia	73		
Lithuania	89		
Netherlands	78	76	81
Norway	77	80	61
Poland	67	75	65
Romania	68		
Slovenia (1992)	76	90	68
Spain	71	80	49
Sweden	74	81	40
Switzerland[b]	48		
Former Yugoslavia (1990)	75		

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.
[b] Since 1947.

Sources: United Nations Economic Commission for Europe *(12)*; data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 14.3: Apartment block dwellings as a percentage of the total in 17 European countries

Country	Percentage
Former Czechoslovakia	46
Denmark	41
Finland	44
France	40
Hungary	39
Iceland	53
Israel	80
Lithuania	70
Malta	20
Netherlands	31
Norway[a]	18
Poland	58
Romania	52
Slovenia	37
Spain	70
Sweden	54
Switzerland	74

[a] Dwellings with 3 or more levels.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

in high-rise apartment blocks is small in most countries that offered this information (around 3%) and the great majority of these have access to elevators, in keeping with the modernity of most of the urban housing stock.

High-rise living can be particularly stressful for mothers with young children. The children themselves, because of reduced opportunities to mix with others, tend to develop capabilities for independent living more slowly. The WHO Commission on Health and the Environment's Panel on Urbanization reinforced the well known advice that small children should not live on the upper levels of multi-storey residential buildings [13]. The numbers who actually do so in Europe at present is not known, but they must make up a small proportion of the total.

However, there is a cultural dimension specific to each European country regarding the preferred pattern of dwelling construction. Some European cultures favour detached houses with large gardens in suburban areas, others prefer apartment blocks in downtown areas. There is no unanimous view on high-rise building, except that it is unsuitable for families with young children.

14.2.4 Space

The proximity in which people live together is a factor in the spread of communicable diseases, such as pulmonary tuberculosis and scabies, through airborne transmission or physical contact. Families whose members are forced to live closely together also experience more tension and aggressive behaviour, particularly if more than one household occupies the same dwelling. The occurrence of burns and scalds is also potentially greater in crowded households.

Rural dwellings have, on average, more living rooms (excluding kitchens) per dwelling than do urban dwellings, reflecting the competition for space in built-up areas. Also, the area of available space per person in living rooms in urban areas is, on average, smaller than in rural areas. There is considerable variation among European populations in the average space available to individuals, ranging from 10.0 to 48.3 m^2 (Table 14.4). This is, in part, because this particular index reflects the average family size as well as the total amount of living room space. Within the former USSR the republics differed in the amount of living space available per person, from Tajikistan (7 m^2), through the Russian Federation (10 m^2), to Estonia (13 m^2) and Georgia (14 m^2).

There is debate as to whether the more significant indicator of overcrowding is the space available per inhabitant or the number of inhabitants per room.

In general, homes in northern Europe provide more space per person than those elsewhere. Climatic conditions dictate that northern Europeans spend more time indoors than southern Europeans, and indoor space is therefore relatively more important. In nearly all countries for which information is available, the average amount of space available to the individual exceeds the Regional Office recommended level of provision of at least 12 m^2 of habitable space per

Table 14.4: Average living room space per person in 22 European countries

Country	Space per person (m²)		
	Total	Urban	Rural
Former USSR (1989)	10.0		
Romania	11.6	11.1	11.6
Former Czechoslovakia	16.1		
Czech Republic	16.7		
Slovakia	14.8		
Israel	17.0		
Poland	17.2	16.8	17.4
Lithuania	18.9	16.9	23.4
Former Yugoslavia	19.0		
Turkey	19.4		
Italy	22.0		
Bulgaria	22.3		
Slovenia	22.8	22.9	22.6
Spain	23.1	22.5	24.7
Hungary	25.0	24.0	27.0
Finland	31.0		
Switzerland	34.0	34.0	33.0
France	34.6		
Germany[a]	34.8	34.0	35.0
Sweden[b]	47.0		
Iceland	47.5		
Denmark	48.3		

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.
[b] Includes kitchen.

Sources: Alexeev, M. et al. *(15);* Goskomstat USSR *(16);* ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

person and no more than two people per room [14]. Where the average value is close to the recommended level, the possibility exists that a proportion of the population may live in substandard conditions.

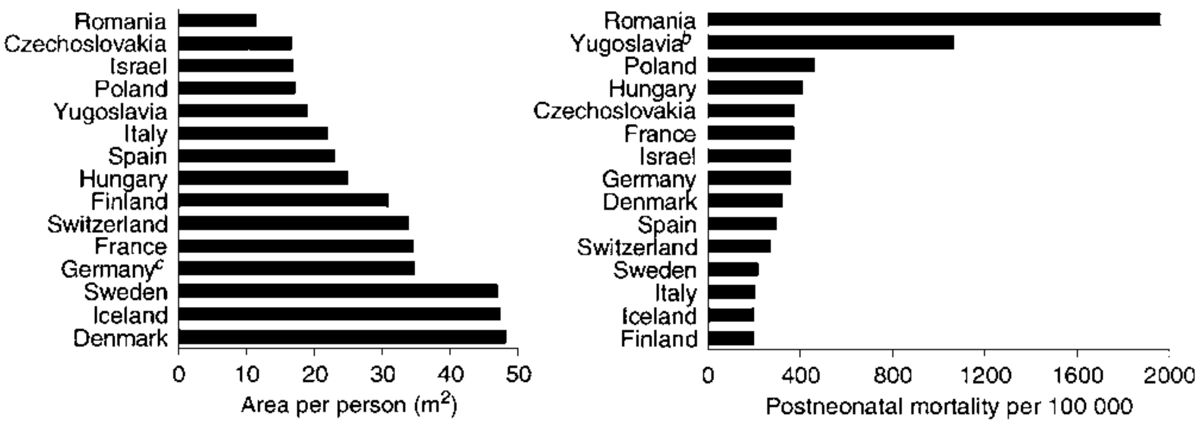
The problems of attributing a measure of health outcome to any one factor have already been discussed. Nevertheless, a comparison of postneonatal infant mortality rates and the average domestic space available to the individual shows a broad direct relationship in countries for which data are available (see Fig. 14.2).

14.2.5 Hygiene

The aims of adequate hygiene and sanitary arrangements are to minimize the risk of transmission of communicable diseases and to ensure a fresh, wholesome environment for daily living.

Food storage and preparation

Hygienic food storage gives security from infestation and preserves perishable foodstuffs. High standards of personal hygiene and adequate arrangements for the storage and collection of waste materials are also required.



[a] Infants over the age of 28 days.
[b] 1987 only.
[c] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.

Source: World health statistics annual, 1987–1992.

Fig. 14.2: Average living area per person and average annual postneonatal infant[a] mortality rates, 1987–1989

Table 14.5: Percentages of households with a refrigerator, and dwellings with a separate kitchen or kitchen area, in 17 European countries

Country	Refrigerator	Separate kitchen
Bulgaria		94
Former Czechoslovakia	90	98
Denmark	90	97
Finland	98	99
France	98	98
Germany[a]	99	
Hungary		96
Iceland		99
Israel	>99	97
Italy		100
Malta	98	90
Netherlands	99	
Norway	97	99
Poland		99
Spain	91[a]	92
Sweden	100	93
Switzerland	99	

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.
[b] 1981 data. Percentage now reported higher.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 14.7: Percentage of dwellings in 18 European countries lacking a fixed bath or shower

Country	Total	Urban	Rural
Bulgaria	36		
Former Czechoslovakia	10		
Czech Republic	8		
Slovakia	12		
Denmark	10	11	8
France	7		
Germany[a]	1		
Hungary	25		
Iceland	<5		
Israel	<1		
Italy	4		
Malta	14		
Netherlands	2	2	2
Norway	3		
Poland	28	17	48
Sweden	<1		
Switzerland	8	12	2
Former USSR (1989)	32		

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.

Sources: Alexeev, M. et al. *(15)*; ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 14.6: Percentage of dwellings in 21 European countries lacking an indoor piped water supply

Country	Total	Urban	Rural
Albania	88	37	95
Austria	5	5	5
Bulgaria (1991)	35		
Former Czechoslovakia	11		
Denmark	0		
Finland	4	3	8
France	<1		
Hungary	15	7	29
Iceland (1961)	<1		
Ireland	8		
Israel	<1		
Latvia	26	15	50
Lithuania	37		
Norway	1		
Poland	15	5	35
Romania	44		
Russian Federation	38	19	81
Slovenia	3	<1	5
Spain	<1		
Sweden	0		
Former USSR (1989)	23		

Sources: Alexeev, M. et al. *(15)*; ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

In all the European countries that provided relevant information, over 90% of households had refrigerators and a similar proportion of housing units had kitchens or special kitchen areas (Table 14.5). Structurally, therefore, the potential for avoiding food contamination in its preparation and storage is generally well advanced in Europe.

Sanitation

Statistical indicators on basic sanitary requirements in a dwelling – an indoor water supply, a fixed bath or shower, a toilet and connection to a piped sewage system or septic tank – indicate that deficiencies are commonest in the CCEE and NIS and rare elsewhere. In all countries, rural dwellings are more likely to lack these amenities (Tables 14.6–14.9). Experience in low-income countries is that a piped water supply is the one factor more than any other that has the greatest impact on the incidence of sanitation-linked infectious diseases.

Table 14.8: Percentage of dwellings in 22 European countries lacking a flush toilet/water closet

Country	Total	Urban	Rural
Albania	70	34	79
Austria	14	14	14
Bulgaria	51	26	93
Former Czechoslovakia	30		
Denmark	3	3	3
Finland	6	3	12
France	6		
Germany[a]	2	1	2
Hungary	23	14	41
Iceland	<5		
Ireland	10		
Israel	<1		
Italy		<1	
Latvia	28	16	54
Malta	<1		
Netherlands	2	3	
Norway	4	3	7
Poland	28	15	53
Russian Federation	41	22	86
Slovenia	10	4	18
Spain	2		
Sweden	0		

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.

Sources: ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 14.9: Percentage of dwellings in 10 European countries not connected to a sewage system or septic tank

Country	Total	Urban	Rural
Bulgaria	35		
Former Czechoslovakia		9	
Denmark	3	0	20
Hungary	14	7	28
Iceland	1		
Israel	<1		
Norway	14		
Slovenia	37	28	47
Switzerland	9	3	19
Former USSR (1989)	26		

Sources: ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

In general, of the small number of countries that provided information for the Concern for Europe's Tomorrow survey, those that rank high in the provision of an indoor water supply tend to have lower postneonatal infant mortality rates (Fig. 14.3). The caveat that must always be considered is that infants die from communicable diseases not only because of poor hygiene but also because of other factors such as immunization coverage. This qualification is also relevant to the interpretation of Fig. 14.2.

Problems of sanitation are, of course, more acute in unplanned urban settlements and among the homeless. The extent of such underprovision is not known, nor is the resulting impact on health.

14.2.6 Indoor air quality

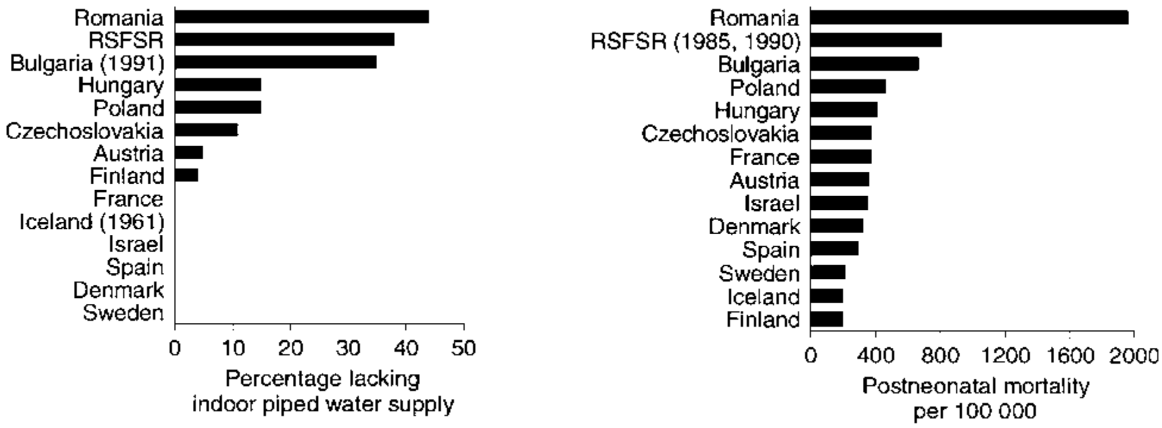
In the WHO report on environmental health in urban development [18] it is noted that:

> The incidence of certain respiratory diseases, intoxications and cancers can be reduced by effective ventilation for the removal of such air pollutants as nitrogen oxides, carbon monoxide, radon, formaldehyde, tobacco smoke, mineral fibres and sulfur dioxide. Apart from the hazards of cigarette smoking, complex air pollutants are produced inside the home by the burning of fossil fuels in open fireplaces; the risks are increased by inadequate ventilation.

Indicators

No system for the routine monitoring of pollutants inside dwellings, from which the general level of exposure to hazards might be deduced, exists in any European country. No statistical indicators are available of the adequacy or otherwise of ventilation, nor is it known what proportion of households are exposed to the types of gas or solid fuel heating apparatus which, when installation or maintenance is faulty, create a risk of carbon monoxide poisoning. Information is also lacking on the use of movable appliances, which are less likely to be connected to a flue and are therefore potentially dangerous. Furthermore, published mortality statistics of carbon monoxide-related deaths do not necessarily distinguish between deaths that occur in the home and those that occur elsewhere.

Even in reports of special surveys of home



Sources: Ministry of Health of the Russian Federation *(17)*; *World health statistics annual*, 1987–1992; data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 14.3: Percentages of dwellings lacking an indoor piped water supply and average annual postneonatal infant mortality rates in 14 European countries, 1987–1989

Table 14.10: Percentage of dwellings in 18 European countries with central heating (all forms)

Country	Percentage
Austria	53
Bulgaria	13
Former Czechoslovakia (1991)	75
Czech Republic	75
Slovakia	76
Denmark	89
Finland	51
France	79
Germany[a]	75
Hungary	43
Israel	8
Lithuania	84
Netherlands	78
Poland	62
Romania	37
Spain	28
Sweden	100
Switzerland	81

[a] Refers to the territory of the Federal Republic of Germany before the accession of the former German Democratic Republic.

Sources: ECE ad hoc reports in 1991–1993 (data for the 1980s); data supplied in country responses to the Concern for Europe's Tomorrow protocol.

deaths the circumstances of carbon monoxide poisoning may not be clearly described. For example, about 200 accidental deaths at home from carbon monoxide poisoning are reported annually in the United Kingdom by the Consumer Safety Unit, and include deaths due to gas, solid fuel, vehicle exhausts (in garages) and fires [19]. The United Kingdom Health and Safety Executive publishes data on carbon monoxide poisoning due to gas fires; on average, over the last five years there have been about 35 fatalities a year and 95 nonfatal accidents requiring hospital admission [20].

In the absence of better indicators, the percentage of dwelling units with central heating systems (see Table 14.10), whether electrical or through circulation of warm water, may be used as an indicator of healthy indoor climate.

Indoor air pollution

Geological differences within the European Region, and differences in air exchange rates in houses, mean that domestic exposures to the naturally occurring radioactive gas radon will vary between and within countries. Associated risks to health are discussed in Chapter 12.

Other risks to health from indoor air pollutants, including the question of sick building syndrome, are dealt with in Chapter 5. One condition deserving special attention, however, is Legionnaires' disease. Community-acquired Legionnaires' diseases is usually sporadic, and the reservoir of infection is often difficult to establish. Large water distribution systems, such as those in large apartment buildings, are more susceptible to colonization with *Legionella* spp. since large storage tanks provide an optimal environment for growth (lower temperatures, commensal microbial flora, scaling and sediment). Household surveys in Canada and the United States have reported drinking-water supplies positive for *Legionella* spp. in 6–32% of residences studied [21]. Clearly, despite the high prevalence of *Legionella* spp. in some domestic water supplies, the occurrence of the disease is relatively uncommon in the domestic setting. There is as yet no indication that the cost and effort of routinely analysing water supplies and specimens from showers, water tanks, taps, cooling towers, humidifiers and water baths would be justifiable in avoiding the occasional sporadic cases of the disease [22].

14.2.7 Indoor climate

Relationship to health

Excessively high or low room temperatures may be physiologically stressful, especially to the very young and the elderly. In a recent report [23] WHO concludes that there is no demonstrable risk to healthy, sedentary people in air temperatures of 18–24 °C when other aspects of the indoor climate are appropriate. A minimum temperature of 20 °C is recommended for the very old and very young, and there is evidence of clear health risks to the vulnerable below 12 °C, such as might be the case in some bedrooms in winter. It may sometimes be difficult to balance the arrangements to ensure adequate heating or cooling, energy saving, and avoidance of atmospheric pollution or excessive humidity.

Mortality statistics do not usually describe adequately the extent to which hypothermia may underly bronchopneumonia as a certified cause of death; nor may deaths from hyperpyrexia in infancy be correctly attributed to excessively high room temperatures. Mortality rates in the temperate countries of Europe are generally higher in winter than in summer, with excess deaths occurring from stroke, heart disease, bronchitis, pneumonia and accidents.

Even among the northern European countries with similar socioeconomic characteristics there remain differences in the extent of the winter excess in mortality [24]. It is probable that low temperatures in houses are a contributory factor. In the most recent quinquennial survey of English housing conditions, 11% of houses were found to have inadequate heating arrangements to make the dwelling fit for habitation throughout the year [25]. Domestic heating arrangements are needed that can maintain an adequate ambient temperature. Affordable district-based central heating, uniformly distributed, is therefore potentially very desirable.

Dampness resulting from poor construction, inadequate heating with condensation, or production of water vapour from the use of paraffin and bottled gas heaters is a determinant of ill-health in two ways. In cold, damp conditions, in addition to physical discomfort, the resistance of the respiratory tract to infection is reduced. Warmer damp conditions promote the growth of fungi on internal walls and mites in house dust and furnishings. Allergens from these sources may precipitate asthma attacks in the susceptible. In general, moulds require a relative humidity of 70% or more for spore germination, and dust mites flourish at 75–80% relative humidity. The occurrence of excessive water vapour may result from inadequate arrangements for heating or, in Scandinavian countries for example, from a combination of central heating and low rates of air exchange because of energy conservation measures (see also Chapter 5). There is no clear indication of the extent to which these conditions occur nationally. In England in 1991, 25% of dwellings did not reach standards of freedom from dampness [25].

The lack of specificity of the health outcome indicators relating to unfavourable indoor climate means that it is necessary to use instead measurements of the relevant indoor environmental conditions to indicate the potential for adverse effects on health.

Central heating

The proportion of dwellings with some form of central heating varies widely from country to country, the highest being in northern Europe (see Table 14.10). Central heating may be provided in the dwelling itself or from a district heating plant.

The availability and affordability of central heating, although advantageous to health and comfort, is not a guarantee of protection against the health effects of extremes of temperature.

Energy for heating

Solid fuel (coal and wood) remains the staple source of heating in many eastern European countries, whether for central heating or for other forms of heating. For example, 56% of fixed heating appliances in Hungary and 77% in the former Czechoslovakia use solid fuel. The potential for indoor (and outdoor) air pollution is therefore greater in those countries (see Chapter 5).

Elsewhere, the trend is away from solid fuel burning. In the former German Democratic Republic, for example, the proportion of central heating boilers using solid fuel fell from 14% in 1978 to 7% in 1987. District heating remains relatively uncommon in most countries of the Region.

Legal minimum temperature

Insulation requirements vary widely, both in extent and in specification. In new housing units they are usually specified in terms of their adequacy to achieve a legal minimum ambient temperature at an efficient level of energy input.

Among European countries, the target minimum ambient temperature for new, low-cost buildings ranges from 13 °C to 24 °C, without any consistent north–south or east–west pattern. Two of the countries with colder climates, Denmark and Switzerland, stipulate no minimum temperature.

Moulds

Few countries systematically report the extent to which dwellings develop mould. Characteristically, the problem is greatest in airtight dwellings with central heating. Some 5% of dwellings in Finland and 3–5% in Sweden were reported to be affected.[a]

14.2.8 Groups with special needs

These include the homeless, the mentally disordered, the physically disabled, frail elderly people and large families. Some individuals may belong to two or more of these categories.

The homeless

The homeless include those who would like to have their own dwellings but cannot because either the total or the affordable housing stock is inadequate, and those who for a variety of reasons are without any shelter. The latter include those who receive temporary shelter in lodgings and those who sleep in improvised shelters such as abandoned cars, subway stations and shop doorways. Many are in transitional situations: those having their homes repossessed for debt or other reasons; those who have been discharged from medical institutional care without adequate follow-up; those whose family situations have been disrupted by death or breakdown of marriage; and those who have travelled in search of employment. The health effects of homelessness include malnutrition, diseases resulting from exposure such as frostbite and hypothermia-induced pneumonia, and the effects of lack of personal hygiene such as insect-borne skin diseases. Predisposing factors are substance abuse and mental disorder.

Given the problems of defining the term "homeless" consistently, the numbers reported as such by seven countries varied

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

widely, and not in relation to the size of their population (Table 14.11) or of their housing stock. For similar reasons, it is not possible accurately to determine whether the problem is increasing or not, but it is widely believed to be larger than it was a decade ago.

Clearly, no routine information system can provide accurate data about the homeless. Special surveys are needed, with international efforts required to ensure some consistency in what is described as homelessness. Similarly, no clear rules exist for estimating the numbers of additional dwellings needed; dwellings may be available but not affordable to those in need, or not located in places with high demand. The numbers of dwellings needed, as reported by six countries, were: Israel and Sweden zero (Sweden claims to have a surplus of dwellings); Spain 163 927 (one for every 227 inhabitants); Turkey 1 million (one for every 57); Hungary 270 000 (one for every 38); and Poland 2.1 million (one for every 18 inhabitants). Not surprisingly the infant mortality rates for these countries – sensitive indicators of socioeconomic deprivation – ranged in 1990 from 6.2 per 1000 live births in Sweden to 80.9 in Turkey.

The elderly and the disabled

When describing the availability of housing for people with special needs, such as the elderly and the physically handicapped, distinctions have to be made between communal housing (residential homes) and dwellings for individuals, and also between housing adapted exclusively to the needs of only one group and where more flexible use is possible. Only one country offered any data in this field: in Sweden 1 % of dwellings are homes for the aged, 1 % are service houses with apartments, and 0.2 % are service apartments in normal buildings. The city of Montpellier in France is particularly proud of the large number of dwellings it has available to meet the needs of disabled people.

Several countries periodically conduct representative surveys of the numbers of disabled in the population, usually using the WHO International Classification of Impairments, Disabilities, and Handicaps to describe the prevalence of various conditions. The findings can be used to interpret the need for rehousing or for adapting existing housing to the needs of those with disabilities. Investing in dwellings that meet the needs of elderly and disabled people is accompanied by savings in institutional costs.

Table 14.11: Numbers and percentages of the population reported homeless in 7 European countries, 1992

Country	Number	Percentage
Denmark	20 000	0.44
Finland	6 339	0.12
Hungary	250 000	2.41
Iceland	100	0.03
Italy	12 000	0.02
Poland	250 000	0.65
Sweden	8 000	0.09

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

The Office of Population Censuses and Surveys in the United Kingdom conducts surveys from time to time on the prevalence of mental, sensory and other physical disabilities, the latest of these being reported in 1988 [27]. Approximately 14 % of people aged 16 years or more had one or more disability, 44 % of whom were severely disabled and 93 % of whom lived in their own households. This is in line with the United Nations policy that, in general, disabled people should not be segregated but wherever possible integrated in the general population. No estimates were made of the proportions who were inappropriately housed. However, such surveys of the prevalence of disability and the appropriateness of housing and other facilities for the disabled should be undertaken periodically.

Families

Most European countries have experienced a dramatic drop in birth rates to a level that does not ensure population replacement and therefore threatens the future financial balance between taxable earnings and welfare coverage, including medical care and pensions. Yet life in cities can be difficult for families with young children, especially large families. Most large families can only afford to live in low-cost blocks of flats and are the front-line victims of overcrowding, as well as the depression and loneliness of the mothers of young children living in high-rise buildings [28]. The younger children of large families are the main victims of overcrowding and unhealthy conditions in the home.

Other types of need: paying for housing

In countries that conduct surveys of family or household expenditure it is found that, in general, the lower a household's income the greater the percentage spent on housing and other aspects of shelter such as heating. For example, in the United Kingdom's 1991 Family Expenditure Survey [24] the households with the lowest 20 % of income spent 22 % of their total income on housing, net of allowances and rebates, while households with the highest 20 % of income spent 17 % on housing. In actual terms, the lowest 20 % of earners spent less than one quarter of the sum spent on housing by the highest 20 % of earners.

There are no absolute standards for how much of a household's income should be spent on housing in order to achieve a basic level of shelter and provision. Member States could usefully compare their housing expenditure along the lines suggested above. Meanwhile, the most relevant intercountry comparison available is that periodically reported by the International Labour Organisation as the percentage of average monthly household expenditure per head devoted to housing. The reports for 1985–1990 showed that, in general, western European countries spent around one fifth to one quarter of the total on housing, while central and eastern European countries spent about one tenth. (Table 14.12).

Table 14.12: Percentage of average monthly household expenditure per head devoted to housing[a] in 18 European countries

Country	Percentage
Austria (1984–1985)	22.4
Czechoslovakia (1989)	9.8
Denmark (1987)	32.0
Finland (1985–1986)	21.6
Germany[b] (1983)	24.8
Greece (1987–1988)	19.5
Hungary (1989)	10.4
Ireland (1987)	15.0
Italy (1989)	19.4
Netherlands (1988)	25.3
Norway (1986–1988)	23.2
Poland (1990)	9.7
Romania (1990)	9.6
Sweden (1988)	22.8
Switzerland (1989)	22.7
Turkey (1987)	20.8
United Kingdom (1989)	21.8
Yugoslavia (1990)	11.5

[a] May include rent, owner-occupied housing cost and imputed rent, fuel and light, or other housing costs.
[b] Combines the German Democratic Republic and the Federal Republic of Germany.

Source: International Labour Organisation *(26)*.

14.2.9 Accidents in the home

European comparisons

The nature and volume of accidents occurring in the home, and the circumstances in which they occur, are becoming clearer through analyses of data collected in the European home and leisure accident surveillance system (EHLASS) in hospitals in 11 member states of the European Union [29]. The International Classification of Diseases permits the external causes of accidents that result in death to be identified in mortality statistics, and these statistics are reported in the *World health statistics quarterly.*

The first European comparison of home and leisure accidents used data from the emergency departments of selected hospitals in six participatory countries – Denmark, France, the Federal Republic of Germany, the Netherlands, Portugal and the United Kingdom. Because of differences in the systems of classifying accidents and in methods of collecting data it has, up till now, proved difficult or impossible to make intercountry comparisons of accident patterns. Where comparison has been possible, no systematic pattern was found across all six countries [29]. It was concluded that individual countries should agree to adopt uniform reporting and to work towards a common understanding of the content of all specified categories.

The fourteenth annual report of the United Kingdom's home accident surveillance system [30] showed that there were 4024 fatal home accidents in 1990 (0.1 per 1000 population). The estimated incidence of home accidents was 56 per 1000 population per year. Younger members of the population had the highest risk of home accidents, but the elderly had the highest risk of an accident proving fatal. Home accidents accounted for approximately 40 % of all fatal accidents, and one third of all accidents treated in hospital.

Most home accidents were falls and mainly affected the elderly and the very young, each accounting for approximately 20 %. Only 2 % of home accidents involved poisoning by ingestion or inhalation, but this amounted to over 60 000 cases; there was a similar proportion of burns.

Table 14.13: Average annual death rates per 100 000 in 28 European countries, 1983–1985: accidental falls, women aged 75 years or over

Country	Rate
Bulgaria	27.5
Spain	58.5
England & Wales	98.5
Israel	103.2
Iceland (1983 only)	105.3
Yugoslavia	106.9
Portugal	117.2
Sweden	134.9
Ireland	141.7
German Democratic Republic	144.9
Greece	151.4
Poland	153.6
Finland	165.7
Federal Republic of Germany	173.1
Netherlands	182.7
Northern Ireland	184.8
Malta (1983 only)	193.2
Luxembourg (1983–1984 only)	205.7
Scotland	206.9
Belgium (1986 instead of 1985)	219.0
Italy	232.9
Denmark	273.3
Austria	274.2
Norway	291.1
Switzerland	308.8
France	325.9
Czechoslovakia	419.2
Hungary	511.7

Source: World health statistics quarterly.

Safety and injury

The United Kingdom analysis of fatal home accidents shows that faulty constructional design is the largest single cause, accounting for one in seven of such accidents.

The range of mortality rates from accidental falls shown in Table 14.13 is very broad. The fact that the rates in two neighbouring countries can vary by as much as 20-fold suggests that local practices of certification of cause of death may vary. This anomaly requires further investigation, and contact with individual government statistical offices will be needed to help clarify the situation.

None of the indices of housing configuration that are routinely published internationally give adequate descriptions of those aspects of housing that put people at risk of falling accidentally. Stairs are hazardous for the elderly and for the young. The most appropriate index in this respect therefore may be the proportion of the population aged 65 years and over living in housing units with one or more parts situated above ground level and without access to an elevator. Coroners' records for England & Wales show that, in 1973–1977, children living above the first floor were nearly 60 times more likely to be killed by falling than children on the ground or first floors [28].

Fire

Death or injury from fire is another physical hazard. In the United Kingdom three quarters of all fatalities that arise from fires are domestic. Death rates are highest among the elderly and again, it is likely that the fires concerned are domestic. Their causation and spread involve various factors such as heating and cooking arrangements, the combustibility of interior fabrics, and the materials from which the external structure of the dwelling was built. Exits that can be used by the elderly are important for determining the outcome of such accidents.

The latest English house condition survey reported that 10% of the housing stock had electrical systems that were defective or inadequate. One quarter of these houses needed complete rewiring [25].

The routinely available statistics do not enable these components to be distinguished from each other. The country profiles of deaths by fire may be related to statistical profiles of dwellings according to construction materials, age of structure, principal cooking arrangements and principal heating arrangements reported in the survey conducted for this report. Cross-national data on other relevant factors, such as the prevalence of tobacco smoking among the elderly, would also be needed in order to gain an accurate interpretation of the role of the dwelling itself.

Table 14.14 shows a 10-fold variation in death rates from fire injury among elderly men in European countries. A similarly wide range is noted among children aged 1–4 years (especially boys) in the various European countries. Table 14.15 ranks countries according to the average annual mortality rate for children aged 1–4 years dying from the effects of fire. The period covered here is subsequent to that displayed for the elderly

Table 14.14: Average annual death rates per 100 000 in 26 European countries, 1983–1985: fire and flames, men aged 75 years or over

Country	Rate
Federal Republic of Germany	3.8
Netherlands	4.1
Switzerland	4.2
Sweden	4.9
Italy	5.6
Israel	5.9
German Democratic Republic	6.2
Poland	6.4
Spain	6.5
Yugoslavia	6.7
Austria	7.0
Belgium (1986 instead of 1985)	7.0
France	7.9
Northern Ireland	8.2
Finland	8.3
Denmark	9.3
England & Wales	9.3
Greece	9.8
Norway	9.8
Bulgaria	11.5
Czechoslovakia	12.5
Croatia	14.9
Portugal	17.0
Scotland	17.1
Hungary	19.7
Ireland	31.4

Sources: World health statistics quarterly; data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 14.15: Average annual death rates per 100 000 in 30 European countries or territories, 1986–1990: fire and flames, males aged 1–4 years

Country	Rate
Iceland	0.0
Malta	0.0
Greece	0.4
Italy (1985–1989)	0.4
Switzerland	0.5
Spain (1985–1989)	0.7
Sweden (1986–1989)	0.8
Finland	0.9
German Democratic Republic	0.9
Czechoslovakia	1.0
Hungary	1.0
Croatia[a]	1.1
Netherlands	1.1
Norway	1.1
Belgium (1986–1989)	1.2
Yugoslavia	1.2
Israel (1985–1989)	1.3
Poland	1.3
Denmark	1.4
France	1.6
Federal Republic of Germany	1.7
Austria	1.8
Luxembourg	2.1
Portugal	2.1
United Kingdom	2.7
Ireland	3.1
Bulgaria	3.3
Byelorussian SSR (1987–1990)	3.3
Ukrainian SSR (1987–1990)	3.9
Romania (1989–1991)	5.0

[a] 0–4 years.

Sources: World health statistics quarterly; data supplied in country responses to the Concern for Europe's Tomorrow protocol.

in Table 14.14; this ensures that where similarities in rank positions occur among the various countries for these two age groups they are not attributable to the involvement of members of different age groups in the same fires. There is a broad similarity in the positions in the rankings for those countries for which statistics were available from the *World health statistics quarterly*. Closer epidemiological scrutiny is warranted, but if these data are valid they imply that there is considerable scope for improvement in home safety in some countries.

Overview

The extent of the differences among European countries in the occurrence of home accidents and the resulting mortality is not known with any certainty. The relevant government departments and consumer organizations should collaborate internationally to achieve standard methods of recording these occurrences and their outcomes, in order to identify more clearly the circumstances in which home accidents occur and the factors determining outcomes.

14.3 Trends

14.3.1 Urbanization

Although there seems little tendency for further urbanization to occur in countries in which 80% or more of the population already live in urban areas, other countries in Europe are likely to continue their present trend towards greater urbanization. There may, however, be local population movements from areas or cities with poor employment opportunities to urban areas, especially large cities where work opportunities may exist. International migration from low-income to high-income countries may also occur.

In parts of Europe, such as some southern countries, urbanization has included unplanned developments with far from adequate housing and a lack of basic public health infrastructures. In conditions of economic hardship there is a danger that this type of development may continue, with accompanying risks of communicable diseases, particularly among children. In the CCEE and NIS, undergoing the difficult transition from planned to market economies, the resulting unemployment may also lead to poor quality urban settlements. A worrying problem in the CCEE and NIS is the trend to give up former programmes of subsidized social housing before alternative sustainable housing policies have been developed.

14.3.2 Homelessness

As pointed out above, it is not possible to determine with any accuracy the extent or causes of homelessness in Europe. Prediction of future trends is speculative. However, if it is assumed that poverty is an important factor, then the widespread economic recession in Europe and the problems of economic transition in the CCEE and NIS would point to an increase in the number of homeless. In certain countries in the Region, refugees from the consequences of armed hostilities add to the homeless population.

14.3.3 Accidents

Information about trends in home accidents is available from the United Kingdom. During the period 1980–1990 there was no marked change in the estimated annual number of non-fatal accidents, but over the same period there was a 25% reduction in the number of fatal accidents in all age groups. Whereas children aged 0–4 years account for nearly a quarter of home accidents, two thirds of fatal accidents occur in people aged over 65 years.

The reason for this trend towards a reduction in fatal home accidents is likely to be multifactorial and needs to be analysed.

Such information could facilitate a wider reduction in fatal home accident rates in Europe.

14.4 Conclusions

In general, the housing stock in the European Region affords adequate space per person for avoiding the worst of the health effects of overcrowding, but there are still some countries that lack adequate space per person.

The piped supply of safe water to housing units is inadequate in some countries of the CCEE and NIS, particularly in rural areas.

There is a lack of conformity, and therefore of comparability, in methods for measuring aspects of the housing environment from country to country. This includes general housing conditions, fitness for habitation, housing structure and insulation, indoor pollution, home accidents and homelessness. For example, there are almost certain to be differences between countries in methods of categorizing home accidents and homelessness, and their causes and effects, making it difficult to make comparisons and therefore to gain opportunities for effecting improvements.

Urban planning and urban development have been inadequate in many European countries (with some notable exceptions such as Denmark) to meet the aspirations of inhabitants for life in a healthy city with sustainable urban development.

References

[1] *Expert Committee on the Public Health Aspects of Housing. First report*. Geneva, World Health Organization, 1961 (WHO Technical Report Series No. 225).

[2] Petersson, B. et al. *Creating supportive environments for health. Report from the 3rd International Conference on Health Promotion, Sundsvall, Sweden, June 1991*. Sundsvall, People's Health Västernorrland, 1992.

[3] *Uses of epidemiology in housing programmes and in planning human settlements*. Geneva, World Health Organization, 1974 (WHO Technical Report Series No. 544).

[4] Martin, A.E. & Oeter, D. *Environmental health aspects of human settlements*. Copenhagen, WHO Regional Office for Europe, 1978 (document ICP/BSM 002).

[5] *Health principles of housing*. Geneva, World Health Organization, 1989.

[6] Smith, S.J. *Housing and health. A review and research agenda*. Glasgow, University of Glasgow Centre for Housing Research, 1989.

[7] Stanners, D. & Bourdeau, P. ed. *Europe's environment: the Dobris Assessment*. Luxembourg, Office for Official Publications of the European Communities, 1995.

[8] Grant, J.P. *The state of the world's children*. Oxford, Oxford University Press, 1985.

[9] Grant, J.P. *The state of the world's children*. Oxford, Oxford University Press, 1993.

[10] *Living conditions in urban Europe*. Dublin, European Foundation for the Improvement of Living and Working Conditions, 1987.

[11] *Annual report 1993*. Washington, DC, World Bank, 1993.

[12] *Annual bulletin of housing and building statistics for Europe and North America*. Geneva, United Nations Economic Commission for Europe, 1993.

[13] WHO Commission on Health and Environment. *Report of the Panel on Urbanization*. Geneva, World Health Organization, 1992.

[14] Ranson, R. *Guidelines for healthy housing*. London, E. & F. Spon, 1991.

[15] Alexeev, M. et al. *Overview of the Soviet housing sector. Report to US Office of Housing and Urban Programs AID*. Washington, DC, PADCO Inc., 1991.

[16] Goskomstat USSR. Press release No. 177, May 4, 1990.

[17] [*Government report on the state of health of the population of the Russian Federation, 1992.*] Moscow, Ministry of Health, 1993.

[18] *Environmental health in urban development*. Geneva, World Health Organization, 1991 (WHO Technical Report Series No. 807).

[19] *Twelfth annual report, home accident surveillance system*. London, Department of Trade and Industry, 1988.

[20] Health and Safety Executive. *Annual report 1992–1993. Statistical supplement*. London, HSE Books, 1993.

[21] Stout, J.E. et al. Potable water as a cause of community-acquired legionnaires disease. *New*

England journal of medicine, **326**: 151–155 (1993).
[22] Morse, D.L. et al. Sporadic cases of legionnaires disease. *New England journal of medicine*, **326**: 1700 (1993).
[23] *Health impact of low indoor temperatures*. Copenhagen, WHO Regional Office for Europe, 1987 (Environmental Health Series No. 16).
[24] Central Statistical Office. *Family spending. A report on the 1991 Family Expenditure Survey*. London, H.M. Stationery Office, 1992.
[25] Department of the Environment. *English house condition survey 1991*. London, H.M. Stationery Office, 1993.
[26] *Household income and expenditure statistics. Annuals 1985–1991*. Geneva, International Labour Organisation, 1985–1991.
[27] Martin, J. et al. *The prevalence of disability among adults. OPCS Surveys of Disability in Great Britain. Report 1*. London, H.M. Stationery Office, 1988.
[28] Freeman, H. *In:* Burridge, R. & Ormandy, D., ed. *Unhealthy housing: research, remedies and reforms*. London, E. & F. Spon, 1993.
[29] Heskith, L.J. *European comparison of home and leisure accidents. Summary report*. London, Department of Trade and Industry, 1992.
[30] *Fourteenth annual report, home accident surveillance system*. London, Department of Trade and Industry, 1990.

Chapter 15
Occupational Health

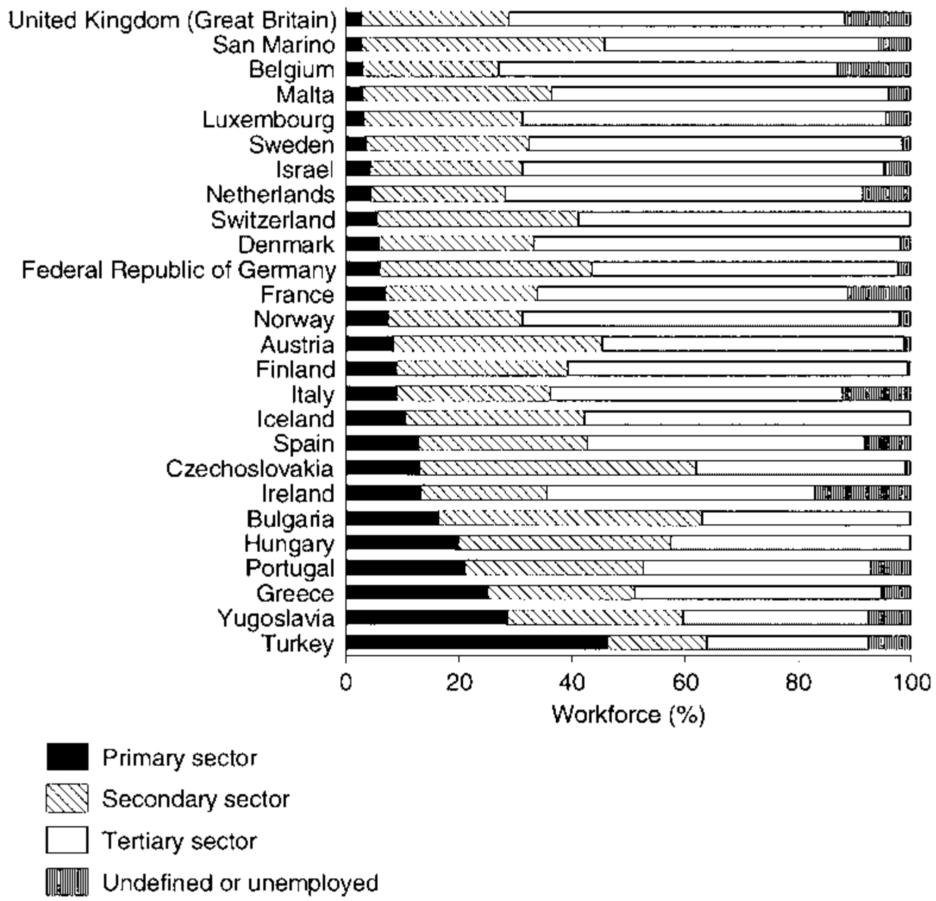
15.1 Current Trends in European Working Life

Major socioeconomic and social changes in both the western and eastern parts of the WHO European Region have affected several societal sectors and working life in particular [1,2]. Economic integration in the western parts of the Region has created a market aiming at the free movement of goods, capital, labour and services across national borders. This requires the determination of minimum conditions of work [3] and the harmonization of the technical, safety and health properties of substances, preparations, materials, tools and machinery.

In the eastern parts of the Region the transition from planned economies to market-driven systems has greatly affected the structures of economies and conditions of work [1]. Large state-owned production units have been split into smaller independent companies and, to a great extent, privatized. As a result, the infrastructures of occupational health and safety services, which were organized according to the big industry model, will experience major changes.

Throughout the Region, the most important questions for occupational health policy are how national policies can ensure at least a minimum standard of safety and health at work during such dynamic changes, and how they can prevent the reduction of social standards at work in the growing economic competition within the European Region and between the various regions of the world [4].

In spite of decades of effort at harmonization by the International Labour Organisation (ILO), the Organisation for Econ-



Source: International Labour Organisation (7).

Fig. 15.1: Distribution of workforces between sectors of the economy in countries of the WHO European Region

omic Co-operation and Development (OECD) and the European Community, and similar efforts in the eastern parts of the Region, the conditions of work still vary widely between countries [5].[a] Such differences are due to differences in the degree of industrialization and in general socioeconomic development. The highly advanced, post-industrialized countries have shown clear improvements in working conditions, while the conditions found in the less industrialized countries of the Region still require major development. Great differences are found in the Region not only between east and west but also between north and south [6].

Out of about 400 million working people in Europe (160 million women and 240 million men) about 80–100 million (20–25 %) are estimated to work in agriculture or other sectors of primary production such as forestry, fishery, mining and quarrying [7]. About 120–140 million (30–35 %) work in different types of industrial manufacturing activity (secondary sector) and about 140–200 million (35–50 %) in various types of service (tertiary sector); the rest, 20–40 million (5–15 %), work in undefined occupations or form part of the growing number of unemployed people [8]. While the post-industrialized northern and western countries of the Region have less than 10 % of their workforce in primary production, often less than 30 % in manufacturing industries and about 60 % in services, the heavily industrialized CCEE typically have more than 10 % in agriculture, 30–50 % in industry and about 30 % in services (Fig. 15.1). Some of the

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

southern and south-eastern countries may still have up to 45% of the workforce in agriculture, a relatively small industrial sector (less than 20%) and a small services sector (less than 30%).

Working conditions and health hazards at work differ substantially between the three main economic sectors. Thus, the two main types of variation in working conditions are the differences between occupations and sectors of the economy, and differences in conditions in the same occupation or sector in different countries or parts of the Region [6].

Another major factor modifying working conditions is technological development. The use of new types of information technology and automation, growing mechanization, the growing use of chemicals, and the introduction of new materials and new biotechnologies modify both the working environment and the organization of work. In general, this will lead to a decrease in heavy physical and manual work and an increase in controlling technical processes or machinery, work in offices, and different types of expert work (the so-called "white-collar" jobs). Provided that such technology is used according to the best principles of occupational health, the ultimate effect of these trends will be beneficial [8].

Further, the Region's workforce is changing dynamically [9,10]. In general, the average age of the working population is increasing, particularly in the alpine and northern countries. This brings the occupational health problems of the older worker to the fore. Simultaneously, the growing participation of women in paid work (at present they comprise about 40% of the workforce) increases the need to modify working conditions for the female physique and to allow for women's family roles. These workers need special consideration in the development of occupational health programmes, as do the growing numbers of mobile workers and migrants (about 20–30 million) from inside and outside the Region. Finally, the number of unemployed people in the Region (about 30–35 million at present) is likely to grow; social and health problems accompany this trend [4].

About 60–80% of enterprises in the Region are of small or medium size, employing fewer than 50 people. Such enterprises employ about 20–50% of the Region's workforce, and they are likely to comprise the only sector of the economy that will provide new jobs. Particularly in industry and agriculture, however, such enterprises are known to have more hazardous work environments than larger companies [8]. This is of particular importance to occupational health, because the small and medium-size enterprises are the most common workplaces for young people, female and elderly workers, and owners' families. Work is often done at home, which implies potential occupational exposure of all members of workers' families. Although occupational health and safety policies have traditionally not covered small enterprises, the growing importance of this sector justifies extending the coverage of policy, legislation and services.

New policies of countries and the European Union (EU) have addressed these trends in working life in the Region, including the special needs of vulnerable groups and workers in smaller enterprises [2,3]. Much remains to be done, however, before the work environment is equally safe and healthy for all working people. International collaboration is needed to ensure that no community or company will compete by lowering the standards of working conditions and occupational health.

15.2 Important Factors at Work and in the Work Environment

Although a growing amount of research data supports the view that a healthy workplace is also the most sustainable and productive one [11] hazardous conditions are still common

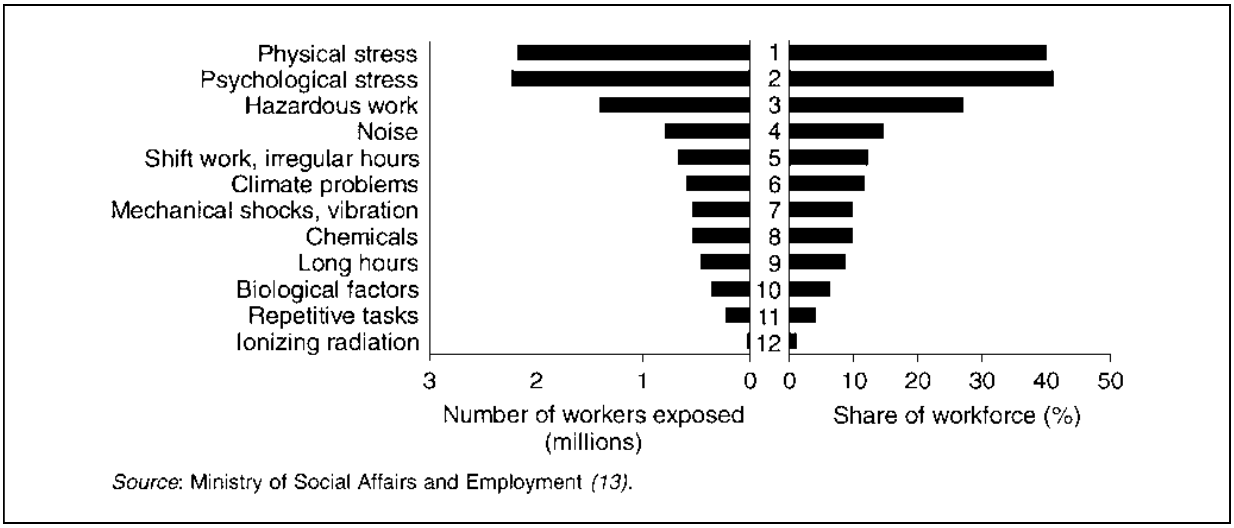


Fig. 15.2: Occupational hazards in the Netherlands

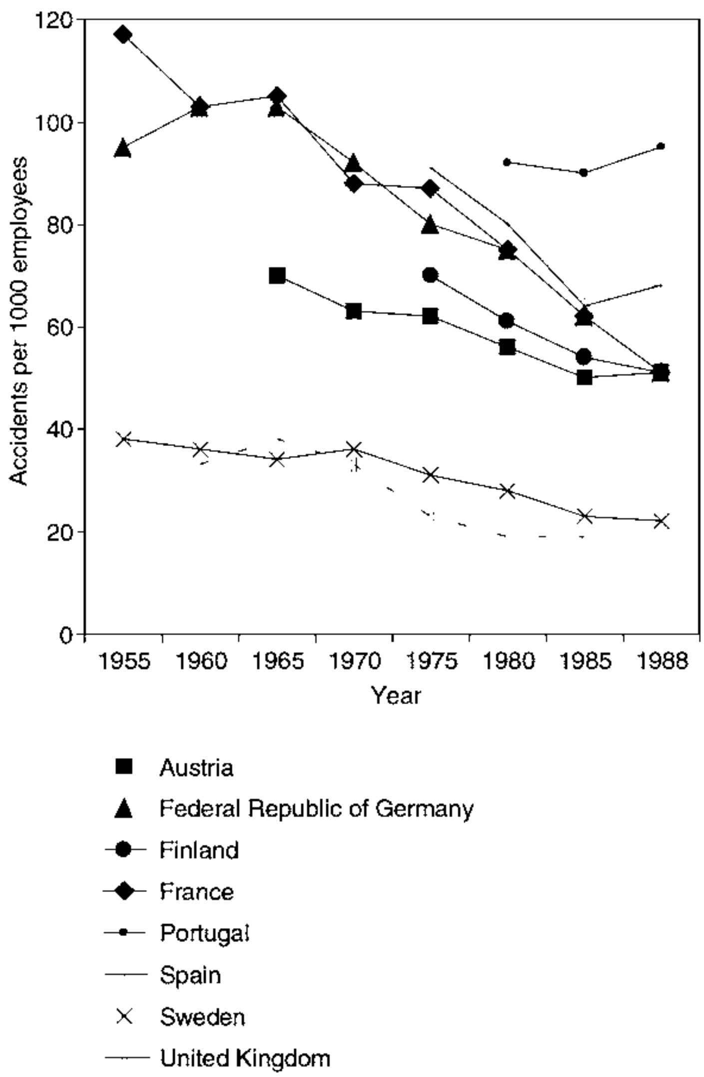
in European work environments. Categories of occupational exposure at work include mechanical factors (and accident risks), physical strain, ergonomic factors, chemical hazards, thermal conditions and microclimate, physical factors, biological factors and organic dusts, ionizing and nonionizing radiation, psychological factors and psychosocial conditions of work [12]. The number of workers exposed to different hazards can vary considerably among countries. Depending on the country and survey in question, 20–50% of the workforce is exposed to health hazards at work. Systematic surveys on exposure levels are rare, but numerous studies are available on individual exposures or the hazards of particular occupations. The numbers of workers in the Netherlands with potential exposure to various occupational hazards are presented in Fig. 15.2 [13]. Parallel results have been obtained from surveys in other countries, such as Finland and Sweden [14,15].

15.2.1 Mechanical risk factors

Although many accidents happen outside the workplace, occupational accidents are the leading group of accidents causing personal injury [16]. The recorded rates of occupational accidents in different countries depend not only on the level of safety of the work environment, but also on the efficiency and coverage of and criteria for registration [7,17]. Great variation in registration practices precludes the comparison of statistics from different countries. Although workplaces in the Region are among the safest in the world [18,19] they vary considerably. Even greater variations would be likely if comparable data on occupational safety and health were available from all countries. There are several reasons to assume that the countries with nonexistent or poor registers are also likely to have the lowest standards of safety and health at work.

The annual average rates for all kinds of occupational accident in countries with good registration systems range from about 20 to 100 accidents per 1000 employees. In most of the European OECD countries, total numbers have declined by 50% in the past 30–40 years; in the second half of the 1980s, however, the numbers levelled off or even increased in some countries (Fig. 15.3) [20,21]. About 10% of such accidents are severe, leading to more than 60 days' absence from work; about 1–5% lead to permanent disability.

Although the registration of occupational accidents is not harmonized in the CCEE and NIS, some conclusions can be drawn about the occurrence and distribution of accidents from data for Estonia, Hungary and Poland. According to data collected by



Source: Organisation for Economic Co-operation and Development *(20,21)*.

Fig. 15.3: Occupational accident rates in eight European countries, 1955–1988

WHO,[a] the registered accident rates were 36.4 per 1000 workers for Hungary in 1990, 8.36 per 1000 in Poland in 1990 and 5.4 per 1000 in Estonia in 1991. Although underreporting may be substantial, these risks are at the levels of the most risky industries in western countries. In Poland, accidents are declining in industry and forestry but rising in trade and agriculture [22]. In the Russian Federation, the industries with the highest risks of accident and death are coal mining, diamond and gold prospecting, and the timber, oil and gas industries. Although accident rates differ greatly among countries, mining and construction show the highest risk in most.

Depending on the country, about 0.1–2.5 % of all registered accidents are fatal [5]. Because deaths are registered effectively in most countries, international comparisons of rates of fatal accidents are more reliable than those of all accidents. Even so, the reported average rates of occupational fatalities range from 0.2 to 25 per 100 000 workers, owing more to differences in the coverage of registration than in the numbers of deaths. In all European OECD countries,

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

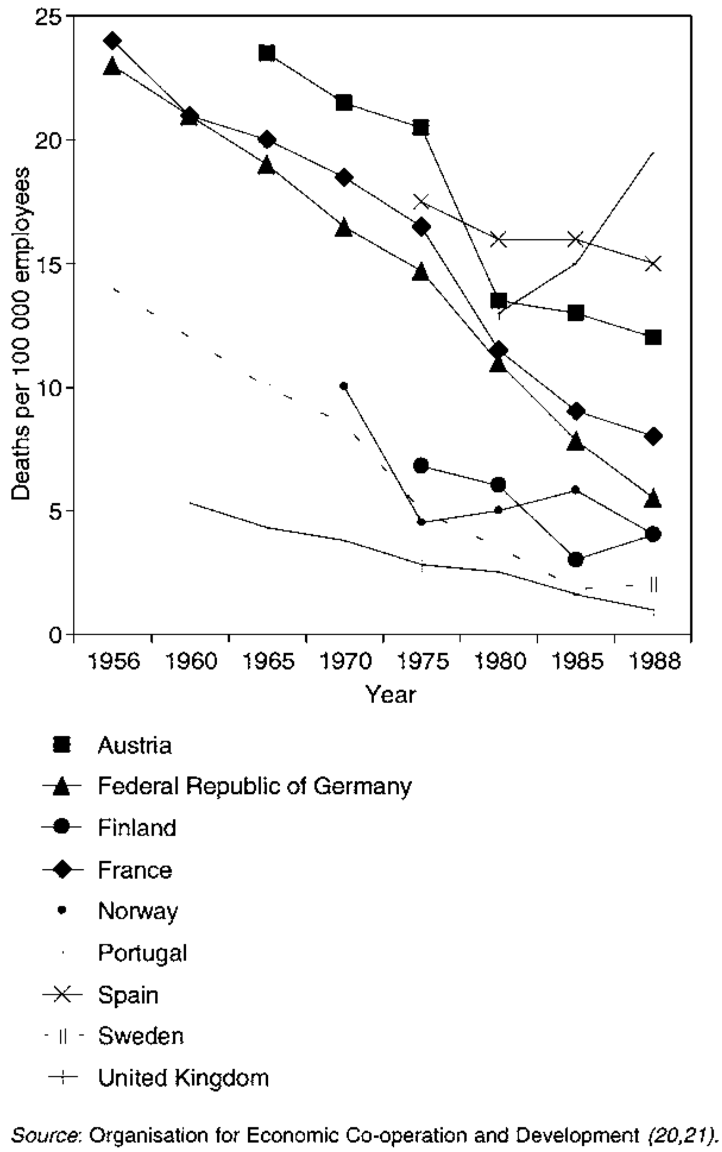


Fig. 15.4: Deaths from occupational accidents in nine European countries, 1956–1988

agriculture, forestry, fishery, mining and quarrying, manufacturing and construction and transportation caused 70–85 % of all fatalities. The reported rates, however, have declined by about 50–60 % in the past 30–40 years in most industrialized countries (Fig.15.4).

In the eastern countries of the Region, the reported rates of fatal accidents were about 1.0 per 100 000 workers for Estonia, 1.4 for Hungary and 0.7 for Poland. The highest risks, as expected, are found in manufacturing and mining; these exceed the risks of transport, for example, by 100 % [7,23].

In some countries such as Portugal and Spain, and apparently in the CCEE and NIS, the reported total numbers of all accidents are increasing as a consequence of either improved registration or intensified production efforts [20,21]. The reported rates of some of the CCEE and NIS are lower than in any western countries with good registration systems, which suggests underreporting in the countries in transition [24]. The high proportion of fatal accidents also suggests underreporting of total numbers of accidents, possibly owing to the practice of not reporting less severe cases. The real accident rates in the countries with severe underreporting have been estimated by the Estonian authorities to be up to three times those of countries with good registers [24].

Both the total number of accidents and the number of fatal accidents vary widely between various industries and occupations [19] (Fig. 15.5 and 15.6). In Finland, for example, the most hazardous occupations have 30 times the risk of the least hazardous [19,25]. The highest risks are related to the high use of mechanical or muscular energy (as in mining and forestry), high flows of material through production units (as in sawmills and transport), rapidly changing work environments (as in construction and transport) and occupations involving manual work with dangerous tools (as in butchery) and those in which weather and natural elements play a major role (as in farming, fishery, forestry and transport).

The most common causes of accidents in industrialized countries are unsafe working floors and gangways, physical strain, and poorly safeguarded machines and hand tools. The type of work and the nature of the work environment very strongly influence the level of accident risk. More than 80 % of occupational accidents in industries have been attributed to hazardous machinery, work organization or factors in the work environment [18]. Some multinational com-

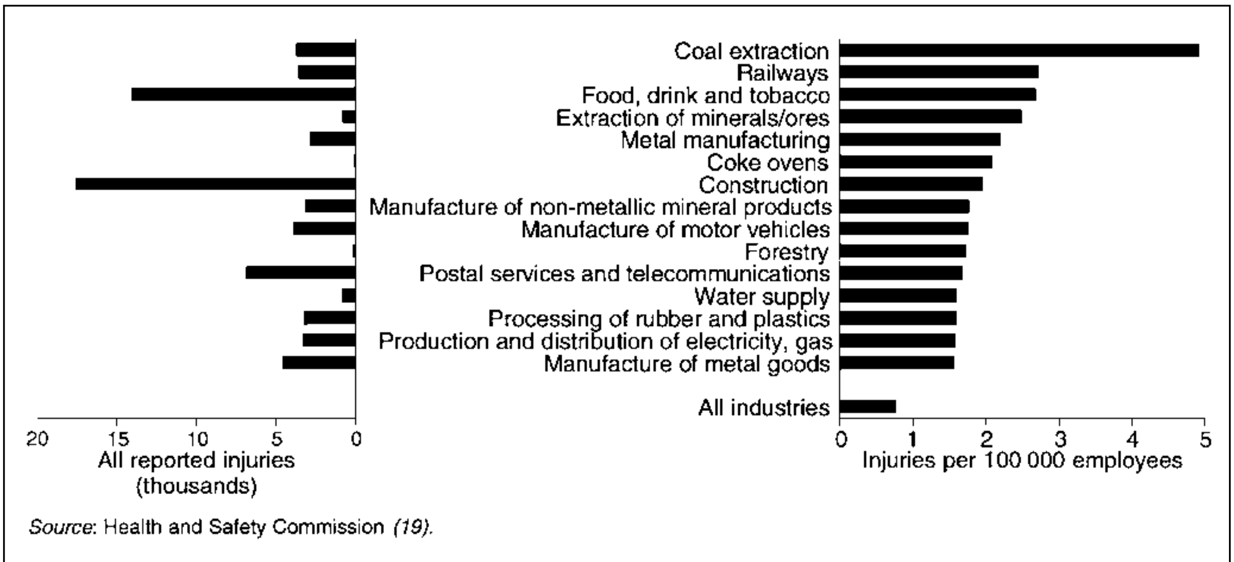


Fig. 15.5: The 15 industries with the highest numbers and rates of injury in the United Kingdom, 1991/1992

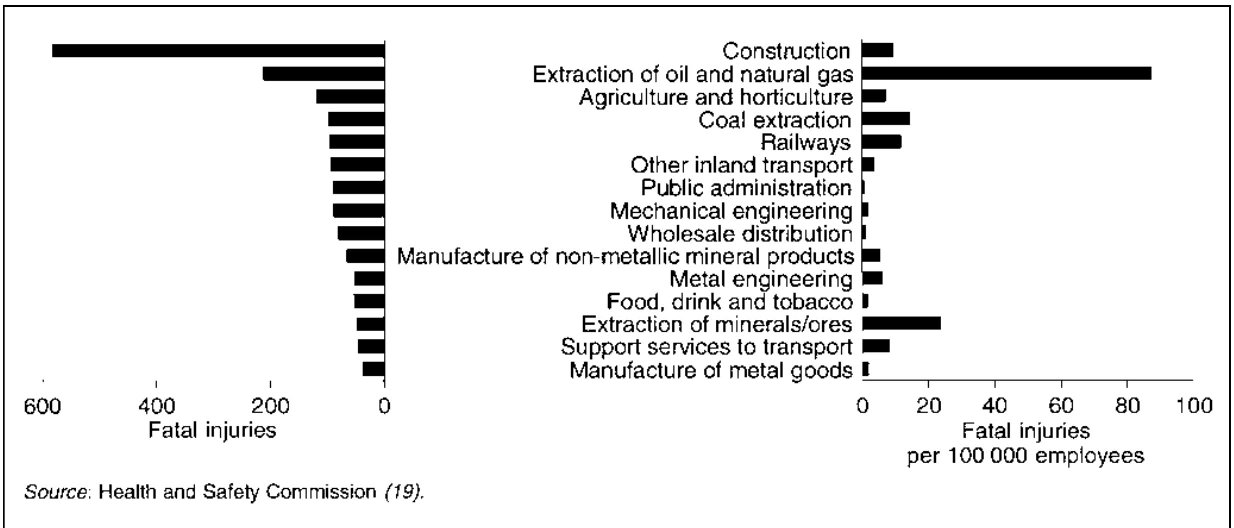


Fig. 15.6: The 15 industries with the highest numbers and rates of fatal injury in the United Kingdom, 1986/1987–1991/1992

Table 15.1: Physically strenuous occupations and their occurrence in the workforce in Finland

Type of workload	Percentage of workforce exposed	Examples of occupations
Heavy dynamic work	10–15	Lumbering, farm work, construction
Moving and lifting	5–10	Warehousing, stevedoring, transport, hospital work, construction
Static muscular work	5–10	Electrical work, repair and maintenance of machinery, car repair, laboratory work, construction, hospital work, office work
Repetitive and monotonous movements and tasks	5	Food industry, semi-mechanized industries, textile manufacturing, construction, wood industry, packing

Source: Rantanen, J. & Lehtinen, S. *(14)*.

panies have successfully applied a built-in "zero-risk" strategy, focusing safety measures on the most hazardous situations identified by systematic safety analyses and considering safety aspects in the planning and design of industrial workplaces.

The great variation in risk – between different occupations, between individual undertakings with similar types of production and between similar branches of industry in different countries – indicates much scope for accident prevention. In some countries, effective preventive programmes have resulted in a permanent decline in accident rates, even in traditionally high-risk industries [26,27]. Accident rates in those countries with long traditions in occupational health and safety, such as Sweden, are remarkably lower than in several other countries that are otherwise as technically advanced.

The costs of occupational accidents may be higher than expected. For example, such costs amounted to 7.5 billion[a] ECU in Belgium in 1990. The economic loss from occupational accidents in some industrialized countries has been calculated as 3–5 % of the gross national product (GNP). Thus, preventive measures are likely to be cost-effective [20,21,28].

Major technological accidents are discussed in Chapter 16.

[a] 1 billion = 10^9.

15.2.2 Workload and ergonomic conditions

The physical workload has decreased substantially in industrialized countries over the past 30 years. The risk of overload, however, still affects 10–30 % of the workforce in highly industrialized countries and up to 50 % of the workforce in less industrialized countries. Physically strenuous work is found in all main types of economic activity: agriculture, forestry, mining, manufacturing and services (Table 15.1). On average, 16 % of all workers, 25 % of manual workers and 33 % of farmers in the EU are reported to be exposed to poor ergonomic conditions at work [6]. Recent research has emphasized the importance of considering ergonomics in lifting, as well as in moving, heavy loads [29,30].

Repetitive strain injuries occur most often in semi-mechanized industries, in which the pace of work is dictated by the movements of machines at rates exceeding 30 per minute. Continuous overstrain results in acute painful musculoskeletal disorders, which make it impossible to continue working. The risk of injury is particularly high if considerable muscular force is needed and if work movements do not follow the usual physiological paths of the upper extremities; that is if they involve, for example, twisting or rotation of the wrist. Numerous surveys of working conditions in various occupations indicate a high and sometimes growing prevalence of ergonomic problems at workplaces in all the main economic sectors [14]. In Sweden, for example, musculoskeletal disorders are carefully registered and there are up to 10–16 cases per 1000 employees, with machine mounters and butchers at the highest risk [12].

In the eastern countries of the Region, objective data on the physical workload are in general very sparse, owing to a short tradition in ergonomics. The physical workload has been found to be near the risk limits in open-cast mining [31] and overloading of the upper extremities is prevalent in semi-mechanized industries [32]. Rates of locomotor system diseases are elevated among Hungarian workers in the mining, metallurgy, textile, leather, shoe, food, printing and woodworking industries, and physical overload causes about 10% of all occupational diseases in the Czech Republic.[a] The demands for increased productivity, particularly in the semi-mechanized industries, is likely to increase the problem further.

Injuries caused by physical workload, and particularly by repetitive tasks, are the leading occupational diseases in many countries. According to WHO data,[a] however, injured workers receive only very limited compensation in some countries, and thus also the registered numbers remain low. Physical workload is growing in importance as an occupational health problem in the Region, where the average age of the working population is increasing and underlying chronic diseases of the cardiovascular and musculoskeletal systems are becoming more prevalent.

Physical workload depends on several factors in the working environment, such as the degree of mechanization, organization of work, ergonomic aspects, quality of tools, availability of work aids, microclimatic conditions and the nature of the work itself. Most of these factors can be effectively regulated, and the risk of overload and strain injuries thus diminished. Improving ergonomic conditions and controlling physical overload will become occupational health priorities in the Region. Many reports [14,20,21] show positive results from increasing workers' freedom to regulate the pace of work, and eliminating the piecework system. These measures permit workers to adjust the workload to their personal working capacity.

15.2.3 Physical factors

Noise

Levels of exposure to noise stabilized or decreased in the 1980s in many of the industrialized countries [14,33] but noise still constitutes an important occupational health hazard. Depending on the type of industry, some 15–50% of all workers are exposed to noise at levels exceeding the threshold for impairment of hearing (80–85 dB). In certain industries such as metal manufacturing, mining and quarrying, and glass, clay and stone production 50% or more of workers may be exposed to levels of over 85 dB [34].

The most important health effect of such exposures is noise-induced hearing loss. Hearing loss develops more rapidly from impulse noise (intermittent bursts of noise), particularly at higher sound frequencies, than from continuous noise. Occupations involving exposure to high levels of such noise, in addition to those already mentioned, include construction and all activities in which power machines and mechanical hand tools are used. Newly recognized problems include the synergistic effect of noise and hand–arm vibration, as well as the suggested synergistic effects of tobacco smoking or solvent exposure and noise. Several other individual or environmental factors may modify the response to noise [34,35]. Since the health effect of noise is cumulative, regardless of the source, the combined effect of exposure to noise in the workplace and during leisure time should be considered. In spite of effective noise control measures at the work-

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

place, the number of cases of noise-induced hearing loss is increasing as a consequence of exposure to high levels of noise from other sources, which affects the hearing of younger workers in particular [33].

The high degree of mechanization and difficulties in controlling noise emissions make it likely that exposure levels at work in the CCEE and NIS are high [36]. In the WHO statistics on occupational diseases, noise-induced hearing loss comprises 12 % of all occupational diseases in Bulgaria, 15.6 % in the Czech Republic, 49 % in Hungary and 25 % in Poland. The lower figures for these countries are at roughly the same level as those for western European countries (20 % in Finland and 23 % in Germany). In Finland there are 0.35–70 cases of noise-induced hearing loss per 10 000 workers [15], this 200-fold variation in risk being dependent on industry and occupation.

Recent research has explored the adverse health effects of noise other than hearing loss [34,37,38]. Even at relatively low levels, noise is known to be a cause of stress and annoyance, disturbance of concentration and lower effective performance at work (see Chapter 13). Several other adverse effects have been reported, such as increased risk of accidents, elevated blood pressure, elevated cardiovascular morbidity and the occurrence of several types of psychosomatic disorder. In addition, noise exposure at work may affect quality of sleep [34].

Vibration

Exposure to vibration is most frequently generated locally by powered or pneumatic hand tools, such as drills, hammers, grinding tools and machines and chain-saws. Up to 5 % of the workforce in industrialized countries may be exposed. The hand and arm are affected, leading to numbness and aching, vasospastic reactions, peripheral nerve injury or, in extreme cases, vacuolation of bones and possibly arthrosis. Depending on the occupation and pattern of exposure, the prevalence of vibration syndromes may vary from 1 % to 80 % of exposed workers [39,40]. The use of powered hand tools is still prevalent in the CCEE, which have a relatively high proportion of vibration-induced disease in workers' hands and arms. According to WHO data,[a] vibration diseases comprise 17 % of all occupational diseases in the Czech Republic, 8.8 % in Bulgaria, 6.8 % in Hungary and 6 % in Poland [22]. They are less prevalent in western countries, comprising, for example, 0.2 % of occupational diseases in Finland and 2.4 % in Germany. This probably indicates the positive impact of modern attenuated hand tools and the introduction of fully mechanized drilling machines for such work as mining and quarrying. The scientific basis for standard setting is, however, still actively debated [39]. Nevertheless, there is wide agreement that the duration and level of exposure to vibration should be reduced to the minimum. The EU limits on hand tool vibration imply a clear reduction from the present levels [41,42].

Workers are exposed to whole-body vibration mainly from road vehicles and railway engines, or from off-road vehicles and power machines such as tractors, forestry machines and tanks. Water-craft and aircraft are well known for exposure to whole-body vibration. About 5–10 % of the workforce is likely to be affected; the levels of exposure are gradually declining. The effects of whole-body vibration on human beings are neurological (feelings of discomfort, disturbances of psychomotor and visual performance, disturbances of balance and EEG changes), gastrointestinal (nausea, vomiting), cardiorespiratory (elevated heart rate and blood pressure and hyperventilation) and musculoskeletal (muscular contractions and degenerative changes in joints, particularly in the backbone) [43,44].

Preventing whole-body vibration is often complicated, particularly when the terrain may be critical in the generation of exposure

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

in vehicles. Nevertheless, there is scope for improvement in the balance, seating and vibration damping of vehicles, in speed restrictions and in the quality of road surfaces.

Nonionizing radiation

Nonionizing radiation (see Chapter 11) comprises three main groups: optical radiation (visible light, lasers and ultraviolet and infrared radiation), radiofrequency waves (microwaves, radio waves) and electric and magnetic fields at extremely low frequencies. About 2–3 % of workers in industrialized countries are exposed to some nonionizing radiation. Exposure to ultraviolet radiation may occur both in industry and in several outdoor occupations such as farming, seafaring and forestry. Intensive exposure to optical radiation may result in skin burns; in the case of ultraviolet radiation there is an increased risk of developing skin cancer or cataract [45,46].

Radiofrequency waves cause thermal effects in deep layers of tissue, or in bordering surfaces of tissue of different consistency. Lasers may also produce acute thermal effects. Exposure to electric and magnetic fields is reported to cause numerous effects on the nervous system [47]. Reports of long-term effects on reproduction and the induction of cancer have been published, but the results are inconclusive [48,49]. Some workers (such as those in metallurgy, plastic welders, power-line, radio and telecommunication workers, and workers in certain health services) may have levels of exposure one or several orders of magnitude higher than those of the general population.

Thermal conditions

Thermal conditions and microclimate in different occupations may vary widely, ranging from extreme cold to extreme heat. In addition to extremes of outdoor climate, temperature problems may occur with indoor work, for example in refrigerated rooms in the food industry, or in poorly ventilated spaces and extreme heat in metallurgy. About 4–5 % of the workforce may work in such conditions [14,50]. Indoor environment problems are associated with very low levels of exposure to multiple chemical, physical and microbiological factors. A relatively new problem of modern working life, particularly in large new office buildings, is the sick building syndrome, although its existence is still debated [51] (see also Chapters 5 and 14). Causal relationships between factors in the indoor environment and the occurrence of somatic or psychological symptoms among employees need further investigation.

15.2.4 Chemical hazards

Global chemical production is about 400–500 million tonnes per year. In 1985, the European members of OECD produced about 30 % of the total, and the CCEE 17 %. During the period of industrial expansion, chemical production grew faster than that of industry on average, and it has decreased less in the current recession. In a typical industrialized country, the amount of all chemicals used in 1990 was about one tonne per head per year, the amount having almost tripled between 1970 and 1990 [52].

The level and associated health hazard of exposure to chemicals are often two to three orders of magnitude higher at work than in any other situation. Toxic responses to industrial chemicals are numerous and depend on the properties of the chemical, on the pattern, level and route(s) of exposure, and on the biological characteristics of the exposed individual. In industrialized countries, over 100 000 different chemical products and thousands of intermediate products can be used in occupational environments [53–55]. At least 10 % of the total mass of chemicals end up as hazardous waste.

In addition to the 2.1 million workers in chemical industries in western European countries (and possibly an equal number in the CCEE and NIS) exposure to chemicals affects employees in all industries and several other sectors, including agriculture,

Table 15.2: Exposure to toxic substances in the work environment in Bulgaria

Substance	Exposed workers	Exposure limit (mg/m^3)[a]	Percentage of plants with exposure exceeding limit
Nitrogen dioxide	17 980	6	60
Ammonia	13 260	35	89
Aniline	2 706	2	58
Arsenic	2 167	0.02	100
3,4-benzopyrene	2 306	0.00015	70
Petrol	35 717	300	96
Benzene	12 573	5	87
Carbon monoxide	46 483	40	69
Vinyl chloride	3 562	2.5	57
Cadmium	3 989	0.05	80
Lead	29 585	0.05	69
Hydrogen sulfide	7 071	14	38
Chromium	3 690	0.5	33

[a] Taken from *NIOSH pocket guide to chemical hazards.* Washington, DC, Government Printing Office, 1987.

Source: Kaloyanova, F. *(56).*

transport, construction and services. Surveys in various countries show, for example, that about 10 % of workers in the Netherlands are exposed to chemicals [13]; almost 50 % of the workforce in Finland could be exposed, but this possibility is realized for a much lower percentage [52]. An EU survey showed that 11 % of all workers and 22 % of manual workers were exposed to hazardous vapours, fumes, dusts or substances. In spite of the growing use of chemicals, exposures exceeding the limits set have decreased in the western countries of the Region, accompanied by declining rates of traditional chemical-induced occupational diseases such as lead poisoning and solvent injury [52,54].

Data for the CCEE and NIS are sparse, but the available reports give exposure to lead, pesticides, mineral dusts, asbestos and silica, and various toxic gases and vapours as the most important. In Poland, 200 000 workers are exposed to fibrogenic dusts and 130 000 to harmful substances [22]. About 70 000 are exposed to carcinogens and at least 15 000 to pesticides at levels exceeding 50 % of threshold limit values. Table 15.2 summarizes exposure to highly toxic substances in Bulgaria [56].

The chemicals used at work have many health effects; these are described elsewhere [53] but are listed in Table 15.3. The main exposure routes in occupational settings are through the lung and skin (more rarely the gastrointestinal tract) but the final target organ may be the liver, kidney, brain, peripheral nerves, bone marrow or others. Exposure to some chemicals affects only a very limited number of workers while exposure to some others, such as lead and organic solvents, may be widely distributed in the work environment. Fig. 15.7 shows the chemicals most commonly causing occupational diseases in Finland [52]. According to WHO data,[a] chemicals cause up to 41.6 % of occupational diseases in Finland (including pneumoconiosis and chemically induced dermatosis), 56 % in Germany, 28 % in Hungary and 29.5 % in Poland.

Acute intoxications are declining. They comprise about 1–4 % of all occupational diseases in the CCEE, but only occasional cases are reported from the western countries of the Region. Some surveys from the CCEE report not only acute pesticide and carbon monoxide poisoning but also acute intoxications from exposure to heavy metals and solvents [56,57].

Several studies of exposure to lead are

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 15.3 a: Examples of occupational exposure to chemicals and related health effects in Finland

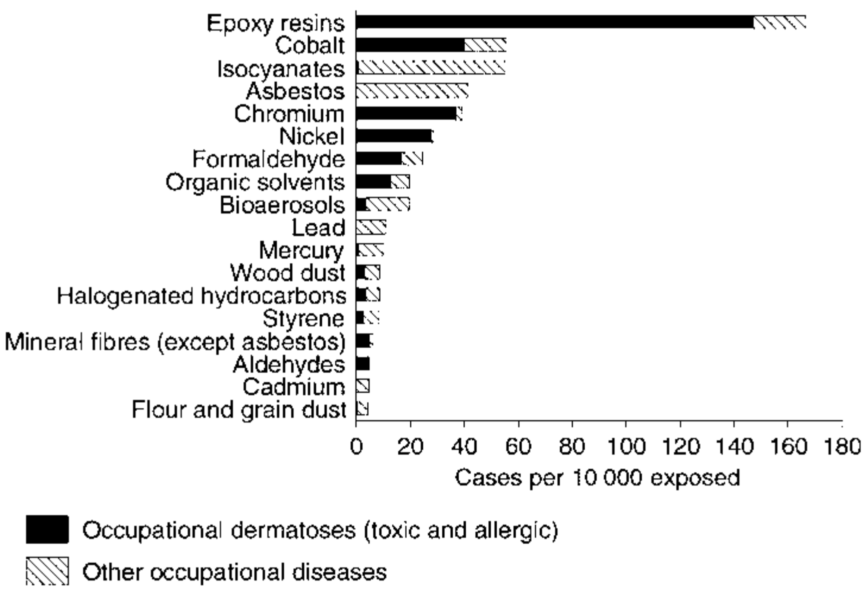
Chemical	Activity	Percentage of total workforce exposed[a]	Average exposure levels (air)	Critical health effects
Metals				
Aluminium	Metal plating, aluminium welding	0.5	1–5 mg/m^3	Neurotoxic effects
Arsenic	Copper enrichment, electronics, special metals production, wood preservation	0.25	0.001–0.4 mg/m^3	Arsenic poisoning, lung cancer, skin changes
Mercury	Zinc enrichment, chemical production, pesticides, electronics, dentistry	0.05	0.01–0.09 mg/m^3	Lung inflammation, kidney and nervous system injury
Cadmium	Zinc enrichment, metal plating, soldering, plastics production	0.04	0.01–0.14 mg/m^3	Acute lung inflammation, kidney injury
Cobalt	Cobalt production, hard metallurgy, metal plating, ceramic and paint industry	0.05	>0.05 mg/m^3	Dermatosis, pneumoconiosis, cardiomyopathy
Chromium	Hard metallurgy, chromium enrichment, paint industry, tanning, plastics industry, wood preservation, stainless steel welding	0.7	0.02–0.2 mg/m^3	Allergy, asthma, cancer
Lead and lead salts	Mining, glass industry, battery production, scrap metal melting, paint industry, plastics industry	1.0	0.01–3.9 mg/m^3	Anaemia, lead poisoning, neurotoxic effects
Nickel	Nickel mining and enrichment, stainless steel, electrical industry, petroleum industry, metal plating	0.5	0.01–0.9 mg/m^3	Allergy, cancer, asthma, acute nicarbonyl intoxication
Gases				
Carbon monoxide	Coke ovens, metallurgy, foundries, steel production	10	1–100 cm^3/m^3	Carbon monoxide poisoning, central nervous system effects, cardiac ischaemia
Chlorine	Chlorine production, pulp bleaching, food industry	5	0.5–1.5 cm^3/m^3	Skin and mucous membrane irritation, pulmonary oedema
Hydrogen cyanide	Electrolysis, chemical industry, polyurethane plastic pyrolysis	<0.1	0.5–5 mg/m^3	Death by cell respiration block, central nervous system effects
Organics				
Benzene	Petrochemical industry, metallurgy, coal gas production, glue and paint industries	0.05	0.5–100 cm^3/m^3	Central nervous system effects, bone marrow depression, leukaemia
Chlorophenols and phenols	Chemical industry, wood preservation, foundries	0.2	0.005–3.0 cm^3/m^3	Mucous membrane irritation, liver and kidney injury, respiratory depression
Isocyanates	Plastics industry, paint industry, construction	0.1	<0.035 mg/m^3	Respiratory irritation, acute intoxications, asthma

Table 15.3 b: Examples of occupational exposure to chemicals and related health effects in Finland

Chemical	Activity	Percentage of total workforce exposed[a]	Average exposure levels (air)	Critical health effects
Pesticides	Farming, gardening, greenhouses, textile industry	3.6–5.5	Depending on compound Substantial skin absorption	Acute multisystem poisoning, chronic effects, including allergies and liver injury, resulting from organophosphate exposure
Mineral dusts				
Asbestos	Construction, car repair, ship scrapping	0.4	0.1–10.0 fibres/cm^3	Pneumoconiosis (asbestosis), cancer (lung and mesothelioma)
Quartz and silica	Stone industry, glass industry, metal industry, foundries, sand blasting	0.3	0.01–10.0.mg quartz/m^3	Silicosis

[a] Exposure confirmed by measurements in the work environment.

Source: Anttila, A. et al. *(52).*



Source: Anttila, A. et al. *(52).*

Fig. 15.7: The 18 chemicals or dusts causing the highest incidence of occupational diseases in Finland

available. For example, about 7% of the workers exposed in a metal industry in Romania showed symptoms of poisoning [57]. In Bulgaria, almost 30 000 workers are exposed to lead and about 70% of the plants surveyed had levels of over 0.05 mg/m^3 in workroom air [56]. Lead caused almost 60% of occupational intoxications in Bulgaria in 1990. Countries such as Finland,[a] Germany,[a] Hungary [58] and Poland [22] show a decline in lead poisoning, but hazardous

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Table 15.4: Occupational diseases caused by exposure to biological agents and organic dusts

Agent	Occupation	Disease
Fungi	Farming, industrial workers (in sawmills, pulp industry)	Allergic alveolitis, asthma
Cotton dust	Cotton and textile industry	Byssinosis
Animal epithelium	Farming, animal husbandry	Allergic rhinitis, asthma
Flour dust	Baking, food industry, grain mills	Allergic rhinitis, asthma
Vegetable extracts and dusts	Farming	Allergic or toxic eczema
Wood dusts	Wood industry and sawmills	Allergic rhinitis, asthma, allergic alveolitis, paranasal cancer
Gram-negative bacteria or their fragments	Farming, animal husbandry, sewage sludge plants	Organic dust-induced toxic syndrome
Mixed vegetable or bacterial dusts	Farming, several industries, printing	Nonspecific chronic bronchitis

Source: Malmberg, P. *(61).*

exposure still occurs and necessitates further control measures for the working environment. In 1991, 161 cases of lead poisoning were reported in Germany (119 were recognized as cases of occupational disease) and 117 cases in Poland [57].

Owing to its negative impact on working capacity, pneumoconiosis comprises an important group of occupational diseases caused by exposure to inorganic dust: 1.7% of all occupational diseases in Finland, 8.4% in Germany, 10% in Poland and 33% in the Czech Republic. In spite of current effective dust control, large numbers of cases are reported as a consequence of exposure in the 1960s and 1970s. According to WHO data,[a] a total of 2878 cases was registered in Czechoslovakia in 1991, and there were 5147 suspected cases in Germany [59]. Several countries register continuous increases in asbestos-related cancer; the incidence may continue to rise until the end of the century.

Pesticides are particularly widely used in agriculture, and the users are not always aware of the hazards involved. According to WHO data,[a] acute occupational pesticide poisonings have been controlled effectively in countries such as the Czech Republic, Hungary [58], Norway and Sweden, but pesticide problems are considered to be a high occupational health priority in countries with a strong agricultural sector. The poor coverage of inspection and registration may result in serious underreporting of pesticide poisoning. The long-term effects of low-level exposure should be more extensively studied (see Chapter 10).

15.2.5 Biological agents and organic dusts

Some 25 occupational groups (Table 15.4) are exposed to about 200 biological agents [60,61]. An estimated 6.7% of the workforce in the Netherlands are exposed and 14–15% of the workforce in Finland may be exposed to various kinds of biological agent [13,14]. Exposure to organic dusts and allergenic chemicals has been reported to be common in the CCEE, but reports of occupational asthma and other allergic responses are very few. Asthma comprises about 1% of occupational diseases in the Czech Republic, in contrast to 4% in Finland where the total for all allergic respiratory diseases is 10% [14]. Exposure to biological agents or organic dusts and the related health hazards are growing in many countries, such as Germany and Sweden. The precise mechanisms in-

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

volved in the causation of disease are often not fully known; an underlying immunological and/or inflammatory reaction is usually involved. If exposure is not controlled, permanent incapacity to work soon follows the onset of disease.

Infectious diseases play an important role in occupational morbidity, particularly in the southern and eastern parts of the Region. Such diseases comprise 5.6 % of all occupational diseases in the Czech Republic, 27 % in Hungary and 20 % in Poland; these are ten times the figures for western countries such as Finland (1.1 %) and Germany (2 %). Hepatitis B virus is the most prevalent of the biological agents carried by blood or other body fluids that may infect health care personnel, although hepatitis C infection is gaining in importance. Health care workers are ten times more likely than the general population to contract hepatitis B infection. Those with acute infections may be off work for weeks or months, or die in the acute phase. One in twelve hepatitis patients will be chronically infected, with the risk of developing liver cirrhosis or cancer [62]. Those without overt symptoms may remain carriers. Up to 20 % of the health care personnel in areas of high endemic incidence have been found to be seropositive to hepatitis B virus, but the total number of people infected at work in the Region is unknown. It has been estimated that, if not vaccinated, as many as 19 000 people are infected at work each year in western Europe [63]. Reducing the risk of contamination from biological hazards depends on good general hygiene at the workplace and appropriate work practices; effective immunity is also available. The available information from the CCEE underlines the urgency of hepatitis B virus prevention programmes [63].

The Society of Occupational Medicine in the United Kingdom has set up a Viral Hepatitis Prevention Board composed of international specialists and representatives of national ministries of health, occupational health departments, the EU, the WHO Regional Office for Europe and WHO headquarters. Its objective is to increase awareness of hepatitis B virus among employers, trade unions and employees at risk, and to encourage the adoption of clearer guidelines on prevention.

The risk of health care workers becoming infected with HIV is much smaller than expected ten years ago, and between two and three orders of magnitude less than that of hepatitis B virus. Improvements in hygiene and the adoption of procedures similar to those recommended for minimizing hepatitis B infection will protect health care workers against occupational HIV infection [64].

Another group of occupational infections results from microbial contamination by animals, which is likely to occur in countries with a large agricultural sector. According to WHO data,[a] various types of occupational zoonosis are likely to be underreported in all countries [6].

Animal epithelium, hair and excreta expose workers in animal husbandry and leather and fur textile production to comparatively high concentrations of bioaerosols. Asthma, allergic alveolitis, allergic rhinitis and chronic bronchitis, as well as organic dust-induced disease, may result [60]. Respiratory symptoms attributable to exposure to bioaerosols occur in 20–30 % of workers who care for laboratory animals [65] and in 17 % of fur textile workers [66]. Dust control and protective equipment for workers are the most important preventive measures.

In most countries of the Region, and particularly in subtropical areas and the CCEE and NIS, the risk of occupational diseases from biological agents necessitates special surveys of the workers most likely to be exposed in agriculture, animal husbandry, health sectors, the food industry and waste handling. The basis for prevention and control strategies comprises careful dust control, appropriate ventilation systems, effective inactivation of microorganisms and adherence to prescribed control techniques, along with the use of protective clothing and equipment

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

and, for infectious agents, immunization if available.

15.2.6 Occupational allergens

In addition to organic dusts and biological agents, several chemicals can cause sensitization of the skin or respiratory tract resulting in allergic dermatosis, rhinitis, asthma or alveolitis [67]. The allergenic potency of chemicals varies greatly. Some substances affect only a part of the workforce after long-term exposure; others, called superallergens, are able to sensitize virtually everyone exposed (even to extremely low doses) in a short time. Widely used allergenic chemicals number at least 50, and at least 500 chemicals are capable of sensitizing exposed individuals. The superallergens include platinum salts and isocyanates; certain biotechnology products, such as enzyme protein products, are newly recognized occupational allergens in both research laboratories and industry [68]. In a typical industrialized country, about 13 % of the workforce are exposed to well recognized allergens. As shown in Fig. 15.8, allergic occupational diseases increased in the 1980s [14,69].

The effect of occupational allergens may be enhanced if the exposed worker is atopic. In some studies, up to 30 % of the population have shown atopic characteristics, which make them particularly susceptible to dermal allergens [67,69,70]. The only effective means of prevention is to eliminate exposure.

15.2.7 Hazards to reproductive health

About 10–20 % of couples of reproductive age have problems with infertility or sterility, and about 9 % of diagnosed pregnancies terminate with spontaneous abortion. The inci-

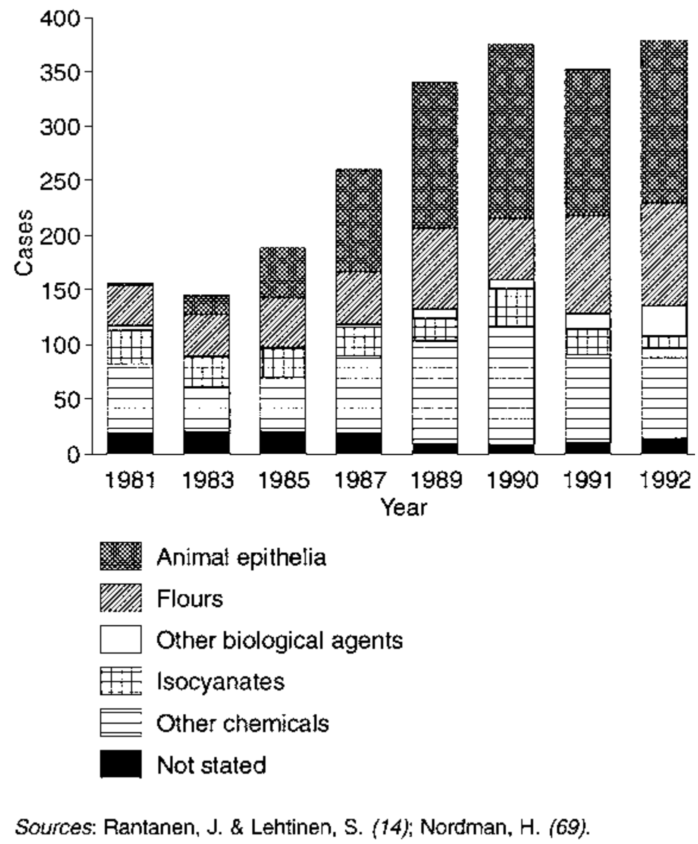


Fig. 15.8: Allergic occupational diseases by exposure in Finland, 1981–1992

Table 15.5: Occupational substances hazardous to reproductive health

Exposure	Effects on the: female	male	fetus
Arsenic			(+)
Acetone			(+)
Benzene	+		+
Beryllium	(+)		
Boric acid		(+)	
Dibromochloropropane		+	
Dimethylformamide	(+)		
Mercury (inorganic)	+	+	+
Mercury (organic)			+
Epichlorohydrin		(+)	
Ethylene dibromide		(+)	
Ethylene glycol			
Ethylene oxide	(+)	(+)	(+)
Formaldehyde	(+)		
Hexachlorobenzene		(+)	
Hexachlorophene			±
Cadmium	(+)	(+)	(+)
Carbaril		+	
Chlordecone		+	
Chloroprene	(+)	+	(+)
Lead (inorganic)	+	+	+
Lead (organic)		+	
Polychlorinated biphenyls	+		+
Carbon disulfide	(+)	+	(+)
Styrene	±		
Tetrachloroethylene	(+)		
Toluene		±	
Trichloroethylene	+	+	
Vinyl chloride	+	+	(+)

\+ = Several positive studies
(+) = Suggestive evidence
± = Controversial research results

Source: Sorsa, M. *(74)*.

dence of congenital anomalies at birth is about 3 %. The fertility of men has been reported to have substantially decreased in the past 50 years, and exposure to industrial factors has been proposed as a causative factor [71,72]. In Finland, where women usually work outside the home, about 1.2 % of the female workforce could be exposed through their occupations to agents hazardous to reproductive health [73]; the corresponding figure for men is not known.

Occupational exposure may affect reproductive health at four different stages: before conception in men or women, during pregnancy by affecting the mother's health, during pregnancy by affecting the development of the fetus directly, and at the neonatal stage through contamination of the mother's milk. The effects may include lower fertility, spontaneous abortion, congenital anomalies or, in rare cases, toxic effects to the fetus or infant through contaminated mother's blood or milk. Sorsa [74] has listed the agents hazardous to reproductive health (Table 15.5).

Some countries, such as Austria, Denmark, Finland and Germany, have made special provisions to protect the reproductive health of female workers. These provisions require the elimination of hazardous exposure and the transfer of pregnant women to other work as soon as pregnancy is declared or, if this is not possible, paid leave up to the time of delivery so that exposure to the hazard can be avoided [74]. Some

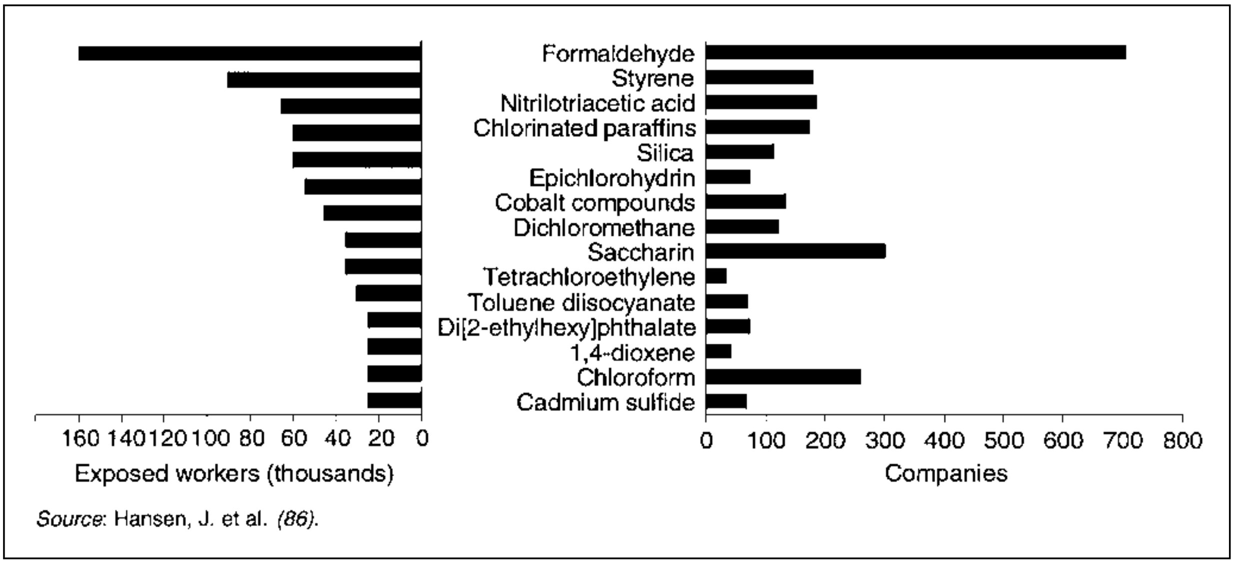


Fig. 15.9: Exposure of workers to suspected carcinogens used by companies in Denmark

other countries of the Region, such as the former USSR, prohibited a number of occupations or types of exposure for women, for the same reason.

15.2.8 Occupational carcinogens

Large numbers of occupational carcinogens have been identified and 60 or more occupations have been found to be associated with elevated risk of cancer [62]. Those most at risk are miners, foundry and metallurgy workers, chemical and rubber industry workers, boot and shoe makers, and construction workers exposed to asbestos. The International Agency for Research on Cancer (IARC) has so far evaluated 768 agents, substances, industrial processes, occupations or exposures for carcinogenicity. It found a total of 317 (60 proven, 51 probable and 206 possible) carcinogens of humans [75]. The most common sites of occupational cancer are the lung, pleura and peritoneum, paranasal sinuses, larynx and lymphatic system [76,77].

Estimates of the proportion of work-related cancer range from 1% of total cancer morbidity to 20% [78–83]. The ILO convention on the prevention and control of occupational hazards caused by cancer [84] requires the registration of workers exposed to carcinogenic hazards and the elimination or minimization of carcinogenic exposure at work. Several European countries have introduced measures to implement this convention, and the EU has a number of directives on the protection of workers against carcinogenic agents [85].

Preventive strategies are based on the elimination of exposure; if this cannot be achieved, isolation of the worker from exposure and protective clothing and equipment are used [84]. The identification, by registration, of workers and workplaces with carcinogenic hazards is crucial to success. Data gathered by WHO[a] showed that 17 out of 19 countries responding to a questionnaire had an official list of occupational carcinogens, and 7 had organized the registration of workers exposed to all or some of the listed carcinogens. The most important carcinogens in different countries were very much alike, being based on IARC evaluations; they included asbestos, benzene, polynuclear aromatic hydrocarbons, arsenic, nickel and its inorganic compounds, chromium, cadmium, aromatic amines, vinyl chloride monomer, benzidine, coal tar and ionizing radiation. In Germany, 200 established or suspected carcinogens are listed. In most countries, the

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

well established carcinogens are comparatively effectively controlled in the work environment. For example, about 4% of the workforce in Finland are exposed to such carcinogens [76]. Nevertheless, large amounts of some suspected carcinogens are used. Research is under way in Denmark [86], for example, to examine the possible association between cancer and occupational exposure to these substances (Fig. 15.9).

15.2.9 Psychological factors

Both the environment and the nature of work have psychological effects. In favourable circumstances the effects may be positive, increasing job satisfaction and motivation, but less favourable situations may induce psychological stress and dissatisfaction. About 40–50% of respondents to a Dutch questionnaire perceived stressful factors at work [13]. Some studies indicate increased psychological stress in the course of the 1980s [14]. Experts in occupational health increasingly understand that psychological and psychosocial aspects of work may be more important determinants of health, motivation and productivity at work than previously considered [87]. The following psychosocial aspects of work and the work environment are discussed from the point of view of occupational health:

- mental workload
- monotony
- time pressure
- responsibility
- disturbing physical factors
- the threat of violence
- lack of a clear role and self-determination
- unusual hours and solitary work
- job satisfaction.

Some 30–50% of employees in industrialized countries assessed their work as "mentally heavy" [6]. Psychological overload may arise from several different types of factor and condition at work; overloading of the worker's psychological, psychomotor or emotional capacity leads to difficulties in coping.

Monotonous work may imply a quantitative psychological overload through continual repetition of movements or tasks, but the worker may be mentally underloaded as a result of psychological monotony. In an EU survey [6] about 35% of workers felt unable to change or choose the order of work tasks or methods; 10–25% assessed their work as monotonous. There is evidence of an elevated secretion of stress hormones resulting from monotony at work [87].

About 20–40% of workers cited time pressure as an important psychological stress factor at work and it is apparently a growing problem [88]. Finnish data show that the implementation of both new types of information technology and management-by-results systems have increased freedom of action in high-level white-collar employees and foremen, while psychological stress and time pressure have increased among female workers on the shop floor [87]. A special group of employees exposed to high time pressure are experts and researchers, who often take on too much work. For manual workers, piecework often causes unreasonable time pressure and increases workload and the risk of accidents.

Responsibility for the safety of other people (in health care and the transport sector for example), for employers' or public property, or for the quality and safety of industrial operations (such as in nuclear plants and chemical processing) may constitute an additional stress factor for employees. If reasonable and manageable, such a responsibility may be experienced as positive, but excessive responsibility with unreasonable demands can lead to stress reactions and even psychosomatic disorders [88].

The physical work environment may constitute a psychological risk factor and disturb performance. Disturbing factors may include noise, chemicals, accident risks, poor organization of work or lack of cleanliness at the workplace. Closed institutions (such as prisons), underground work sites, mobile work sites (such as lorry and aeroplane ca-bins and ships) and offshore platforms are examples of psychologically unique work environments. These environments may cause additional psychological stress by limiting the possibilities for social contact, or sometimes requiring special relationships between employees and clients (prisons and mental hospitals, for example) [87,89].

The threat of violence is a psychological stress factor for employees in several service occupations, particularly those who work alone. According to questionnaire studies, up to 50 % of workers working alone and serving customers in small shops have experienced such a threat during a working year, while about 4 % actually encountered violence [90].

Unclear role identification, lack of personal development and poor opportunities for self-determination increase stress and job dissatisfaction, and affect health and well-being as well as productivity and the quality of work [90–92].

Up to 25 % of workers work unconventional hours, in shifts or alone in conditions that may result in psychological harm or psychosomatic morbidity. Sleep disturbances and psychosomatic disorders are overrepresented, particularly among night-shift workers [6,14].

Work has, however, indisputable positive effects on health [93]. Despite adverse psychological factors, about 80–95 % of workers surveyed in the Netherlands said they were satisfied with their jobs; the corresponding figures for the EU and Finland were about 53 % and 85–90 %, respectively [14,16].

In addition to factors at work, the threat of unemployment is recognized as an important psychological problem [94,95]. More than 30 million people in the Region are unemployed and the numbers are still growing. By breaking the daily routine, isolating people from social contact, causing economic difficulties and harming self-esteem, unemployment creates severe psychological stress, which has been found to affect people's mental health and capacity to work [88,96]. Unemployment is associated with unhealthy lifestyles, a gradual decline in working capacity and elevated mortality [88,94,96].

Very little is known about psychological stress in workplaces in the CCEE and NIS, but some of the data available suggest that stressful work situations are common. Moykin et al. [32] reported a high, monotonous and static workload among clothing industry workers in the former USSR. Such conditions are known to contain a remarkable component of psychological stress [88]. In data gathered by WHO,[a] five out of the seven CCEE responding to a questionnaire ranked psychological stress as of medium importance, while two countries (Hungary and the former Yugoslavia) gave it the highest importance. A realistic assumption is that the current transition is particularly stressful for workers because of uncertainty about the future and the pressure for higher productivity and efficiency in unstable and changing organizations. Further and more detailed studies are needed on the psychological characteristics of workplaces in the CCEE and NIS.

The importance of psychological aspects of work and the work environment depends on the overall level of safety and health in the country. Where the implementation of new technology, effective mechanization and automation have eliminated or reduced the physical and chemical hazards and physical workload, psychological stress may be the major occupational health problem. This does not imply, however, that psychological aspects do not occur in those countries and industries where traditional physical and chemical hazards remain the priority problems. Occupational factors are not often seen to be the cause of severe mental disorders. The most common health outcomes are neurotic reactions, burn-out syndrome, psychosomatic disorders or depression [97]. Major disasters such as large-scale explosions or fires at industrial plants, or severe violence (such as when robberies have resulted in personnel being killed or taken

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

hostage), however, have caused severe acute or chronic psychological disorders [93].

Besides having an impact on job satisfaction and performance, adverse psychological factors may affect workers' somatic health. Occupations providing unreasonable stress and poor possibilities for self-determination are associated with a higher risk of death from coronary heart disease and suicide [88].

15.2.10 New technologies

Several types of new technology are being introduced in the workplace. Intensive computerization and automation, and new production systems, materials and processes continuously change work and the work environment. Biotechnology, using genetically manipulated organisms, is another major new development that needs special discussion from the perspective of occupational health.

Information technology

The most common new technology affecting occupational health is modern information technology, which is used by 30–60% of manufacturing workers and 70–90% of banking, insurance and other service workers in western European countries. The use of this technology has been associated with several occupational health problems [14] but it also has positive effects by improving management of the work environment, increasing productivity and permitting better isolation of the worker from hazardous conditions and processes through remote control.

Apart from some individual reports there is little evidence of severe health effects, such as cancer or congenital anomalies in the offspring, in women who use visual display units. An increased risk of spontaneous abortion has been reported, but other studies have not confirmed the finding [98,99]. On the other hand, much evidence is available on visual and ergonomic problems, poor organization of work, and information overload and psychological stress among such workers. Following the ILO guidelines on organizing the workplace and work procedures [98] or implementing the relevant EU directive [100] can eliminate many of these problems.

Biotechnology

Two major types of biotechnological process are used in industrial and laboratory activities: traditional fermentation, and modern cellular or molecular biology techniques based on recombinant DNA and genetically manipulated organisms. The new techniques have grown intensively in the past 15 years, and several large-scale applications are in use in agriculture and in the food and feed, pharmaceutical, enzyme production, waste handling, metallurgy and oil industries in industrialized countries [101,102].

Virtually all the health hazards associated with traditional biotechnological processes are due to toxic or allergic reactions to the microbial agents used or the resulting protein products. The risk of sensitization may vary widely, affecting up to 30% of exposed workers [103,104].

Fears expressed 10–15 years ago about the generation of new pathogenic organisms by recombinant DNA techniques have failed to materialize, although work with DNA derived from human tumour cells with activated oncogenes justifies careful precautions. No evidence is available on elevated cancer risks among biotechnology workers [105–107].

The hazards most likely to be associated with working with the new methods are allergic reactions to the organisms used, their growth media or their peptide or protein products. On the other hand, many chemical reagents used in DNA biochemistry or in biotechnology are toxic and highly reactive, and may possess mutagenic or carcinogenic properties [107]. No systematic evidence is available on, for example, infections by new pathogens or increased tumour risk among exposed workers. Good laboratory practice and good industrial large-scale practice (as recommended by OECD), good microbial technique and good manufacturing practice [106] – complemented by the training of managers and workers in prudent working practices, the use of protective clothing and equipment and appropriate health surveillance – are probably sufficient to control the potential hazards of new technology. Following up the health of biotechnology workers, however, is justified to identify any adverse health outcomes as early as possible [106–108].

15.3 Public Health Impact of Employment

15.3.1 Accidental injuries

As indicated, accidental injuries are common, affecting up to about 10 % of the workforce in the sectors that report cases. Up to 50 % of workers in industrialized countries can be exposed to the risk of accidents, but the incidence of severe permanent injury is of the order of 20–100 per 100 000 employees per year. Within high-risk groups such as construction workers, however, up to 25 % may have an occupational accident each year. The work time and production lost create remarkable economic losses, amounting to 3–5 % of GNP [109,110]. The health and economic consequences (psychological stress and lost productivity) of hazardous work environments and jobs have not been estimated. The 22 European members of ILO reported about 6 million occupational accidents a year between 1987 and 1991 [7]. The rough estimate of fatalities amounts to 25 000 a year. The problem of underreporting, particularly of total numbers of accidents, is severe; the real figure may be 10 million rather than 6 million accidents a year if non-reporting countries are taken into account.

Accident rates indicate the degree of safety at work and therefore reflect the overall quality of the current management of production systems in different industries. Particularly for high-risk groups, occupational accidents constitute a health hazard comparable with any acute or chronic public health problem. Examples from several countries in the European Region demonstrate that occupational accidents can be prevented [27,111]. By introducing safer structures at the workplace, better organization of work and safer work practices, preventive programmes are also cost-effective. There is some evidence that such measures are accompanied by increased productivity and improved work quality, as well as by greater psychological wellbeing [25]. The positive effects appear quickly, if not immediately.

15.3.2 Occupational diseases

The countries of the Region use different concepts and definitions of occupational disease, and this affects the assessment of morbidity data. The practices and criteria for the diagnosis, notification and registration of occupational diseases also vary widely, and comparable Region-wide data cannot be obtained. Even the reported incidence varies by one or two orders of magnitude (Table

Table 15.6: Incidence of occupational diseases in 11 countries of the WHO European Region

Country	Cases per 1000 employees
Austria	0.41
Denmark	5.00
Finland	3.70
Federal Republic of Germany	0.15
Italy	1.08
Norway	1.20
Poland	1.54
Sweden	12.20[a]
Switzerland	1.60
Turkey	0.35
United Kingdom	0.20

[a] The high figure for Sweden is mainly due to broad definition and careful registration of occupational musculoskeletal disorders.

Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

15.6) and the differences do not necessarily reflect the real variation in working conditions [14]. Official lists of occupational diseases also vary, from a few disease categories up to 50 or 60.

Countries with good registration systems report average rates of occupational disease at the level of 4–12 cases per 1000 employees per year. In most countries, the leading occupational diseases are noise-induced hearing loss, chemical-induced dermatosis, asthma caused by chemicals or organic dusts, and pneumoconiosis caused by inorganic dust. In those countries that recognize musculoskeletal disorders as occupational diseases, these are often the most common (72% of all cases of occupational disease in Sweden for example). The rates of acute poisoning and chronic metal and solvent intoxication are declining, while those of allergies and musuloskeletal disorders are increasing [15,59]. In most countries, mining and quarrying, the metal and chemical industries, manufacturing in general, and construction are the sectors with the highest risk of occupational disease – from 3 to 40 times the average for all sectors [20,21].

For high-risk groups, the incidence can be up to 20 cases per 1000 per year, clearly exceeding the rates of other chronic diseases. The risk of disease is extremely unevenly distributed among the different occupations (Fig. 15.10); incidence in the groups at highest risk is 40 times that of the groups at lowest risk [14]. If estimated on the basis of incidence figures reported by countries with good registration systems, the total number of occupational diseases in the Region's workforce (400 million people) should be 2 million new cases per year.

Unlike accident statistics, the reported figures for many occupational diseases only partially reflect the current quality of the work environment, since several diseases have a long latency period. For example, current figures on asbestos-related cancer reflect exposure to asbestos 15–30 years ago; the health consequences of current asbestos

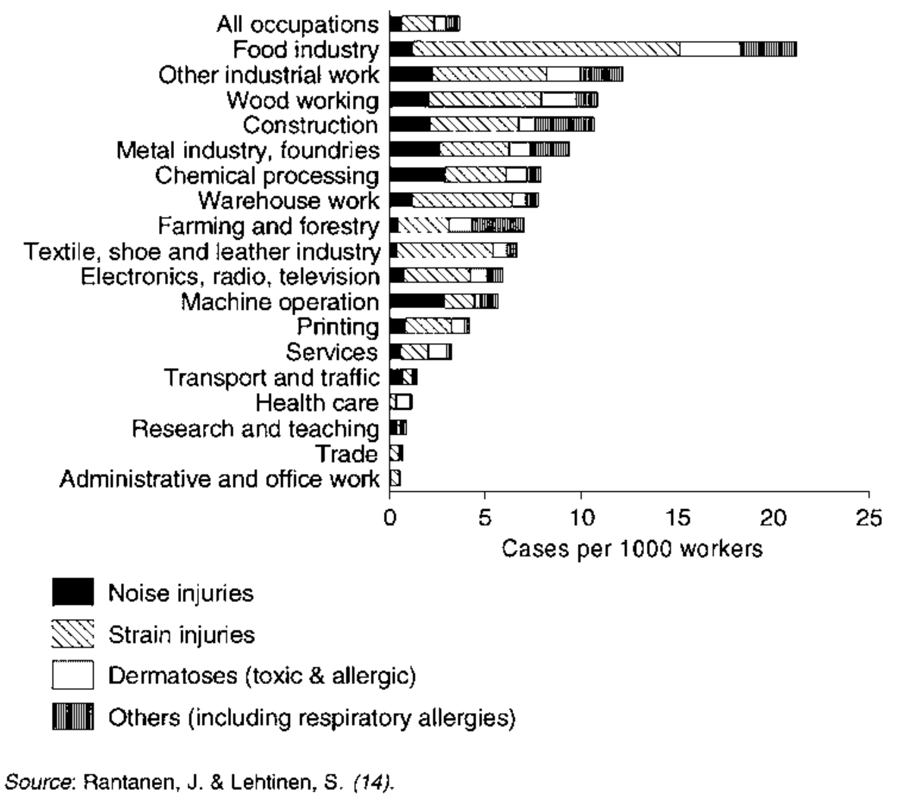


Fig. 15.10: Incidence of occupational diseases in various occupations

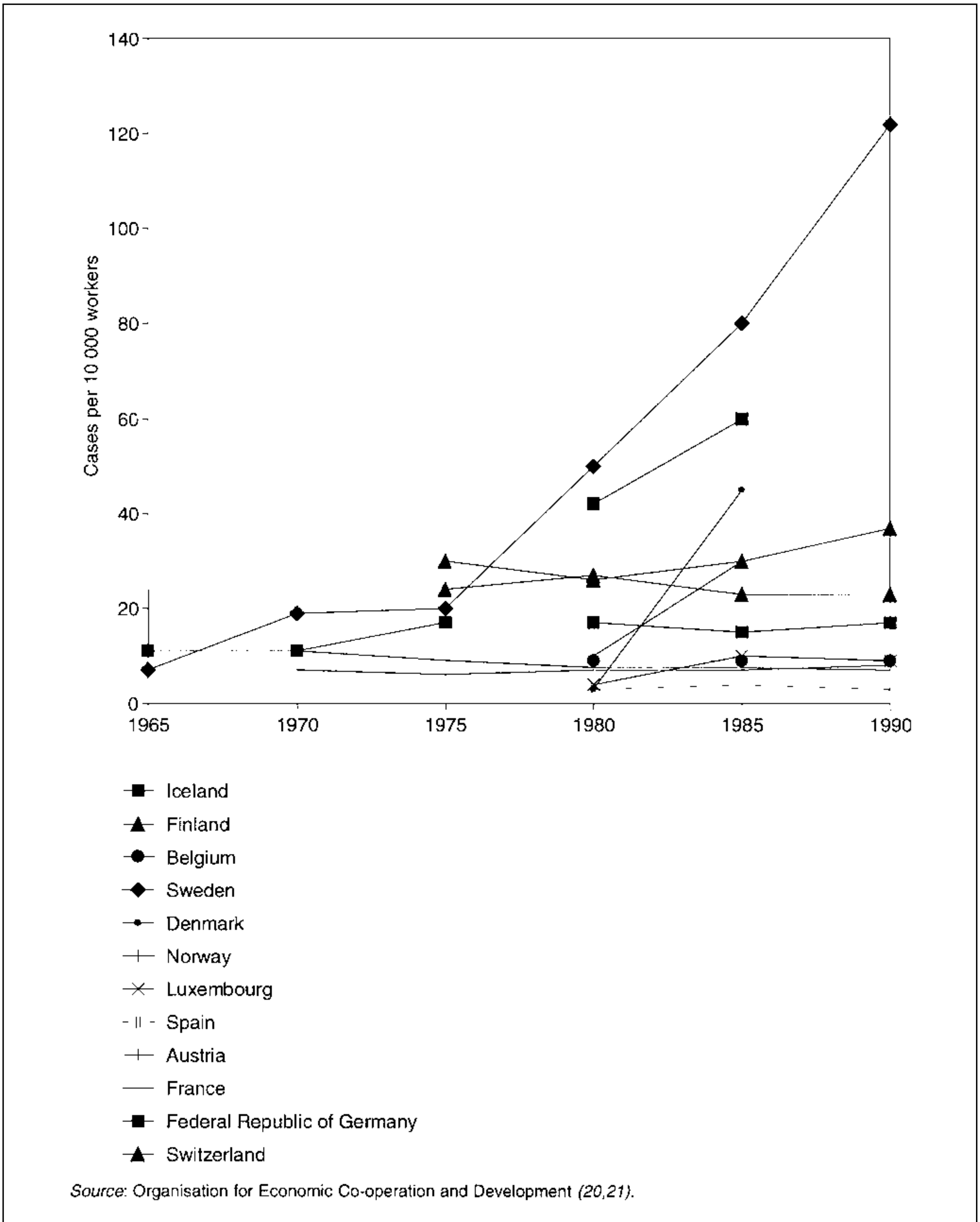


Fig. 15.11: Incidence of occupational diseases in 12 European countries, 1965–1990

exposure will begin to appear between 2015 and 2020.

The trends in occupational diseases show two different patterns in the Region. Incidence is stable or declining slightly in countries such as France, Spain and the United Kingdom, and rising in Denmark, Germany, Norway, Sweden and Switzerland. These differences (Fig. 15.11), however, are more likely to reflect changes in criteria for registration and compensation and the efficiency of diagnosis and registration than changes in morbidity or exposure [20,21]. Increases in musculoskeletal disorders, allergies and diseases with a long latency period, such as asbestosis and asbestos-related cancers, account for most of the rising trends.

15.3.3 Work and noncommunicable disease

The prevalence of common noncommunicable diseases – such as cardiovascular, respiratory and musculoskeletal disorders, cancer and certain psychological disturbances – tends to increase with age [10]. Along with accidents, these diseases are the leading causes of work disability and loss of healthy and productive working years. The increasing average age of the European working population calls for more attention to be paid to preventing such diseases and thus to maintaining and promoting physical and mental capacity for work. The factors that reduce work capacity and can lead to disability and premature retirement need identification. The question of the relationship between work and noncommunicable disease and the possibility for early preventive action are gaining more importance in occupational health programmes [112,113].

A WHO Expert Group defined work-related diseases as diseases of multicausal origin that have an etiological component at work, are of non-occupational origin but can be aggravated by work, or are associated with behavioural or lifestyle factors influenced by work. In addition, the planners of strategies to prevent and control work-related diseases and to promote workers' health should consider diseases of non-occupational origin that can be effectively controlled by occupational health approaches [114,115].

Expert groups and individual researchers have critically evaluated the relationship of work to noncommunicable disease [5,113–116] and a measurable proportion of cardiovascular disorders, respiratory diseases, musculoskeletal disorders and cancer has been related to work [117]. In questionnaire

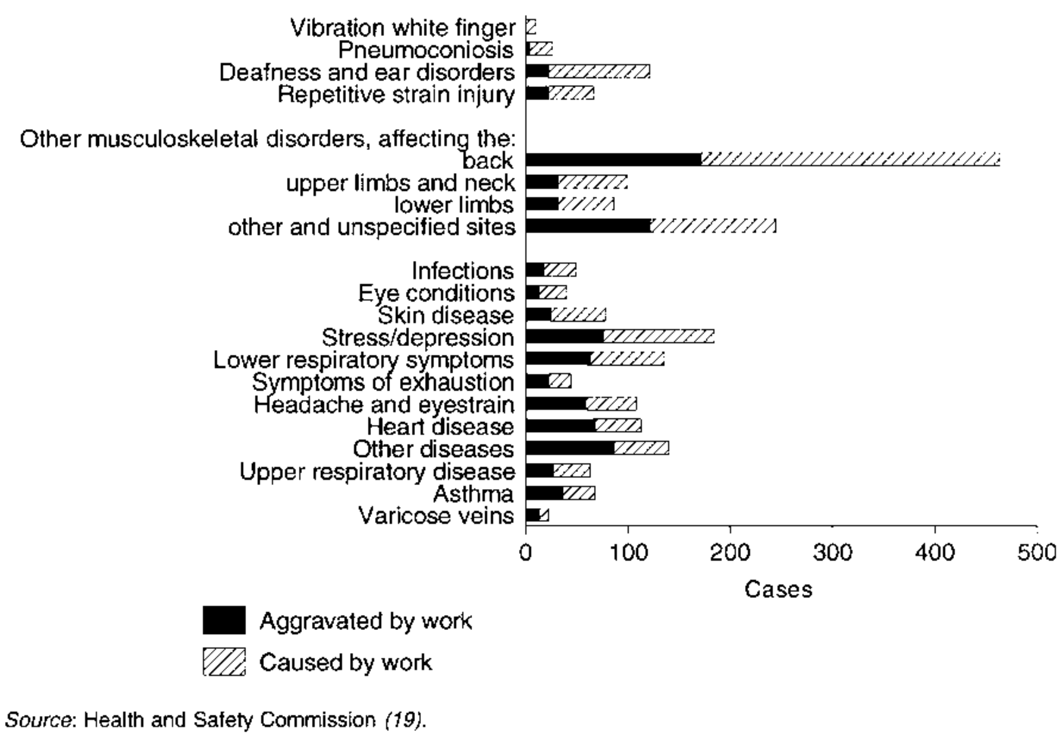


Fig. 15.12: Estimated twelve-month prevalence of self-reported work-related illness by disease category in England & Wales, 1990

surveys, people attributed a very high percentage of their illnesses to work. For example, about 55% of Dutch workers associated their illnesses with their jobs; as many as 60% of respondents with psychological conditions, 12% with cardiovascular conditions and 84% with musculoskeletal conditions associated their illness with work [13]. The results of the 1990 Labour Force Survey in England & Wales showed a relatively high occurrence of work-related back disorders, nonspecific musculoskeletal disorders, hearing problems, and stress or depression (Fig. 15.12). Some of the respondents also considered that work aggravated their ill-health.

The control of work-related diseases requires a comprehensive occupational health approach that can identify workers' chronic diseases, target preventive measures to exposure at work and in other environments and modify workers' lifestyles, particularly towards proper nutrition, sufficient physical activity, and the control of smoking and drinking habits and stress. This requires a comprehensive occupational health service, including both curative and preventive elements [28].

15.3.4 Work disability and mortality of working populations

Population studies have shown that not only work-related morbidity but also a high risk of disability and premature mortality are associated with occupations involving heavy and unhygienic work [116]. Social class alone cannot explain the observed differences in risk between various occupations; several health hazards at the workplace contribute to the greater morbidity and mortality of some workers. The economic losses resulting from premature mortality and work incapacity have been estimated to amount to 10–15% of GNP in some countries [109]. Such data should be considered in setting occupational health priorities and in planning programmes for prevention and health promotion. The hazardous factors in the work environment should be the primary target for prevention, and such programmes should be directed particularly to the work environments of high-risk occupations.

15.4 Conclusions

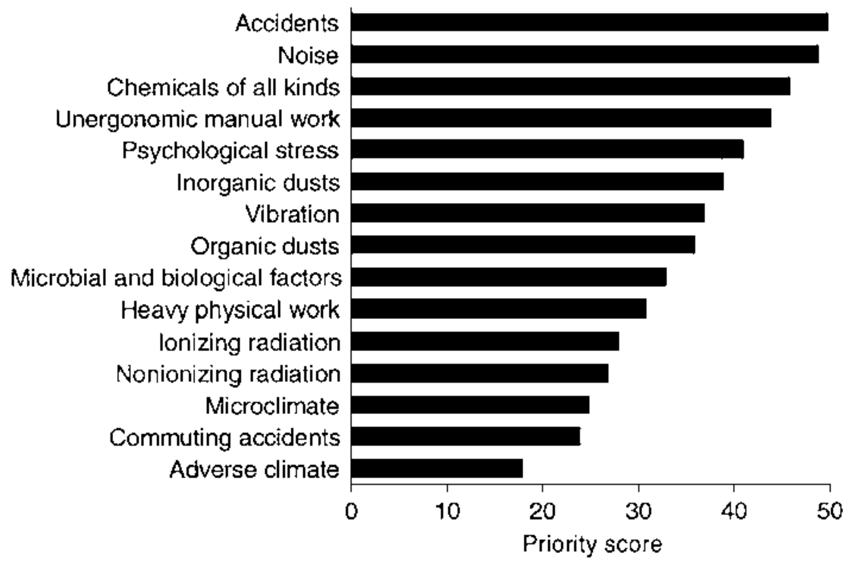
WHO asked Member States to name the problems in occupational health to which they gave priority. The lists supplied proved to be very similar, regardless of a country's geographical location and stage of development. Fig. 15.13 shows the priorities of 17 countries in descending order of importance. Accidents, noise, chemical hazards, ergonomic problems and psychological stress were the top five items on almost all lists; the importance attached to other problems varied more. The countries' priorities corresponded well with the problems reflected in national statistics of adverse occupational health outcomes, and with the results of objective risk assessments and numerous independent surveys [117].

The priority types of exposure to be addressed in the next five years differed slightly from those causing current problems (Fig. 15.14). In the future, exposure to chemicals and psychological stress will receive the most attention. The countries listed slightly different priorities for future action on occupational health outcomes (Fig. 15.15). Countries' lists of the top 10 problems were almost identical, although the order in which items were named varied slightly.

All countries are committed to controlling health and safety hazards at work, but they use very different instruments for the task. Some have well developed legislation on occupational health and safety, effective inspection and trained staff, and extensive service infrastructures to implement occupational health and safety programmes. Others lack these advantages. Almost all countries mentioned financial constraints on the further development of occupational health programmes.

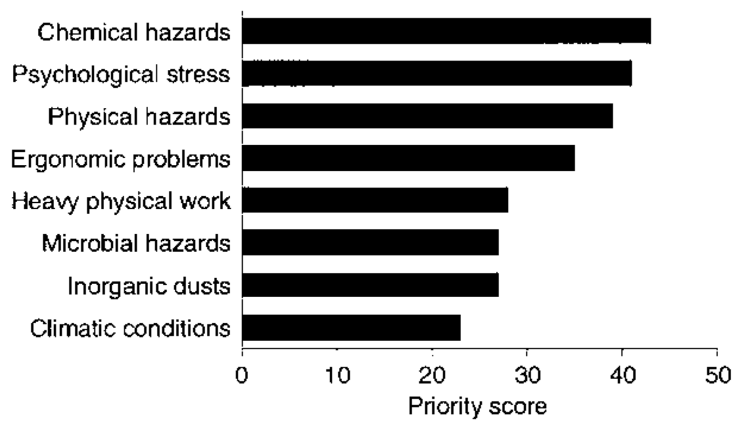
Nevertheless, almost all needed to improve the coverage of registration and data systems for working conditions and their effects on health. More effective methods are needed to identify occupational health problems, to focus preventive and control measures and evaluate their impact, and to analyse trends. In addition, the coverage, content and methods of occupational health services need development. About 56% of the workforce in the Region are estimated to lack access to special occupational health services. Further, new occupational health hazards are not visible in current national statistics; to be recognized, they first need study by research organizations.

The current transition in the CCEE and NIS hinders assessment of the exposure of workers to occupational health hazards and their impact on health. The data available from individual research projects and occupational health and safety experts suggest a high prevalence and high levels of exposure



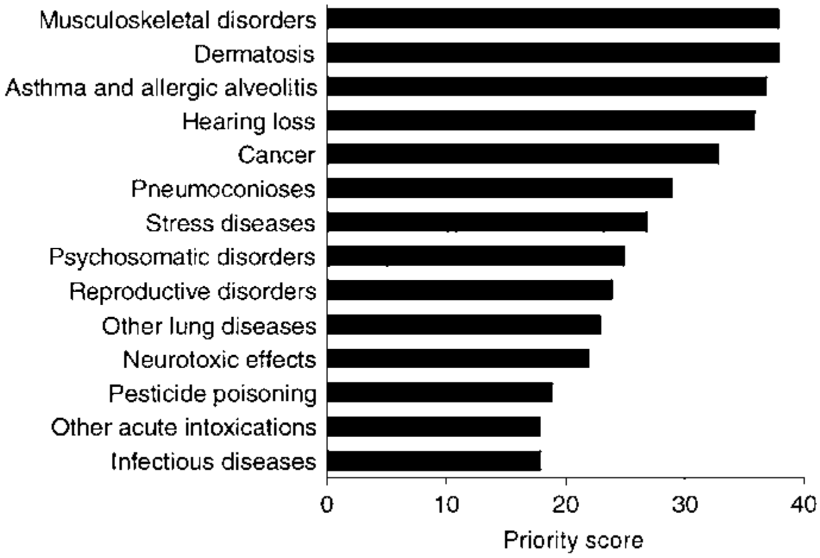
Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 15.13: Priority scores for current occupational health problems as assessed by 17 countries in the WHO European Region



Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 15.14: Current priority types of exposure as assessed by 17 countries in the WHO European Region



Source: Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

Fig. 15.15: Priority scores for future occupational health problems as assessed by 17 countries in the WHO European Region

to all the traditional occupational hazards in these countries [117]. Owing to the economic structure and, in some countries, a low level of mechanization and automation, the physical workload is also considerable. Published data suggest greater risks of occupational accidents and disease in eastern than in western countries of the Region. As a result of incomplete coverage and variation in the criteria for registration, however, the reported figures are often relatively low.

Throughout the Region, and in the CCEE and NIS in particular, registration and database systems need improvement and definitions of occupational diseases and accidents need harmonization. Most countries have numerous experts in occupational hygiene and occupational health, as well as in occupational safety and work psychology, and some have recognized the need to reorient the training of these experts to adapt to the new situation. Special programmes for the identification, control and prevention of occupational hazards in high-risk occupations, such as mining, agriculture, metallurgy and the metal and woodworking industries, are also urgently needed.

Professional assistance and possible financial aid from abroad can probably accelerate the development of better work environments in the CCEE and NIS. Sustainable activity, however, requires effort and expertise, with sufficient personnel trained in modern occupational health practice. In addition, some countries need to update their occupational health and safety legislation, and institute effective inspection for compliance. Furthermore, training for workers and employers needs to be organized in all countries to improve awareness of occupational health and safety at the plant level. Achieving these aims requires the design of a national policy with realistic objectives, and priorities that are set on the basis of a systematic survey of the major problems and the identification of the workers at highest risk.

Experience from the most industrialized countries provides evidence of a close relationship between productivity and quality of products on the one hand, and overall standards of health and safety in the work environment on the other. Thus, preventing and reducing hazards to occupational health and safety can benefit not only a country's workforce but also its economic development.

References

[1] *Employment outlook, July 1992*. Paris, Organisation for Economic Co-operation and Development, 1992.

[2] Neal, A.C. & Wright, F.B., ed. *The European Communities' health and safety legislation*. London, Chapman & Hall, 1992.

[3] Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC). *Official journal of the European Communities,* **L183**: 1 (1989).

[4] *Global outlook 2000. An economic, social, and environmental perspective by the United Nations*. New York, United Nations, 1990 (ST/ESA/215/Rev. 1).

[5] *Global estimates for health situation assessments and projections*. Geneva, World Health Organization, 1990 (document WHO/HST/90.2).

[6] Paoli, P. *First European survey on the work environment 1991–1992. European Foundation for the Improvement of Living and Working Conditions*. Luxembourg, Office for Official Publications of the European Communities, 1992.

[7] *International labour statistics, 1980–1991*. Geneva, International Labour Organisation, 1992.

[8] Rantanen, J. et al. *Health promotion and health protection in small-scale enterprises*. Geneva, World Health Organization (in press).

[9] *From pyramid to pillar. Population change and social security in Europe*. Geneva, International Labour Organisation, 1989.

[10] *Aging and working capacity. Report of a WHO Study Group*. Geneva, World Health Organization, 1993 (WHO Technical Report Series No. 835).

[11] *Best in the world. What can we learn from companies with high productivity?* Stockholm, Royal Swedish Academy of Engineering Sciences, 1992.

[12] Rantanen, J. *Occupational health: emerging trends and perspectives. Proceedings of a WHO Symposium. Occupational health for the 1990s, Amsterdam 13–16 March 1990*. Copenhagen, WHO Regional Office for Europe, 1990 (document EUR/ICP/OCH 138).

[13] *Integrated policy plans on working conditions*. The Hague, Ministry of Social Affairs and Employment, 1991.

[14] Rantanen, J. & Lehtinen, S., ed. [*Working environment and occupational health in Finland*.] Helsinki, Finnish Institute of Occupational Health, 1992 (Reviews No. 119).

[15] Arbetsmiljökommissionen. [*Occupations exposed to special health hazards in Sweden*.] Stockholm, Arbetarskyddsstyrelsen, 1989.

[16] Heiskanen, M. et al. *Accidents and violence 1988*. Helsinki, National Research Institute of Legal Policy, 1991 (Publication No. 108).

[17] Clarke, R. & Glendon, I. *How occupational accidents and diseases are reported in the European Community*. Dublin, European Foundation for the Improvement of Living and Working Conditions, 1988.

[18] Takala, J. Level of development, safety and health. *In*: Lehtinen, S. et al., ed. *Towards the 21st century. Work in the 1990s. International Symposium on Future Trends in the Changing Working Life, Helsinki. Proceedings 3*. Oitmäki, Finnish Employers' Management Development Institute, 1991 (Aavaranta Series No. 29).

[19] Health and Safety Commission. *Commission Annual Report 1991/92*. London, H.M. Stationery Office, 1992.

[20] *Employment outlook, July 1989*. Paris, Organisation for Economic Co-operation and Development, 1989.

[21] *Employment outlook, July 1990*. Paris, Organisation for Economic Co-operation and Development, 1990.

[22] Koradecka, D. Health, work and the economy in Poland. *In*: Levy, B.S. & Levenstein, C., ed. *Environment and health in eastern Europe. Proceedings of the Symposium on Occupational and Environmental Health during Societal Transition in Eastern Europe, Pécs, Hungary, 22–27 June*. Boston, Management Sciences for Health, 1990, pp. 80–81.

[23] Rantanen, J. The Finnish experts help in improving working conditions in Estonia. *Baltic review,* **32**: 36–37 (1993).

[24] Nermann, H. Worker and the work environment. *Estonian newsletter on occupational health and safety,* **1**: 15–16 (1993).

[25] *Industrial accidents 1989*. Tampere, Finland, National Board of Labour Protection, 1990.

[26] Doll, W. Weiterhin weniger tödliche Unfälle. Unfallverhütungsbericht 1991. *Bundesarbeitsblatt,* **3**: 11–13 (1993).

[27] Saari, J. et al. *Successful accident prevention. Recommendations and ideas field-tested in the Nordic countries*. Helsinki, Finnish Institute of Occupational Health, 1991 (Reviews No. 12).

[28] Rantanen, J. Global trends in occupational health and safety. *In*: Lehtinen, S. et al., ed. *Towards the 21st century. Work in the 1990s. International Symposium on Future Trends in the Changing Working Life, Helsinki. Proceedings 3*. Oitmäki, Finnish Employers' Management Development Institute, 1991 (Aavaranta Series No. 29).

[29] Leskinen, T.P.J. *Evaluation of the load on the*

spine based on a dynamic biomechanical model, electromyographic activity of back muscles, and changes in stature. Tampere, Finland, Tampere University of Technology, 1993 (Tampere University of Technology Publications No. 112).

[30] PHEASANT, S. *Ergonomics, work and health*. Hong Kong, Macmillan, 1991.

[31] SZERDAHELYI, J. ET AL. Physiological strain of workers at high production open-cast mining. *In*: *Proceedings of the Fifth Finnish-Hungarian Joint Symposium: Prevention of Occupational Health and Safety Hazards*. Helsinki, Finnish Institute of Occupational Health, 1988, pp. 93–98.

[32] MOYKIN, Y.V. ET AL. The relationship of functional condition of workers' upper extremities' neuro-muscular system and the value of static-dynamic load. *In*: *Eighth Finnish-Soviet Symposium on Occupational Health, 26–29 August 1991, Nauvo, Finland. Extended abstracts*. Helsinki, Finnish Institute of Occupational Health, 1991, pp. 17–22.

[33] KÖRPERT, K. Risiko faktoren für Larmbedingte Hörverluste. Erkenntnisse aus Reihenuntersc-hungen an Lärmarbeitern und Lehrlingen. *In*: Moncelon, B., ed. *Maitriser le risque au poste de travail. Actes du IVe colloque international du Comité de recherches de l'Association internationale de la sécurité sociale, Strasbourg, 22–23 octobre 1992*. Nancy, Presses Universitaires de Nancy, 1993, pp. 399–405.

[34] STARCK, J. Exposure to physical factors. Noise. *In*: Kalliokoski et al., ed. [*Occupational hygiene*.] Helsinki, Finnish Institute of Occupational Health, 1992, pp. 46–55.

[35] TOUMA, J.B. Controversies in noise-induced hearing loss (NIHL). *Annals of occupational hygiene,* **36**(2): 199–209 (1992).

[36] STARCK, J. ET AL. Pilot study on the modelling of hearing loss at noisy occupations. *In*: *Eighth Finnish-Soviet Symposium on Occupational Health, 26–29 August 1991, Nauvo, Finland. Extended abstracts*. Helsinki, Finnish Institute of Occupational Health, 1991, pp. 99–103.

[37] KJELLBERG, A. ET AL. Estimation of dose–responses for noise annoyance in working environments. *Arbete och hälsa*, **42**: 1–21 (1992).

[38] KJELLBERG, A. Subjective, behavioural and psychophysiological effects of noise. *Scandinavian journal of work, environment and health*, **16**(Suppl. 1): 29–38 (1990).

[39] GEMNE, G. ET AL. Disorders induced by work with hand-held vibrating tools. A review of current knowledge for criteria documentation. *Arbete och hälsa*, **6**: 1–83 (1993).

[40] HAGBERG, M. ET AL. [High risk of symptoms in hands among certain occupational groups.] *Svenska läkartidningen*, **87**(4): 201–205 (1990).

[41] Council Directive of 14 June 1989 on the approximation of the laws of the member states relating to machinery (89/392 EEC). *Official journal of the European Communities*, **L183**: 9 (1989).

[42] Council Directive of 12 May 1986 on the protection of workers from the risks related to exposure to noise at work. *Official journal of the European Communities,* **L137**: 28 (1986).

[43] GRIFFIN, M.J. *Handbook of human vibration*. London, Academic Press, 1990.

[44] SEIDEL, H. ET AL. On prevention of a health risk for spine caused by whole-body vibration – the significance of applied research for the revision of current standards. *Abstracts of the XIII World Congress on Occupational Safety and Health, New Delhi, India, 4–8 April, 1993.*

[45] KECK, G. UV-exposure in open-air work. *Abstracts of the International Conference Safety Together, Vienna, 1–3 December 1993* (in press).

[46] *Potential health effects of climatic change. Report of a WHO Task Group.* Geneva, World Health Organization, 1990 (document WHO/PEP/90.10).

[47] *Electromagnetic fields (300 Hz to 300 GHz)*. Geneva, World Health Organization, 1993 (Environmental Health Criteria No. 137).

[48] KNAVE, B. Electrical and magnetic fields and health outcomes – an overview. *Scandinavian journal of work, environment and health,* Special issue (1994).

[49] SUESS, M.J. & BENWELL-MORISON, D.A., ED. *Nonionizing radiation protection*, 2nd ed. Copenhagen, WHO Regional Office for Europe, 1989 (WHO Regional Publications, European Series, No. 25).

[50] GAUHED, D. & HOLMÉR, I. Work in the cold – clothing, heat balance and thermophysiological reactions. *Arbete och hälsa,* **32**: 1–42 (1992).

[51] FINNEGAN, D.W. ET AL. The sick building syndrome: prevalence studies. *British medical journal,* **289**: 1573–1575 (1984).

[52] ANTTILA, A. ET AL. [*Occupational chemical exposure in Finland.*] Helsinki, Finnish Institute of Occupational Health, 1992.

[53] WHO COMMISSION ON HEALTH AND ENVIRONMENT. *Report of the Panel on Industry.* Geneva, World Health Organization, 1992 (document WHO/EHE/92.4).

[54] RANTANEN, J. Preventive measures in solvent use. *In: IMF World Conference on Safety in the Metal Industry, Oslo, 16–19 August 1976.* Geneva, International Metal Workers' Federation, 1976.

[55] VAINIO, H. ET AL. *Complex mixtures and cancer risk*. Lyon, International Agency for Research on Cancer, 1990 (IARC Scientific Publications No. 104).

[56] KALOYANOVA, F. A perspective from Bulgaria. *In*: Levy, B. S. & Levenstein, C., ed. *Air pollution in central and eastern Europe. Health and public policy. Edited Proceedings of the Second Annual Symposium on Environmental and Occupational Health during Societal Transition in central and eastern Europe, Frydeck-Mistek, Northern Moravia, Czechoslovakia (CSFR), 14-19 June 1991.* Boston, Management Sciences for Health, 1991, pp. 114–121.

[57] HERTZMAN, C. & AYRES, W. *Environment for Europe. Environment and health in central and eastern Europe*. Washington, DC, World Bank, 1993.

[58] UNGVARY, G. Workplace air contamination in Hungary. *In*: Levy, B.S. & Levenstein, C., ed. *Air pollution in central and eastern Europe. Health and public policy. Edited Proceedings of the Second Annual Symposium on Environmental and Occupational Health during Societal Transition in Central and Eastern Europe, Frydeck-Mistek Northern Moravia, Czechoslovakia (CSFR), 14-19 June*. Boston, Management Sciences for Health, 1991, pp. 19–23.

[59] DREXEL, G. ET AL. *BK-DOK. Dokumentation des Berufskrankheiten-Geschehens in der Bundesrepublik Deutschland '90*. Sankt Augustin, Schriftenreihe des Hauptverbandes der gewerblichen Berufsgenossenschaften, 1992.

[60] DUTKIEWICZ, J. ET AL. Occupational biohazards: a review. *American journal of industrial medicine*, **14**: 605–623 (1988).

[61] MALMBERG, P. Micro-organisms. Nordic Expert Group for Documentation of Exposure Limits. *Arbete och hälsa*, **44**: 1–29 (1991).

[62] TOMATIS, L. ET AL., ED. *Cancer: causes, occurrence and control*. Lyon, International Agency for Research on Cancer, 1990 (IARC Scientific Publications No. 100).

[63] VAN DAMME, P.& TORMANS, G.A. European risk and cost-benefit model. *In*: Hallauer, J. et al. *Eliminating hepatitis B as an occupational hazard*. London, Viral Hepatitis Prevention Board, 1993, pp. 55–60.

[64] TOKARS, J. ET AL. Percutaneous injuries during surgical procedures. *Journal of the American Medical Association,* **267**: 2899–2904 (1992).

[65] BLAND, S.M. ET AL. Allergy to laboratory animals in health care personnel. *Occupational medicine: state of the art reviews*, **2**(3): 525–546 (1987).

[66] UITTI, J. [Allergy among fur animal farmers and fur textile workers.] *Työ ja ihminen*, **7**(Suppl. 2) (1993).

[67] ASBERTS, V.M. & BROOKS, S.M. Advances in occupational asthma. *Clinics in chest medicine*, **13**(2): 281–302 (1992).

[68] TARVAINEN, K. ET AL. Berufsallergien durch cellulase, xylanase und alpha-amylase. *Zeitschrift für Hautkrankheiten,* **66**: 964–967 (1991).

[69] NORDMAN, H.. [Occupational lung diseases.] *Työ ja ihminen*, **7**(Suppl. 2): 254–269 (1993).

[70] KANERVA, L. *Allergy and work. The action programme of the Finnish Institute of Occupational Health*. Helsinki, Finnish Institute of Occupational Health, 1993.

[71] SHARPE, R.M. Declining sperm counts in men – is there an endocrine cause? *Journal of endocrinology*, **136**: 357–360 (1993).

[72] NIEMI, M. [Male fertility decreased by 50% in 50 years?] *Duodecim,* **109**(6):471–474 (1993).

[73] TASKINEN, H. Effects of parental occupational exposure on spontaneous abortion and congenital malformation. *Scandinavian journal of work, environment and health*, **16**: 297–314 (1990).

[74] SORSA, M. [*Adverse effects of the working environment on reproductive health.*]. Helsinki, Ministry of Social Affairs and Health, 1993.

[75] VAINIO, H. *List of occupational carcinogenic exposure/agents evaluated by IARC by 1993.* Lyon, International Agency for Research on Cancer, 1993.

[76] AITIO, A. [Work-related cancer.] *Työ ja ihminen,* **7**(Suppl. 2): 220–234 (1993).

[77] *Prevention of occupational cancer – international symposium*. Geneva, International Labour Organization, 1982 (Occupational Safety and Health Series No. 46).

[78] HIGGINSON, J. & MUIR, C. Environmental carcinogenesis: misconceptions and limitations to cancer control. *Journal of the National Cancer Institute*, **63**: 1291–1298 (1979).

[79] WYNDER, E.L. & GORI, C.B. Contribution of the environment to cancer incidence: an epidemiological exercise. *Journal of the National Cancer Institute*, **58**: 825–832 (1977).

[80] COLE, P. Cancer and occupation: status and needs of epidemiologic research. *Cancer,* **39**: 1788–1791 (1977).

[81] FOX, A.J. & ADELSTEIN, A.M. Occupational mortality: work or way of life? *Journal of epidemiology and community health,* **32**: 73–78 (1978).

[82] BRIDBORD, K. ET AL. *Testimony submitted to US Occupational Safety and Health Administration on proposed regulations for the identification, classification and regulation of toxic substances posing a potential occupational carcinogenic risk to humans*. Washington, DC, US Occupational Safety and Health Administration, 1978.

[83] DOLL, R. & PETO, R. The causes of cancer: quantitative estimates of avoidable risk of cancer in the United States today. *Journal of the National Cancer Institute*, **66**: 1191–1308 (1981).

[84] *Convention No. 139 concerning prevention and control of occupational hazards caused by carcinogenic substances and agents*. Geneva, International Labour Organisation, 1974.

[85] Skov, T. et al. Legislation of the European Community on carcinogens. *Pharmacology and toxicology,* **72**(Suppl. 1): 155–160 (1993).

[86] Hansen, J. et al. Availability of data on humans potentially exposed to suspected carcinogens in the Danish working environment. *Pharmacology and toxicology*, **72**(Suppl. 1): 77–85 (1993).

[87] Kalimo, R. et al., ed. *Psychosocial factors at work and their relation to health*. Geneva, World Health Organization, 1987.

[88] Karasek, R.A. New strategies in training. *In*: Lehtinen, S. et al., ed. *Towards the 21st century. Work in the 1990s. International Symposium on Future Trends in the Changing Working Life. Proceedings 3*. Oitmäki, Finnish Employers' Management Development Institute, 1991 (Aavaranta Series No. 29).

[89] Lindström, K. [Psychological workload.] *Työ ja ihminen,* **7**(Suppl. 2): 111–141 (1993).

[90] Gamberale, F. et al. Behavioral and psychophysiological effects of the physical work environment: research strategies and measurement methods. *Scandinavian journal of work, environment and health*, **16**(Suppl. 1): 5–16 (1990).

[91] Cooper, C.L. Coping with stress in organizations: the role of management. *In*: Kalimo, R. et al., ed. *Psychosocial factors at work and their relation to health*. Geneva, World Health Organization, 1987, pp. 185–205.

[92] Cox, T. & Cox, S. *Psychosocial and organizational hazards at work. Control and monitoring*. Copenhagen, WHO Regional Office for Europe, 1993 (European Occupational Health Series No. 5).

[93] Westlander, G. Self-efficacy and self-esteem in an occupational context: theoretical background to a measurement of psychosocial reward. *In*: *A healthier work environment. Basic concepts and methods of measurement. An international meeting, Högberga, Lidingö, Stockholm, 27–30 May 1991.* Copenhagen, WHO Regional Office for Europe, 1993, pp. 199–212 (document).

[94] Westcott, G. et al., ed. *Health policy implications of unemployment*. Copenhagen, WHO Regional Office for Europe, 1985.

[95] Arnetz, B.B. et al. *Stress reactions in relation to threat of job loss and actual unemployment. Physiological, psychological and economic effects of job loss and unemployment*. Stockholm, National Institute for Psychosocial Factors and Health, 1988 (Stress Research Reports No. 206).

[96] Schwefel, D. et al. *Unemployment, social vulnerability and health in Europe*. Berlin, Springer-Verlag, 1987.

[97] Olkinuora, M. Mental health and mental disorders in the working life. *In*: Lindström, K. & Kalimo, R. [*Work psychology. Health and the type of work.*] Helsinki, Finnish Institute of Occupational Health, 1987, pp. 142–156.

[98] Dy, F.E.J.F. *Visual display units: job content and stress in office work. New technologies and the improvement of data entry work*. Geneva, International Labour Organisation, 1985.

[99] Knave, B. & Bergqvist, U. *Update on visual terminals and workers' health*. Geneva, World Health Organization, 1990 (document WHO/OCH/90.3).

[100] Council Directive of 29 May 1990 on the minimum safety and health requirements for work with display screen equipment (90/270/EEC). *Official journal of the European Communities*, **L156**: 14 (1990).

[101] Ducatman, A.M. & Liberman, D., ed. The biotechnology industry. *Occupational medicine: state of the art reviews,* **6**(2): 1–326 (1991).

[102] Collins, C.H. & Beale, A.J., ed. *Safety in industrial microbiology and biotechnology.* Oxford, Butterworth, 1992.

[103] Duffus, J.H. & Brown, C.M. Health aspects of biotechnology. *Annals of occupational hygiene,* **29**(1): 1–12 (1985).

[104] Grenquist-Norden, B. [Granulation would reduce enzyme allergy.] *Työ terveys turvallisus,* **20**(16): 9–12 (1990).

[105] [*Biotechnological occupational health problems in the Nordic Countries.*] Helsinki, Finnish Institute of Occupational Health, 1989 (Project Report No. 42.53.06).

[106] *Recombinant DNA safety considerations*. Paris, Organisation for Economic Co-operation and Development, 1986.

[107] *Laboratory biosafety manual*, 2nd. ed. Geneva, World Health Organization, 1993.

[108] Andrup, L. et al. Biosafety considerations in industries with production methods based on the use of recombinant deoxyribonucleic acid. *Scandinavian journal of work, environment and health*, **16**: 85–95 (1990).

[109] Ahonen, G. *The costs of occupational accidents and diseases in the Nordic countries.* Helsinki, Nordic Institute for Advanced Training in Occupational Health, 1994 (NIVA Reports No. 3).

[110] Litske, H. *Occupational accidents in the Nordic countries – socioeconomic consequences*. Stockholm, Nordic Council of Ministers, 1987 (Nord 1987:4E).

[111] Hunter, W. Workplace safety, European Community style. *Safety and health*, February 1993, pp. 36–39.

[112] *Identification and control of work-related diseases. Report of a WHO Expert Committee.* Geneva, World Health Organization, 1985 (WHO Technical Report Series No. 714).

[113] Hernberg, S. Some aspects of work-related diseases and their prevention. *In*: Rantanen, J. & Lehtinen, S., ed. *New trends and developments in occupational health services*. Amsterdam, Elsevier Science Publishers, 1991 (Excerpta Medica, International Congress Series No. 890).

[114] *Proposed national strategies for the prevention of leading work-related diseases and injuries. Part 1.* Washington, DC, National Institute for Occupational Safety and Health, 1986.

[115] *Proposed national strategies for the prevention of leading work-related diseases and injuries. Part 2.* Washington, DC, National Institute for Occupational Safety and Health, 1988.

[116] Koskela, R.-S. [Work disability and premature mortality.] *Työ ja ihminen*, **7**(Suppl. 2): 163–177 (1993).

[117] *Epidemiology of work-related diseases and accidents. Tenth report of the Joint ILO/WHO Committee on Occupational Health*. Geneva, World Health Organization, 1989 (WHO Technical Report Series No. 777).

Chapter 16
Accidents and Man-made Disasters

16.1 Introduction

Both natural disasters and those resulting from conflicts or technological accidents may severely harm human health and the environment. Further, these emergencies may have considerable economic consequences. Both environmental and economic effects may have further indirect effects on health. Natural disasters – such as floods, storms, droughts, volcanic eruptions, earthquakes and landslides – may cause injury and death, damage to property and public health infrastructures, and land loss and crop damage. Recognizing these facts, the Forty-fourth Session of the General Assembly of the United Nations launched the International Decade for Natural Disaster Reduction in 1990.

The risk of natural disasters largely depends on geographical location, and the consequences are determined by a number of factors including population density, public awareness, building structures and the construction materials used, the duration of the event, its suddenness or unexpectedness, and the state of preparedness for responding to an emergency. About 95% of all natural disasters are estimated to occur in developing countries [1] while industrialized countries have substantially higher risks of technological accidents associated with the production, transport or use of hazardous chemicals or with the production of energy, such as nuclear or oil platform accidents [2]. Acts of war, civil unrest or sabotage may have similar or even greater effects on environmental integrity and human health than natural disasters or technological accidents.

Such disasters may have quite diverse consequences for environmental health, such as interruption of the drinking-water supply, release of chemicals from damaged or destroyed chemical installations, and chemical or microbiological pollution of drinking-water and food. The fighting in the former Yugoslavia and in other parts of the European Region has focused attention on these issues and on the huge loss of life entailed, particularly among young people.

Appropriate planning of responses to emergencies at the national and local levels is essential if the consequences of any major accident are to be rapidly and effectively mitigated. A state of preparedness includes the capability for rapid assessment of the potential hazards and, where appropriate, the establishment of early warning systems.

One should remember, however, that technological accidents in general are preventable. An awareness of high-risk circumstances and the use of preventive measures based on accurate, site-specific assessments of environmental impact and potential risks to health should therefore receive high priority. In recognition of the importance of possible human error staff development and training should include awareness of the risks of accidents and means of preventing them. It should also cover preparedness to respond to technological accidents, should they occur.

This chapter has two parts. The first deals with major technological accidents with environmental effects that may affect the health of a part of the population. The second part addresses accidents affecting individuals, including poisonings and traffic accidents. While individual domestic and occupational accidents strongly affect health, they are dealt with elsewhere (Chapters 14 and 15).

16.2 Technological Accidents with Environmental Effects on Health

Technological accidents may have serious environmental, health and economic consequences. Clean-up and aftermath measures, for example, may cause enormous costs to society.

Apart from these considerations, public anxieties about the possible risks of technological accidents are important. Public concern about risks of accidental exposure is considerable, especially for people living close to industrial installations or nuclear power stations. Such concern may be much greater than the actual risk, but still needs to be addressed. It is important to conduct realistic, site-specific assessments of potential hazards and to provide adequate and correct information to the public. All possible preventive measures should be taken in designing, constructing, operating and maintaining a plant.

In addition, training and education in accident prevention and preparedness by all concerned are a prerequisite for minimizing the possible health consequences of technological accidents. The groups to receive periodic training include managers and workers, staff of emergency services and the public. The responsible authorities, emergency services, health personnel and other involved groups need to develop, implement and take part in regular tests of agreed joint emergency response plans. Communication is important, particularly with the mass media and the public. The International Programme on Chemical Safety, the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme and the WHO European Centre for Environment and Health [3] have jointly developed guidance on awareness of, preparedness for and response to chemical accidents, and the WHO European Centre has prepared similar material on nuclear emergencies [4].

16.2.1 Chemical accidents

In general terms, a chemical accident is the result of an uncontrolled release into the external environment of one or more chemical compounds that are hazardous to health or harmful to property or the environment. The risks from a chemical accident largely depend on the properties of the compound itself, the quantities being handled, the processes used, and the nature of the accident or the release, as well as the surroundings (including meteorological conditions), population density, and the emergency response measures taken to minimize the consequences [1]. In countries lacking appropriate legislative and administrative infrastructures for dealing with emergencies, chemical accidents have a larger impact on the environment and human health [5]. Owing to the diversity of chemicals that might be released and the different routes of possible exposure, an accident may give rise to a wide spectrum of health effects.

Types

A compound may be dangerous because it is toxic, reactive, explosive, inflammable, corrosive or radioactive. Toxic substances include man-made chemicals, such as dioxins or organophosphates, and those of natural origin. With such compounds, both the toxic potency and the amount released are important. The most dangerous class of hazardous chemical comprises gases condensed under pressure, such as liquefied petroleum gas, chlorine, sulfur dioxide and ammonia.

Chemical accidents may result from a fire, an explosion or a leak that leads to a sudden release of hazardous substances. They may occur during manufacture, storage, transport (by rail, road, air, water and pipeline), use and disposal. The causes of chemical accidents are quite diverse. They may be related to a process, but may also arise from machinery failure or human error. For example, a reactor vessel may rupture owing to wrong temperature and/or pressure, leading to the unintentional production and release of hazardous compounds. Gas releases may result from the accidental mixing of chemicals. Fires may lead to the formation of toxic compounds that are released into the environment as a result of the fire or the efforts to put it out [1].

Inadequate maintenance and/or the malfunction of emission control equipment in fixed installations may lead to a continuous release of chemicals into the environment. The result could be substantial pollution of the immediate neighbourhood, which might have health effects similar to the long-term consequences of short-term, major accidents.

External factors affect the probability of an accident. In fixed installations (such as chemical plants, storage rooms, warehouses and reprocessing sites) natural events such as floods or extreme weather as well as, for example, power cuts may lead to an uncontrolled release of chemicals. The risk of chemical accidents during road transport depends on factors such as traffic density, road conditions and speed limits; the effects depend on where an accident occurs.

Environmental media affected

In principle, accidental releases of hazardous chemicals may affect all environmental media (air, water and soil) and consequently the food-chain, independent of the type of release and the environmental medium initially affected. Explosions or leaks of inflammable materials can release quantities of toxic chemicals into the atmosphere, the distribution of which depends on the height of the plume and the meteorological conditions. The chemicals released may subsequently contaminate land, water, food crops or livestock. Chemical spills affect soil and/or water first, but may contaminate food crops and livestock. External factors, such as temperature, extreme precipitation and wind, can influence the amount of chemical released and its dispersal [1]. While most chemical accidents occurring in fixed installations tend to be contained within the industrial compound itself, the problems generated by major chemical accidents may cross national borders [5].

Routes of exposure and acute health effects

The nature of a chemical accident ultimately determines the routes and types of exposure. An accidental release of large amounts of a chemical may have acute effects through direct exposure, but may also lead to long-term exposure to lower levels of the chemical, especially when the food-chain is affected. Besides, acute exposure may yield delayed effects without causing acute symptoms. In the event of a chemical accident, the major direct routes of exposure are inhalation, skin or eye contact and ingestion [6].

Exposure via inhalation is the main direct route of exposure to gases, fumes, aerosols or respirable dust. Irritant gases damage the respiratory tract mucosa; the site, nature and severity of the damage is a function of, on the one hand, the water solubility, reactivity, concentration and particle size and on the other, the duration of exposure and any underlying disease in the people exposed. Highly water-soluble irritants, such as acids and ammonia, mainly affect the upper respiratory tract and produce immediate effects: watering of the eyes and nasal congestion. The lower the water solubility of an inhaled compound or the longer the duration of the exposure, the more likely it is that the lower respiratory tract will be affected, leading to inflammation of the lungs. Substances that are toxic when inhaled may cause systemic effects on almost any organ, with no direct effect on the respiratory tract. Some inhaled compounds, however, may create both local irritation and systemic toxicity.

Skin exposure may result in local injury – usually chemical or corrosive burns – but may also produce systemic poisoning if dermal absorption takes place. The higher the lipid solubility of the chemical involved, the more likely it is to be absorbed through the skin; it will also be enhanced in the presence of organic solvents and in the case of increased skin blood flow from inflammation or rubbing, or skin damage. Eye injury is most likely to result from exposure to gases, vapours or dusts, but also by direct contact with the eye through splashing, for example. Such effects are most likely to occur among workers at the site of an accident. Decontamination is essential for limiting injury.

Acute local injury to the gastrointestinal mucosa may follow the ingestion of corrosive, oxidizing or coagulative agents, and the absorption of certain chemicals may result in systemic poisoning.

The central nervous system is often the target of chemicals, including a wide range of organic solvents and pesticides. Some chemicals, when inhaled, impair cellular utilization of oxygen, while other agents may have acute effects on heart function. Halogenated hydrocarbons are well documented as causing sensitization of the heart muscle; additional or future exposure to similar compounds may then result in abnormal heart rhythms, possibly leading to death.

Long-term health effects

The long-term consequences of accidental exposure to chemicals may include cancer, damage to the immune system, delayed neurotoxicity, specific organ toxicity, reproductive disorders, genetic damage and effects on the skin [6]. In every chemical accident, it is essential to try to identify the chemical or chemicals involved and the level of exposure as quickly as possible. When long-term effects are anticipated, or there is risk of such effects, epidemiological studies should be considered and arrangements made to undertake them, including the early collection of appropriate samples for exposure assessment.

Ingestion is a major route of long-term exposure following chemical contamination of the food-chain and/or drinking-water. It is also the major route of exposure following incidents that take place silently without producing marked acute effects, such as accidental spills affecting water or soil. In such cases, establishing causal relationships between exposures and effects may be difficult, particularly where there is a long latency period. For example, the identification of factory discharges into the sea as the source and of organic mercury compounds as the agents responsible for Minamata disease took several years of investigation.

In addition to health effects directly related to the chemicals involved, stress-related effects, both psychological and physical, are often observed. Symptoms of post-traumatic stress are quite common, and may occur not only at the time of an accident but also weeks or months afterwards. The symptoms may consist of intrusive memories of the event, sleeping problems, irritability, and depressed or anxious moods. In addition, a chronic stress syndrome may develop, especially in cases of exposure to chemicals that are known to pose long-term hazards to health (see the section on radiation accidents below). The symptoms may be similar to those observed with post-traumatic stress, but may also involve nonspecific somatic symptoms.

Physical consequences may result from the precipitation of symptoms of existing ill health under a severely stressful experience. Increased mortality from cardiovascular diseases was observed soon after the accident in Seveso, Italy in 1976, for example [7].

Major chemical accidents in the European Region

Knowledge about chemical accidents that have occurred, and analysis of their characteristic features, are prerequisites for developing adequate measures to prevent future incidents, or to respond to and mitigate their effects. Many chemical accidents have occurred in the European Region; Table 16.1 lists some of the major ones. This list is not comprehensive, however, and some countries of the Region lack adequate reporting systems.

As an example of a major chemical accident, the release of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) in Seveso is described in some detail. The accident occurred during the production of 2,4,5-trichlorophenol (TCP). Owing to an unexpected reaction of a nature and cause as yet unknown, the reactor temperature rose, causing a pressure surge that blew safety devices. The chemical mixture in the reactor was consequently discharged through a pipe vent into the atmosphere, forming a cloud containing trichlorophenol, sodium trichlorophenate, ethylene glycol, sodium hydroxide and, as discovered later, a substantial amount of TCDD (estimated at 1.3 kg) [9,10].

In the close vicinity of the plant (an area downwind later designated as zone A) signs of environmental contamination affecting birds, other animals and vegetables were observed within three days, but the presence of TCDD was suspected only a week after the incident and a further nine days passed before the evacuation of zone A (735 residents) began. Studies conducted in zone A later revealed that soil had been heavily contaminated with TCDD [5] with mean soil levels ranging from 15.5 to 580 $\mu g/m^2$.

The acute health effects observed were mainly mild forms of a skin disorder (chloracne) appearing in a small segment of the population. In general, the lesions healed rapidly and completely. Hepatotoxicity, neurological symptoms or disordered porphyrin metabolism were not observed, even in people that developed chloracne. The results of epidemiological studies published in 1979 provided no proof of exposure-related effects on, for example, pregnancy outcome, immune response, occurrence of chromosomal aberrations, functions of the nervous system, haematological parameters, liver function, morbidity or mortality [9]. Taking account of the results of recent epidemiological studies, which indicate that TCDD is a (nongenotoxic) human carcinogen at high doses [11], possible carcinogenic outcomes cannot be ruled out and will obviously depend on the TCDD dose. Owing to the long latency period for such effects, and the lack of adequate case–control studies (although some are under way), more time will be needed to assess the long-term health sequelae of the accident.

Despite the lack of dramatic health consequences, this accident clearly demonstrated how delay in both recognizing the severity and chemical nature of an incident and responding fully to it may result in continued exposure of the population to toxic chemicals released into the environment.

Prevention and mitigation

As long as chemicals are manufactured, transported, stored, used or reprocessed, the risk of accidents will continue. Recognizing the necessity of appropriate measures to control industrial accidents, some governments have established national and/or regional plans for accident prevention and emergency response. After the Seveso accident, an EC directive was issued to ensure that measures would be taken to reduce the

Table 16.1 a: Major chemical accidents in the WHO European Region, 1928–1983

Year	Country (location)	Chemical(s) involved	Type of accident	Consequences		
				Deaths	Injuries	People evacuated
1928	Germany (Hamburg)	Phosgene	Release	10	>200	–
1939	Romania (Zarnesti)	Chlorine	Release	60	–	–
1948	Federal Republic of Germany (Ludwigshafen)	Dimethyl ether	–	30	–	–
1952	Federal Republic of Germany (Wilsum)	Chlorine	Leak	7	–	–
1966	France (Feyzin)	Liquefied petroleum gas	–	18	90	–
1974	United Kingdom (Flixborough)	Cyclohexane	Explosion	28	–	–
1975	Federal Republic of Germany (Heimstetten)	Nitrogen oxide	Warehouse fire	–	–	10 000
	Netherlands (Beek)	Propylene	Explosion	14	104	–
	Netherlands	Ethylene	Explosion	4	35	–
1976	Finland (Lapua)	Gunpowder	Explosion	43	71	–
	Italy (Seveso)	TCDD/other dioxins	Release	–	>200	(Entire area)
	Norway	Flammable liquid	Explosion	6	(Not known)	–
1977	Italy (Gela)	Ethylene oxide	Explosion	1	2	–
	Italy (Cassino)	Propane/butane	Explosion	1	9	–
1978	Italy (Manfredonia)	Ammonia	Plant accident	–	–	10 000
	Spain (Los Alfaques)	Propylene	Road transport	216	200	–
1979	Austria (Vienna)	Hydrogen cyanide/carbon monoxide	Fire	25	–	–
	Greece (Suda Bay)	Propane	Explosion (during trans–shipment)	7	140	–
	Turkey (Istanbul)	Crude oil	Explosion (ship)	52	3	–
	USSR (Novosibirsk)	"Chemicals"	Plant accident	300	?	–
1980	Italy (Rome)	Oil	Ship collision	25	26	–
	Spain (Ortuella)	Propane	Explosion (school)	51	90	–
	Turkey (Danaciobasi)	Butane	Explosion (bottled gas)	107	?	–
	United Kingdom (Barking)	Sodium cyanide	Fire	–	12	3 500
1982	Italy (Todi)	"Gas"	Explosion	34	40	–
	United Kingdom (Salford)	Sodium chlorate	Fire	–	60	300
1983	Turkey (Istanbul)	"Gas"	Explosion	42	50	–
1984	Romania	"Chemicals"	Plant accident	100	100	–
	United Kingdom (river Dee)	Phenol	Spill	–	(Large number)	–
1985	Italy (Priolo)	Propylene	Leak	–	–	>20 000
	Spain (Algeciras)	Gasoline	Ship transport	33	37	–

Table 16.1 b: Major chemical accidents in the WHO European Region, 1928–1983

Year	Country (location)	Chemical(s) involved	Type of accident	Consequences		
				Deaths	Injuries	People evacuated
1986	Bulgaria	Vinyl chloride	Explosion	17	19	–
	Switzerland (Basle)	"Chemicals"	Warehouse fire	(Gross environmental and river pollution)		
	United Kingdom (Hemel Hempstead)	Red lead oxide	Road transport	–	150	–
1987	France (Nantes)	Fertilizers	Fire	–	24	25 000
	Federal Republic of Germany (Herborn)	Gasoline	Road transport	4	38	–
	Italy	Methane	Fire	4	1	–
	Spain (La Coruna)	Sodium	Fire (on vessel)	23	–	–
	USSR (Annau)	Chlorine	Rail transport	–	200	–
1988	Yugoslavia (Sibanik, Croatia)	Fertilizers	Fire (process failure)	–	–	>60 000
	France (Tours)	"Chemicals"	Fire	–	3	200 000
	USSR (Arzamas)	Explosives	Explosion (rail transport)	73	230	90 000
	United Kingdom (Camelford)	Aluminium sulfate	Spill	–	?	–
	United Kingdom (West Bromwich)	Nitric acid	Leakage	–	22	50 000
1989	USSR (Jonava)	Ammonia/nitrogen phosphate and potassium fertilizers	Explosion, fire	6	53	30 000
	USSR (Acha Ufa)	Gas	Explosion (pipeline)	575	623	–
	USSR (Yurga)	Ammunition	Explosion	1	3	20 000
1990	Federal Republic of Germany (Alfeld)	Chlorine	Release (from lorry)	–	200	–
	USSR (Ufa)	Phenol	Leakage	–	?	600 000
1991	Italy (Livorno)	Oil	Explosion (tanker in harbour)	140	?	–
	United Kingdom (Immingham)	Magnesium/ammonia	Fire (storage)	–	126	–
1992	Portugal (Scavem)	Chlorine	Release	–	75	–

Note: The criteria for inclusion were: 25 or more deaths, 125 or more injuries, 10 000 or more evacuated or deprived of water supply, or US $10 million or more damages to third parties. The country names given are those valid in the year in question.

Source: Organisation for Economic Co-operation and Development *(8)*.

risk of accidents involving hazardous chemicals; it is often called the Seveso Directive [12].

Although, according to OECD statistics, the probability of a member of the general population being killed in an accident involving hazardous substances is lower than the probability of being struck by lightning, the direct impact of a major chemical accident on both human health and the environment may be considerable. Taking all necessary measures to prevent chemical accidents is therefore essential; this is the most effective strategy for control [5,13–15]. In addition, preparedness programmes must be available to prevent and mitigate the effects on health of any accidents that occur [3,13,15]. Essential elements in emergency response include:

- rapidly identifying the chemicals involved;
- assessing the potential scale of the consequences (including important pathways for exposure, the number of people likely to be exposed and the risks to their health); and
- providing information and advice to the public.

Effective and rapid response is essential and requires overall control of all actions taken by responsible individuals and authorities. Finally, in the post-emergency phase, adequate rehabilitation measures for human health and the environment must be taken [16] and, where appropriate, follow-up arranged for affected populations so that any long-term effects on health can be investigated.

16.2.2 Radiation accidents

Despite being rare events, nuclear accidents arouse great concern in the public and receive considerable attention from the mass media, owing to the serious and long-term implications of major accidents. Other reasons for this concern, however, are probably due to the fact that people cannot sense radiation, and that they tend to view a nuclear accident as similar to the explosion of a nuclear bomb. Nuclear accidents may affect a variety of installations such as power stations, reprocessing plants, medical facilities and research institutions. The main environmental health hazards are related to long-term exposure, the risks of which are discussed in more detail in Chapter 12.

Origin and hazards

Accidents to nuclear facilities usually involve explosions and/or fires; were it not for the subsequent uncontrolled release of radionuclides to the environment, these would have little health impact except on the people immediately involved, such as workers and firefighters. The persistence of radionuclides in the environment, their contamination of the food-chain, and their uptake and retention (and sometimes concentration) in particular human tissues, however, result in a threat to the health of the exposed population. Of particular note are strontium-89 and -90, caesium-134 and -137, iodine-131, -132, -133 and -135, tellurium-132 and the actinides, particularly the isotopes of americium, plutonium and curium.

With the exception of iodine and tellurium, each of the nuclides has relatively long-lived and persistent isotopes. Iodine isotopes are damaging because of their affinity for the thyroid gland, where they concentrate to yield very high doses; tellurium decays in the bloodstream to yield an isotope of iodine.

Health effects

Widespread contamination of the environment leads to hazards from external exposure to long-range radiation emanating from ground deposits, and from internal irradiation from nuclides ingested in food or inhaled from resuspended nuclides. Certain nuclides do not present a risk of internal exposure, except perhaps to the lung, and others such as the actinides do not present a risk through external exposure. In addition there is a risk, particularly to people close to the site of an accident, of exposure to the plume of radioactive material. Few generalizations can be made; each accident has to be treated as a separate case. Like chemical accidents, radiation accidents give rise to psychological and physical symptoms related to stress, particularly owing to fears about radiation and uncertainty about the real risks associated with exposure. Chapter 12 discusses the health effects of such accidents in greater detail.

Major radiation accidents in the European Region

This section discusses three major accidents in the Region: those at Windscale, Kyshtym and Chernobyl.

In 1957, part of the Windscale reactor in Cumbria, United Kingdom, caught fire while undergoing a procedure to anneal radiation damage in the core. The reactor had been shut down for a number of days before the fire. The fire caused the release of volatile fission products from the core. A filter trapped much of the released radioactivity, but a substantial amount of iodine isotopes was released to the environment. The material was carried in a south-easterly direction across the country, resulting in iodine contamination of milk supplies over a large area of the counties nearest to London, in addition to Cumbria and the more immediate district to the south-east of Windscale.

Measurements in people living close to the site revealed uptake of iodine by the thyroid gland in children. As a result, milk supplies from an area surrounding the site of the accident were discontinued and further doses to the thyroid prevented. In London and nearby counties, several million people received very small radiation doses from drinking milk produced in that region. No adverse effects on health were detected.

Also in 1957, a container storing waste from nuclear fuel reprocessing at a plant near Kyshtym, in the USSR, exploded as the result of a failure of the cooling system. This led to the dispersal to the atmosphere of a large quantity of fission products producing a long (300-km), narrow trail of radioactive contamination affecting a number of rural populations in the region. Substantial areas were evacuated within days or weeks of the accident to limit doses to the population, and some are still uninhabitable. The dominant isotope was strontium-90. Further details of this accident are provided in Chapter 12.

In 1986, during testing prior to a shutdown period for maintenance, part of the Chernobyl reactor in the Ukraine, USSR, experienced a large chemical explosion that destroyed the roof of the reactor building and all the facilities to control the reactor. The death toll among reactor operating staff and firefighters was 30 in the first three months after the accident. In the fire that followed, substantial amounts of fission products were released into the environment and were initially blown in a north-westerly direction across much of the southern part of the Byelorussian SSR, Poland, the Lithuanian SSR and Finland. The fire burned for ten days, continuing to release radioactivity. Chernobyl-related fallout has been detected in almost all parts of the world, but potential long-term health effects are probably confined to the countries of the former USSR closest to the accident site, namely Belarus and part of the Russian Federation as well as the northern part of Ukraine. An area 30 km in radius is uninhabitable, and food produced from a much wider area is still under surveillance.

An increase in thyroid cancer in children in southern Belarus (see Chapter 12) is probably related to the initial passage of the cloud containing high concentrations of iodine isotopes. The duration of the event and the fact that it occurred in an operating reactor resulted in a very complex dosimetric situation, particularly for the iodine isotopes; some have very short half-lives and therefore could not be measured after the accident. Residual contamination is mainly of caesium-137. The accident has created great concern in the local population because of health and psychosocial effects (in addition to thyroid cancer in children) that are real although not directly induced by radiation. Long-term radiation-induced adverse health effects can be expected in the population living close to the accident site. The fact that measurable levels of environmental contamination exist in areas at greater distances from Chernobyl does not imply that an increase above background rates of cancer can necessarily be detected.

Prevention and mitigation

Accidents in nuclear installations, while rare, may result in releases of radioactivity into the environment. In most cases radioactivity will be released into the atmosphere, but releases into water may also be encountered. As with chemical accidents, emphasis should be placed on prevention (see Chapter 12) but it is also necessary to develop the capability to deal effectively with any accident that may occur. This ability to respond requires methods for the rapid assessment of the nature and scale of the accident, and potential environmental health effects, along with planned measures for the rapid mitigation of effects through such means as the sheltering or evacuation of the population and the control of food. In addition to such contingency plans, an appropriate information policy and the capability to implement effective remedial measures need to be developed. The transboundary nature of nuclear accidents necessitates cooperation among governments.

16.2.3 Accidents affecting food and drinking-water

Accidents and the food-chain

Because the quality of food reflects the environmental conditions under which it was grown or produced, handled (processed, packed, transported, delivered and prepared) and eaten, any release of potentially hazardous agents such as bacteria, viruses, toxins, chemicals and radionuclides can adversely affect the food-chain and thus the health of consumers. The release of any potentially hazardous agent to air, soil or surface water may result in direct (through deposition on plant surfaces) or indirect (through incorporation into food plants or ingestion by livestock) contamination of food. The intentional adulteration of food presents a special problem not only with controlling the action but also because of the potential for causing widespread health effects if the commodity is sold in a number of countries.

Possible health effects

In principle, any accident or emergency affecting the food-chain may have acute or long-term adverse effects on human health, such as intoxications and infections. The outcomes of such emergencies range from no effects being observed to severe effects of considerable magnitude, depending on the agents or organisms involved, the number of people affected, and the response mounted and containment measures taken.

Major food-related accidents in the European Region

Some of the accidents and emergencies affecting the food-chain in the Region have had significant implications for human health and/or environmental integrity. Four such incidents are discussed.

First, a new foodborne disease broke out in epidemic proportions in Spain in May 1991. The disease, which came to be called toxic oil syndrome, developed in people who consumed adulterated rape-seed oil sold as cooking oil. The syndrome affected more than 20 000 people, several hundred of whom died within the first year. To date, most of those affected continue to display symptoms affecting the nervous and respiratory systems, liver and skin to varying degrees, and more than 800 have died. Investigations continue; the etiology is not yet fully understood. Apparently, the intentional adulteration of the oil to maximize the profits of a few people was behind this catastrophe [17].

Second, the adulteration of wine and alcoholic drinks with methyl alcohol has often been observed. Among the more recent incidents was one documented in Italy in which methyl alcohol was intentionally added to an alcoholic drink, causing a number of deaths. In Albania, some people died and many had to be admitted to hospital after consuming drinks adulterated with methyl alcohol.

Third, a fire broke out in a warehouse belonging to the Sandoz chemicals company at Schweizerhalle near Basle, Switzerland, in 1986. The fire spread rapidly, threatening nearby buildings in which large amounts of highly inflammable liquids were stored. Water used to extinguish the fire became contaminated with pesticides and other chemicals and flowed into the river Rhine, killing fish and other aquatic life. Health effects were avoided because the responsible authorities took immediate measures to control water supplies, fisheries and food, and information was rapidly made available to the public.

Fourth, the Chernobyl accident, which is described above and in Chapter 12, had serious effects on the food-chain throughout the Region. Directly after the accident, the levels of radioactivity were markedly elevated in several food items of both vegetable and animal origin in some areas of central Europe. Levels of radionuclide contamination of certain foods in some parts of the Region are still high enough to prohibit consumption. For example, the consumption of reindeer meat is still considered unsafe in some areas of northern countries. The confusion of authorities responsible for food safety during the first days after the accident clearly demonstrated the need for effective rapid alert systems and coordinated action, in order to avoid overreaction but to recognize real risks.

Prevention and mitigation

Accidents affecting the food-chain will occur as long as human beings handle hazardous substances. The responsible authorities at all levels must take proper measures both to prevent and to respond effectively to such accidents. Events have demonstrated that adequate information is one of the most important factors in avoiding adverse health effects due to food contamination. Special attention should therefore be paid to measures to improve communication and the flow of information.

Data on hazardous compounds or organisms and on accidents that have occurred should be compiled and made available to authorities involved in accident prevention and/or response. Where plans are not yet in place for dealing with food contamination due to technological accidents, these should be developed. Such plans should clearly characterize the type of information needed at any stage of an emergency, and clearly define the channels of communication. To ensure an adequate and timely response (for example, by preventing the ingestion of possibly contaminated foodstuffs) early warning systems to initiate the action required should be established. The education and training of both professionals participating in the response and the general public will ensure a controlled and adequate response to an emergency. The public needs adequate information to avoid both underestimating actual risk and overreacting to the contamination of foodstuffs following accidents and emergencies. The extent to which such arrangements are in place throughout the WHO European Region is not yet known; countries are thought to differ considerably.

Finally, the intentional adulteration of foods and drinks must be prevented. Containing such criminal acts requires not only action at the national level but also cooperation among governments. Such action should cover both control systems to detect intentional adulteration and deterrent measures.

Accidents and drinking-water

The main source of raw water for drinking is fresh surface water or groundwater. Accidents affecting drinking-water may result from the release or spillage of hazardous materials to surface water or groundwater, or may occur in a treatment plant or distribution system. Lack of maintenance of plants or distribution systems may be the precursor of the accidental pollution of drinking-water supplies.

Accidents leading to the pollution of surface water used for drinking occur most frequently during industrial, agricultural and transport activities. The polluting agent may be discharged in the handling of the agent or of its "carrier". The accident at Schweizerhalle, when water from fire extinguishers was not handled properly, provides an example of the latter.

Transboundary movement is a feature of growing importance in such accidents; the accident at Schweizerhalle, for example, affected four countries: France, Germany, the Netherlands and Switzerland. The situation in Hungary also shows the importance of this factor. In 1989, 27 of the 213 accidental water pollution incidents that affected Hungary arose in other countries. In addition the Budapest waterworks – treating surface water from the Danube with a capacity of 200 000 m^3 per day – has had to be closed down several times in the last 10 years because of deterioration in water quality caused by accidental pollution.

In general, accidental pollution of groundwater used for drinking arises in a different way. The most serious sources of pollution are unprotected landfills, particularly those containing hazardous waste. (The pollution of groundwater due to seepage of nitrates and pesticides from agricultural land is not considered accidental.) Nearly all the hazardous waste landfills throughout the Region pollute groundwater, since extremely few – if any – have been constructed to avoid the seepage of leachate. This has not, however, resulted in drinking-water supply emergencies affecting human health, although it may have led to abandonment of the use of groundwater sources. Chapter 8 considers this problem in more detail.

Accidents in treatment plants may occur in chemical treatment (such as coagulation and chlorination) or result from damage to equipment (such as pumps and filters) in the plant. Such an accident occurred at a water treatment plant at Camelford, United Kingdom in 1988, when about 20 tonnes of concentrated aluminium sulfate was delivered into the wrong tank. This gave a foul taste to the water. The people who drank sufficient water developed acute gastrointestinal symptoms, which were attributed to copper toxicity due to mobilization from copper water pipes as a result of the acidity of the water supply. Public anxiety about prolonged or delayed toxic effects was considerable, and many complaints were made of subsequent ill-health. Investigation did not establish any relationship between the symptoms and ingestion of polluted drinking-water [18].

Leakage creates the most serious emergencies in the distribution system. It may result from lack of maintenance or from direct damage to drinking-water pipelines, which can take place during construction work, for example. Practically all drinking-water distribution systems leak. Apart from the waste of resources, leakage may also cause adverse health effects, as drinking-water can become polluted, for example, with chemicals present in soil, or microorganisms from adjacent sewage systems (see Chapter 6).

Accidents or emergencies caused by war or civil unrest and that affect drinking-water quality and human health are causing serious concern in the Region. In such cases, pollution of drinking-water may result from the destruction of or damage to water treatment plants or distribution systems, or from insufficient treatment due to a lack of chlorine or coagulants.

Possible health effects

Polluted drinking-water may have different types of adverse health effect, depending on the nature and the amount of the pollutant(s) involved. Microbial contamination resulting in acute outbreaks of infectious disease is usually readily detected, and the causal relationship with water contamination established. Similarly, the concentration of a chemical pollutant may be sufficient for acute toxic symptoms to result in people drinking the water. Possible long-term effects, however, either as a sequel to acute exposure or as a result of continuing exposure to lower levels of chemical contamination, are more difficult to ascertain. This problem is common to all assessments of environmental effects on health and is discussed more fully in other chapters.

Major water-related accidents in the European Region

Accidents leading to the pollution of the rivers Rhine and Danube have already been mentioned. Neither reportedly had any direct adverse health effect; such accidents are usually detected quickly, and the distribution of drinking-water from polluted sources avoided.

Countries were asked to provide information on emergencies related to drinking-water as part of the data for use in this report.[a] Five countries provided information on incidents that led to infections with hepatitis A and Norwalk viruses, salmonellosis and shigellosis and a large number of unidentified types of gastroenteritis. The most frequent causes of such incidents were sewage contamination, flooding and heavy rains, or lack of adequate chlorination.

The lack of further information from countries may be due to the lack of a central database and/or inadequate reporting; this does not imply, however, that such accidents seldom occur.

Prevention and mitigation

Although drinking-water pollution due to accidents affecting surface water resources cannot be completely prevented, action should be taken to minimize the possible health effects. Such action requires the development of methods for monitoring and predicting the possible consequences of any detected pollution. Early warning systems will allow immediate and adequate responses to such incidents. Such systems have already been established on the Rhine, the Hungarian stretch of the Danube, and the river Dee in the United Kingdom. Plans for response should include arrangements for the use of alternative sources of drinking-water if interruption of supplies is likely to persist, and for an effective public information network.

The further development and use of technology for emergency treatment will permit appropriate responses to acute water pollution events. This technology includes processes such as aeration (the removal of volatile substances), solid/liquid phase separation (the removal of solids or solidified substances by precipitation), adsorption (the removal of most organic and some inorganic constituents) or a sequential combination of such methods. In addition, major efforts should be directed towards improving the maintenance and operation of treatment plants and drinking-water distribution networks in order to prevent accidental contamination.

[a] Data supplied in country responses to the Concern for Europe's Tomorrow protocol.

16.3 Accidents Affecting Individuals

Accidents affecting individuals include traffic accidents that do not relate to the transport of dangerous goods (which are considered to have a potential impact on a larger proportion of the public) and accidental poisoning. Domestic and occupational accidents also belong to this category; they are discussed in Chapters 14 and 15, respectively.

16.3.1 Traffic accidents

In the European Region today, transport is an important part of the economy. It significantly affects the lifestyles and everyday activities of the population. One of the adverse outcomes of the intensive movement of people and materials is traffic accidents. They occur on roads, railways and water, and in the air. They may affect health directly, through the death and injury of the people involved, or indirectly through spills and leaks of toxic or other harmful substances to the environment and the contamination of air, water or soil. The latter have similar effects to those of spills and leaks from stationary sources, which were discussed earlier. The important difference is that the risk is distributed along transport routes, and not centred on a well defined point source for which specific potential hazards can be identified and appropriate response measures planned. In the case of transport accidents involving spills, not only may the population at risk be relatively large and scattered over a wide area, but the type of hazard may be less predictable or even difficult to identify after an accident has happened. The probability that such an accident will occur is distributed over a large area.

Mortality statistics can be used to measure the impact on health of traffic accidents. As with other health issues, these data relate solely to the most severe cases and provide only a rough indication of the total burden on the population. Nevertheless, mortality data are the only type of information about the health outcome of accidents that is collected in a similar way in most countries of the Region.

As a result of all road, water and air traffic accidents, over 155 000 people or 21 per 100 000 population died each year in the Region at the end of the 1980s; mortality ranged from 10 to 30 per 100 000. On average, road traffic accidents accounted for nearly 90 % of these deaths, their share of the total ranging from about 60 % in Iceland and 65 % in Norway to over 95 % in several southern European countries.

Death and injury due to accidents

Many countries collect information on the occurrence of road traffic accidents involving injury and on the number of people injured, and data from 25 of these are included in the health for all database of the WHO Regional Office for Europe. The United Nations Economic Commission for Europe is an important source of additional information [19]. Countries register road accidents in different ways. OECD has its International Road Traffic and Accident Database on which the mortality information from member countries is adjusted to fit a uniform definition, which includes death occurring within 30 days after an accident. These adjusted data are used below. Countries not belonging to OECD, however, may register accidents in a different way, which may have implications for the following analysis.

According to the available data, over 1.72 million road traffic accidents involving injury, or 230 per 100 000, occurred annually in the Region at the end of the 1980s. The rate varied among countries, ranging from 72 per 100 000 in Bulgaria to 634 per 100 000 in Belgium. In several countries with relatively high rates, registered accidents declined significantly between 1980 and 1989, particularly in France (from 448 to 289) and the Federal Republic of Germany (from 616 to 438). No improvement was seen in Austria, Belgium or the United Kingdom, where the rates of registered accidents remain higher than in the other countries of the Region.

The number of people injured exceeded the number of accidents by an average of 25 %. The highest ratios, between 1.45 and 1.51, were reported from France, Greece and Ireland. In several countries, however, the reported number of accidents equalled the number of people injured.

Road traffic accidents caused 13.9 deaths per 100 000 in the Region in 1990. Fatal accidents were three times more frequent in males than in females. The total age-adjusted mortality rates ranged from around 9 per 100 000 in Iceland, the Netherlands, Norway, Sweden and the United Kingdom to 23–24 in Hungary and Poland and 27 in Portugal. Road traffic accidents accounted for 1–3 % of all deaths. The age distribution of the victims of road traffic accidents is very different from that of adults dying from natural causes. In the latter group, the mortality rates increase rapidly with age, but the mortality rates for road traffic accidents are similar in all groups of people over 15 years of age. This results in very high proportional mortality due to road traffic accidents: 19% in males aged 15–44 years in the European OECD countries.

Over the last 10 years, this mortality has steadily decreased in western Europe; the most rapid drop was seen in Luxembourg (from 28 to 17 per 100 000) and the Federal Republic of Germany (18 to 11). In eastern Europe and the USSR, rates were stable or declining up till 1986–1987, but rose at the end of the 1980s. The most rapid change occurred in Hungary (from 16 to 24 deaths per 100 000) starting in 1989. The same pattern occurred in Poland and, to a lesser extent, in Bulgaria and Czechoslovakia. A similar pattern of change was observed in all age groups.

The four countries with the highest mortality rates also had the lowest number of motor vehicles registered per 1000 population, and thus the highest numbers of deaths per 100 000 motor vehicles at the end of the 1980s: 82 in Greece, 91 in Poland, 108 in Hungary and 117 in Portugal. The figures for the remaining countries with data ranged from 13 deaths per 100 000 vehicles in Norway to 47 in Ireland.

Accidents in built-up areas accounted for an important proportion of deaths (from 17% in Spain to 56–57% in Poland and Yugoslavia) and injuries (from 48% in Spain to 72% in Cyprus and Poland, and over 60% in many other countries).

The most frequent victims of road accidents were drivers and passengers in personal cars: they comprised 33% of all deaths (from 25% in the Byelorussian SSR and the RSFSR[a] to 61–70% in Luxembourg and Sweden) and 50% of injuries. Pedestrians comprised 30% of those killed (from 10% in the Netherlands to 41% in Poland) and 17% of those injured. In countries where bicycle use is very common, cyclists were relatively frequent victims of accidents. They comprised 22% of people killed and 24% of those injured in the Netherlands and 17% and 23%, respectively, in Denmark. On average, however, cyclists constituted 5% of people killed and 8% of those injured in road accidents.

At the end of the 1980s, the fatality rate from road traffic accidents, that is, the number of deaths per 1000 people injured in such accidents, ranged from 16–23 in Belgium, the Federal Republic of Germany and the United Kingdom to 230 in Bulgaria and the USSR. The analysis of fatality rates indicates that pedestrians suffer the most serious injuries. On average, 110 people died per 1000 reported injured; this figure ranged from 29 in the United Kingdom to 162 in Poland and 282 in Bulgaria.

The fatality rate for motorcyclists was 85 per 1000 injured (ranging from 20–24 in the United Kingdom and the Federal Republic of Germany to 123 in Poland and 213 in Bulgaria). The rate for users of personal cars was 41 per 1000 injured (ranging from 13–16 in the United Kingdom and the Federal Republic of Germany to 221 in Bulgaria). The differences between countries should be interpreted with caution, owing to possible differences in reporting.

Driving while under the influence of alcohol is an obvious risk factor for traffic accidents. It is estimated that, in relation to people with no alcohol in their blood, the risk of an accident doubles for drivers with 0.5 g/litre of alcohol in their blood, and increases almost tenfold in people with a level of 0.8 g/litre [20]. The available data on the frequency of alcohol-related accidents are not reliable, however, owing to differences in registration systems and legal consequences. This is illustrated by the diversity of the reported rates of accidents involving alcohol, which varied from 0.4 per 100 000 population in Italy to 304 per 100 000 in France.

Economic effects

Traffic accidents, and road traffic accidents in particular, lay a significant burden on societies in the Region, including acute and

[a] The Russian Soviet Federal Socialist Republic, now the Russian Federation.

chronic impairment of health, increased workload for the health services, and major economic consequences. The latter are due not only to the material damage caused but also to the cost of treatment immediately after an accident and, in many cases, throughout the remaining life of disabled victims. Economic consequences are intensified by the fact that the frequency of accidents is much higher among young and middle-aged people than others. This restricts the contribution of the most active members of society to social and economic activities. The data available illustrate only a part of this burden. Most countries do not register temporary or permanent disability.

Prevention and mitigation

The underregistration of non-fatal injuries may bias the accident incidence and fatality rates. This is less likely for mortality statistics. The pattern of mortality rates, as well as mortality per vehicle, indicates that improvement in both the safety of road traffic and the quality and effectiveness of care provided to the injured are badly needed in the CCEE, the NIS and several southern countries of the Region. A rapid increase in road traffic, if not associated with appropriate accident prevention measures, results in a sharp increase in the number of casualties, as indicated by the trends observed in several of the CCEE in recent years. In addition, the experience of other countries suggests that the maximum mortality from road accidents occurs 10 years after a rapid increase in traffic volume [21]. This means that a certain time of adjustment or learning was necessary in these countries. Assuming that the same process takes place in the CCEE and NIS, an acceleration of the adjustment and learning process could reduce the severe health effects of increasing traffic. This requires an anticipatory, not a reactive, approach to improvements in road traffic policy. Important improvements include modifications in traffic systems (such as the development and maintenance of a motorway network, including the building of ring roads around cities, towns and villages) and the upgrading of public transport [22].

Analyses of data from selected countries can show the feasibility of improving traffic safety with regulatory or organizational measures. For example, the number of car users killed or seriously injured in the United Kingdom fell 20% after the introduction of the compulsory use of seat belts by drivers and front seat passengers in 1983 [23]. The rate of seat belt use increased from 40% to 95% following the introduction of the law. The introduction of random testing of alcohol consumption by drivers in Australia was also correlated with a sharp decrease in the frequency of fatal accidents [20]. Other measures for preventing or mitigating the effects of road traffic accidents, which may not be uniformly used in all countries of the Region, include regular tests for drivers (with restrictions related to age and disability), the regular testing of old cars, strict enforcement of speed limits, and educational measures. The cost-effectiveness of this type of prevention is evident. Relevant environmental factors include the design and maintenance of roads and motorways, the separation of pedestrians and cyclists from motor vehicles on the road, control of traffic density and road use planning. In countries with a well developed road infrastructure and low mortality rates from traffic accidents, the availability of advanced trauma care was found to be an important predictor of survival by the accident victims [24]. Ideally, measures to prevent accidents and injuries should precede costly medical treatment measures but these are, nevertheless, necessary to save lives if the former fail or are insufficient.

16.3.2 Accidental poisoning

Acute poisoning is a matter of public concern, particularly because chemicals have become an indispensable part of modern life. The use of chemicals in the household, for hobbies and at work has increased, leading to a higher probability of exposure that may result in poisoning. Children are those most vulnerable to accidental poisoning, but adults may also ingest toxic compounds by mistake (as a consequence of mislabelling, for example) or be exposed to volatile solvents as a result of using large amounts of certain sprays, such as those for leather impregnation, in unventilated rooms.

Health effects

The frequency of non-fatal acute poisoning is difficult to estimate, because of the lack of adequate reporting systems. Deaths due to accidental poisoning, by contrast, are usually subject to reporting, and can therefore be more readily assessed. Such deaths have shown a slight tendency to increase in recent years in most parts of the world, but in general suicidal intoxication predominates. Accidental poisoning in domestic and occupational environments probably comprises some 25 % of the total of cases of acute poisoning.

In the European Region, data were available on mortality due to accidental poisoning in 25 countries (Table 16.2). In males, mortality due to acute accidental intoxication was mostly below 5 per 100 000 population, although higher rates were observed in Bulgaria, Finland, Iceland, Poland and the USSR. In females, deaths due to accidental poisoning ranged from 0.1 per 100 000 in the Federal Republic of Germany, Israel and the Netherlands to 3.6 in Finland; the exception was the USSR, where the rate reached 6.5 per 100 000. These numbers have to be treated with caution, as countries differ in their definitions and reporting of accidental poisoning. In addition, it is difficult to estimate the total number of cases of accidental

Table 16.2: Average mortality rates due to accidental poisoning in 25 countries of the WHO European Region

Country	Years	Deaths per 100 000 population	
		Males	Females
Austria	1989/1990	1.3	0.7
Bulgaria	1989/1990	5.5	1.2
Czechoslovakia	1989/1990	4.65	2.3
Denmark	1989/1990	4.3	1.9
Finland	1988/1989	19.4	3.6
France	1988/1989	0.8	0.6
German Democratic Republic	1989[a]	4.4	3.7
Federal Republic of Germany	1989[a]	0.3	0.1
Greece	1988/1989	0.9	0.5
Hungary	1989/1990	3.9	1.2
Iceland	1989/1990	6.3	2.0
Ireland	1988/1989	0.8	0.5
Israel	1987/1988	0.3	0.1
Italy	1988[a]	0.9	0.6
Luxembourg	1989[a]	3.8	1.0
Netherlands	1988/1989	0.5	0.1
Norway	1988/1989	3.4	1.1
Poland	1989/1990	11.1	2.7
Portugal	1989/1990	0.7	0.2
Spain	1986/1987	1.5	0.6
Sweden	1988[a]	2.7	0.7
Switzerland	1989/1990	3.5	1.0
United Kingdom	1989/1990	1.6	0.9
USSR	1989/1990	22.8	6.5
Yugoslavia	1988/1989	1.4	0.5

[a] Data for one year only.

Source: World health statistics annual, 1991 and 1992.

intoxication on the basis of mortality rates, because of differences among countries in their capability to respond to poisoning.

Prevention and mitigation

Accidental poisoning can be prevented. The most important primary measure is the provision of adequate information and education to enable people to avoid hazardous situations. Other primary measures include the identification and assessment of high-risk circumstances and susceptible population groups, legislation to allow the marketing of only those compounds whose basic toxicological properties are known, correct labelling of toxic materials, the use of child-resistant containers for the storage of hazardous materials at home, the use of protective equipment and measures in the workplace and of adequate inspection procedures, and activities to increase awareness by both the workforce and the general public [14]. Secondary measures include preparedness for and provision of appropriate first-aid treatment (such as decontamination and antidote therapy) and hospital treatment of poisoning victims [14].

To minimize risks from accidental intoxication, programmes to prevent and respond to poisoning by chemicals need to be developed and put in place. In this respect, poison control centres play an essential role, mainly by providing antidote therapy 24 hours a day and specific information and advice on any chemical involved in a poisoning incident. The centres may also work in the fields of toxicovigilance, antidote evaluation and training, and in planning and providing necessary information for response to major chemical accidents [14,25].

16.4 Trends

Both man-made and natural disasters will continue to occur, despite the possible existence of foolproof systems to control technological hazards. While technological improvements to safety systems may be expected to continue, along with the necessary professional training, protection of the environment and health will continue to require preparedness for and response to emergencies. A state of preparedness for dealing with technological emergencies strongly reinforces preparedness for natural disasters and vice versa. Thus, the activities related to the present International Decade for Natural Disaster Reduction can be expected to enhance preparedness for responding to technological disasters, particularly international cooperation to prevent and control their transboundary consequences.

16.5 Conclusions

In theory, both technological accidents with large-scale environmental effects on public health and accidents affecting individuals can be prevented; in practice, they continue to cause enormous health and economic costs to society. Environmental factors may be important in the causation of some accidents in both categories, and need to be taken into account in developing improved strategies for accident prevention.

Risk assessment and measures to reduce the probability of technological accidents should be inherent in the design, siting, construction and operating procedures for any hazardous installation [15] as well as the transport, storage and use of hazardous materials. Risk assessment methodology needs further development to permit the adoption of appropriate management measures.

Measures to prevent technological accidents should include legislation, technological development, maintenance and control procedures, and training.

Contingency planning is a major element of accident preparedness. It should deal with all aspects of emergency response, including:

- the rapid provision of information needed for accident assessment;

- plans for decontamination, food and water controls, evacuation and rehabilitation; and
- communication with the mass media and the public.

Both professionals involved with and the general population living near hazardous installations need to be informed about the potential hazards and trained to deal with emergencies.

The establishment of early warning systems is of particular importance for mitigating the transboundary effects of major accidents, and coordinated action is required for the adoption of effective controls.

The situation is different with traffic accidents in general, and road traffic accidents in particular. They are a continuing reality in all countries of the European Region, killing over 350 people and injuring over 6000 each day. To some extent, accidents are related to such a lack of adequate training of drivers and other road users, as well as to human error or negligence (including the combination of alcohol drinking with driving). Proper education and information of the public are needed to improve this situation. Nevertheless, a crucial factor in determining the frequency and severity of accidents is the state of development of traffic systems and infrastructures: the quality of roads, the organization of traffic, the technical condition of vehicles, the adequacy of legislation and enforcement measures, and the availability of public transport. All these elements can be considered environmental. Secondary prevention – the improvement of the services available to care for accident victims – cannot replace the improvement of the environment to prevent or reduce the severity of road traffic accidents.

The prevention of accidental poisoning requires the collection and dissemination of adequate toxicological information, the adoption of measures to reduce the risk of exposure to chemicals, and the provision of appropriate means of protecting vulnerable population groups. Preparedness for and response to chemical intoxication require the availability of information, trained personnel and adequate therapeutic measures. Poison control programmes, with poison control centres as an essential and integral part, need to be put in place.

References

[1] *Hazard identification and evaluation in a local community*. Paris, United Nations Environment Programme, 1992 (UNEP Technical Report No. 12).

[2] Industrial accidents. *In*: *Environmental indicators*. Paris, Organisation for Economic Co-operation and Development, 1991, pp. 48–49.

[3] *Health aspects of chemical accidents: guidance on chemical accidents awareness, preparedness and response for health care professionals and emergency responses*. Paris, Organisation for Economic Co-operation and Development, 1993.

[4] *Manual on public health action in radiological emergencies*. Copenhagen, WHO Regional Office for Europe, 1995 (document EUR/ICP/CEH 119).

[5] *Prevention of chemical accidents. The health dimension*. New York, Hemisphere, 1989.

[6] Baxter, P.J. Review of major chemical incidents and their medical management. *In*: Murray, V., ed. *Major chemical disasters – medical aspects of management*. London, Royal Society of Medicine Services, 1990, pp. 7–20.

[7] Bertazzi, P.A. et al. Ten-year mortality study in the population involved in the Seveso incident in 1976. *American journal of epidemiology*, **129**: 1187–1200 (1989).

[8] *Environmental data compendium 1993*. Paris, Organisation for Economic Co-operation and Development, 1993, pp. 168–172.

[9] Homberger, E. et al. The Seveso accident: its nature, extent and consequences. *Annals of occupational hygiene*, **22**: 327–370 (1979).

[10] *Polychlorinated dibenzo-para-dioxins and dibenzofurans*. Geneva, World Health Organization, 1989 (Environmental Health Criteria No. 88).

[11] Fingerhut, M.A. et al. Cancer mortality in workers exposed to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. *New England journal of medicine*, **324**: 212–218 (1991).

[12] Council Directive of 24 June 1982 on the major-accident hazards of certain industrial activities (82/501/EEC). *Official journal of the European Communities*, **L230**: 1–7 (1982).

[13] *World Conference on Chemical Accidents*. Edinburgh, CEP Consultants, 1987.

[14] *Prevention of acute chemical poisonings: high-risk circumstances*. Copenhagen, WHO Regional Office for Europe, 1987 (Environmental Health Series No. 28).

[15] *Guiding principles for chemical accident prevention: preparedness and response*. Paris, Organisation for Economic Co-operation and Development, 1992.

[16] *Rehabilitation following chemical accidents: a guide for public officials*. Copenhagen, WHO Regional Office for Europe, 1989 (Environmental Health Series No. 33).

[17] *Toxic oil syndrome. Current knowledge and future perspectives*. Copenhagen, WHO Regional Office for Europe, 1992 (WHO Regional Publications, European Series, No. 42).

[18] DEPARTMENT OF HEALTH. *Water pollution at Lowermoor, North Cornwall. Second report of the Lowermoor Incident Health Advisory Group*. London, H.M. Stationery Office, 1991.

[19] UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE. *Statistics of road traffic accidents in Europe.* New York, United Nations, 1993.

[20] CRONDEAU, C. ET AL. Die Verkehrssicherheit in der Europäischen Gemeinschaft. *Zeitschrift für Verkehrssicherheit,* **38**: 66–93 (1992).

[21] OPPE, S. The development of traffic and traffic safety in six developed countries. *Accident analysis and prevention*, **23**: 401–412 (1991).

[22] OPPE, S. & KOONSTRA, M.J. *Traffic and traffic safety in central and eastern European countries. 17th International Study Week on Traffic Engineering and Safety, Warsaw, 7–12 September 1992.*

[23] *Accident fact sheet No. 4.* London, Department of Transport, 1991.

[24] VAN BECK, E.F. ET AL. Determinants of traffic accident mortality in the Netherlands: a geographical analysis. *International journal of epidemiology*, **20**: 698–706 (1991).

[25] *Public health response to acute poisonings – poison control programmes.* Copenhagen, WHO Regional Office for Europe, 1986 (Environmental Health Series No. 11).

Chapter 17
Environmental Health in the CCEE and NIS

17.1 Introduction

Of the 50 Member States of the WHO European Region, 22 did not have a national focal point participating in the development of the Concern for Europe's Tomorrow project when the environmental health protocols were distributed. Of these 22 countries, the following 20 have now provided information: Armenia, Azerbaijan, Belarus, Croatia, the Czech Republic, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, the Republic of Moldova, the Russian Federation, Slovakia, Slovenia, Tajikistan, The Former Yugoslav Republic of Macedonia, Turkmenistan, Ukraine and Uzbekistan.

The information from these 20 countries was received too late for integration into the body of this report, although data on some issues in the countries (such as the environmental hazards to health resulting from the Chernobyl accident) were available from other sources and could be included in the appropriate chapters. This separate chapter summarizes the information provided by the 20 new Member States. It is based on the reports that they made to WHO, and the resulting text was submitted to them. The references therefore reflect only published sources and WHO documents.

17.1.1 Data limitations

Using the data collected involved dealing with problems similar to those described elsewhere in this report. A common problem is the lack of comprehensive and comparable environmental monitoring data. Here, there are additional difficulties. It was not possible in the time available to obtain information comparable to that from the original Concern for Europe's Tomorrow protocol, and none of these recent data has been verified. Furthermore, the sheer size of the Russian Federation, for instance, or the inaccessibility of parts of Tajikistan create obvious problems for the acquisition of adequate data, in both quantitative and qualitative terms. In addition, much of the data was presented in a way that limits comparison on a regional basis: little exposure information was expressed in $\mu g/m^3$ or litres, but data on emissions or discharges and situations where maximum permissible concentrations are exceeded are provided, sometimes without an indication of the degree by which they were exceeded. The maximum permissible concentrations tend to be more restrictive than those specified by European Union directives or recommended in WHO guidelines. While systematic comparisons may be difficult, information provided clearly indicates the deleterious impact of human activities on the environment and the likely adverse effects on health in many of these 20 countries.

Lack of exposure–effect data is another common problem throughout the Region. Many associations between environmental pollution and mortality or morbidity are described, sometimes with recognition of the possible importance of other factors, such as lifestyle and nutritional and socioeconomic status, as determinants of health. Sometimes a causal relationship is inferred between "pollution" and health detriment that lacks both specificity and plausibility. Obviously, lack of firm evidence of a causal relationship does not mean that it does not exist, and action to mitigate pollution at levels likely to affect health should not depend on its demonstration. Nevertheless, more work is needed to show that specific exposures to particular agents are producing particular adverse effects on health.

In addition to the information provided by the 20 countries, use has been made of the "highlights on health" issued by the WHO Regional Office for Europe, the national integrated programmes on environment and health of the WHO European Centre for Environment and Health at Bilthoven, the Environmental Action Programme for Central and Eastern Europe of the United Nations Economic Commission for Europe, and other national and international sources.

17.2 State of the Environment and Health

Tables 17.1, 17.2 and 17.3 summarize information on a country-by-country basis. Table 17.1 covers basic information on country size, population, life expectancy and gross national product (GNP) and purchasing power parity (PPP) per head, using data from the World Bank [1,2], the United Nations Development Programme [3] and country reports. Vast differences clearly exist among countries. GNP tends to be significantly lower in the CCEE and NIS than in other countries of the Region (see Chapter 1, Table 1.2) and can be correlated in general terms with lower life expectancy. Economic stability, as reflected in GNP and PPP, is of primary importance for tackling environmental health problems.

Table 17.2 summarizes prevailing environmental pollution conditions and the main economic activities in the 20 countries. It is most important to note that the categorization of the severity of conditions cannot be used as a basis for comparisons between countries, nor as an indication of where priorities for any international action might lie. The data provided are not directly comparable. Furthermore, the categorization does not take into account the number of people exposed or the severity of the effect on health. Rather, these categories are an attempt to reflect the relative importance attached by individual countries to different environmental problems. The immediate effects of transition have been the closure of many uneconomic industries and therefore a decrease in levels of environmental pollution. Thus, the information provided by individual countries and presented below may sometimes no longer be correct as to details. Despite such temporary "improvements" effected by economic recession, however, the underlying problems remain to be solved.

Table 17.3 lists the resulting national assessments of priority environmental health issues, and notes any special situations that exist.

The rest of the chapter discusses environmental health in a manner similar to that used in earlier chapters for the rest of the Region.

17.2.1 Air pollution

The main cause of air pollution in the CCEE and NIS (see Tables 17.2 and 17.3) is the

Table 17.1: Basic data on the CCEE and NIS

Country	Area (thousands of km^2)	Population in millions (1992)	Population distribution (%)		Life expectancy at birth (years)	GNP per head (US $) (1991)	PPP per head (US $) (1991)
			Rural	Urban			
Armenia	30	3.5	32	68	72	2150	4610
Azerbaijan	87	7.1	46	54	71	1670	3670
Belarus	208	10.3	32	68	71	3110	6850
Croatia	56.5	4.8	40	60	67 (M) – 75.5 (F)	2750	
Czech Republic	78.8	10.4	–	–	72.1	2440	–
Estonia	45	1.6	28	72	71.2	3830	8090
Georgia	70	5.5	44	56	69 (M) – 76 (F)	1640	3670
Kazakhstan	2717	17.0	43	57	69	2470	4490
Kyrgyzstan	199	4.5	62	38	68	1550	3280
Latvia	65	2.6	30	70	71	3410	7540
Lithuania	65	3.8	32	68	72.6	2710	5410
Republic of Moldova	34	4.4	53	47	65 (M) – 72 (F)	2170	3500
Russian Federation	17 075	148.9	26	74	70	3220	6930
Slovakia	49	5.3	43	57	68 (M) – 76 (F)	1920	–
Slovenia	20	1.9	49	51	69 (M) – 77 (F)	6330	
Tajikistan	143	5.5	68	32	70	1050	2180
The Former Yugoslav Republic of Macedonia	26	2.0	42	58	73[a]	–	–
Turkmenistan	488	3.8	55	45	63 (M) – 70 (F)	1700	3540
Ukraine	604	52.1	33	67	66 (M) – 75 (F)	2340	5180
Uzbekistan	447	21.3	59	41	69	1350	2790

[a] Taken from data from the former Yugoslavia.

Sources: World Bank *(1,2);* United Nations Development Programme *(3);* country reports to the WHO Regional Office for Europe.

continuing use of obsolete and inefficient coal-fired power and heavy industrial plants that cannot readily be fitted with air and waste treatment equipment. Where emission control technology has been installed it was primarily for reducing emissions of large particles, continuing to allow the release of gaseous compounds.

Current figures reveal that, although a sharp decline in industrial production has followed the economic difficulties of transition, there has been no matching decrease in air pollution levels. For example, in 1992 industrial production in the Russian Federation declined by about 18 % from that of 1991; emissions to the atmosphere from stationary sources diminished by 11 %, while emissions from vehicles increased by 27 %. Levels of air pollution are high in many cities and regions of the CCEE and NIS.

In the northern Bohemia region of the Czech Republic, where low-grade coal is used for power generation and metal smelters predominate in industry, maximum concentrations of SO_2 (1-hour measurements) may be as high as 2500 μg/m^3 during inversion periods, even though 150 μg/m^3 is the maximum permissible level. High concentrations of heavy metals are also present. A correlation has been found between air pollution and mortality and morbidity rates, especially with regard to respiratory diseases and allergies in children. Infant mortality has particularly been correlated with levels of suspended particulate matter.

In Skopje in The Former Yugoslav Republic of Macedonia there were two episodes between 1990 and 1993 of classical winter smog due to pollution with sulfur dioxide (SO_2) and black smoke, which resulted in increased mortality in elderly people with cardiovascular and respiratory diseases.

North-eastern Estonia is a unique region in which oil shale is extracted, processed and burned in power plants, and thus experiences high levels of SO_2 and formaldehyde.

Table 17.2 a: Principal pollution conditions in the CCEE and NIS

Country	Urban air pollution		Drinking-water pollution: Chemical (rural)		Drinking-water pollution: Microbiological (mainly rural)		Soil and/or water pollution		Main economic activities
	Mainly from stationary sources	Mainly from traffic	Pollution of sources by agricultural chemicals	Degradation of sources due to poor irrigation practices	Pollution of sources due to lack of sewage system and/or inadequate wastewater treatment	Lack or poor condition of drinking-water supply systems	Actual or potential contamination due to inadequate waste disposal	Contamination due to high levels of industrial pollution	
Armenia	–	Increasing	Serious	Serious	Serious	Extreme	–	Serious	Heavy industry (non- ferrous metals), mining, agriculture
Azerbaijan	Serious	Increasing	Very serious	Very serious	Extreme	Serious	Serious	Very serious	Oil/petrochemicals, heavy industry (metallurgy), agriculture
Belarus	Very serious	Serious	Serious	–	Very serious	Serious	Very serious, radionuclides	Serious	Heavy industry (power plants, chemicals), agriculture
Croatia	–	Serious	–	–	–	–	–	Serious	Agriculture, tourism
Czech Republic	Extreme	Serious	–	–	Serious	–	Very serious	Serious	Heavy industry, agriculture
Estonia	Very serious	–	–	–	–	–	Very serious, radionuclides	Serious	Mining (oil shale), chemical industry
Georgia	Very serious (4 cities)	Serious	Very serious	–	Very serious	Very serious	Extreme	–	Agriculture, heavy industry (metallurgy, fertilizers)
Kazakhstan	Very serious	Increasing	Very serious	Extreme	Very serious	Serious	Extreme, radionuclides	Serious	Mining (minerals, ores), heavy industry (coal power, non-ferrous smelters), agriculture

Table 17.2 b: Principal pollution conditions in the CCEE and NIS

Country	Urban air pollution		Drinking-water pollution: Chemical (rural)		Drinking-water pollution: Microbiological (mainly rural)		Soil and/or water pollution		Main economic activities
	Mainly from stationary sources	Mainly from traffic	Pollution of sources by agricultural chemicals	Degradation of sources due to poor irrigation practices	Pollution of sources due to lack of sewage system and/or inadequate wastewater treatment	Lack or poor condition of drinking-water supply systems	Actual or potential contamination due to inadequate waste disposal	Contamination due to high levels of industrial pollution	
Kyrgyzstan	–	Serious	Very serious	–	Very serious	Very serious	–	–	Heavy industry, agriculture
Latvia	Serious (very localized)	–	–	–	Serious	Serious	Extreme	–	Heavy industry, light industry, chemical industry
Lithuania	Serious (localized)	Serious	–	–	Very serious	Serious	Very serious, radionuclides	–	Agriculture, industry
Republic of Moldova	–	–	Extreme	–	Very serious	Very serious	–	–	Agriculture
Russian Federation	Extreme	Very serious	Very serious	Extreme	Extreme	Extreme	Extreme, radionuclides	Extreme	Heavy industry, chemical industry, agriculture
Slovakia	Very serious	–	Serious	–	Serious	Serious	–	–	Heavy industry, agriculture
Slovenia	Very serious	Serious	Serious	–	–	–	–	Serious	Heavy industry, fossil fuel energy production, agrochemical industry
Tajikistan	Very serious	–	–	Very serious	Extreme	Very serious	–	–	Industry (aluminium), agriculture (7%)
The Former Yugoslav Republic of Macedonia	–	Serious	Serious	–	–	Very serious	–	–	Industry, agriculture
Turkmenistan	Serious	–	Serious	Extreme	Very serious	Very serious	Very serious	–	Oil, gas, agriculture

Table 17.2 c: Principal pollution conditions in the CCEE and NIS

Country	Urban air pollution		Drinking-water pollution: Chemical (rural)		Drinking-water pollution: Microbiological (mainly rural)		Soil and/or water pollution		Main economic activities
	Mainly from stationary sources	Mainly from traffic	Pollution of sources by agricultural chemicals	Degradation of sources due to poor irrigation practices	Pollution of sources due to lack of sewage system and/or inadequate wastewater treatment	Lack or poor condition of drinking-water supply systems	Actual or potential contamination due to inadequate waste disposal	Contamination due to high levels of industrial pollution	
Ukraine	Extreme	Serious	Very serious	Extreme	Serious	Serious	Very serious, radionuclides	Extreme	Heavy industry (metallurgy, chemical and petrochemical), mining (coal), agriculture
Uzbekistan	Serious	–	Extreme	Extreme	Very serious	Very serious	Very serious	Serious	Heavy industry (iron and aluminium smelters), agriculture

Note: Serious and extreme problems exist in localized areas within countries of greatly differing size and population density. The classifications reflect the relative importance attached to different pollution problems by the individual countries.

Sources: Mnatsakian, R.A. (4); data reported to or gathered by the WHO Regional Office for Europe.

Morbidity in children from respiratory diseases, allergies and anaemia is higher in this region than in other parts of the country. Correlations with health detriment in adults, especially pregnant women, have also been suggested [5].

In Latvia, especially at centres of the chemical industry in Ventspils and Olaine, pollutants such as methanol, butanediol, tetrachloroethane, nitracetic acid, ammonia (NH_3), formaldehyde, phenol and benzo[*a*]pyrene are released and not regularly monitored. An increase in respiratory disease and allergies, particularly in children, has been reported in these polluted areas. So have increases in gastric and gynaecological disorders, and suppression of the immune system [6].

At the major industrial centres of Novopolotsk, Minsk, Mogilev and Mozyr in Belarus, chemical plants pollute the air with carbon disulfide, NH_3, nitrogen dioxide (NO_2), hydrogen sulfide, formaldehyde, phenols, dust, SO_2, carbon monoxide (CO), hydrocarbons and benzo[*a*]pyrene. Studies in the region have shown high levels of respiratory diseases (including asthma), blood diseases and eye conditions, and reports suggest that diseases of the digestive system are higher in these polluted areas than in the rest of the country.

In the industrial centres of eastern Ukraine (such as the Donbas region and the areas of Dnepropetrovsk, Krivoy and Rog) high levels of air pollution with benzo[*a*]pyrene, formaldehyde, phenols, NH_3, hydrogen fluoride (HF), chlorine, CO, SO_2, lead and mercury are caused by a combination of emissions from coal and ore mining, metallurgical and chemical plants, and power stations. As a result of the recent decline in heavy industry pollution is also declining, although the consequences of long-term exposure to high levels of air pollution are still reported in the population. Blood diseases, allergies (including dermatitis), respiratory disease (including asthma), cardiovascular diseases and cancer are between 20% and 60% more frequent in such polluted cities than in other parts of Ukraine. Congenital malformations and impairment of development in children are also reported to be higher.

At Baku and Sumgait in Azerbaijan, where chemical, petrochemical and oil refinery industries are concentrated, the air is polluted with soot, formaldehyde, NO_2, benzo[*a*]pyrene, sulfur, HF and dust. Significantly higher levels of cancer, ischaemic heart disease and diseases of the respiratory, circulatory and digestive systems and the skin have been reported in Baku than in other areas. The incidence of cancer increased from 85 per 100 000 population in 1985 to 127 per 100 000 in 1989. During the last few years respiratory diseases and eye and ear diseases among children have also increased in Sumgait.

In the eastern region of Kazakhstan, where the non-ferrous metal industry and mining of coal and ores are the major economic activities, levels of air pollution are high. The air is polluted with SO_2, NO_2, phenols, formaldehyde, benzo[*a*]pyrene, lead, beryllium and other heavy metals. During five years of observation (1986–1990) morbidity increased by 58% in the whole population of the region and by 21% in children. The increased morbidity is reflected in respiratory diseases (including asthma), mental impairment and iron deficiency anaemia in children, and cardiovascular and cerebrovascular diseases, endocrine disorders, asthma, gastrointestinal disease and cancer in adults. There are 29 non-ferrous metal smelters in Kazakhstan, and these are likely to give rise to similar air pollution problems.

In the Russian Federation, poor air quality is especially evident in the Archangelsk region in the north, in the Moscow region in the centre, in all major industrial centres of the Volga and Ural regions and in the major cities of Siberia, where the high levels of air pollution are aggravated by winter anticyclones that prevent dispersion. In 1992, 171 cities recorded levels of one of more air pollutants above the maximum permissible average annual concentrations. In 84 of those cities, with a total population of 50 million, air pollution levels exceeded standards by 10 times or more. It is estimated that only 15% of the urban population of the country breathes air that is considered not to pose a hazard to health. Air pollution is estimated to have caused a 20% increase in morbidity, including lung cancer attributed to benzo[*a*]pyrene, and respiratory and skin diseases (including allergies) in children. In addition, infant mortality has increased owing to respiratory disease and infections.

In centres of ferrous metallurgy, such as Magnitogorsk, Novokuznetsk, Nizhniy Tagil and Lipetsk, the prevalent diseases are those of the circulatory and digestive systems, eczemas and eye conditions; the incidence of these conditions is, on average, 20%–40% higher than in relatively clean cities. Morbidity levels have been correlated with pollutants specific to metallurgy. There are about 70 cities with such metallurgy plants in the Russian Federation.

In cities with petrochemical industries, such as Sterlitamak, Yaroslavl, Ufa and Chaikovsky, the incidence of asthma in children is 2–3 times higher and that of allergic diseases (mainly dermatitis) is 1.5–2 times higher than in regions free of air pollution.

In cities with biochemical plants, such as Kirishi, Svetloyarsk, Angarsk, Shebekino and Manturovo, where factories use oil paraffins as a source of artificial albumen production, the general morbidity of the population has increased by a factor of 1.5–3 times and allergic diseases by a factor of up to 12 times.

The scale of air pollution in the NIS, especially in the Russian Federation and Ukraine, is much higher than in other eastern countries of the Region. For example, the largest single polluter in the Russian Federation is an ore enrichment and rare metals complex in Norilsk (eastern Siberia), which emits 2.24 million tonnes of SO_2 per year. This is nearly 20% of the total for the country; it is more than the SO_2 emissions in Poland, more than in the Czech Republic, and nearly equal to the total for the former Czechoslovakia. In addition to such major pollutants as SO_2, dust, CO, nitrogen oxides and hydrocarbons (emissions of which are measured in millions of tonnes per annum) emissions of lead, fluorine compounds and chlorine amount to thousands of tonnes annually, and those of benzo[*a*]pyrene and mercury tens of tonnes. In 1992, Russian industrial discharges of heavy metals were about two orders of magnitude greater than those for the whole of the European Community, even though the Russian Federation has significantly less industry.

About 3 million people, including about 0.75 million children, are thought to live in extremely polluted areas of Russian cities, a further 7 million in seriously polluted areas, and 15 – 17 million in relatively polluted areas.

Road transport

Almost all of the 20 countries report that road transport makes an increasing contribution to urban air pollution, including that from lead. Economic recession appears to have slowed this trend too, but sometimes to a lesser extent than industrial emissions. In countries such as Belarus, Georgia, Lithuania, Tajikistan and Uzbekistan, road traffic is the major source of urban air pollution.

Associations between air pollution and disease

Interpreting the associations reported between various health problems and air pollutants is difficult. The available data did not include information on, for example, smoking habits, alcohol intake or nutritional or economic status, each of which may be an important determinant of health.

Infant mortality may be subject to fewer confounding factors than other indicators. In the Russian Federation, the usual pattern of higher infant mortality rates in rural compared to urban areas is reversed for polluted industrial areas.

Increases in respiratory diseases, including asthma, and allergies in children may well be causally related to exposure to urban air pollutants. Even in this young group, however, interpretation of the association is not straightforward. First, some countries appear to show a general increase in asthma that is unrelated to ambient pollution, although the increase may be more pronounced in polluted areas. Second, indoor air pollution may also be relevant to respiratory illness in children. Few data are available in the Region as a whole on indoor exposure to environmental tobacco smoke, NO_2 or biological allergens, for example.

The incidence of cancer, especially lung cancer, is higher in polluted areas, particularly those with metal, oil and petrochemical industries. Assessing the role of environmental pollutants in causation remains difficult, however, not only in the absence of information on smoking habits in different populations but also when the increase is confined to males.

These qualifications point to the need for further investigation, but do not justify delay in mitigation. It is unlikely that the reported levels of ambient air pollution have no adverse effects on health.

Similar questions are relevant to correlations observed between health indicators and the environmental pollutants discussed below.

17.2.2 Water supply and quality

The lack or inadequacy of water treatment facilities has resulted in the discharge of sewage and liquid industrial and agricultural waste directly to surface waters and may also contaminate groundwater sources. This situation is combined with shortcomings in the coverage of piped supplies and deficiencies in distribution systems, and with the use of surface water or wells in rural areas. As a result of these factors large proportions of the population, particularly in the NIS, consume contaminated and unwholesome water.

Waterborne infectious disease

The lack of sewage treatment systems, and the contamination of treated water supplies in defective distribution systems, are the major causes of the reported increases in the incidence of waterborne infectious diseases in the CCEE and NIS.

The incidence of typhoid, cholera and hepatitis A and the growing recorded incidence of gastrointestinal parasitic diseases, particularly in the central Asian republics and the Russian Federation, give cause for extreme concern and indicate the need for systems of basic sanitation to be devised and installed as a first priority in many countries (Table 17.3).

In Armenia, for example, 40 % of sewage is not treated and the water distribution systems need repair, which is prevented by the current economic blockade. Supplies cannot be maintained for 24 hours a day, and at least 20 % of the available water is lost during distribution. In 1992 there were five outbreaks of waterborne infectious disease, with a total of 1253 cases. Nine outbreaks were recorded, with 1347 cases, in the first 10 months of 1993.

In Azerbaijan, sewage treatment is quite inadequate; even in Baku 80 % is untreated. In 1991, over 100 cases of waterborne typhoid were reported; salmonellosis and helminthic infections in 2–4 % of the population were reported. There have been eight outbreaks of waterborne disease in the last ten years.

In Georgia, hepatitis A is the main waterborne disease problem. Morbidity is always high, and rises further in summer. Earthquakes and the aftermath of war have left water treatment and distribution systems in poor condition. Many towns have no facilities for sewage treatment, and water chlorination is now possible only in Tbilisi.

In Kazakhstan, only about 10 % of the rural population have a sewerage system, and over 40 % use water from surface waters or local wells. There is considerable morbidity from hepatitis A (470 cases per 100 000 population) and gastrointestinal infections (411 per 100 000), including dysentery and typhoid. Parasitic infections are also common.

In Kyrgyzstan, basic sanitation is a prior-

Table 17.3 a: Main environmental health issues and priority needs in the CCEE and NIS

Country	Main environmental health problems	Reported health effects	Priority needs	Special situations/other environmental health problems
Armenia	Lack of food supply Drinking-water quality Inadequate sewage treatment	Life expectancy decreased by 2 years, 1980–1991 Sharp increase in waterborne infectious diseases	Food and water quality management International aid to assist refugees Improved water distribution and sewage treatment systems	Earthquake in 1988 (25 000 dead, 0.5 million homeless, damage to nuclear power plant) Refugees (0.4 million) Economic blockade since 1989 (re-opening of nuclear power plant) Lake Sevan
Azerbaijan	Air pollution Water pollution Pollution of Caspian Sea	Increased incidence of cancer Outbreaks of waterborne infectious diseases	Reconstruction strategies for after civil war Water quality management Industrial waste management strategy Measures to reduce air pollution Caspian Sea pollution: – need to identify and measure impacts of specific pollutants – reduce pollutants in concert with all countries involved	Civil war Refugees Salinization of irrigated agricultural land
Belarus	Radioactive contamination Drinking-water quality (NO_3) Air pollution	Increased thyroid cancer in children Increased morbidity and psychological stress Increase in respiratory disease, including asthma	Medical assistance Pollution control strategies Water quality management	Chernobyl contamination
Croatia	Water coverage and quality Sanitation Food supply	Conditions of refugees and homeless associated with increase in diarrhoeal diseases and respiratory infections	Rebuilding of infrastructure (water, sanitation) Restoration of agriculture	War Refugees (about 0.25 million displaced persons and over 0.25 million war refugees costing 4% of GNP)
Czech Republic	Air pollution Toxic waste Soil contamination Water quality	Increased respiratory disease and allergy Increased mortality including infant mortality	Pollution control Water quality management Industrial waste management	Radon in dwellings Urban noise from transport

Table 17.3b: Main environmental health issues and priority needs in the CCEE and NIS

Country	Main environmental health problems	Reported health effects	Priority needs	Special situations/other environmental health problems
Estonia	Air pollution Inadequate sewage treatment Water quality Toxic waste (oil shale, uranium)	Respiratory disease in children	Air pollution control Waste management	Radon in dwellings Contamination from former military sites
Georgia	Air pollution Water quality	Increased morbidity (including allergies) in children Hepatitis A Waterborne gastrointestinal infections	Provision of humanitarian relief Reconstruction of water treatment and distribution systems after war	Civil wars Economic blockade Earthquakes
Kazakhstan	Radiation Toxic waste Air pollution Water quality Inadequate sewage treatment	Increased cancer incidence in Semipalatinsk Increased respiratory disease (including asthma) in children and impaired mental development High morbidity from hepatitis A and gastrointestinal and parasitic infections	Industrial waste management Air pollution control Basic sanitation Provision of safe water supply Restoration of Aral Sea area	Contamination from nuclear testing sites in Semipalatinsk Aral Sea pollution (ecological disaster area with profound impacts on health) Meteorological conditions in south-east (low wind velocity and inversion)
Kyrgyzstan	Air pollution Inadequate sewage treatment Water distribution systems Water and food quality Waste disposal	Poor health of children Waterborne viral infections, particularly hepatitis A	Basic sanitation (simple disinfection for enteroviruses) Repair of water supply systems Waste disposal sites	Mountainous and isolated areas Meteorological conditions (inversion)
Latvia	Air pollution Water quality Inadequate sewage treatment and water distribution systems Municipal and toxic waste disposal	Increased respiratory diseases and allergies especially in children Waterborne infectious diseases, including hepatitis A	Improved water treatment and supply Waste management Air pollution control	Heavy pollution in Riga Bay resort area Urban noise from industry
Lithuania	Air pollution (including heavy metals) Inadequate sewage treatment and water supply Waste disposal	Increased respiratory and eye disease in children, plus hair loss and neurotoxicity Waterborne infectious diseases, including hepatitis A	Improved water treatment and supply Waste management strategy, including radioactive waste	Ignalina nuclear power plant (accidents, waste) Transport (high level of polluting emissions) Extreme pollution of water reservoirs

Table 17.3 c: Main environmental health issues and priority needs in the CCEE and NIS

Country	Main environmental health problems	Reported health effects	Priority needs	Special situations/other environmental health problems
Republic of Moldova	Land contamination (pesticides) Water contamination from lack of chlorine for water treatment and lack of piped supply to rural areas	Hepatitis A and salmonellosis Mortality in children 3 times higher in high-nitrate areas Pesticide depression of immune system (?)	Improved rural water supply Urgent need for chlorine supplies Land use and agricultural management strategy	Aftermath of 1992 civil war Lack of basic medicines Extreme pollution of soil and surface waters by pesticides
Russian Federation	Severely impaired air quality Drinking-water quality (defective distribution system) Radioactive pollution (Ural region) Waste disposal Impacts on aquifers and agriculture	Increase in respiratory disease and allergy in children; increase in lung cancer related to (benzo[*a*]pyrene ?) High rates of waterborne infections and parasitic infestations Increase in leukaemia and other cancers	Measures to mitigate pollution Regionalization policy to address regional environmental health issues Development of more comprehensive and reliable environmental health information systems	(Territory too vast to summarize simply; some details provided in main text)
Slovakia	Water quality (rural) Air pollution (particularly from transport)	Outbreaks of waterborne infectious disease	Improvements in water supply and distribution Integrated environmental health management strategy	50% of electricity from nuclear power Urban noise from transport
Slovenia	Air pollution in industrial zones Pollution of water sources (agrochemicals and industrial waste) Inadequate waste disposal Microbiological contamination of food and water	Increased incidence of allergic disease in children, and in chronic respiratory diseases; also some cancers Foodborne and waterborne infectious diseases (e.g. hepatitis A, salmonellosis)	Food and water quality management Waste management Air pollution control in industry/energy Measures to reduce noise	Winter atmospheric inversion Need to protect Zitny Ostrov, the largest source of drinking-water in central Europe Traffic noise in urban areas
Tajikistan	Poor sanitation Lack of water treatment agents Drinking-water quality in rural areas Food supply Air pollution in major cities	Serious situation with waterborne infections High morbidity in children	Reconstruction strategies for after the war Urgent need for chlorine and flocculants for water treatment Improve basic sanitation and water supply coverage Food supply	Only 7% agricultural land Mountainous terrain, with 60% of of all water resources central Asia Civil war refugees and food shortage United Nations has described an “invisible emergency”

Table 17.3 d: Main environmental health issues and priority needs in the CCEE and NIS

Country	Main environmental health problems	Reported health effects	Priority needs	Special situations/other environmental health problems
The Former Yugoslav Republic of Macedonia	Air pollution Rural water quality	Winter smog in Skopje with premature death in the elderly with pre-existing cardiac or chronic respiratory disease Outbreaks of shigellosis and hepatitis A	Local measures to control air pollution Extension of piped water supply to rural areas	Refugees from the former Yugoslavia
Turkmenistan	Lack of sewage systems and treatment Drinking-water supply and quality Waste disposal Excessive use of/exposure to pesticides	High rates of waterborne infectious disease (including viral hepatitis) and parasitic disease, with high mortality in children and pregnant women Pesticide-related morbidity	Irrigation and wastewater management Water quality strategy	Adjacent to Aral Sea and related soil and water pollution problems Irrigation systems creating problems of aquifer pollution with pesticides Inadequate housing
Ukraine	Severe air pollution Sources: 33% from metallurgy, 40% from energy/coal, 7% from petrochemicals Radiactive contamination Water pollution Waste disposal (heavy metals)	Decrease in birth rate and increase in mortality rate in the 1980s leading to a negative population balance Increased morbidity in industrial cities Increases in diarrhoeal diseases, hepatitis A and parasitic infections	Air pollution control Waste and water management Regionalized environmental health management structure	Radioactive pollution over large area of country from Chernobyl Vast area of eastern Ukraine affected by air, water and soil pollution Irrigation mismanagement and lack of adequate drinking-water supply in southern Ukraine
Uzbekistan	Air pollution Water pollution (lack of piped water supply in rural areas and of sewage treatment) Improper irrigation and overuse of agrochemicals	High rates of respiratory disease Waterborne infections, including hepatitis A	Agricultural policy on irrigation and agrochemical use Basic sanitation measures Improved piped water supply	Aral Sea pollution Fergana Valley: fertile plain with pesticide pollution of soil and water, and cities with high air pollution

Note: Serious and extreme problems exist in localized areas within countries of greatly differing size and population density. The classifications reflect the relative importance attached to different pollution problems by the individual countries.

Sources: Mnatsakian, R.A. (4); data reported to or gathered by the WHO Regional Office for Europe.

ity problem. Inadequate sanitation is combined with a widespread lack of piped water and a distribution system in need of repair and maintenance. These factors have led to a marked increase in the incidence of waterborne diseases (hepatitis A, gastrointestinal infections and parasitic conditions) in the population.

Until recently, Latvia had no sewage treatment facilities, and defects in the distribution system cause water shortages. There were serious outbreaks of hepatitis A in Riga in 1987–1988. In 1992, the reported incidence per 100 000 population of waterborne diseases was 61 cases of salmonellosis, 170 cases of other acute gastrointestinal infections, 120 cases of hepatitis A and 16 cases of leptospirosis.

In Lithuania, only about a quarter of wastewater treatment is considered adequate, and only about two thirds of the population have a piped supply of water. The incidence of diarrhoeal disease in children was 0.63% in 1991; there were from 1000 to 2000 cases of hepatitis A, salmonellosis and dysentery.

Rural areas of The Former Yugoslav Republic of Macedonia largely lack centralized piped supplies of water. There were two outbreaks of shigellosis (with more than 6000 cases) and two of hepatitis A (376 cases) between 1988 and 1993.

In the Republic of Moldova, less than 20% of the rural population are supplied with piped water, and supplies of chlorine are currently inadequate for effective water treatment. Infections with hepatitis A virus and *Salmonella* spp. occur.

In the Russian Federation, bacterial and viral pollution of rivers create a constant threat of epidemic outbreaks of acute intestinal infections [7]. Nearly 30% of the water supply does not come from centralized piped supplies, and 75 000 breakdowns in the distribution system are reported annually. In 1990–1992, the reported incidence of waterborne infections per 100 000 population was 200 cases of hepatitis A, 80–95 cases of salmonellosis, 14 cases of dysentery, 70 cases of other gastrointestinal diseases, and 300 cases of unknown cause. The rates were higher in 1993.

In rural areas of Slovakia, nearly a quarter of the population obtain water from individual wells. Where there are piped supplies, contamination has been reported in about 15% of the water distributed. During 1988–1992 there were 19 outbreaks of waterborne infectious disease, with 1785 cases.

Tajikistan has a current shortage of water treatment agents, and about two thirds of the rural population obtain drinking-water from open sources. Infectious diseases affect nearly 40% of the population; 80% occurs in children under 14 years of age, who comprise about 40% of the total population. Dysentery causes 30% of deaths in children under 5 years of age. Viral hepatitis is common and increasing: the incidence per 100 000 was 548 in 1990, 780 in adults and 1375 in children under 14 years in 1991, and 419 in adults and 757 in children in 1992 (the apparent decrease is probably related to registration difficulties during the civil conflict).

Turkmenistan lacks sewerage systems, particularly in rural areas, and facilities for wastewater treatment. Water distribution systems are obsolete; about 7000 breakdowns are registered annually. Rates of infectious disease are high, especially in children. Infant mortality runs at 45 deaths per 1000 live births, 24% of which are due to intestinal infections and parasitic disease attributable to poor water quality. Viral hepatitis is common, and associated with high mortality in pregnant women. The mortality rate from infectious and parasitic diseases is the highest in the NIS.

Ukraine showed an overall reduction in diarrhoeal disease in 1986–1991, but an increase in salmonellosis and hepatitis A. The incidence of hepatitis A rose by 30% in 1990–1991.

In Uzbekistan, sewerage systems have been constructed in about one third to one half of urban settlements. They are generally overburdened and therefore inefficient. In addition to the lack of sanitation, less than half of the rural population have piped water supplies. Most people obtain drinking-water from open watercourses. Recently, the incidence of typhoid, paratyphoid and viral hepatitis has been reduced, but there are still about 250 000 cases of hepatitis A each year.

Chemical contamination of water supplies

The practice of intensive agriculture in many countries, but particularly the central Asian republics where cotton production was a priority, has resulted in the contamination of land and water by pesticides and fertilizers. The use of such water for irrigation, along with the salinization of soils that has resulted from the irrigation practices adopted, affects the current and future quality and production of food (Table 17.2). In addition, unwholesome drinking-water is a major problem for all 20 countries (Tables 17.2 and 17.3).

In rural regions of Slovakia, mainly in eastern areas, there were 2536 cases of methaemoglobinaemia in infants in 1971–1990 as a result of high levels of nitrate in drinking-water. Many people in these areas obtain water from wells.

In Belarus, about 64 % of the rural population obtain water from shallow wells. In some areas up to 80 % of wells are polluted with nitrates as a result of fertilizer use.

The Republic of Moldova has a long history of high pesticide and fertilizer use, among the highest in the former USSR. When combined with the high percentage of arable land, this practice has resulted in contamination of surface water and groundwater used for drinking. Overall, about 55 % of the population (about 95 % in cities) has access to piped water supplies, although shortages result from breakdowns in distribution. The remaining 45 % (the rural population) obtains water from local sources, with over 60 % of samples not meeting chemical standards for pesticides and fertilizers. More than 75 % of groundwater sources are polluted with nitrates. The high fluoride content of drinking-water is due to the natural composition of the rocks. Fluorosis affects 9 % of preschool children, 41 % of children of school age, and 50 % of adults.

The Dniepr is the largest river in Ukraine and the source of drinking-water for 35 million people. Some 70 % of Ukraine's industrial base (about 10 000 industrial sites) is located within the river's catchment area. The river was diverted into a chain of five large artificial reservoirs, which are heavily polluted from the surrounding industrial centres. It is estimated that about 12 km^3 of highly polluted industrial and communal wastewaters are discharged into the Dniepr each year, and eutrophication of the water in the reservoirs has occurred. Discharges contain 120 tonnes of mercury, 90 tonnes of chromium and 2 tonnes of cyanide. The sediments of the reservoirs contain radioactive material released after the Chernobyl accident.

In Odessa, a city of 1.1 million people in southern Ukraine, the water supply is heavily polluted with agrochemicals. In eastern Ukraine, chemical factories around the cities of Lisichansk, Slavyansk and Rubezknoye have contaminated groundwater supplies for about 150 km^2, and many wells can no longer be used. There are over 200 regions in Ukraine with severe groundwater pollution affecting an estimated 6 % of existing wells.

In Armenia the water table in Lake Sevan, which had been a major source of fresh water, has dropped because of the diversion of rivers for hydropower and irrigation. Eutrophication from communal and agricultural waste is accompanied by bacterial contamination. An increase in morbidity in the local population is thought to be due to the excessive use of pesticides. Life expectancy for males and females has decreased by two years in the last decade and this, too, has been attributed to environmental factors.

In the central Asian republics of Kazakhstan, Turkmenistan and Uzbekistan, irrigation and loss of water from the Aral Sea has affected drinking-water sources. The problem has been further aggravated by the overuse of agricultural chemicals, especially pesticides, to improve cotton production, and by the salinization of irrigated soil.

More than 3.5 million people live in areas adjacent to the Aral Sea, with less than 3% of settlements having piped water supply systems. The vast majority are supplied from wells, where the bacteriological and chemical quality of the water is extremely poor. In Uzbekistan, gall and kidney stones have been estimated to be 12–17 times more common in the Aral Sea area in 1992 than in 1985. Infant mortality rates in this region are high at about 70 per 1000 live births, with up to 100 per 1000 in some areas. Traces of DDT have been found in 40% of breast milk sampled. Increased morbidity is reported from tuberculosis, oesophageal cancer, cardiovascular and blood diseases, and diseases of the digestive organs. Increases in infant mortality have also been reported in Kazakhstan, along with increased morbidity related to blood disorders, cardiovascular diseases, and liver and kidney diseases. In Turkmenistan, 45% of morbidity has been attributed to exposure to pesticides, aggravated by heat stress in the summer.

In the many regions of the Russian Federation, water pollution problems from both agricultural and industrial sources are having an extreme effect on water supplies. In the St Petersburg region, high levels of nitrate pollution of the Ladoga lake and Neva river, the main sources of water supply to the city, have caused blue–green algal blooms. Around the city itself, numerous military and industrial complexes release heavy metals and other toxic substances. Cancer has shown a measurable increase in the St Petersburg area during the last decade.

The Volga and its main tributary, the Kama river, were diverted into chains of artificial reservoirs which are heavily polluted from adjacent industrial centres. The Volga basin receives nearly 33% of all polluted wastewaters discharged in the Russian Federation: about 10 km^3 per year. The quality of drinking-water in the region is extremely poor.

In the Ural region, about 33% of non-ferrous metal smelters and 25% of other metallurgical plants discharge wastewaters to rivers without treatment; the technology for waste treatment in pulp and paper mills is about 50 years old. In the region as a whole, all rivers are extremely polluted; groundwaters are also contaminated in many areas. For example, samples of drinking-water from aquifers in the Ekaterinburg region often contain such elements as arsenic, bromine, iron, lithium and ruthenium. The only treatment of supplies is by filtration and chlorination [8].

The Kuzbass basin, in south-western Siberia, was one of the most important industrial regions of the former USSR, with a high concentration of coal and ore mining, metallurgy, chemical and other heavy industries. This region also produces major quantities of phenol–formaldehyde tars and plastics. Consequently the Tom river and its tributaries are polluted with oil, aniline, phenols, caprolactam, formaldehyde, methanol and other agents at levels tens of times greater than maximum permissible concentrations. In cities supplied by this water source, there has been a 1.5- to 6-fold increase in spontaneous abortions and congenital malformations in recent years.

17.2.3 Solid waste

In general, the treatment of industrial waste in the CCEE and NIS is inadequate. In the large industrial complexes of Bohemia in the Czech Republic, north-eastern Estonia and Ukraine, the lack of treatment systems means that considerable amounts of toxic industrial waste have accumulated. In the Ural region, stockpiles of industrial waste affect groundwater supplies and create hazards to the environment and health. In major cities, the predominant municipal and industrial waste management problem relates to the overuse of existing dumping sites and the leaching of toxic sludges from such areas, which contaminate soil, crops and water supplies.

Some countries gave specific examples of problems of solid waste disposal. In Azerbaijan, there are about 20 unauthorized toxic waste sites around the capital, Baku, containing for example vanadium, mercury and asbestos. About 60 million tonnes of toxic waste from ferrous and non-ferrous smelters has accumulated. The main problem in Belarus is related to the annual accumulation of about 30 million tonnes of mineral waste from potassium mines. The country has two waste treatment plants, which together can handle less than 10 % of the industrial waste produced. In the Czech Republic 60 % of solid industrial waste, containing arsenic, cadmium and lead, for example, is dumped without treatment or adequate control measures [9].

Estonia has special solid waste problems arising from the mining and processing of oil shale, and from previous uranium mining and associated military activities. Oil shale waste, containing coke and ash, comprises about 10 million tonnes of the total annual production of just over 11 million tonnes of solid waste; 230 million tonnes of oil shale waste are already in dumping sites. In addition to the threat of leaching from these sites, the water filling abandoned mines contains high concentrations of chemicals and is in direct contact with groundwater. Full assessment of the effects of the former military complex has yet to be made; uranium waste has been dumped in a "tailing" on the coast of the Gulf of Finland, and is estimated to contain 1200 tonnes of uranium and thorium, with radium activity exceeding 7 kCi (259 TBq) [10].

In Georgia, the collection and disposal of solid municipal waste are inadequate even within the capital, Tbilisi, and throughout the country toxic waste is buried or dumped in reservoirs without treatment. In Latvia, too, the disposal of both municipal and toxic waste is inadequate, and there are no waste treatment facilities. There are more than 500 landfills, which lack measures to prevent leaching.

In Lithuania, there was virtually no management of wastes of any category before 1991. Over 300 landfills are thought to exist in rural and urban areas and hazardous waste is deposited with domestic waste. There are also problems due to inadequate arrangements for the storage and disposal of banned pesticides and radioactive waste, and from soil pollution with mercury.

Storage and disposal arrangements are also inadequate in the Russian Federation. It is estimated that 75 million tonnes of hazardous waste were produced in 1990. Only 18 % of the waste produced is treated or recycled; most is deposited or stored on site, in other designated places or in sites not designed for storing hazardous waste, including those for domestic waste. In the Ural region, virtual mountains of industrial waste have accumulated on the surface near their sites of origin. Hazardous components of industrial waste include heavy metals, polychlorinated biphenyls and dioxins. Another problem arises from a lack of proper storage of unused chlorine- and phosphorus-containing pesticides, with resulting contamination of air (from dusts) and groundwater. The country has only two installations that can detoxify hazardous wastes, and their technology is obsolete.

Ukraine supplies 5 % of mineral raw materials produced globally, and the eastern areas produce 85 % of the country's toxic industrial waste. The contamination of soil with heavy metals is not confined to industrial sites and urban areas, but extends to very large areas of surrounding farmland.

Turkmenistan has no proper sites for solid waste disposal and no incineration facilities; wastes just accumulate.

17.2.4 Radiation

Environmental contamination

The contamination of land by radiation has affected most regions in the NIS, especially in Belarus, Georgia, Kazakhstan, the Russian Federation and Ukraine. High levels of contamination with long-lived isotopes of caesium and strontium are affecting the health of the population, as demonstrated by the reported increase in cases of cancer. Large areas of the former USSR are subject to high levels of radioactive contamination following the Chernobyl nuclear disaster. Radiation accidents in the southern Ural region and nuclear weapons testing in Kazakhstan have also resulted in high levels of contamination.

In Belarus, the Chernobyl accident has had very serious consequences: 130 000 people were evacuated and 23 % of the land, occupied by 1.8 million people, is still polluted with long-lived radionuclides, mainly caesium-137 and strontium-90. Areas where soil activity is up to 5 Ci/km^2 (155 Bq/km^2) include Gomel, two other cities and many smaller towns and villages. Activity of 15 Ci/km^2 (555 Bq/km^2) or more affects an area of more than 6000 km^2. The incidence of thyroid cancer in children, who are likely to have been exposed to isotopes of iodine shortly after the accident, has risen; the rate is now almost 3 per 100 000 compared with only rarely recorded cases before the accident. The frequency of congenital malformations is also reported to have increased, along with psychosomatic disorders in children. The adult population has shown increased morbidity due, for example, to cardiovascular diseases and gastric or duodenal ulcers, which may be stress-related.

In Ukraine, about 2.5 million people are living in areas contaminated by the fallout from Chernobyl. In an area of about 1500 km^2 the activity is 15 Ci/km^2 (555 Bq/km^2) or more. In addition, about 180 000 people were involved in dealing with the immediate consequences of the accident and were thus exposed to high levels of radioactivity, and several thousand children are thought to have received high doses to the thyroid gland from radioactive iodine. To date, no increase in thyroid cancer incidence has been observed, but there are reports of an increase in the incidence of other types of cancer.

In the Russian Federation, an area of about 2400 km^2 still has an activity of 15 Ci/km^2 (555 GBq/km^2) or more as a result of contamination from the Chernobyl accident. In the Bryansk region up to 1992, the anticipated increase in thyroid and haematopoietic cancers in children had not been detected. The effects of the Chernobyl accident are referred to in more detail in Chapters 10, 12 and 16.

A major problem of environmental contamination with radioactivity is now known to exist in the Ural region as a result of the activities of the Mayak military nuclear reactors. Between 1949 and 1956, 3 MCi (111 PBq) of liquid waste was released into the Techa river. Subsequently, over 7000 people were evacuated from nearby villages, and the use of river water was forbidden. Among some 40 000 people estimated to have received substantial doses, there is an increase in the incidence of leukaemia and solid tumours [11] (see also Chapter 12).

An accident at the Mayak complex, near the village of Kyshtym, released large quantities of strontium-90 and led to the evacuation of 10 000 people. This area still has strontium activity of up to 1500 Ci/km^2 (55.5 TBq) and access is strictly controlled. (See also Chapter 12.)

In Kazakhstan, Semipalatinsk was the site of nuclear weapons testing; 470 tests were made between 1949 and 1990, and these are estimated to have released about 200 kg of strontium-90 and caesium-137 over vast areas of eastern Kazakhstan. Uranium mines and enrichment plants are located in the same area; it is estimated are that wastes comprise 250 million tonnes with a total activity of 0.2 MCi (7.4 PBq). Cancer incidence in the Semipalatinsk region is reported to be twice that in other parts of Kazakhstan. (See also Chapter 12.)

The full effects of occupational exposure to radiation associated with uranium mining and processing in Estonia, Kazakhstan and the Russian Federation are still to be assessed. Studies of workers at the Mayak complex have shown increases in the incidence of leukaemia and solid cancers.

Radon in dwellings

Only 2 of the 20 countries mentioned radon in dwellings as a problem. In the Czech Republic, it is estimated that 10–20 % of the annual incidence of lung cancer may be attributable to radon. In Estonia's north-eastern region, where bedrock and sediments contain uranium, high concentrations of radon may be present in dwellings in some places. Concentrations of over 800 Bq/m^3 have been observed in 5% of dwellings, reaching 5 kBq/m^3 in a few.

17.3 Discussion

The centrally planned economy of the former USSR resulted in large industrial conglomerates with interacting industries located near each other. Overwhelming priority was given to productivity, and less attention paid to emission control or waste disposal. Thus, air pollution is a substantial problem in many industrial areas, and is associated with increased morbidity from respiratory diseases and allergies, particularly in children. In addition, widespread soil and water contamination resulted from storing liquid industrial waste in artificial, uninsulated ponds (when it was not discharged directly into surface waters) and/or simply dumping solid industrial and municipal waste in the ground. Further, the excessive use of agrochemicals, in the interests of increased productivity, has contributed to soil and water pollution in some areas. The inadequate disposal of radioactive waste, as well as fallout from accidental releases or nuclear weapons testing, has also caused radionuclide contamination of the environment in several areas of the NIS.

Reliable, piped supplies of safe drinking-water are lacking for 110 million people in the European Region, 86 million of whom live in the NIS. These basic inadequacies in supply are aggravated by poorly maintained distribution systems, with resulting interruptions in supply, leakage and contamination. Like other types of waste, sewage is inadequately treated in many areas. Waterborne infectious diseases such as hepatitis A and parasitic infections are common, and sporadic outbreaks of cholera have occurred.

Some of these problems also exist in parts of the CCEE. Urban air pollution is of concern in certain industrial areas, and pollution of water resources by industrial and agricultural wastes is a widespread problem.

Finally, wars have directly or indirectly affected the lives of millions of people, destroyed public services and agricultural land, and created large numbers of refugees in both the NIS and the CCEE. Epidemics threaten, and there are shortages of food, medicines and even water treatment agents. Such natural disasters as earthquakes have caused similar problems. Man-made ecological disasters, such as the destruction of the Aral Sea region, also have profound effects on health. Considerable efforts continue to be needed to restore basic infrastructures and services, including those to regain and support environmental health.

17.4 Conclusions

As in the Region overall, the CCEE and NIS have a clear need for comprehensive but well targeted and harmonized environmental health monitoring, with appropriate quality assurance and control, along with exposure assessments and selected studies of related health effects. These will provide the basis for the evaluation of environmental hazards to health.

Environmental pollution may be reduced at present, as a result of transition and economic recession. This is only a temporary situation, however, during which plans may be made for long-term sustainable redevelopment in which the adoption of control measures at the source of pollution will prevent adverse environmental effects on health.

Urgent action is needed now to deal with severe existing problems. While each country must determine its own priorities for action, support from the international community is likely to be needed in three main areas:

- regions affected by war (where essential public services are disrupted and epidemic diseases threaten) and areas where the ecological situation is deteriorating (such as the Aral Sea) with profound consequences for environmental health;
- severely polluted cities, which need not only long-term solutions but immediate mitigation of specific problems; and
- predominantly rural areas with inadequate water treatment and supply systems and high levels of contamination of soil and water, both microbiological and agrochemical; in more general terms, programmes are needed for the repair and maintenance of disintegrating water distribution systems and the disposal of waste.

References

[1] World Bank. *World development report 1993. Investing in health*. New York, Oxford University Press, 1993.
[2] *World Bank atlas 1994.* Washington, DC, World Bank, 1994.
[3] United Nations Development Programme. *Human development report 1994*. New York, Oxford University Press, 1994.
[4] Mnatsakanian, R.A. *Environmental legacy of the Former Soviet Republics (as collated from official statistics).* Edinburgh, University of Edinburgh, 1992.
[5] *Estonia.* Copenhagen, WHO Regional Office for Europe, 1993 (document "Highlights on health").
[6] Andrusaitis, G. Environment and health in Latvia. *In*: *Environment and health in the Baltic countries: report on a WHO meeting*. Copenhagen, WHO Regional Office for Europe, 1993 (document EUR/ICP/CEH 213).
[7] *Russian Federation.* Copenhagen, WHO Regional Office for Europe, 1992 (document "Highlights on health").
[8] [*National report of the USSR to the 1992 UNCED Conference in Rio de Janeiro*]. Moscow, State Committee on National Protection.
[9] *National report of the Czech and Slovak Federal Republic.United Nations Conference on Environment and Development, Brazil, June 1992.* Prague, Czechoslovak Academy of Sciences and the Federal Committee for the Environment, 1992.
[10] *Estonian Environment 1991.* Helsinki, National Board of Waters and the Environment, 1991 (Environmental Report 4).
[11] Cochran, T. & Norris, R. *Russian/Soviet nuclear warhead production.* Washington, DC, National Research and Development Council, 1992 (NWD 1992-4).

Part III

Analysis, Discussion, Conclusions and Recommendations

Chapter 18
Estimated Health Effects of Environmental Exposure and Role of Economic Sectors

18.1 Effects on Health of Environmental Exposure

Human health is determined by a number of factors including genetic predisposition, lifestyle, nutrition, socioeconomic status, access to adequate health care, and the environment. The continuing availability of environmental resources – air, water, food and shelter – as well as appropriate climatic and socioeconomic conditions, is a prerequisite for health and survival. Environmental conditions are not always optimal, however, and populations may be exposed to a variety of environmental factors that may adversely affect their wellbeing. These environmental health hazards may result from natural causes and/or human activities, as described in the previous chapters.

Estimates of the impact of environmental agents on health require information on exposure and on the quantitative relationship between exposure and effects on health. Precise estimates of exposure are rarely possible, however, owing to the scarcity of monitoring data. The estimates of exposure are, therefore, based on limited information and, whenever feasible, supplemented by extrapolations based on some reasonable assumptions; the resulting uncertainties may be considerable.

Further, knowledge of the effects on human health of various exposures, based on epidemiological and toxicological studies, is far from complete. This leads to further uncertainties. In general, the severity of the impact on health is assumed to depend on the extent of the exposure and the corresponding dose of the environmental agent, but the precise dose–response relationship is often not known. For some environmental agents, doses below a certain threshold level can be accommodated and are not harmful, or may even be beneficial. Others, such as allergens, ionizing radiation and chemical genotoxic carcinogens, are believed to have no threshold dose and to pose a risk at all levels of exposure. In addition, human response to environmental factors is not homogeneous in the population, since some people are more susceptible than others. This is obvious in the case of allergies, but responses to carcinogens also vary. The source of the increased susceptibility may be genetic predisposition, but coexisting environmental or lifestyle factors are also known to influence the response.

In many situations a combination of factors may have a different or worse effect on health than exposure to each factor separately. Further, unfavourable environmental, social and lifestyle conditions coexist in some parts of society. People may have a poorly balanced or inadequate diet, be exposed to occupational hazards, adopt a harmful lifestyle (by excessive alcohol consumption or tobacco smoking, for example) and, at the same time, be exposed to one or more environmental hazards. This combination may increase the risk of disease above the level expected if the factors acted separately. For example, asbestos or radon appear to cause ten times more lung cancer in smokers than in nonsmokers.

However incomplete, the available information has been used to estimate the impact of environmental hazards on the health of the population of the European Region. Whenever the exposure and epidemiological data allow, the proportion of illnesses or other health impairments in the population that might be attributable to the exposure has been estimated as an "attributable proportion" [1].

The basic elements of the methodology are presented in Box 18.1. This may be an oversimplification of the situation; the risk may increase continuously with increasing exposure instead of by a step increase as assumed. Data are scarce, however, and a more precise incremental risk model could rarely have been used. In addition, the risk estimates derived from one epidemiological study may be specific to the population studied, owing to a particular exposure situation or to the characteristics of the population at risk. In this analysis, risk estimates were based on several similar studies con-

Box 18.1: Estimation of attributable proportion

The proportion of cases occurring in a combined population of exposed and unexposed individuals that is attributable to exposure can be determined as:

$AP = (I_t - I_o) / I_t = (RR - 1) / (RR + 1/P - 1)$

where:

I_t is the overall incidence in the combined population of exposed and unexposed individuals;
I_o is the incidence in the unexposed population;
RR is the relative risk of the disease due to the exposure (the ratio of the incidence in the exposed to the incidence in the unexposed population); and
P is the proportion of the total population that is exposed.

The actual number of cases of disease that can be attributed to the exposure N_+ can be estimated as:

$$N_+ = I_t \times AP \times N$$

where N is the population at risk.

The information for these calculations is derived from epidemiological studies estimating both relative risk and the incidence of the disease in the total population. The uncertainty of the AP and N_+ estimation can be assessed by the use of the various estimates of relative risk or exposure prevalence obtained from different studies, or the use of different assumptions.

ducted in different populations to diminish this problem. Further, for some types of exposure and health effect, the number of studies is large but, for others, reported studies are few. For this reason, too, the estimates should be considered with caution.

18.1.1 Situation in the European Region

Chapter 4 identifies the main health issues in various parts of the European Region and describes the current health status of the population, showing the inequalities between groups where possible. Notwithstanding the limitations of the available data, several aspects of health status differ significantly between various parts of the Region's population.

In particular, as assessed by infant and total mortality rates, life expectancy and analysis of the incidence of selected diseases, the health of people in the European members of the Organisation for Economic Co-operation and Development (OECD) has improved in recent decades, while the health of the populations of the CCEE and NIS has shown either no improvement or a deterioration in some areas or age groups over the last two decades. These different trends are reflected in markedly higher mortality rates in eastern parts of the Region than in the European OECD countries. The differences are relatively greater among young adults and people of middle age, especially males. The most pronounced differences in premature mortality are due to cardiovascular and respiratory diseases and, in males, to injury and poisoning, and some types of cancer. The limited data on morbidity support the conclusions based on evaluation of mortality patterns.

In summary, the most significant finding is the deterioration in health of middle-aged people, particularly men, in the CCEE and NIS.

The question of the causes of these differences and of the possible contribution of environmental agents is difficult to address because of the number of factors (including genetic makeup, lifestyle, socioeconomic status and access to adequate health care) that affect health status in addition to the environment. Nevertheless, an attempt has been made to assess the extent of the impact of environmental factors on the inequalities in health identified in the Region's population.

The possible role of environmental hazards in each of the main disease categories is considered in turn. Since not all deficiencies in health can be classified as disease, the effects of environmental hazards on well-being are also discussed.

Estimates of population exposures to selected environmental hazards, and the related potential health effects, are summarized in Tables 18.1–18.3. Where possible, the available data have been extrapolated to provide an estimate of the probable exposure of these populations. The nature, frequency and intensity of the effects on health will depend on the extent of the exposure, as well as on individuals' characteristics and lifestyles.

Cardiovascular diseases

In all the countries of the European Region, the most common cause of death is disease of the circulatory system. Mortality due to cardiovascular diseases is considerably lower in the European OECD countries than in the CCEE or NIS. Owing to a decreasing trend in the western countries of the Region[a] and an increase – or at best stabilization of rates – in the rest of the Region, the difference in mortality between the two increased from 33 % at the beginning of the 1970s to 100–150 % at the end of the 1980s. The main recognized risk factors for cardiovascular diseases in general, and coronary heart disease in particular, are hypertension, high blood cholesterol and tobacco smoking. In-

[a] See the definition of "western countries" given in Chapter 4, page 91. Many of the data sources used in this chapter refer to "European OECD countries" instead, and therefore do not include data on Israel, Malta, Monaco or San Marino.

terrelated factors that are correlated with the three main risk factors include obesity, inadequate physical activity and a diet rich in saturated fats and/or salt. Environmental factors almost certainly play a small role in the etiology of cardiovascular diseases in the general population. On the other hand, exposure to elevated levels of carbon monoxide may aggravate cardiovascular diseases [2]. People in certain occupations (garage attendants, tunnel workers and police officers), as well as commuters in heavy traffic, may be subject to such exposure. While environmental tobacco smoke has been considered as a risk factor, the evidence is not consistent [3].

A number of studies have shown a statistically significant inverse relationship between the hardness of drinking-water (related to dissolved calcium and magnesium) and cardiovascular diseases. According to the recently revised WHO guidelines for drinking-water quality, however, the available data are inadequate to prove that the association is causal [4].

Cancer

In all countries of the Region, cancer is the second commonest cause of death after diseases of the circulatory system. The differences in cancer mortality within the Region are less dramatic than those seen for cardiovascular diseases. The most common sites of fatal cancer are different in males and females. In males, lung cancer accounts for over 27% of cancer deaths in western Europe and about 33% in the rest of the Region. In females, lung cancer is less frequent than in men but it causes a greater proportion of cancer deaths in western Europe than in the rest of the Region. The main risk factor for lung cancer is tobacco smoking. In females, breast cancer is the commonest cause of cancer death, and accounts for a greater proportion of cancer deaths in the European OECD countries than in the NIS. The risk factors for breast cancer are not clear, but genetic, reproductive and various hormonal factors may play a role. The other common cancers in both sexes are of the stomach, colon and rectum; dietary factors are thought to influence the risk.

A number of factors are considered to increase the risk of cancer, including aspects of lifestyle (smoking, alcohol consumption, diet, reproductive behaviour) and genetic and hormonal factors. Environmental agents also play a role; although smaller overall than that of the above factors, this role may be relevant in selected areas and population groups. For instance, special environmental circumstances such as occupations or local practices or conditions may enhance cancer risks, particularly for cancer of the skin and of the respiratory and urinary tracts.

The following sections focus on ionizing radiation, nonionizing radiation and selected chemicals present in the human environment. When considering the possible impact of these environmental exposures on cancer causation, one must make an important distinction between genotoxic carcinogens, for which no threshold is assumed, and non-genotoxic carcinogens, for which evidence suggests that no cancer risk exists below a certain threshold.

Ionizing radiation

The effects on health of ionizing radiation have been a source of public concern for several decades. The potential hazards that need to be considered are: radon from uranium-bearing rocks, occupational exposure, nuclear accidents, nuclear weapons testing and waste disposal.

The main effect on health of environmental exposure to ionizing radiation is the induction of cancer, and it is assumed that no threshold dose exists below which there is no risk of an effect.

Increases in lung cancer related to radon exposure have been observed mainly in uranium miners, but recent data from Sweden indicate that domestic exposure may also increase the risk of lung cancer considerably. The Swedish study showed that, compared with those exposed to radon in time-weighted average concentrations below 50 Bq/m^3, the risk increased by some 30% in people exposed to 140–400 Bq/m^3 and by 80% in those exposed to concentrations over 400 Bq/m^3 [6]. The study also showed that 16% of all lung cancer cases in the Swedish population may be attributed to radon exposure [7]. Since most other countries in the Region have lower levels of residential radon exposure, the attributable proportion of lung cancer would probably not be as high as in Sweden and other parts of Scandinavia. Further, the Swedish study indicated a strong interaction between residential radon and smoking that is close to a multiplicative effect. This implies that most cases of radon-related lung cancer are likely to appear in smokers.

In general, the exposure of populations in different countries of the Region to domestic radon is difficult to evaluate because concentrations in the same geographical area and the extent of household ventilation vary markedly. Nevertheless, the data reviewed in Chapter 12 make it possible to estimate the proportion of people living in dwellings with concentrations of radon gas above the level of 200 Bq/m^3 [a] at which simple remedial measures should be considered (see Table 18.1) [8]. The proportion of people estimated to be exposed to radon gas concentrations above the level (400 Bq/m^3) at which WHO advises immediate remedial action [8] ranges from 0.01% in the United Kingdom to 1.5% in Sweden. This corresponds, for example, to approximately 5500 people in the United Kingdom and 80 000 in Sweden.

Occupational exposure is another potential source of risk. Uranium miners are particularly at risk, but workers in the nuclear power industry, health care and research are also potentially exposed. The size of the populations monitored for exposure to radiation in the health care, research and nuclear power sectors ranges from about 700 in Luxembourg to about 320 000 in Germany. Air crews have not, in the past, been classified as occupationally exposed, but they may receive doses from cosmic radiation that are comparable to those of radiation workers. For several countries in the Region, data are not available on the number of radiation workers or the doses they receive. The dose limit recommended by the International Commission on Radiological Protection is 20 mSv a year, averaged over five years. The great majority of workers in countries with data receive doses well below 5 mSv annually. If a dose of 5 mSv were received annually for 40 years, then this might result in a 5% increase in the existing probability (from 0.2 to 0.25) of a person dying from cancer. A very approximate estimate of the number of radiation workers exposed to levels that raise concern for their health is presented in Table 18.2. A higher risk of lung cancer must be expected in several hundred thousand workers in uranium mining in central Europe in the past. These mining activities have now largely stopped; where they continue, exposure is far lower than in the past, possibly averaging about 10 mSv a year.

The possibility of nuclear accidents is associated with the potential for radiation-induced cancer in the general population. Since the Chernobyl accident, health surveys have been conducted in the various populations exposed to the released radionuclides. No increase in the incidence of childhood leukaemia has been observed so far, either in Belarus [9] or in various European countries with different levels of population exposure [10]. On the other hand, a sharp increase in the incidence of thyroid cancer has been observed in Belarus among children who appear to have been exposed to large doses of radioiodine [11]. This increase occurred earlier than would have been expected from previous knowledge of thyroid cancer after radiation exposure, and corresponded to an eightyfold rise in incidence [12]. It has recently become apparent that previous radiation accidents and radioactive waste discharges in the south Ural region, nuclear weapons testing in Kazakhstan, and discharges from military installations in the Kraznoyarsk region have resulted in significant levels of radioactive contamination of

[a] Also expressed as 100 Bq/m^3 equilibrium equivalent radon as an annual average.

Table 18.1 a: Estimated exposure of the general population to selected environmental risk factors and their potential health effects

Environmental factor	Level or circumstance of concern for health	Size and type of reference population (millions)	Estimated population exposed at level of concern		Potential health effects	Comments
			Number (millions)	Percentage of reference population		
Air pollution (ambient)						
SO_2: short-term exposure	> 24-hour WHO air quality guideline level for at least 1 day/year	700 West of the Urals	200	29	Transient respiratory disorders, aggravation of (existing) chronic respiratory diseases potentially precipitating death	The number of people exposed is extrapolated to all cities from the mean number exposed in areas with data (see Box 18.2)
SO_2: long-term exposure	Annual mean > 100 μg/m^3 (twice the WHO air quality guideline level)	314 Urban west of the Urals	6	2	4–7% decrease in average level of pulmonary function	The level of concern for health is based on a multicentre study conducted in France. The number of people exposed is extrapolated to all cities from the mean number exposed in areas with data (see Box 18.2)
Total suspended particulates: short-term exposure	> 24-hour WHO air quality guideline level for at least 1 day/year	314 Urban west of the Urals	29	9	Transient respiratory disorders, aggravation of (existing) chronic respiratory diseases potentially precipitating death	Only the people exposed in cities with data were included in the analysis.The number of exposed may be up to 10 times higher if other cities have similar exposure to total suspended particulates (see Box 18.2)
Total suspended particulates: long-term exposure	Annual mean > 140 μg/m^3 (no WHO air quality guideline)	314 Urban west of the Urals	5	2	5% decrease in pulmonary function, increased incidence of chronic airways disease	
NO_2: short-term exposure	> 24-hour WHO air quality guideline level for at least 1 day/year	314 Urban west of the Urals	31	10	Lower respiratory illness in children, throat and eye irritation in adults	The number of people exposed is extrapolated to all cities from the mean number exposed in areas with data (see Box 18.4)

Table 18.1 b: Estimated exposure of the general population to selected environmental risk factors and their potential health effects

Environmental factor	Level or circumstance of concern for health	Size and type of reference population (millions)	Estimated population exposed at level of concern		Potential health effects	Comments
			Number (millions)	Percentage of reference population		
O_3: short-term exposure	1 hour mean > 200 μg/m^3 (the WHO air quality guideline level) at least once a year	170 Children west of the Urals	85	50	Cough and eye irritation; small, transient changes in pulmonary function in children	(See Box 18.5)
Lead	Annual mean > 0.5 μg/m^3 (the WHO air quality guideline level)	170 Children west of the Urals	0.5	0.3	Impaired mental development of children	(See Chapters 5 and 10)
Air pollution (indoor)						
Environmental tobacco smoke	Mother smoking at home	7 Infants west of the Urals	2	30	Lower respiratory illness in infants	Effects are also seen in scholchildren but it is more difficult to assess the extent of their exposure (see Box 18.6)
	Being married to smoker	340 Nonsmoking adults west of the Urals	85	25	Lung cancer in nonsmokers	
NO_2	Use of gas stove, equivalent to + 30 μg/m^3	31 Urban schoolchildren west of the Urals	15	50	Lower respiratory illness in schoolchildren	(See Box 18.6)
Water and food	Occurrence of microbiological contamination	852 Total in the WHO European Region	130	15	From mild gastrointestinal disturbances to severe gastroenteritis	Extrapolation to the entire population of the Region based on data from the Netherlands (see Chapter 9). *Salmonella* or *Campylobacter* spp. involved in at least half the cases

Table 18.1 c: Estimated exposure of the general population to selected environmental risk factors and their potential health effects

Environmental factor	Level or circumstance of concern for health	Size and type of reference population (millions)	Estimated population exposed at level of concern		Potential health effects	Comments
			Number (millions)	Percentage of reference population		
Housing	Lack of piped water	852 Total in the WHO European Region	110	12	Waterborne infections	86 million out of 110 million lacking piped water are in the NIS (see Chapters 6 and 14)
	Dampness	852 Total in the WHO European Region	170–250	20–30	Allergies, including asthma, and respiratory infection	Extrapolation from data from the United Kingdom (see Chapter 14)
Ionizing radiation						
Radon gas concentration (residential)	> 200 Bq/m^3	852 Total in the WHO European Region	43	9	Lung cancer	Estimate based on information on population exposure to radon provided by 12 countries (see Chapter 12)
Noise	> 65 dBA	700 Total west of the Urals	180	26	Annoyance and sleep disturbance	(See Chapter 13)

Table 18.2 a: Estimated exposure of the working population in the WHO European Region to selected environmental risk factors and their potential health effects

Environmental factor	Level of concern for health	Size and type of reference population (millions)[a]	Estimated population exposed at level of concern		Potential health effects	Comments
			Number (millions)	Percentage of reference population		
Radiation	15 mSv per year	? 1–2 Radiation workers	< 0.1 to 0.2	< 1	Cancer	Data not available for many countries on radiation workers' doses. Percentage based on data from Germany and the United Kingdom (see Chapter 12)
Chemicals	Above occupational exposure limits	400 Workers	40	10	From acute intoxications to permanent health impairment or death	Based on surveys in Finland and the Netherlands and a questionnaire study in the countries of the EU (see Chapter 15)
Carcinogenic agents	Occurrence	400 Workers	16	4	Increased risk of cancer, e.g lung or bladder	The potential to be exposed to carcinogenic agents at work exists but cannot be estimated. The estimated exposure is based on the Finnish register of workers exposed to carcinogens (see Chapter 15)
Allergens	Occurrence	400 Workers	52	13	Sensitization or allergic reactions of respiratory system, skin or mucous membranes	The potential to be exposed to allergenic agents at work exists but cannot be estimated. The estimated exposure is based on a survey in Finland (see Chapter 15)
Physical workload/ ergonomic conditions	Physical overload, objectively assessed	400 Workers	108	27	Overload of cardio-respiratory or musculoskeletal system, strain, injury, accident or sudden death	The workers exposed are those in occupations where (a) the oxygen consumption is at an average ≥ 30% of maximal value, (b) the maximal duration of static muscular contraction occurs up to exhaustion, or (c) repetitive movements at frequency > 30/min are performed for several hours a day (see Chapter 15)
Psychological overload	Perception of overstrain	400 Workers	120	30	Stress symptoms, psychosomatic disorders, depression	In systematically validated questionnaire or interview surveys, the population exposed to some type of psychological stressor is assessed as suffering substantial psychological strain, measured by the occurrence of stress symptoms (see Chapter 15)

Table 18.2 b: Estimated exposure of the working population in the WHO European Region to selected environmental risk factors and their potential health effects

Environmental factor	Level of concern for health	Size and type of reference population (millions)[a]	Estimated population exposed at level of concern		Potential health effects	Comments
			Number (millions)	Percentage of reference population		
Noise	> 85 dBA	400 Workers	60	15	Transient threshold shift in hearing, permanent hearing loss, psychological reaction	Based on surveys of noise levels in various industries in Finland and a questionnaire survey in countries of the EU. In the latter, 10% of workers are continuously exposed to hazardous noise levels and 27% for at least a quarter of the time (see Chapter 15)

[a] 400 million equals the total workforce in the WHO European Region.

Source: Stanners, D. & Bourdeau, P. *(5)*.

Table 18.3: Estimated number of accidents in the WHO European Region and their health effects

Type of accident	Health effect	Cases per year		Comments
		Number (thousands)	Rate per thousand	
Home	Injury treated in a clinic Fatal injury	50 000 61	56 0.07	Extrapolation of rates from the United Kingdom to the entire Region (see Chapter 14)
Road traffic	Injury Fatal injury	2 150 120	3 0.14	(See Chapter 16)
Occupational	Notified injury Fatal injury	10 000 25	25 0.06	Estimated from data reported by 22 countries to ILO (see Chapter 15)

Source: Stanners, D. & Bourdeau, P. *(5)*.

the environment and potential hazards to the health of local populations.

Radionuclides from natural sources are unavoidably present in food. Contamination from artificial sources is low in comparison, except for certain foods from areas contaminated by significant levels of radionuclides after the Chernobyl accident. Estimates of any increased cancer risks are hampered by lack of monitoring and food consumption data and reliable cancer statistics, but food contamination is unlikely to lead to observable increases in cancer; the doses received from external contamination are substantially larger.

General environmental exposure to man-made sources of ionizing radiation (other than that resulting from major accidents or, earlier, from nuclear weapons tests) is insignificant in comparison with that from natural sources such as radon.

Nonionizing radiation

The main sources of nonionizing radiation are ultraviolet (UV) radiation from the sun and artificial light sources, and both natural and man-made electromagnetic fields (see Chapter 11).

Although the link between solar UV radiation and skin cancer is well established [13] the excess of cancer caused is difficult to estimate because of lack of exposure estimates and, in the case of cutaneous melanoma, because the exposure–response relationship is complex. The incidence of the common forms of skin cancer is increasing by 2–3 % a year. While malignant melanoma is a rarer form of skin cancer, it has a high fatality rate of 30–50 %. Its incidence has risen markedly in the last few decades (for example, by 50 % in England between 1980 and 1986). It is widely feared that depletion by chlorofluorocarbons and similar agents of the stratospheric ozone layer, which filters out the more harmful components of solar UV radiation, may be causing this increase in skin cancer. The main risk at present, however, is from excessive exposure to UV radiation through individual choice, and changes in behaviour could counter many of the potential hazards. An annual two-week holiday in the sun can increase the lifetime risk of non-melanoma skin cancer fivefold in northern European indoor workers, because it doubles their annual dose of biologically effective UV. An equivalent change in exposure in northern Europe would require an approximately 50 % decrease in the ozone layer. In the case of malignant melanoma, intermittent exposure and exposure sufficient to cause sunburn both increase the risk. The effects of changes of the order of 10 % in the ozone layer may therefore not be as important in this respect. The International Agency for Research on Cancer suggests that a decrease in sunbathing could reduce the risk of skin melanoma by 40 % [14].

At present, the question as to whether environmental exposure to electric and magnetic fields of extremely low frequency has adverse biological effects remains unresolved. Published studies lack consistency: some suggest that cancer, especially in people occupationally exposed to such fields, or leukaemia in children may be related to exposure, while other studies show no effect [15]. A recent study in Sweden found an increased risk of childhood leukaemia related to estimated exposure to electric and magnetic fields. From a public health point of view, the risk was insignificant: less than one extra case of childhood leukaemia per year in a population of 9 million was associated with living near high voltage power lines [16,17].

The high prevalence of exposure to electric and magnetic fields of extremely low frequency, the inconclusive evidence from epidemiological studies, and strong public concern are arguments for conducting investigations to resolve the issue. At present, the possible impact of exposure on health cannot be estimated.

Chemicals

The impact of potentially carcinogenic chemicals is difficult to assess quantitatively because of the scarcity of appropriate data. Assuming there is no safe level of exposure to genotoxic carcinogens, the presence of such chemicals in the environment poses a potential risk.

Air is one of the main carriers of chemical carcinogens to humans. Exposure to products of the incomplete combustion of fossil fuels that contain possible human carcinogens (polynuclear aromatic hydrocarbons, PAH) is relatively common. A few epidemiological studies have demonstrated a relation between risk of lung cancer and ambient particulate air pollution [18,19]. Assessing the exposure retrospectively and accounting properly for confounders are both difficult. This severely restricts the opportunities for quantitative risk assessment. In a case–control study conducted in Cracow, Poland, about 4 % of lung cancer cases in males and 10 % in females were attributed to residence in an area with air pollution (black smoke at an annual average concentration of over 150 $\mu g/m^3$) observed several years before registration of the cancer cases [20]. In the available monitoring data (see Chapter 5) such high levels of black smoke were found in one small city in Poland in the period 1981–1986; in more recent years the highest reported annual average did not exceed 120 $\mu g/m^3$. The current possible impact of urban air pollution on lung cancer incidence will therefore be smaller and more difficult to assess. Other studies suggesting a higher risk of lung cancer related to ambient air pollution were performed in populations living near some types of industry. The evidence was strongest for non-ferrous smelters, where arsenic emissions might be important.

The passive inhalation of cigarette smoke (environmental tobacco smoke) has recently been implicated as a contributor to lung cancer among nonsmokers working closely or living with heavy smokers. The combined evidence from 25 epidemiological studies indicates an increase in risk of 20–30 % in nonsmokers married to smokers [21]. The limited data on smoking prevalence indicate that about 60 % of adults over 15 years of age in the Region, that is 340 million people living west of the Ural mountains, do not smoke. At least 50 % of them (some 170 million) are exposed to environmental tobacco smoke. Thus, an estimated 9–13 % of all lung cancer cases in adult nonsmokers are attributable to such exposure. In other words, with an incidence of 10 lung cancer cases per 100 000 nonsmokers, one would expect 3000–4500 cancer cases per year to be related to environmental tobacco smoke exposure. A recent study [22] found that the risk of lung cancer was significantly increased (by 30 %) only in the 25 % of nonsmokers living with smokers who were exposed to the highest levels of environmental tobacco smoke. This more conservative approach attributes an estimated 3.6 % of lung cancer in nonsmokers to this factor, or 1200 cases per year in the Region.

Exposure to certain potentially carcinogenic substances such as benzene and some PAH depends to a large extent on lifestyle, since active cigarette smoking and environmental tobacco smoke are important sources of exposure. Vehicle exhaust may also contribute to exposure. In particular, exhaust from diesel engines, a complex mixture of a number of chemicals including PAH, is considered probably carcinogenic to humans [23].

Some epidemiological studies have suggested that smoking has interactive effects, increasing the cancer risk related to environmental agents. The best evidence concerns the risk of lung cancer related to asbestos or to radon exposure, which appears to be ten times greater in smokers than in nonsmokers.

Sources that may contaminate food and water with chemical carcinogens range from industrial and human activities to agricultural practices, the processing, packaging and preparation of food, and water disinfection practices. The relative contribution of carcinogenic contaminants in food and water to the overall impact of diet on cancer is not known.

Concern about possible carcinogenic risks from chemical contaminants in drinking-water is directed mainly at certain pesticides, halogenated organic compounds (such as tri- and tetrachloroethylene) and inorganic compounds (such as arsenic and nitrate). Although large areas of European waters are contaminated by these chemicals, levels are in general well below WHO guideline values.

It has been suggested that the chlorination of water may give rise to complex mixtures of halogenated compounds with potential carcinogenic effects on people with a lifelong exposure to them. The evidence is controversial, however, and the issue unresolved. The experience of Peru, where discontinuation of water chlorination for fear of cancer induction contributed significantly to the spread of the 1991 cholera epidemic, points to the need for careful assessment of competing risks [24].

In large areas of the CCEE (in Hungary and Romania) high levels of arsenic are known to occur in drinking-water as a result of local geology. In other countries such as Bulgaria, high levels result from industrial contamination. Arsenic ingestion has been associated with an increased incidence of (mostly benign) skin tumours, but no convincing evidence of increased incidence has been found in the affected areas of the CCEE. This may be the result of the trend to use bottled water imported from uncontaminated areas, as has happened in parts of Hungary. The evidence for the role of nitrate in the causation of gastric cancer is weak.

In summary, the pollution of water with potentially carcinogenic pesticides and organic chemicals may, in principle, pose a health hazard. According to available data, however, the level of exposure of the overall population of the Region does not seem to constitute a health risk, although in some places these contaminants may at times exceed levels of concern.

With food, the possible cancer hazards of chemical contamination encompass a number of pesticides, organic compounds such as polychlorinated biphenyls, dibenzo-*p*-dioxins and dibenzofurans, inorganic compounds such as nitrate and some heavy metals, and natural toxins such as mycotoxins of the aflatoxin type. In general, the contribution of these factors to the actual cancer risk of the population in the Region is difficult to assess and is probably small. The contribution of aflatoxins to the risk of liver cancer seems to be negligible [25] whereas ochratoxin A is suggested as one of the causative agents for Balkan endemic nephropathy, a condition that appears to be associated with a greatly increased risk of developing urinary tract tumours [26].

Procedures for the collection, disposal and treatment of waste can also be sources of carcinogenic hazard if chemical agents are present in the emissions to ambient air of the gaseous and particulate products of waste incineration, or in leachate from landfill sites to surface water and groundwater. Several epidemiological studies have explored an association between living near waste sites and various types of cancer. There is no convincing evidence of health risks.

The use of appropriate technical and management procedures can minimize or even eliminate any potential threat to human health from waste. Nevertheless, the past accumulation of waste, particularly hazardous waste, creates a considerable problem and may affect health in the future owing to the persistence and low biodegradability of the carcinogenic components. The inadequate disposal of hazardous waste in the past is now a particular problem for the NIS and some of the CCEE. Waste transported across national borders, sometimes without proper authorization and documentation, may give rise to similar situations.

Over 30 occupations have been associated with an elevated risk of cancer. Recognized carcinogens are relatively effectively controlled in the work environment. Even in Finland, however, where occupational safety standards are well established, some 4% of the workforce may be exposed to carcinogenic chemicals. Such an increased risk of, for example, lung or bladder cancer in a small number of workers will not usually be detectable in population cancer statistics.

Respiratory diseases

In general, diseases of the respiratory system are a less frequent cause of death than cardiovascular diseases or cancer. While their share in total mortality has diminished, they are still an important problem in some parts of the Region. In the NIS respiratory diseases, including infections, are diagnosed as the cause of death in 25 % of children aged 1–14 years, and these mortality rates exceed those in the CCEE and the European OECD countries threefold and over twentyfold, respectively. Among adults, the variation in respiratory mortality rates and in their trends was greater between these groups of countries than for other frequent causes of death.

An important group of respiratory diseases is chronic airways diseases, namely bronchitis, emphysema and asthma. These diseases have tended to be less frequent causes of death in recent years than at the beginning of the 1970s. This improvement is most marked in people aged 45–64 years, and especially in western European males. Improvement in mortality rates is less evident in younger people, however, where asthmatic rather than chronic obstructive forms of respiratory disease are more frequent. Owing to their high prevalence and chronic character, the frequent restrictions on normal activities and the costs of medication, chronic airways diseases impose a significant burden on both affected individuals and society. The main risk factor for chronic obstructive airways diseases is tobacco smoking. In addition to smoking, however, outdoor and indoor air pollution and occupational exposure to dusts have an important role in the etiology of the disease.

The asthmatic form of chronic respiratory disease remains poorly understood. Recent

Box 18.2: Sulfur dioxide (SO_2)

Epidemiological studies from Cracow [32] and Barcelona [33] indicate that ambulatory or emergency hospital visits due to respiratory diseases, including exacerbated chronic obstructive lung disease or asthma, are 15 % more likely on days with SO_2 concentrations over 125 μ/m^3 than on days with lower levels of pollution (below 75 μ/m^3). Taking account of the frequency and extent of the exposure, the proportion of disease spells associated with exposure can be estimated to range from 0.2 % (if such pollution occurs only in the areas with the available data) to 0.4 % of all cases (if urban air pollution data are extrapolated to all European cities west of the Ural mountains). In the cities most frequently exceeding the WHO guideline value, as much as 8 % of the respiratory disease episodes necessitating a visit to a medical centre can be attributed to pollution with elevated levels of SO_2. If it is assumed that the population incidence of mild respiratory disease in adults is 10 % per year, as is suggested by data from Cracow, it can be expected that 89 000–205 000 such episodes and medical visits per year in Europe are associated with such pollution. In Barcelona, emergency admissions due to respiratory disease numbered about 4 per 1000 adults per year; one can thus expect 4000–8000 such admissions per year in the Region to be attributable to pollution episodes.

Similar steps and risk estimates based on studies from France and Greece [34,35] lead to an estimate of 0.10–0.23 % deaths precipitated by pollution in people aged 65 years or more. This amounts to 6000–13 000 deaths per year in Europe west of the Urals.

The long-term effects of air pollution with elevated SO_2 concentrations are expected to include decreased pulmonary function. Residents in areas with mean annual SO_2 levels exceeding 100 μ/m^3 are expected to have an average level of pulmonary function 4–7 % below that of people living in areas with annual pollution levels below 50 μg/m^3 [36]. The available exposure data indicate that this decline can be expected in 3 million or, with extrapolation of the coverage to all cities, 9 million people. The effects should be concentrated in the CCEE and NIS, since annual mean levels of SO_2 were found to exceed 100 μg/m^3 only in the cities of these countries.

studies from Sweden and the United Kingdom indicate that asthma prevalence is on the increase [27, 28]. Genetic predisposition and a sensitization to allergens (including environmental allergens such as biological contaminants in indoor air) are important determinants of the clinical disease. Some 200 organic and inorganic compounds are known to induce or exacerbate occupational asthma [29], which is a rapidly growing occupational disease in industrialized countries. The role of air pollution in asthma is still not clear; while aggravation of the existing disease seems to be related to several air pollutants, the question of whether air pollution increases asthma prevalence remains unresolved [30].

The respiratory system is the primary target organ of air pollutants. The volume of air inhaled regularly (about 6–7 litres per minute at rest) causes pollutants at relatively low concentrations to penetrate the respiratory system in considerable quantities. The spectrum of possible effects ranges from temporary, reversible changes in pulmonary function, through episodic symptoms that restrict normal activities, to permanent respiratory dysfunction and clinical forms of chronic respiratory disease [31]. The most severe effects may increase respiratory mortality in the most susceptible groups of a population. Epidemiological studies have provided evidence for each of these effects, and this is summarized in Chapter 5. In Boxes 18.2–18.6 this evidence is combined with the exposure estimates derived in Chapter 5 to provide an approximate assessment of the health impact of major air pollutants. The estimates should be treated with caution, however, because of uncertainties in the data and in the underlying assumptions.

Since the analysed ambient air pollution data cover only part of the Region, two exposure estimates for the population are considered. In one, the population exposed to levels over a selected threshold is assumed to be limited to the residents of cities with air pollution data that show such levels. This should be considered as a lower limit of the exposure estimate, as one can expect that data are lacking from several cities with heavy air pollution. The other estimate is based on an extrapolation of the information on air pollution, assuming the same population distribution of exposure among residents of all areas (with and without data) in the European Region west of the Urals. In many cases, such extrapolation is likely to overestimate the real pollution situation since measurements are, in general, more common in the more polluted cities. This estimate should therefore be taken as an upper limit for the range of exposure.

The estimates of the effects of individual air pollutants are presented separately. This allows the health burden to be associated with particular types of contaminant and sources of air pollution. In most cases, however, populations are exposed to mixtures of pollutants, and the effects on health of the mixture may not be a simple sum of the effects of individual pollutants. Different environmental conditions may result in different patterns of respiratory morbidity. For example, a high prevalence of bronchitic symptoms in children in Leipzig was associated with high particulate pollution levels in the city, while a high prevalence of asthmatic symptoms in Munich was attributed to aeroallergens, possibly linked with pollution from road traffic, which is much more intensive in the western than in the eastern part of Germany [47,48].

As the estimates presented in Boxes 18.2–18.5 and Table 18.1 indicate, a rather substantial population is exposed to ambient air pollution at concentrations of concern to health. Estimates of the consequences for health indicate that this may cause a significant number of respiratory disorders. Currently, exposure to particulate pollution seems to produce the greatest effects. In most cases, however, the symptoms are mild and the most common effects on pulmonary function are small and transient; their clinical relevance is not clear. But recent epidemiological evidence indicates that even relatively low levels of air pollution (mainly suspended particulate matter and SO_2) may promote serious health effects, including the

Box 18.3: Suspended particulate matter (SPM)

Several studies from Germany, Italy, the Netherlands and Switzerland [37–40] indicate that acute lower respiratory tract morbidity in children is associated with particulate pollution at daily levels around 150 μg/m^3. On the basis of these reports and the results of several studies conducted in the United States, one can expect a 30–50 % increase in respiratory morbidity following a day with 24-hour concentrations of total SPM exceeding 120 μg/m^3. In European cities providing data for the analysis presented in Chapter 5, over 95 % of residents (29 million people) were exposed to such concentrations for at least a few days a year. Taking account of the frequency of such events it can be estimated that, depending on the relative risk estimate, 7–10 % of all respiratory disease episodes in children living in towns with total SPM data can be attributed to high, short-term total TSP levels. In the cities most frequently exceeding 120 μg/m^3, over 21 % of respiratory disease episodes in children are estimated to be attributable to pollution. If children living in European cities have an average of four episodes of respiratory symptoms or illness per year, as is indicated by Swiss data [40], 2–3 million such episodes can be expected in those cities with data on total SPM pollution. These estimates increase tenfold (to 22–31 million episodes of respiratory illness in children per year associated with pollution) if the pollution data are extrapolated to all cities in the Region west of the Urals.

Several studies on the association between daily mortality and air pollution allow one to assume a 4–7 % increase in risk of death among older adults on days with levels of total SPM over 120 μg/m^3. Calculations similar to those for morbidity indicate that, on average, 0.9–1.6 % of deaths can be precipitated by the excess pollution in all cities for which data are available, with the proportion reaching 3.4 % in the most frequently polluted towns. With an average mortality of 1000 per 100 000, this would result in 3000–5000 deaths per year in the cities with data, or 27 000–48 000 deaths if the exposure distribution is extrapolated to all European cities west of the Urals.

Chronic effects include a 3 % decrease in average levels of pulmonary function per 50 μg/m^3 of annual average total SPM concentration over 60 μg/m^3 [41]. The results presented in Chapter 5 indicate that lung function may be reduced in over 60 % of residents of cities with data, with the changes exceeding on average 2 % of a normal level in half of this group (9 million people). In the cities with the highest observed pollution levels, the decrease may exceed 5 % of the normal level; this can be expected in Barcelona, several cities of northern Italy, Sofia and Ruse in Bulgaria, and Lithuanian cities (4.5 million people or 15 % of the population with data).

A prospective study in California [42] found that the risk of obstructive airways disease was increased by about 1.3 times and the risk of asthma by 1.7 times per 1000 hours with total SPM levels over 200 μg/m^3 in a ten-year period. Since data on one-hour total SPM concentrations were not available for this analysis, these risks are assumed to be associated with 100 days per year with 24-hour total SPM concentrations exceeding 150 μg/m^3. This is probably a conservative estimate, but it is necessary to consider the possible interaction of total SPM with other pollutants, such as oxidants, in the exposure of the Californian population studied. Such a situation was recorded for over a quarter of the residents of European cities with data on total SPM. On average, 7 % of all cases of obstructive airways disease and 15 % of asthma cases might be attributed to exposure to total SPM in these cities, the proportions reaching 11 % and 23 %, respectively, in those Lithuanian cities with the greatest part of the population exposed. Assuming that the annual inci-

Box 18.3: Suspended particulate matter (SPM)

dence of obstructive airways disease is 8 new cases per 1000 population, and that of asthma 4 cases per 1000, then an estimated 18 000 new cases of obstructive airways disease and 18 000 new cases of asthma per year can be attributed to the excess total SPM in cities with data. These cases are expected to occur in Bulgaria, the Czech Republic, several cities of northern Italy, Lithuania and Romania. If the data are assumed to be representative for all European cities, the expected number of new cases of obstructive airways disease and asthma attributable to total SPM exposure increase to 176 000 and 183 000 per year, respectively. When the lower limits of the confidence intervals for the relative risk estimates from the California study are considered (1.11 for both types of disease) total SPM exposure could account for at least 2.8 % of cases of obstructive airways disease and asthma.

Box 18.4: Nitrogen dioxide (NO_2)

Several epidemiological studies indicate an increase in the incidence of irritant symptoms (eye irritation, sore throat and phlegm) and transient decreases in pulmonary function in the days with increased NO_2 levels (see Chapter 5). Lower respiratory tract illness in children, provoking a medical visit, is a more serious effect. Based on a study from Germany [39] it can be assumed that the incidence of lower respiratory tract illness increases by 30–50 % in days with mean NO_2 concentrations over 150 μg/m^3. According to the analysis presented in Chapter 5, about 23 % of the populations in cities with NO_2 data experience an average of 16 such days per year. The proportion of episodes of lower respiratory tract illness that can be attributed to NO_2 is therefore estimated to be 0.3–0.5 % in children of all cities in the Region west of the Urals. For Belgrade, with 88 days per year of high NO_2 levels, the proportion of cases of lower respiratory tract illness attributable to NO_2 pollution episodes reaches 11 %. If, on average, there are 25 cases per 100 children per year,[a] then 17 000–29 000 illness episodes per year can be attributed to increased levels of NO_2 in cities with data. If the exposure in the remaining cities is similar, the total number of cases in children attributable to high NO_2 pollution should be in the range 58 000–99 000 per year.

Based on an analysis of data from a national study conducted in the United States [43] one can expect a 2–5 % lower level of pulmonary function in populations exposed to an annual mean level of NO_2 exceeding 60 μg/m^3 than in residents of less polluted areas (a 5 % decrease for each additional 40 μg/m^3). The available exposure information indicates that over 17 million people live in cities with such NO_2 levels; this can be assumed to be the minimum number of people affected. When the exposure situation is extrapolated to all cities in the Region west of the Urals, the number of people with decreased pulmonary function rises to an estimated 60 million. The percentage change that indicates a clinically adverse effect can vary between groups and situations [31].

[a] Braun-Fahländer et al. [40] quote an incidence of 50–100 episodes per year of respiratory disease with breathing difficulty; a conservative estimate would be that half of these are episodes of lower respiratory tract illness.

precipitation of death, in the most susceptible groups of a population [19,50].

In considering the impact of environmental factors on the respiratory system, the role of indoor air pollution must be emphasized, since people spend a substantial part of their lives indoors and exposure to several factors occurs mainly indoors. Energy conservation measures may be associated with low rates of air exchange and increased concentrations of contaminants. The effects of involuntary smoking on the respiratory health of children are probably the best recognized and have been extensively illustrated in recent reviews [3,44]. Exposure to nitrogen oxides may also increase the frequency of respiratory illness in young children. Issues of emerging importance include the biological components of indoor air pollution, which may increase allergic sensitization [51]. Significant determinants of this type of pollution are building construction and ventilation. Warm, damp conditions promote the growth of biological agents (house-dust mites, fungal spores) producing allergens that may provoke allergic respiratory disease, especially in small children [52,53].

To summarize, current trends in air pollution exposure lead one to expect a general decrease in the incidence of respiratory health problems most clearly related to

Box 18.5: Ozone (O_3)

Several North American and European studies indicate that the risk of acute episodes of cough and eye irritation in children can be about twice as great during days with one-hour concentrations of O_3 exceeding 200 $\mu g/m^3$ than on days with lower concentrations; these effects were not seen in adults. In a sunny year such as 1989, between 38 % and 56 % of the European population was estimated to be exposed to O_3 concentrations over 200 $\mu g/m^3$ for an average of 3.8 days. The resulting proportion of symptoms attributable to this exposure could be 0.4–0.6 % with the lower, more realistic, estimate corresponding to the assumption that O_3 levels in large cities in northern parts of Europe do not exceed 200 $\mu g/m^3$. With an average of four episodes of throat and eye irritation occurring annually in each child, as indicated by a Swiss study [40], one can expect a surplus of 2.6–4 million episodes per year. In children living in the southern parts of Belgium, Luxembourg and the Netherlands and adjacent areas of France and Germany, where O_3 concentrations exceeded 200 $\mu g/m^3$ for 19 days (the maximum frequency estimated for 1989), 3–5 % of the estimated episodes during the year could be attributed to O_3 exposure.

In a year with low O_3 levels, such as 1985, the attributable proportion falls to 0.07–0.09 % of episodes.

The above estimates are likely to represent the upper limit of the effect. The relative risk of 2.0 is based on a study conducted in a summer camp where children spent most of the time outdoors and some were involved in exercise, increasing the respiration rate. If a more conservative risk estimate of 1.5 is applied, the attributable proportion falls to 0.20–0.29 % in a sunny year and to 0.03–0.05 % in a normal year. The symptoms are rather mild, and the small (1–4 %) transient changes in pulmonary lung function connected with exposure that were observed in several studies (see Chapter 5) are of uncertain clinical significance.

A cross-sectional analysis [43] has indicated that one can expect a 2–4 % decrease in pulmonary function in people aged 6–24 years and living in areas with long-term average O_3 concentrations of 120–140 $\mu g/m^3$. The percentage of the European population experiencing such exposure rose from about 3 in 1985 to 27 in 1989. To predict a resulting decrement in lung function in the population with sufficient confidence, however, the results would need confirmation by other studies.

winter-type smog episodes: lower respiratory tract illness or the aggravation of symptoms of chronic obstructive lung disease. On the other hand, the old problems may possibly be replaced by an increase in allergic sensitization and allergic diseases, including bronchial asthma, owing to more frequent exposure to allergens in the outdoor and (mainly) indoor environments. With the levels of summer-type smog pollutants rising, the incidence of allergic symptoms may increase in the Region.

Communicable diseases

The role of infectious diseases as a cause of death has fallen over the past 20 years in the Region as a whole, but mortality has been markedly above the average and has declined more slowly in the NIS. The main infectious diseases causing death are respiratory tuberculosis and various forms of septicaemia. In the Region in general, effective immunization programmes have substantially reduced the incidence of several infectious diseases. Diphtheria, however, has dramatically increased in recent years in some of the NIS, mainly the Russian Federation and Ukraine, most probably owing to the failure to maintain effective vaccination programmes.

Tuberculosis continues to present a major problem in the Region. In many European OECD countries, the historical decline in notification has ceased in recent years and in some the trend has reversed. Tuberculosis mortality is steadily increasing in a number of the NIS, while no decline is seen in most of the CCEE. The extent to which this general deterioration is due to social and economic factors, multiple drug resistance or, in some countries, the spread of infection with HIV is unclear and requires research.

Infant mortality rates from infectious diseases vary strikingly, ranging from 0.4 per thousand live births in the European OECD countries, through 4.7 in the CCEE, to 9.2 in the NIS. These differences indicate clearly that infectious disease in the first year of life is a priority area for intervention in the CCEE and NIS.

Box 18.6: Indoor air pollution

Several air pollutants present indoors may affect the respiratory system. Among them, the best evidence concerns the effects of environmental tobacco smoke and NO_2.

Available epidemiological data indicate that the risk of lower respiratory tract illness in infants increases by about 1.5–2.0 times if mothers smoke at home [44]. Assuming that 35 % of children have mothers smoking at home (based on the range of 20–50 % reported by nine countries) maternal smoking can be estimated to account for 15–26 % of episodes of lower respiratory tract illness in infants. With an annual incidence of 30 % among 7 million infants living west of the Urals, one can expect 300 000–550 000 episodes per year of lower respiratory tract illness to be attributable to this factor. This number would be greater if allowance were made for an increased risk (although to a lesser extent) of lower respiratory tract illness in older children.

The risk of various respiratory symptoms in schoolchildren (ranging from chronic cough or chronic wheeze to bronchitis), due to increased levels of NO_2 in homes equipped with gas stoves, was found to increase by some 20 % for an increase of 30 $\mu g/m^3$ NO_2 [45]. Assuming that about 50 % of housing in urban areas of Europe is equipped with gas appliances, some 9 % of respiratory symptoms can be attributed to indoor exposure to NO_2; the attributable risk ranges from 4 % to 14 % in situations of extreme exposure. If the average estimate is applied to 31 million children in cities in the Region west of the Urals, in which the incidence of chronic respiratory symptoms is 1–2 %, we can expect that 28 000–56 000 children per year may have chronic respiratory symptoms related to indoor NO_2 exposure.

The quality and availability of data on exposure to pathogenic microorganisms in drinking-water vary greatly across the Region; data are generally inadequate in the CCEE and NIS. Nevertheless, large populations in the CCEE, particularly in rural areas and more widely in the NIS, clearly suffer serious deficiencies in both the availability and quality of the water supply.

Waterborne hepatitis A infection remains a public health problem in several countries, with relatively high rates in Poland, Romania and the NIS. While imported cases of cholera occur sporadically throughout the Region, recent outbreaks of indigenous cholera have also been reported in the Russian Federation (1990 and 1991), Tajikistan (1993) and Ukraine (1991). Romania has reported cases in small villages in the Danube delta in each of the last four years. Several other types of waterborne gastrointestinal infection have been reported in the Region (due to *Salmonella*, *Shigella*, *Campylobacter* and *Cryptosporidium* spp. and *Escherichia coli*, for example).

Foodborne microbiological contamination has increased over the last decade, as shown by a dramatic increase in related diseases [54]. Salmonellosis is still the most important foodborne disease, even though it is no longer the leading gastrointestinal infection in some countries. In the Netherlands, for example, *Campylobacter* infections are three times more common than *Salmonella* infections; a similar trend has been observed in England, Wales and Scotland. Cases due to *E. coli* have increased in all countries. Localized increases have been recorded of infection with *Listeria monocytogenes* in some western European countries, of brucellosis in Turkey and of trichinellosis in Bulgaria, Poland, Romania and the former Yugoslavia.

The contamination of meat or freshwater fish with parasites is an increasingly recognized problem in the Region. Some two million people in the Russian Federation, for instance, may be infected with liver flukes; the prevalence is also high in endemic areas of Kazakhstan and Ukraine.

Underreporting of both foodborne and waterborne infections is certain to occur, since only the more severely affected people will seek medical treatment. Because national standards vary, data on levels of contamination that exceed them cannot be interpreted or used for extrapolation in the same way as has been possible for major air pollutants. On the basis of a study in the Netherlands, however, 130 million people in the Region may suffer from gastroenteritis annually (see Table 18.1): the cost of such infections in the Region may be in the order of billions[a] of US dollars each year.

For bathing water, links have been established between sewage contamination and gastrointestinal and upper respiratory tract symptoms [55]. Swimming in heavily polluted water carries the risk of contracting infections such as typhoid fever, shigellosis, leptospirosis and hepatitis A. The link between moderately contaminated water and minor infections is more contentious because these conditions are common and multicausal.

The Mediterranean basin, which receives waste and sewage from 18 countries, offers an example of the problems of bathing water pollution. These problems were recognized by the launching of the Mediterranean Action Plan. About 130 million people live in the area and 100 million tourists visit annually. The real size of the health effects has yet to be evaluated but preliminary estimates indicate that, for each million people at risk, 25 000–40 000 will have gastrointestinal symptoms caused by contaminated bathing water. Assuming that at least 100 million people a year bathe in the Mediterranean, a minimum of 2.5 million cases of gastrointestinal infections are to be expected annually.

Waste may contain hazardous biological agents; an accumulation of municipal solid waste that is not properly disposed of can lead to an increase in the number of rats or insects acting as carriers of infectious disease. Infection from direct contact with waste contaminated with microorganisms is limited but may occur in an occupational set-

[a] 1 billion = 10^9.

ting, particularly where people handle hospital waste containing sharps contaminated with hepatitis B or hepatitis C virus and, potentially, HIV. Pathogenic agents from improperly stored or treated waste may also contaminate drinking-water sources, and in this indirect way constitute a potential source of communicable diseases.

Inadequate housing conditions facilitate the transmission of pathogenic microorganisms. The proportion of dwellings that lack an indoor piped water supply or are not connected to sewage systems or septic tanks exceeds 80 % in certain of the CCEE and NIS, particularly in rural areas. According to the available data, as many as 110 million people live in dwellings without a piped water supply (see Table 18.1) and this includes 86 million people in the NIS. This may increase the risk of communicable diseases, through contact with microbiologically contaminated water and through lack of water for personal and domestic hygiene, especially in densely populated urban areas. The available data are too scarce, however, to provide an estimate of the contribution of these conditions to the incidence of communicable disease. Overcrowding and inadequate ventilation may increase the incidence of infectious (mostly respiratory) diseases but, again, quantification of the risk is difficult.

Thus, the incidence of communicable diseases (and resulting infrequent mortality) is closely related to the microbiological contamination of food and drinking-water in many parts of the Region. Deficiencies in urban and rural development that affect sanitation and housing may also have a significant impact on morbidity from communicable disease. The most important health-related problem with bathing water is microbiological contamination.

Injury and poisoning

Among males aged 1–44 years and females aged 1–14 years, injury and poisoning are the leading causes of death throughout the Region. In all European OECD countries except Finland, however, the mortality rates have been declining for most of the past 20 years. In the CCEE, mortality from injuries and poisoning is also declining but at a slower rate, having been higher than in western Europe by almost 100 % in males and 70 % in females for most of the past 20 years. The main causes of fatal accidents are road traffic accidents, suicide and self-inflicted injuries. Mortality rates due to poisoning are extremely high in the NIS, being more than three times those in the CCEE and over ten times those in western Europe.

Accidents at work, which result in 10 million injuries annually, are an important public health problem. They result in the deaths of about 25 000 workers in the Region per year, and cause permanent disability in 20–30 workers per 100 000 [56]. In high-risk occupations such as construction, 25 % of workers suffer accidents. The cost to the individuals affected and their families is immeasurable; that to society can be measured as a significant economic loss in the region of 1–4 % of gross national product.

The existing methods of assessing and registering accidents at home preclude a precise assessment of the overall size of this health problem. Domestic accidents largely affect the very young and the elderly, with most of the deaths occurring in the elderly. Data from one country indicate that a significant fraction (about 13 %) of fatal accidents in the home can be attributed to defects in housing construction.

The number of casualties from road traffic accidents is extremely high, with over 350 people killed and 6000 people injured daily. The number has increased in some of the CCEE since 1989. Countries with the highest mortality rates also have the lowest number of vehicles per person and therefore the highest number of deaths per 100 000 vehicles. The extent of accident risks, and of those risks affecting health, varies markedly between countries. Annual mortality rates from road traffic accidents range from 9 per 100 000 in the Netherlands, Norway, Sweden and the United Kingdom to 23–27 per 100 000 in Hungary, Poland and Portugal. Since most accident victims are young or middle-aged, the loss to society is particularly significant.

Estimates of the impact of these almost entirely preventable accidents on the population of the Region are given in Table 18.3.

Major industrial (including nuclear) accidents with large-scale environmental impacts on health are a serious potential hazard. All possible measures should be taken to prevent them and to mitigate the consequences of any such accidents that may still occur (see Chapter 16).

Effects on the nervous system and mental disorders

The prevalence of mental disorders ranges from 6 % to 22 % in various parts of the Region. The more severe forms, such as schizophrenia, have a frequency of 1.5–4.2 per 1000 population. Common mental disorders such as depression, anxiety, aggressive behaviour or alcohol abuse precede most suicides, which are the cause of 1.5 % of all deaths and 23 % of deaths due to injury and poisoning. Suicides are more frequent in males than in females by a factor of 2.8. Overall mortality due to suicide tended to decrease in the last decade, but that in males increased in several countries. The possible role of environmental factors in causing or aggravating these disorders is rather uncertain.

Several chemicals may be a hazard to the nervous system. An overview of environmental exposure to selected chemicals concludes that exposure to lead is at levels of concern for health in several parts of the Region. A threshold for the neurobehavioural effects of exposure to low levels of lead is difficult to identify, so it is prudent to assume there is no safe level [57]. Exposure to elevated levels of lead can still be caused by plumbosolvent drinking-water in lead pipes, flakes of old lead-containing paint, dust and contaminated soil, including the deposition of emissions from vehicles using leaded petrol and from lead in the air in areas around some industrial emission sources such as metal smelters and processing plants, particularly in the CCEE and NIS. Some two million people, including 400 000 children, are estimated to be exposed to levels of lead in ambient air exceeding WHO air quality guideline levels (see Table 18.1). The most important potential effect is impaired mental development in children [58], which can be expressed as a reduction in IQ scores by an average of 2–10 points in this group of 400 000. Also, it can be estimated that the number of children with a relatively high IQ (above 125) is reduced by approximately 20 000 in the affected areas of the CCEE. The loss of IQ points is likely to be most important at the lower end of the distribution, where it will push more people into the mentally subnormal range with consequent costs for individuals and society. Lead deposited on the soil around industrial hot spots (where levels of pollution are such that adverse effects on health are to be expected) persists in the environment, so the exposure of children and the related effects on their health may continue even after industrial emissions have been controlled. The exposure can be significantly reduced, however, by such means as appropriate soil recultivation and the exclusion of food production from the contaminated areas. The exposure of populations to lead, especially in eastern European cities, may be expected to increase with increasing traffic density unless unleaded petrol is introduced on a significant scale. This is indicated by the experience of western European countries from the 1970s, when leaded petrol combustion was the major source of lead exposure.

A risk of neurological effects may be linked with exposure to methylmercury. Blood levels of 200 µg/l may be associated with an approximate 5 % risk of mild neurological effects [59]. People who consume large amounts of fish may be exposed to high levels of methylmercury, but in a recent study in the Faroe Islands blood levels of methylmercury did not exceed 50 µg/litre even in those eating five fish meals a week [60]. The effects of methylmercury exposure on the developing nervous system are more difficult to assess. The lack of adequate data has not permitted the setting of a tolerable intake level. Thus, a potential but unquantifiable risk to the fetus and infant is associated with the pregnant woman and nursing mother who consume large amounts of fish contaminated with methylmercury.

Effects on the developing nervous system in babies might be expected from exposure to polychlorinated biphenyls in mothers' milk. Any such risk may be expected to be greater in population groups that consume large amounts of fish [61].

Several occupational factors may have an impact on the nervous system or on mental health (see Table 18.2). Noise at intensities exceeding safety levels is associated with a number of occupational activities and is estimated to affect 20–50 % of workers. Besides noise-induced hearing loss, exposure is known to produce psychological stress and sleep disturbances. Psychological stress significantly affecting the wellbeing of workers has become an important issue in increasingly competitive societies. Psychological overload (reported by 30–50 % of surveyed workers) time pressures at work and job dissatisfaction create strains that may also affect the somatic health of employees and contribute to cardiovascular morbidity [62].

In addition, emergencies can affect mental health; in the 1980s the term "post-traumatic stress disorder" was introduced to describe repeated findings in survivors of various types of catastrophe [63]. The chemical accident at Seveso was followed by an increase in cardiovascular mortality soon after the accident. This has been interpreted as most probably due to aggravation, under severe stress, of existing ill health [64].

Various psychosocial effects were described in the aftermath of the Chernobyl accident, both in the areas close to the accident and in other countries affected by the radioactive cloud that followed the explosion at the reactor. These effects ranged from anxiety and psychosomatic disorders among people living in the areas close to Chernobyl [65] to behavioural changes that led, for instance, to a decrease in the conception rate and an increase in induced abortions in some other populations [66,67].

Haematological effects

Methaemoglobinaemia in infants may be associated with exposure to nitrates in drinking-water exceeding 100 mg/l (the WHO guideline is 50 mg/l). Such concentrations of nitrates have been detected in several countries. In samples from 2000 locations in Romania, for example, nitrates exceed 100 mg/l in 17 %; in Bulgaria this value is exceeded on a regular basis. In Denmark, high nitrate concentrations have forced some small water supply systems to close.

Exposure to elevated levels of carbon monoxide (CO) with the formation of carboxyhaemoglobin may similarly impair the oxygen-carrying capacity of the blood. In addition to the aggravation of cardiovascular disease the effects, which can occur in domestic situations, range from mild drowsiness to unconsciousness and death. Home accident statistics from the United Kingdom report 200 deaths a year from CO poisoning. Data on nonfatal outcomes are limited. It seems likely that CO exposure may pose a similar hazard in other countries of the Region.

Musculoskeletal disorders

Musculoskeletal disorders are a frequent outcome of inadequate ergonomic conditions at work, including physical overload or strain. Such conditions are estimated to affect 16 % of workers in the European Union. In many countries, growing mechanization and automation is reducing the number of exposed people, but harmful work conditions may still prevail in certain parts of the Region (see Table 18.2). Some 5 % of workforces are exposed to vibration. Besides aggravating the effects of noise, vibration produces musculoskeletal disorders and affects the peripheral nervous system.

Birth defects and reproductive effects

Exposure to environmental contaminants before or after conception may affect reproduction by causing cell death or damage. This can lead to infertility in the adult or spontaneous abortion of the conceptus, and low birth weight, birth defects or later structural or functional defects in the offspring. The cause of a large proportion of birth defects is unknown [68] and it has been suggested that environmental exposure may play an important role [69].

Exposure to various environmental factors such as methylmercury, polychlorinated biphenyls and pesticides has been associated with reproductive effects. The diversity of prevalence of the birth defects selected for study may be attributed largely to differences in ascertainment among registries of birth defects. The role of other factors, however, including environmental exposure, cannot be ruled out. In some cases accidental environmental exposure to pesticides, for example, has been suspected of causing congenital malformations, as reported from Hungary [70].

Wellbeing

Besides effects on physical or mental health, various environmental factors may and do affect wellbeing.

Waste may directly affect some groups of people by diminishing the aesthetic value of the environment. The visibility of litter and waste is the main worry for local populations, both urban and rural; odours from waste disposal sites may also be detrimental to wellbeing. The perception of a health hazard, even without environmental contamination, may also be significant, as it impairs wellbeing by promoting anxiety. The problem of anxiety induced by misunderstanding or uncertainty about risks also applies to other environmental factors, particularly radiation.

To a large extent, living conditions determine the feeling of wellbeing. In general, the population of the Region does not suffer from obvious, severe deficiencies of housing as seen in other parts of the world, where massive shanty towns surround large cities and inner cities show gross deterioration. The Region has the problem of homelessness, however, although statistics are not always available. This problem can be expected to increase, owing to the greater mobility of people within and between countries and the unsatisfactory economic situation in many of them, as well as the influx of war refugees in some countries. The average space per person in houses in the Region usually exceeds minimum hygienic requirements although, in some of the CCEE and NIS, this average may be very close to or less than the minimum. As well as facilitating the spread of communicable disease, overcrowding is a potent cause of stress.

Recreational activity can also be an important factor for wellbeing. Physical exercise may promote a feeling of wellbeing, accompanied by measurable improvements in physical fitness.

The frequency of complaints about noise indicates that a significant proportion of town residents in the Region feel that it affects their wellbeing and quality of life (see Table 18.1). Road traffic is the major source of residential noise, but people increasingly complain about the behaviour of neighbours, and this is a much more difficult source to control. The tendency over time shows a degradation: the percentage of the population exposed to levels above 65 dBA was estimated at around 15% at the beginning of the 1980s, and 26% by the early 1990s [71,72].

The main adverse effects of such noise are general annoyance, and disturbance of sleep and communication. Prolonged exposure may possibly have long-term consequences for health. Whether or not leisure noise, such as loud music, may permanently impair hearing is still unclear.

18.1.2 Global and transboundary effects

The potential health effects of possible global warming from the generation of greenhouse gases, or of stratospheric ozone depletion by chlorofluorocarbons and similar compounds, are discussed in Chapters 5 and 11. It is difficult to consider such effects in the context of existing differences in health status in the Region. The problem concerns possible effects in the future – even in future generations. In addition, it is the possible indirect effects on health of both global warming and ozone depletion that would be of greater importance. This is not to say that increases in ultraviolet B radiation, which may result from ozone depletion, will not increase the risks of developing skin cancer and cataract (Box 18.7) but these sequelae are preventable by simple measures. Indirect effects on food production, the distribution of vector-borne diseases and the creation of refugees from environmental disasters, for example, would be far more difficult problems to tackle.

Other transboundary issues, such as acid deposition and the pollution of river basins, are of more obvious and immediate environmental health concern but also have possible long-term effects on human health. Major rivers such as the Rhine and the Danube, and hundreds of smaller rivers that either cross national frontiers or form natural boundaries, require joint management by all the countries concerned to protect the availability and quality of water supplies. Such management must take account of the vulnerability of downstream populations to uncontrolled activities in the higher reaches of such watercourses. Inland lakes and seas

Box 18.7: Ultraviolet (UV) radiation and cataract

In 1988, 17 million people worldwide were estimated to be blind due to cataract. In the United States alone, some one million cataract operations take place each year. In addition to acute skin damage (erythema) and skin cancer, UV radiation can cause cataracts. Depletion of the stratospheric ozone layer by chlorofluorocarbons and similar compounds results in an increase in the UVB 280–315 nm component of solar UV radiation reaching the earth; the amount of UVA (315–400 nm) remains much the same. Any such enhancement of terrestrial UVB from solar radiation will increase cataract formation and therefore blindness.

The interaction causing cataract is better understood at the chemical level than that leading to late effects on the skin, and is mediated by photo-oxidation of lens proteins among other processes. The action spectrum for cataract formation is still being investigated but, with existing solar energy distribution, 300–340 nm is most damaging.

On the basis of information on the dependence of the incidence of non-melanoma skin cancer on UV radiation [46], it can be calculated that a 1% decrease in stratospheric ozone will lead to about a 2% increase in UV radiation and somewhat more than a 2% increase in cataract. The effect would not be strictly linear, and it is estimated that a 10% or 50% decrease in ozone would cause an increase in cataract formation of 24% or 400%, respectively.

It is thought that during the next decade the daily dose of erythema-causing UVB may increase by up to 6% in the Northern Hemisphere (at 35°N), depending on the season, as a result of ozone depletion. It may be assumed that cataract induction will increase by up to 10% as a result, unless preventive measures are adopted.

Everyone is susceptible to cataract induction, and skin pigmentation is not a protective factor. Thus, everyone should adopt precautions to limit exposure, such as wearing glasses and wide-brimmed hats and avoiding the midday sun. Diet could be a sensitizing or a desensitizing factor; for example, vitamins C and E seem to provide protection against the photo-oxidation of proteins and thus cataract formation. Drugs such as chlorpromazine are known to be capable of enhancing cataract formation in the presence of UV radiation.

with coastlines shared between two or more countries also require joint management for the protection of water supplies, fishing resources and recreational waters, all of which are important for health and wellbeing.

International migration and its often associated homelessness also have short- and long-term implications for human health.

Another potentially important category of transboundary problem relates to trade, whether in contaminated food, industrial goods or hazardous waste. These activities may have adverse and more immediate effects on health. But for these problems, too, steps need to be taken now to change trade procedures and prevent continuing risks to health.

18.1.3 Effects on health of non-environmental factors

Environmental factors are only one of the known causes of health problems, and only rarely the single cause. This can be the case for communicable, foodborne or waterborne diseases, for example, or for the very specific, rare effects of exposure to high levels of radiation or toxic chemicals, usually resulting from occupational exposure or an accident. The registered occupational diseases are, in the vast majority of cases, fully attributable to environmental conditions at work.

Many factors are known to increase the risk of diseases linked to environmental exposure. Probably the most important is tobacco smoking. Active smoking at least doubles the risk of chronic obstructive airways disease and significantly affects lung function. In populations where smoking prevalence exceeds 40%, the proportion of this disease attributable to it approaches 30%. This exceeds, by at least a factor of two, the maximum contribution of urban air pollution. In addition, tobacco smoking has been recognized as a significant risk factor for cancer at various sites, and the elimination of smoking is estimated to have the potential to reduce mortality from such cancer by 30% (for cancer of the pancreas) to 90% (for lung cancer in males) [14]. Smoking is known to interact with some types of environmental exposure. For example, as previously mentioned, smokers exposed to asbestos or radon have a greater risk of lung cancer than nonsmokers. A part of the excess mortality in males is interpreted as resulting from the difference in smoking prevalence between the sexes [73]. To a large extent, the unfavourable trends in cardiovascular and cancer mortality observed in middle-aged men in the CCEE and NIS can also be attributed to smoking.

Certain types of cancer may be associated with alcohol consumption, as is a significant proportion of injuries and deaths caused by accidents in road traffic, the home and the workplace. In such accidents, the external environmental conditions combine with people's reduced ability to cope with them.

Dietary factors (including fat, fibre and vitamin intake) are crucial in the etiology of cardiovascular disease and may also be important contributors to major types of cancer, particularly of the stomach, colon, rectum and breast.

The relationship between inequalities in various indicators of health status and socioeconomic factors are discussed in Chapter 4. Poor socioeconomic status is likely to be accompanied by poor lifestyle habits and quality of the environment. Extreme poverty is associated with restricted access to adequate food, water, housing and health services; with living in highly polluted urban areas; and with a lower level of education. The last of these influences the choice of lifestyle, the understanding of hygiene and the use made of health care services. There are strong and obvious associations between poverty and health. While poverty is a less severe problem in the European Region than in some other parts of the world [72] the proportion of people living close to or even below the social minimum income level is considerable in many countries.

This situation may be aggravated in some areas of the Region by economic recession and unemployment, social change and the unstable political situation, which in extreme cases has resulted in war. Inadequate social support systems to assist people in these circumstances can result in a significant deterioration in their health. Ineffective preventive medicine and health services may have the same effect. An example is the dramatic increase in diphtheria incidence in some of the NIS. Economic deterioration in a country may also reduce the ability of government organizations to protect the population from exposure to environmental health hazards.

18.1.4 Discussion

According to the existing data presented in Chapters 5–17, several environmental hazards occur at levels of concern to health in the European Region. Tables 18.1–18.3 summarize the extent of the estimated exposures. The analysis has emphasized measurable data and recognizable effects and, wherever possible, the data have been extrapolated to entire populations. The data presented in Table 18.1 reflect an important difference between the monitoring of air and water pollutants for assessing population exposures. Local monitoring of ambient air pollution provides an index of exposure and a basis for assessing the related risks to health. The equivalent – monitoring of surface waters – although relevant to a greater proportion of the population, gives little information about actual exposure to pollutants in drinking-water. In general, the monitoring of water quality is concentrated on the early stages of the supply system and is aimed at anticipating and controlling exposure and reducing risks through subsequent management, rather than evaluating actual exposure and effects. Thus, exposure–effect data are even more limited for water pollutants than for air.

The precision or uncertainty of the estimates depends on the quality and availability of the data, as well as on the validity of the assumption described earlier in this chapter. Even allowing for the considerable uncertainties, the estimates indicate that a substantial proportion of the population of the Region is exposed to environmental factors that are a potential risk to some aspect of health. The most common outcomes are mild illnesses, which are difficult to register by existing systems. Deaths, on the other hand, are well registered in most countries and provide the main basis for comparisons of health status. Fatalities are rarely attributable to environmental exposure, except in the case of accidents. The magnitude of the impact of environmental conditions on the health of the population of the Region, in terms of morbidity, is hard to estimate at present.

As a number of uncertainties remain about exposure patterns and effects on health, no assessment can provide a complete and exact picture. In particular, local environmental problems are not sufficiently documented and a number of hot spots have therefore probably not been recognized. Although hot spots may significantly increase the risks to a large number of people, their impact may be diluted to the point of concealment in overall population data. Further, the range of health effects considered may be limited owing to a lack of appropriate monitoring data and/or insufficient quantitative risk assessment of certain potential hazards [14]. For example, the extent of population exposure to potentially carcinogenic air pollutants such as PAH is impossible to assess, although estimates of their emissions to the environment or of their ambient concentrations may be known in selected areas. The recent developments in the methodology of environmental health assessment, including molecular biomarkers, promise to provide better tools for estimating exposure and detecting early health effects. An example of this is provided by a study conducted in Poland [74] where a higher rate of genetic alterations in somatic cells was observed in people living in Silesia, a heavily industrialized region, than in predominantly rural control areas. Intensive research work is also being carried out to assess the possible role of such genetic changes in the etiology of cancer [75]. These developments may help to resolve the present difficulties in establishing a causal relationship between long-term, low-dose (and often ill-defined) exposure to environmental agents and the occurrence of various common types of cancer, the cause of which is probably multifactorial. A small contribution by the environment in public health terms may nevertheless mean that environmental factors affect the health of a large number of people. Work is also needed to identify vulnerable subgroups in the population and elucidate the basis for their increased susceptibility to environmental agents. In addition, the extent to which such groups are unprotected by existing guidelines needs to be established.

The estimates of people's exposure to environmental factors and the related effects on their health (presented in Tables 18.1–18.3) indicate a number of environmental hazards that potentially affect the health of the Region's population, in addition to the important effects of lifestyle or socioeconomic factors. Recent experience indicates that much environmental exposure, and the morbidity related to it, can be reduced.

As far as anyone knows, the dominant risk factors for the most common severe diseases, such as cardiovascular diseases and most types of cancer, are related to individual characteristics or to lifestyle, including smoking habits and diet; certain occupations may also be important determinants. Mortality from these diseases is also inversely correlated with national income. These factors seem likely to be major causes of the differences in mortality between countries in the eastern and western parts of the Region. The state of the environment, however, can be an important determinant of morbidity and have a positive or negative influence, even if indirect or secondary, on the development of many other diseases. Assessing the risk attributable to environmental factors is the first step in risk management to promote an environment supportive to health in the Region. Better information on population exposure and better understanding of the links between health and environment are needed to reduce uncertainties in risk assessment.

18.1.5 Conclusions

The first part of this chapter has provided an integrated account of the effects on health of environmental exposure in the Region. In so doing, it has taken account of the interaction of the environment with personal, social and economic influences. The conclusions reached, when read with the recommendations at the end of this report, should provide a framework within which each Member State can identify its own environmental health priorities. The European Region contains over 850 million people, stretches from Greenland to the Pacific Ocean, and embraces a rich variety of cultures, terrains and climates and different stages of socioeconomic development. It would be vain to expect that a single set of priorities would be relevant to all. The provision of a universal, safe and convenient water supply may well be the top priority in one Member State, radon exposure in buildings in another, and the problems of rapid urbanization or inner city decay in a third. Nevertheless, a number of the issues that have emerged from the Concern for Europe's Tomorrow assessment are of such actual or potential importance to so many people in the Region that, in the interests of equity and solidarity, they are considered worthy of the urgent attention of all Member States.

Lack of information about environmental health

Lack of comparable data of an appropriate quality is a major obstacle to priority setting and environmental health management in the Region. A set of core environmental health indicators needs urgently to be agreed and developed for use on a Region-wide basis. This will help in the assessment of environmental effects on health and the formulation of feasible interventions to improve both environment and health. In addition, better information for the public is needed to promote understanding of environmental health risks and priorities.

Microbiological contamination of water and food

Without ready access to a supply of safe water 110 million people in the Region, principally in the CCEE and NIS, are at risk of serious health problems; the situation is aggravated by poorly maintained distribution systems and lack of water treatment plants. The microbiological contamination of food is a more general and increasing problem in the Region. Contamination originates principally from the farm, but can occur at any stage from production to consumption.

Death and injury due to accidents

When considered together, accidents on the road, at work and in the home are the largest single cause of death and disability among young people in the Region, with a correspondingly heavy burden of social and economic loss to society.

Although behavioural factors are important, appropriate and practicable environmental interventions to reduce accidents are available. In its *World development report 1993*, the World Bank [76] introduced a measure for the burden of disease that takes account of disability as well as loss of life expectancy: the disability-adjusted life year (DALY). According to this approach, 473 million DALYs of disease burden per year are attributable globally to selected environmental threats. Of the 50 million of these that can be averted by feasible interventions, the burden due to road traffic and occupational accidents comprises the largest number, 22 million. Accidents in the home were not specifically included in the World Bank's analysis but here, too, there is scope for prevention.

Major technological accidents capable of causing severe environmental effects on the health of large numbers of people are a serious potential hazard. The principal need is to reduce the likelihood of their occurrence. Accident prevention should be built into the design and operation of all potentially hazardous installations, and backed up by adequate resources for proper maintenance and repair, including trained staff. Finally, it is essential that contingency plans be developed to deal with any accident that may still occur.

Air pollution

Although emissions of particulate matter (including lead) and SO_2 have been reduced in many parts of the Region, they still create unacceptable levels of urban air pollution, particularly in some southern European cities and the CCEE and NIS. The rapid expansion of road traffic throughout the Region is increasing air pollution from nitrogen oxides, volatile organic compounds (with resulting formation of ozone) and, where unleaded petrol is not used, lead. Thus winter and summer types of smog still occur.

More attention should be given to the effects on health of indoor air pollution. The effects of environmental tobacco smoke, especially on the health of children, and of radon are of particular concern.

It is estimated that some hundreds of millions of people may be exposed to air pollutants at levels exceeding the WHO air quality guidelines. In most cases, the exposures relate to urban populations and occur in short episodes. Associated health effects are usually mild and restricted to transient respiratory symptoms. In some susceptible people, however, the effects may be more severe.

Road traffic

While the impact of energy production and industry on environmental health is understood, the impact of road traffic is less well acknowledged. In addition to the mortality and disability due to accidents on the road and the increase in air pollution related to road traffic, the growth in the number of private motor vehicles causes increasing noise, congestion and delays in most cities in the Region. Although these effects on physical and mental health must be balanced against the advantages of private motor cars, overall transport policies are needed that take full account of environmental health.

Housing and urban development

In a Region where more than two thirds of the population live in towns, the complex environmental problems of the urban situation deserve urgent attention. In addition to urban noise and traffic, problems include rapid urbanization without proper infrastructures in the south, and inner city decay in the west, with substandard housing and homelessness. Inadequate municipal waste disposal is a public health problem in some parts of the Region, while lack of facilities for recreation impairs the health and well-being of many city dwellers. An integrated approach is needed that builds on the WHO Healthy Cities project.

Occupational health

The health effects of occupational exposure, in contrast to other types of environmental exposure, can usually be anticipated in certain types of industry or workplace. Appropriate preventive measures can reduce health effects, including accidents, although it is rarely possible to eliminate some hazards completely. Just over half the Region's workforce has no access to specialist occupational health services; this is a major impediment to achieving such improvements Region-wide.

Global issues

Finally, there is the need to consider issues that – even if they have little impact today – may, if not checked, exert a significant impact on the health of future generations in the Region.

Some of these environmental health issues are of global concern: possible climatic change due to the production of greenhouse gases and ozone depletion by chlorofluorocarbons. While the industrialized countries in the Region clearly have a role as major contributors to these environmental effects, the impact of these changes on the health of the overall population is at present uncertain.

Predicting climatic change and the effects of global warming on health is difficult. Nevertheless, the indirect consequences of any such changes on human health by the end of the next century are likely to be great. They could result, for instance, from adverse effects on food production, changes in the distribution of vector-borne diseases, and increased migration [71].

Changes in terrestrial levels of ultraviolet radiation, as a result of the continuing depletion of stratospheric ozone, directly increase the risks of skin cancer and probably of cataract (although both are preventable by simple protective measures) and may indirectly affect human health by disturbing the normal food chain (by inhibiting the growth of crop plants and phytoplankton). Changes in ultraviolet radiation could also enhance the effects of global warming.

Both these potential hazards to the health of future generations require action now, at least to prevent further deterioration.

18.2 Role of Economic Sectors

The first part of this chapter discussed the contribution of environmental factors to the causation of common diseases. The next step, a crucial one for the purposes of prevention, is to link environmental exposures and related health effects to economic activities. In general, the contribution of economic sectors to the environmental health burden in the Region can only be defined in qualitative terms; to go further would first require quantitative information on source emissions, resulting extent of exposure, and exposure–effect relationships. Such comprehensive data are largely lacking, even at the national level. In their absence, quantitative comparisons of the environmental effects on health of different economic activities cannot be made.

Countries need such comparative assessments to develop policies to improve environmental health. The more localized and specific a problem is, the more likely it is that the source will be readily identifiable and its environmental impact on health ascertainable. If an environmental agent has more than one possible source or an effect has multiple causes, however, apportioning responsibility can be very difficult. The difficulty can only increase in moving from local to national and then Region-wide situations.

In addition, all economic sectors provide considerable benefits to health, whether direct or indirect, by contributing to socioeconomic development. The need is to ensure a proper balance between the health benefits and detriments arising from an activity. However, the methodology for costing these benefits and detriments (particularly in the context of environmental health) as well as for assessing the expected health gains compared with the costs of intervention (at source or by means of environmental cleanup) is still rudimentary. Research is needed to develop methods that can be applied in a variety of circumstances.

The report of the WHO Commission on Health and Environment [72] and of its panels on energy, food and agriculture, industry and urbanization (including transport) addresses the question of the benefits of economic activities to, and their adverse environmental effects on, health in qualitative terms and in a global context. Rather than attempting to repeat or add to the reports, the following sections try to provide a European perspective on economic activities in the agricultural, energy, industry, transport and tourism sectors relevant to the main environmental health issues identified in the first part of this chapter.

18.2.1 Agriculture

Land used for agriculture comprises about 40% of the total in the Region, ranging from less than 10% in Finland to over 70% in Hungary, Ireland, Ukraine and the United Kingdom. In the European Union, farming makes a small and declining contribution to gross domestic product (GDP) (about 2–4% on average). The contribution is much higher in the eastern part of the Region, but has declined since 1985. The major environmental effects of agriculture (see Table 18.4) result from the introduction of intensive farming methods to increase the production of food and its availability at reasonable cost to the consumer.

Animal husbandry

Large-scale, intensive animal husbandry is accompanied by the widespread risk of contaminating animal food products with *Salmonella* or *Campylobacter* spp; related human gastrointestinal infections are increasing in many countries of the Region. The situation is not uniform. A few countries have eradicated, or are trying to eradicate, stocks of infected animals, and of course not all animal food production is of this intensive type. In addition, animal waste may contaminate water sources and add to their nutrient load.

Agricultural chemicals

Fertilizer and pesticide use have increased food production in recent decades, but have also led to diffuse contamination of large areas of soil and thence groundwater and surface water. The rates of application, and proportional productivity, vary widely in the Region (Table 18.5).

Fertilizers and manure are widely overused or misused, but the average figures given for countries in Table 18.5 may be misleading. The figure for the Netherlands, with a high proportion of agricultural land, cannot be compared with that for Italy, for example, where the proportion is only 30% and some areas such as the Po valley may be receiving far greater amounts of fertilizer per unit area. Also, the average rates of application for the former Czechoslovakia, Hun-

Table 18.4: Overview of significant environmental impacts from agricultural practices

Agricultural practice	Effects on environmental media			
	Air	Surface water	Groundwater	Soil
Intensive animal husbandry	Emissions of methane, nitrogen oxides	Emissions of silage effluent, organic matter and nutrients in water bodies (see organic fertilizers)	(See organic fertilizers)	Effects from spreading manure; application of silage high in heavy metal content leading to elevated soil concentrations Possible increased risk of contamination of animal food products, particularly with *Salmonella* and *Campylobacter* spp.
Fertilizers (organic, commercial and sewage sludge)	Ammonia volatilization, nitrous oxide	Organic matter in water bodies: nitrate and phosphate run-off leading to elevated nutrient levels, which can cause eutrophication of fresh and coastal waters	Possible contamination of resources, including drinking-water, by nitrate leachate and phosphate run-off	Accumulation of heavy metals (which may enter food chain), local acidification from overuse; deterioration of soil structure, imbalance in nutrients
Pesticides (insecticides, fungicides, herbicides)	Evaporation, spray drift, residues; possible long-range transport of pesticides	Leaching of mobile residues and degradation products, which may affect wildlife and fish, and drinking-water resources used by humans		Depending on type of pesticide, accumulation of persistent pesticides and degradation products, which may lead to contamination and leaching to groundwater; effects on soil microflora – use of broad spectrum pesticides, which may change bacterial soil structure and affect or eradicate non-target organisms

Source: Stanners, D. & Bourdeau, P. *(5)*.

Table 18.5: Annual nitrogen application rates to agricultural soil, 1990

Country	Nitrogen (kg/ha)		
	Fertilizer	Manure	Total
Albania	63.0	40.5	103.5
Austria	37.8	39.2	77.0
Belgium	129.2	122.7	252.0
Bulgaria	67.8	29.4	97.1
Czechoslovakia	90.6	41.8	132.3
Denmark	129.4	60.2	189.6
Finland	81.9	30.3	112.3
France	78.3	37.9	116.3
German Democratic Republic	105.4	60.9	166.3
Federal Republic of Germany	126.4	72.3	198.6
Greece	43.4	16.9	60.3
Hungary	84.2	25.3	109.5
Ireland	57.3	42.2	99.2
Italy	54.9	31.5	86.4
Luxembourg	142.9	89.3	232.1
Netherlands	243.8	203.6	447.4
Norway	108.8	73.2	182.0
Poland	66.5	34.4	100.9
Portugal	43.2	35.3	78.5
Romania	48.0	35.4	93.4
Spain	33.7	14.9	48.6
Sweden	65.1	25.9	91.0
Switzerland	33.6	47.5	81.1
Turkey	26.7	14.5	50.5
United Kingdom	83.4	40.7	124.2
USSR	32.0	11.0	43.0
Yugoslavia	34.1	23.9	58.0

Source: Stanners, D. & Bourdeau, P. *(5)*.

gary and Romania are not particularly high, but high levels of nitrate in water and cases of methaemoglobinaemia in infants have been reported in these countries.

In addition to these possible health effects, increased inputs of nutrients to fresh waters and to coastal seawaters may lead to algal blooms, which may sometimes cause toxic effects in bathers and in consumers of seafood from the area. In fresh waters, continued eutrophication may eventually lead to oxygen depletion. The economic consequences of these changes in water quality justify preventive action, even in the absence of pronounced effects on human health. It should also be noted that the use of ammonia fertilizers in some north-western countries of the Region may contribute directly to the acidification of soils and groundwater.

Adverse effects on health from occupational or accidental exposure to pesticides are well documented. The exposure of the general population to low levels of pesticides in drinking-water and food are not known to affect health. Very high levels of pesticide use are reported in some of the NIS, and a number of health effects have been attributed to exposure in areas around the Aral Sea, for example.

Irrigation

The area of irrigated land has considerably increased in the last 10–15 years, particularly in the semi-arid regions of the Mediterranean, the CCEE and the NIS. The CCEE have the highest percentage of irrigated land in the Region.

The adverse environmental effects of irrigation include the depletion of water supplies from upland areas, rivers and local artesian sources, and the salinization and alkalinization of soils by mobilization from deeper levels, which makes them unfit for agriculture or grazing. The area around the Aral Sea provides an all too clear example of what can be wrong with irrigation schemes, and what may result: desertification, loss of two thirds of the water inflow to the Sea, and the eradication of local fishing.

Another and more direct effect of irrigation on health, resulting from the diversion of rivers and the creation of artificial reservoirs, is the spread of human parasite diseases whose life cycle involves aquatic intermediate hosts. One of the most serious of these is a species of liver fluke, which has a prevalence of 40% or more in parts of Kazakhstan, the Russian Federation and Ukraine. Two million people are thought to be affected in the Russian Federation, with an estimated annual economic loss in excess of US $700 million.

Global climate change

Table 18.6 indicates the global sources of man-made greenhouse gases. Agricultural activities contribute significantly to the generation of methane and nitrous oxide, from anaerobic denitrification in soils and sediments with high levels of nitrate. Changes in agricultural practices have been suggested, including the more efficient use of nitrogenous fertilizers, recovery of animal waste, improved methods of rice cultivation and special diets for ruminants.

Trends

As mentioned, agricultural production has increased enormously in the Region in the last few decades, largely as a result of the intensification of agricultural and animal husbandry practices, particularly in northern countries. While the provision of adequate amounts of food at affordable prices is essential for health, the associated environmental effects have been serious and the potential implications for health significant. A better balance is needed between productivity and consumer safety.

There is evidence of change in this direction, particularly in the European Free Trade Area, and even a revival in some western countries of traditional or "organic" methods of farming. Traditional farming accounts for less than 1% of total activity, and has increased costs for the consumer. Public interest in such a development, however, can only increase pressure for changes in mainstream agricultural practices.

18.2.2 Energy

Table 18.7 summarizes the main effects of energy production and use. The combustion

Table 18.6: Percentages of total anthropogenic emissions of greenhouse gases from various sources, 1990

Sources	Greenhouse gas			
	Carbon dioxide	Methane	Nitrous oxide	Chlorofluorocarbons
Energy	80	26	9	–
Other industry	3	–	15	100
Deforestation/land clearing	18	–	17	–
Fertilized soils	–	–	48	–
Enteric fermentation	–	24	–	–
Rice cultivation	–	17	–	–
Landfills	–	11	–	–
Biomass burning	–	8	11	–
Animal waste	–	7	–	–
Domestic sewage	–	7	–	–

Source: Stanners, D. & Bourdeau, P. *(5)*.

Table 18.7: Overview of significant environmental effects of energy activities

Energy source	Effects on environmental media: Air	Water	Soil	Effects on human health
Fossil fuels	Combustion of fossil fuels → increasing levels of greenhouse gases → climatic effects	Electricity generation → thermal releases from cooling → raised water temperature	Deposition of acidifying compounds → raised soil acidity	Electricity generation and transmission cables → electric and magnetic fields→ possible human health impacts (see Chapter 11)
	Combustion of fossil fuels → emission of particulates, SO_2, H_2S (gas) NO_x, CO, CO_2, CH_4, small amounts of heavy metals and radionuclides (coal) → poor air quality, acid deposition and global warming	Mining activities → pressure on available water resources Gas leaks → explosions and fires (high leak potential) Coal mining → liquid mine waste (containing acids and salts) → contaminated water	Solid wastes and ash disposal from coal mines → contaminated water percolating through slag heaps → pollution of groundwater and soil	Noise from mines and power stations → disturbance to nearby settlements
	Gas leaks → explosions and fire	Coal washing → water pollution NO_x and SO_2 emissions → acid deposition → acidification and eutrophication of water bodies Oil spills (accidental and operational) and leaks → water pollution		
Nuclear power	Nuclear accidents → potential release of radioactive plumes	Uranium mining → contaminated underground water	Nuclear accidents → risk of soil contamination due to deposition from air	See Chapters 9, 12 and 17
		Mine tailing water → toxic metal, chemical and radioactive waste	Long-term storage of high-level radioactive wastes → potential contamination	
		Plant operation → thermal releases from cooling water and liquid emissions of radionuclides	Decontamination and decommissioning of nuclear power plants → potential contamination	
		Accidental releases → risk of contamination of water resources	Risk of accident during transport of spent fuels → environmental contamination	

Source: Stanners, D. & Bourdeau, P. *(5)*.

Table 18.8: Approximate relative emissions of pollutants from the main fossil fuels per unit of energy delivered

Pollutant	Fuel		
	Coal	Oil	Gas
Carbon dioxide	2	1.5	1
Sulfur dioxide	1–3	1.0	0
Nitrogen oxides	4	2.5	1

Source: Stanners, D. & Bourdeau, P. *(5)*.

of fossil fuels for energy production in power plants, industry and transport is the major source of urban ambient air pollution with suspended particulate matter, nitrogen oxides (NO_X), carbon dioxide (CO_2) and SO_2. In general, coal is the most polluting fossil fuel (particularly if its sulfur content is high) followed by oil; gas is the cleanest, producing far less SO_2 and particulates. Table 18.8 shows the approximate relative proportions of air pollutants emitted by the main fossil fuels.

Sulfur dioxide

About 90% of all SO_2 emissions result from fossil fuel combustion in power stations, central heating plants and industry, the highest emissions coming from sulfur-rich coal and heavy fuel oil. The levels of emission in the CCEE are very high in comparison to the scale of energy consumption because of their dependence on poor quality coal, along with the lack of control technology; the domestic use of coal also contributes. Emissions of SO_2 in the NIS are relatively the lowest because of the high proportion of natural gas used. In general, most western countries of the Region now have a reasonably balanced use of fuels, with adequate technological control of emissions.

Particulate matter

Coal combustion largely accounts for emissions of suspended particulate matter (particularly in the CCEE) although the use of diesel- and petrol-fuelled vehicles also contributes.

Smog

The combustion of fossil fuels is largely responsible for winter-type smog in urban areas, and for levels of SO_2 and suspended particulate matter that exceed the WHO air quality guidelines; these have potential adverse consequences for health, particularly the respiratory system. The effects are greatest in the eastern and some southern countries of the Region that use sulfur-rich coal. Technologies exist for controlling emissions of SO_2 and particulate matter, and the incorporation of such technologies in all new plants utilizing coal and oil will be an important element in achieving sustainable development.

Transboundary acid deposition

The generation of SO_2 and NO_X results in transboundary acid deposition. As mentioned above, 90% of SO_2 emissions arise from fossil fuel combustion, and about 30% of the total emissions of NO_X in the Region come from power and heating plants (about 20% of emissions in western countries and 40% in eastern countries). Fig. 18.1 shows the contributions of different sources to acid deposition. Significant reduction in NO_X emissions has not occurred on a Region-wide scale. Improved energy efficiency and conservation may prove to be more practicable options than the introduction of denitrification techniques or burners producing low levels of NO_X.

Global climate change

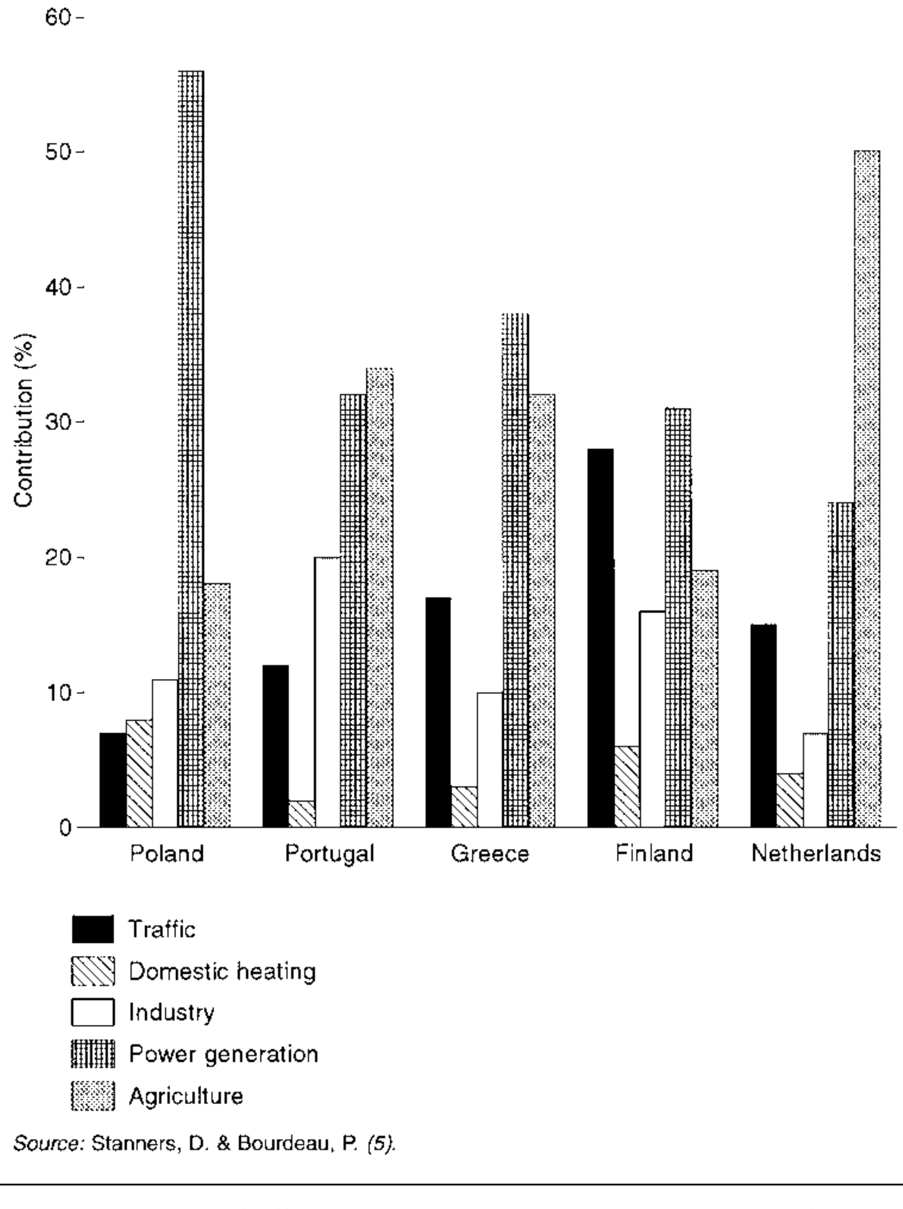
As mentioned, greenhouse gases such as CO_2 and methane may have important indirect effects on health by changing the global climate. About 80% of total CO_2 emissions come from energy sources; coal and oil contribute comparable amounts to the total in the Region. Coal production and leakage from gas distribution systems contribute significantly to methane emissions (see also the section on agriculture, p. 497). Improved energy efficiency and conservation are probably the most important tools for reducing emissions of CO_2. Another possibility is the use of alternative, renewable energy sources.

Nuclear energy

As discussed earlier in this chapter, the main risks to environmental health from nuclear energy are related to the possibility of accidents and the problem of high level radioactive waste disposal. Routine releases to the environment constitute a far smaller hazard to health than does exposure to natural sources of radiation such as radon gas.

Trends

Future emissions from fossil fuels in the Region will depend largely on changes in the mixture of fuels used to produce energy in different countries, and the extent to which control technologies are introduced where these are not already in place. Economic conditions, particularly in the countries in transition, make it likely that major changes



Source: Stanners, D. & Bourdeau, P. *(5)*.

Fig. 18.1: Estimated contributions of different sources to the potential acid deposition in five European countries, 1990

will be slow to take place. Energy efficiency has greatly improved in recent years in the western countries of the Region, whereas centrally planned economies had no incentive for such improvement because of subsidies.

Nuclear power is unlikely to develop much further in the near future; a few countries, such as Bulgaria and France, already meet most of their energy needs from this source. Of the possible renewable sources of energy, the most likely options for development seem to be wind, biomass, waste and landfill gas, but their contribution will remain minor in the short term.

It is estimated that energy consumption will grow by about 1 % per year across the Region in the next decade, depending on the pace of economic recovery from recession. Table 18.9 indicates the current and estimated future patterns of use. The increased use of gas is the most serious prediction; this would certainly reduce environmental effects on health associated with the energy sector.

18.2.3 Industry

Table 18.10 indicates the environmental pollutants associated with different types of industrial activity. In general the traditional heavy, energy intensive, air polluting industries (iron and steel, non-ferrous metals) predominate in the eastern parts of the Region, while the western countries have moved towards service industries. Chemical industries (agrochemicals, paints and pharmaceuticals) are of major importance in the Region; the potential environmental effects are primarily hazardous waste and accidents. The production of plastics increased substantially in western countries and the CCEE in the 1980s but is now slowing. Plastics manufacture is associated with low-level releases of solvents, but a more important environmental problem is the disposal of solid waste, ultimately including the end-products. At present, semiconductor (electronics) industries are largely located in western countries; they use a wide range of metals, acids and solvents, which may give rise to environmental hazards to health if there is leaching into drinking-water supplies.

The preceding section made clear that much of the environmental impact of industry is related to the use of fossil fuels as a source of energy. In the European Union, for example, about 25 % of total SO_2 emissions from fossil fuel combustion arise from industrial use. Fig. 18.2 illustrates the final energy consumption by industry in different parts of the Region. The average efficiency of fuel (and raw material) consumption has been higher in the established market economies.

Firm evidence linking the environmental health effects of particular environmental pollutants to particular industrial activities is limited, but it exists for certain heavy metals and arsenic, for example. For the great majority of industrial environmental pollutants, health effects may have been documented among people with occupational exposure (at levels 1–3 orders of magnitude greater than those encountered by the general public) or following accidents; nevertheless, there is no adequate evidence of effects on health from the low levels of exposure to in-

Table 18.9: Current and future shares of the main energy sources in gross consumption

Region	Percentage share, 1990				Estimated percentage share, 2005			
	Oil	Coal	Gas	Nuclear	Oil	Coal	Gas	Nuclear
EU	44	24	17	13	42	19	24	12
NIS	31	20	42	4	26	13	55	3
CCEE	24	49	20	4	21	35	37	3

Source: Stanners, D. & Bourdeau, P. *(5)*.

Table 18.10: Overview of significant environmental effects of industry

Industry	Effects on environmental media		
	Air	Water	Soil
Chemicals	Combustion of fossil fuels → many and varied emissions depending on processes used and chemicals manufactured → emissions of particulates, SO_2, NO_x, CO, CFCs, VOC	Process water, cooling water with organic chemicals, heavy metals (cadmium, mercury chromium), cyanide, suspended solids, organic matter, phenols, PCBs	Chemical waste
Paper and pulp	Electricity used → heat and steam → emissions of SO_2, NO_x, CH_4, CO_2, CO, H_2S, mercaptans	Process water with suspended solids, organic matter, chlorinated organic substances (dioxins, furans)	
Cement, glass, ceramics	Electricity used → heat and emissions of SO_2, NO_x, CO_2, dust, cadmium, chromium, lead, zinc (and CO, asbestos, fluorides)		
Iron and steel	Combustion of fossil fuels → emissions of SO_2, NO_x, CO, H_2S, PAH, lead, arsenic, cadmium, chromium, copper, mercury, nickel, selinium, zinc, PCDDs/PCDFs, PCBs, particulates	Process water with organic matter, oil, suspended solids, metals, benzene, phenol, acids, sulfides, sulfates, ammonia, cyanides, thiocyanates, thiosulphates, fluorides (scrubber effluent)	Slag, sludges, oil and grease residues, hydrocarbons, salts, sulfur compounds, heavy metals
Non-ferrous metals	Combustion of fossil fuels, electricity, heat → major local pollution with particulates, SO_2, NO_x, CO, H_2S, hydrogen chloride, hydrogen fluoride, chlorine, aluminium, arsenic, cadmium, chromium, copper, mercury, nickel, lead, magnesium, PAH, fluorides, silica, manganese, carbon black, hydrocarbons, aerosols (local exposure depending on the particular material being processed)	Scrubber water with metals; scrubber effluents containing solids, fluorine, hydrocarbons	Sludges from effluent treatment, coatings from electrolysis cells
Refineries, petroleum products	Combustion of fossil fuels (especially gas) → emissions of SO_2, NO_x, H_2S, hydrocarbons, CO, mercaptans, particulates, benzene, PAH and other toxic organic compounds	Cooling water with hydrocarbons, mercaptans, caustics	Often "hazardous" waste
Leather, tanning	Leather dust, H_2S, CO_2	Process water with effluents from the many toxic solutions employed	

Source: Stanners, D. & Bourdeau, P. *(5)*.

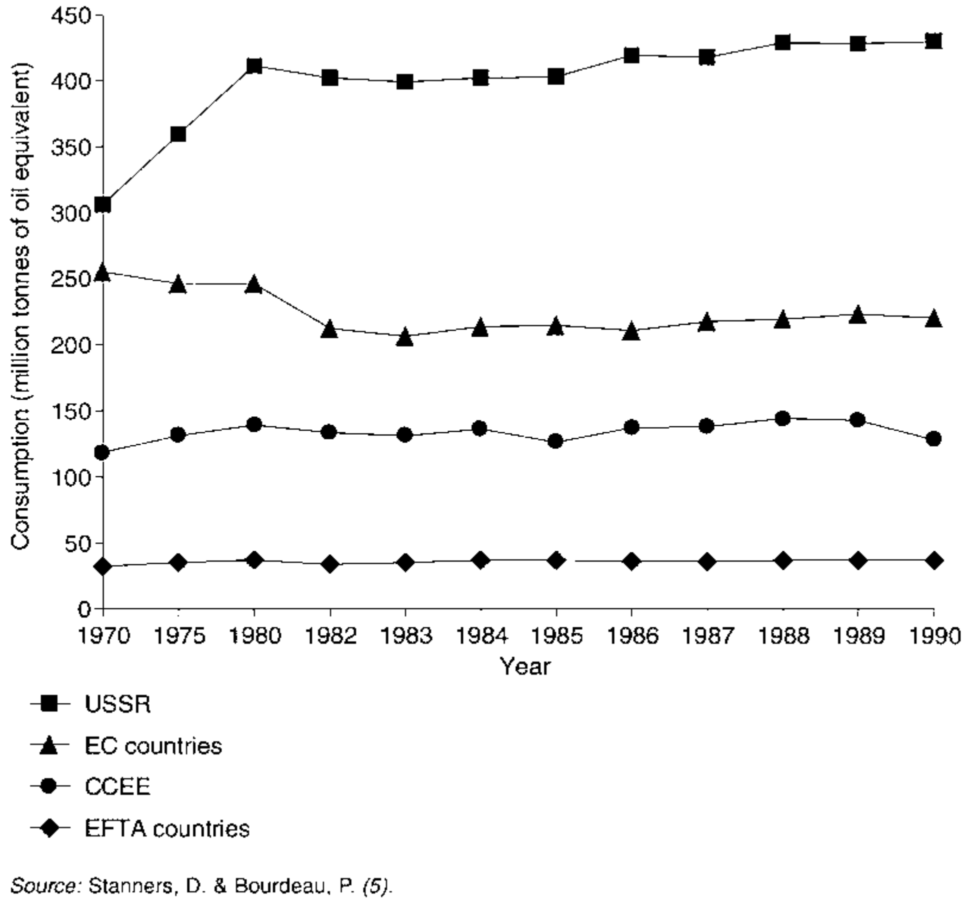


Fig. 18.2: Final energy consumption by industry, 1970–1989

dustrial pollutants in the general environment. Thus, while the potential for adverse effects from a variety of toxic chemicals remains and necessitates continued surveillance, the main focus for current environmental health concerns about industrial activities is related to hot spots of air, soil and water pollution, particularly with heavy metals.

Emissions to air

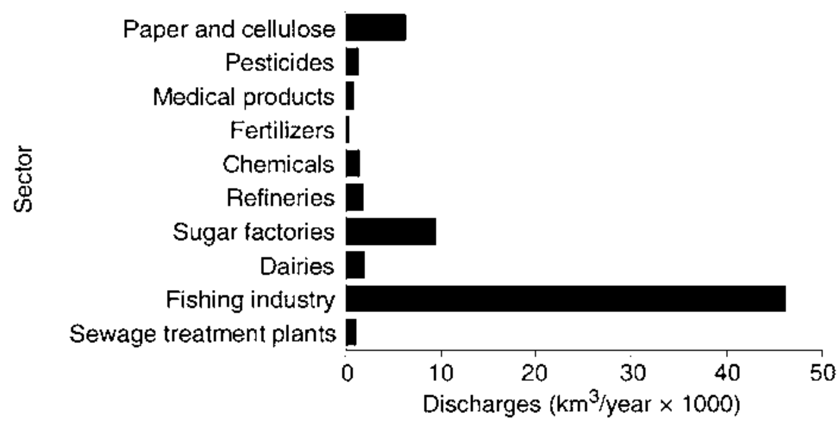
Not only is the proportion of heavy industry greater in eastern than in western countries of the Region (the former USSR was the world's largest producer of iron and steel) but many of the plants in operation were built when productivity had absolute priority, and measures to control emissions were not incorporated in their design. Thus some non-ferrous metal smelters in the so-called Black Triangle (in the Czech Republic, eastern Germany and Poland) and parts of Romania, for example, have produced levels of environmental contamination with lead that outweigh any contribution from road traffic. The contamination of soil with heavy metals will persist as a legacy of industrial pollution even after emissions have been controlled.

Ozone depletion

Industry is the source of ozone-depleting chlorofluorocarbons (CFCs) and halons, which are widely used as propellants and coolants. International protocols to protect the stratospheric ozone layer, by phasing out the production and use of man-made ozone-depleting agents, are in place and are likely to be further refined. In the short term, less damaging halocarbons are replacing CFCs as coolants; for the long term, non-halogenated compounds are the goal. It should be noted that CFCs are also important greenhouse gases.

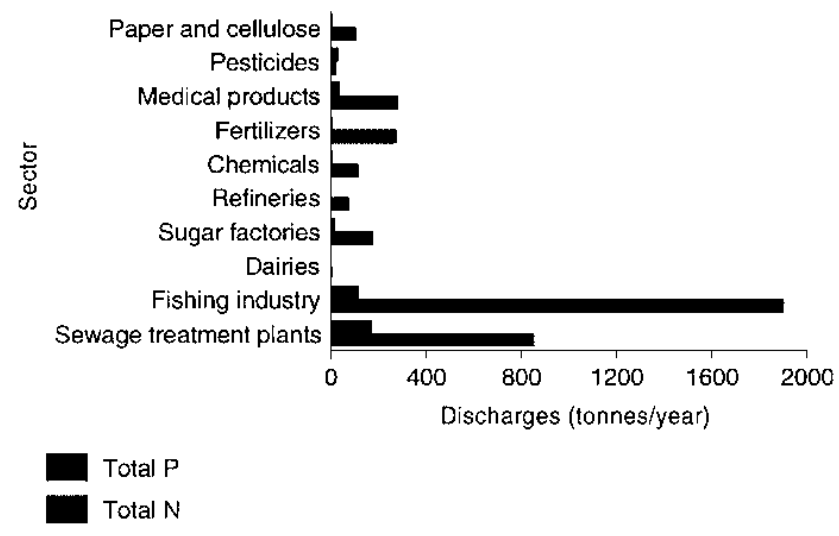
Industrial wastewater

Industrial discharges, particularly of organic chemicals and heavy metals, may also directly contaminate water. Data on discharges to water according to industrial sectors are scarce, but the Danish Environmental Protection Agency has published such information [77] (Fig. 18.3 and 18.4). In the European Union, industrial treatment of wastewater before disposal is common practice. Many large industries in eastern Europe would have adopted similar treatment, but its high cost and the economic difficulties of transition have increased discharges of industrial effluents into municipal waters, where there is no equipment to deal with such waste. The prohibitive additional costs involved may preclude the treatment and use of water sources for drinking. While potential effects on health can thus be avoided, the costs of industrial pollution have to be measured instead in fewer sources of drinking-water.



Source: Danish Environmental Protection Agency *(77)*.

Fig. 18.3: Discharges of wastewater by industry in Denmark, 1992



Source: Danish Environmental Protection Agency *(77)*.

Fig. 18.4: Discharges of nitrogen and phosphorus by industry in Denmark, 1992

Hazardous waste

The proper disposal of hazardous industrial waste (containing for example solvents, acids, oils, paints and heavy metals) is essential if health effects are to be avoided. In the European OECD countries more than 70 % of such waste is disposed of in landfill sites, about 8 % is incinerated and 10 % recovered. In the former USSR, however, waste management had much lower priority than industrial output; the NIS have many thousands of dumps of unprocessed industrial waste, which pose serious potential environmental hazards to health.

Accidents

The potential effects of major industrial accidents are well recognized, but this is perhaps not the case with accidents to workers during routine industrial operations. Nevertheless, these cause huge health and economic (3–5 % of gross national product) costs to society. The total annual average rates are 20–100 accidents per 1000 workers, of which about 10 % are severe and 1–3 % result in permanent disability. There are about 25 000 fatal accidents a year among the 400 million workforce in the Region (see Table 18.3). The risks vary between industries, and between similar industries in different countries. Scope for prevention already exists, and environmental factors (including hazardous machinery) are important determinants.

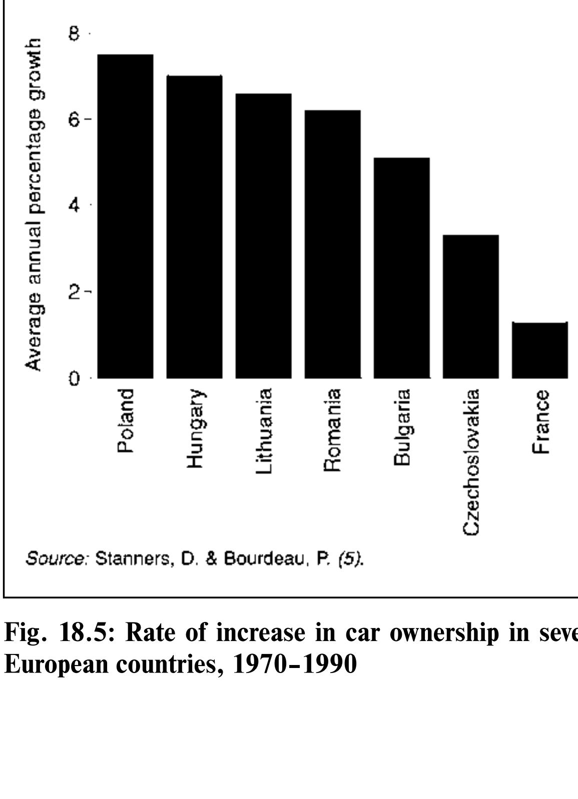
Trends

In the western countries of the Region large industrial companies, particularly those in chemicals and oil, have led the way in the last decade in adopting integrated environmental management practices. These substitute prevention for environmental clean-up, include environmental costs in production costs, analyse product life cycles, and move towards clean technology and waste minimization. These measures may be backed up by government use of economic instruments, and the requirement for environmental impact assessment (preferably environmental health impact assessment) prior to new industrial developments.

Such environmental management systems have yet to be applied in the CCEE and NIS. The clean-up of existing environmental health problems remains a priority. At the same time, however, investment in a sustainable market economy will inevitably be accompanied by the use of improved technologies and practices to prevent environmental impacts on health.

18.2.4 Transport

Transport is both a tool for and an indicator of economic development. Road transport in particular constitutes an important use of fossil fuel energy in the Region, varying from 7 % of total energy consumption in the former Czechoslovakia to about 30 % in France. Nearly all the western countries of the Region have increasingly moved away from less polluting and more energy-efficient rail and water transport to road and air transport for both passengers and freight. Former policies in the CCEE and NIS promoted public transport, including railways; even in



Source: Stanners, D. & Bourdeau, P. *(5)*.

Fig. 18.5: Rate of increase in car ownership in seven European countries, 1970–1990

Bulgaria, which has the highest proportion of road traffic use in the CCEE, only one third of total freight is moved by road. The use of cars, however, shows every sign of increasing in these countries (Fig. 18.5) while increasing trade between eastern and western countries makes it likely that the number of heavy goods vehicles will also increase. Table 18.11 summarizes the main environmental effects of road, water and air transport.

Accidents

About 350 people are killed each day on the roads in the Region, and a further 6000 are reported injured; the incidence is proportionally greater among young people. A decrease in mortality has been observed in western countries over the past decade. In eastern European countries, the rates have increased after remaining stable or declining until 1986–1987, and are likely to increase further as the number of vehicles on the roads increases.

Air pollution

Because of the low height of emissions from road vehicles, they are particularly important in determining exposure at ground level in cities.

As a result of a major switch to unleaded petrol in western countries, lead emissions from cars decreased by 50% from 1982 to 1989 while remaining unchanged in eastern countries. Although diesel engines emit more particulate matter than petrol engines, the latter emit a significant proportion of small, respirable particles.

Road traffic contributes about 50–60% of total NO_X emissions in the Region, the proportion being higher in western than in eastern countries. The more energy-efficient diesel engines contribute proportionately more and, although comprising only 2.5% of total vehicles, they give rise to 45% of NO_X from road traffic. The rise in the number of cars lessens the benefits of the increasing use of catalytic converters in petrol-fuelled vehicles in western countries. Many of the cars in eastern European countries have highly polluting two-stroke engines, and an increase in numbers is unlikely to be accompanied by an increase in use of catalytic converters in the short term.

Fewer data are available for volatile organic compounds (VOC). About 35–45% of these are thought to result from road traffic, by fuel combustion and evaporation. A substantial reduction in population exposure to ozone requires the control of emissions of NO_X and VOC. Three-way catalysts are important for both, along with improved energy efficiency and traffic regulations in urban areas.

Global climate change

About 25% of the total man-made emissions of the greenhouse gas CO_2 come from transport, of which road traffic makes up about 80%. Emissions of CO_2 from vehicles cannot be controlled by end-point technology such as catalytic converters, but will depend on increased fuel efficiency and a switch to smaller, lighter cars.

Noise and urban congestion

Noise and urban congestion from traffic impair the quality of urban life. As with air pollutants, an increase in the number of cars is likely to undermine or negate the effects of improvements in technology to reduce noise per vehicle. Road traffic controls to decrease congestion are also likely to reduce the impact of noise.

Trends

Without major changes in transport policies and public attitudes, the environmental health effects of transport can only grow worse as the number of motor vehicles increases. Effective public transport systems are an alternative that could reduce accidents, congestion, pollution and noise, but several approaches are likely to be needed including the segregation of road users, the en-

Table 18.11 a: Overview of significant environmental effects of the main transport activities

Transport activities	Effects on environmental media			Effects on health	Effects on resources
	Air	Fresh water	Sea		
Road transport	Combustion of petroleum products → CO_2, NO_x → global warming Combustion of petroleum products → "conventional emissions" of NO_x, CO, VOC, particulates NO_x emissions → tropospheric O_3 Use and release of fuel additives → emissions of lead and solvent vapours	Run-off containing oil, salts and solvents from road surfaces → pollution of surface water and groundwater NO_x and SO_2 emissions → acidification Carwashes → solvents, wastewater Roads → modification to hydrological systems	Transport of hazardous substances → potential risk of accident	Noise and vibration Human and animal casualties Urban stress "Conventional emissions" →health effects (mainly respiratory)	Road transport → significant consumption of non-renewable petroleum products → potential scarcities Waste products: discarded vehicles, waste oil, batteries, old tyres Road construction → land lost for infrastructure and service stations → pressure on land resources
Rail transport	Generation of power to run electric trains → emissions of NO_x and SO_2 Diesel trains → emissions to air Steam trains (coal powered) → emissions to air	Railways → modification to hydrological systems	Transport of hazardous substances → potential risk of accident	Noise and vibration	Rail construction → land lost for infrastructure → pressure on land resources

Table 18.11 b: Overview of significant environmental effects of the main transport activities

Transport activities	Effects on environmental media			Effects on health	Effects on resources
	Air	Fresh water	Sea		
Water transport (maritime and inland)	Concentrated harbour activities → emissions to air Enclosed seas and crowded traffic routes → emissions to air Bunkering of fuel and loading of fuel → emissions to air (VOC)	Discharge of ballast water from ships → water pollution Accidental and operational spills at sea (including oil) → water pollution Sewage and waste from ships → water pollution Antifouling paints → water pollution (tributyl tin is now banned in EU) Changes in water courses with canalization, port construction	Material from canal construction and dredging → waste disposal problem	Port areas as local source of noise	
Air transport	Aircraft → emissions of NO_x and CO_2 (high emissions especially during take-off, taxiing and landing) → ground-level smog and acid rain; stratospheric ozone depletion and global warming at higher levels Associated road traffic at airports → increased emissions	Run-off from airports contains oil and anti-freeze → water pollution Airport construction → alteration of water tables and river courses		Noise and vibration	Land lost for airports → pressure on land resources
Pipelines	Emissions to air (CH_4) → global warming	Leaks of oil → potential water pollution			

Source: Stanners, D. & Bourdeau, P. *(5)*.

forcement of speed limits and parking restrictions, and the use of economic incentives.

18.2.5 Tourism

Tourism is important as a source of employment and as a contributor to GDP; globally it is second only to oil as an economic factor. Consumer demand is growing. Most northern countries of the Region are net spenders, while tourism makes an important contribution to GDP in some Mediterranean countries: nearly 7% in Portugal, for example. Fewer data are available for the eastern European countries (except Hungary, where tourism contributes 3% of GDP) but it is anticipated that tourism may serve as a focus for economic recovery in some areas. Most tourism in the European Region is concentrated around the Mediterranean and the Alps, with 157 million and 100 million tourists per year, respectively.

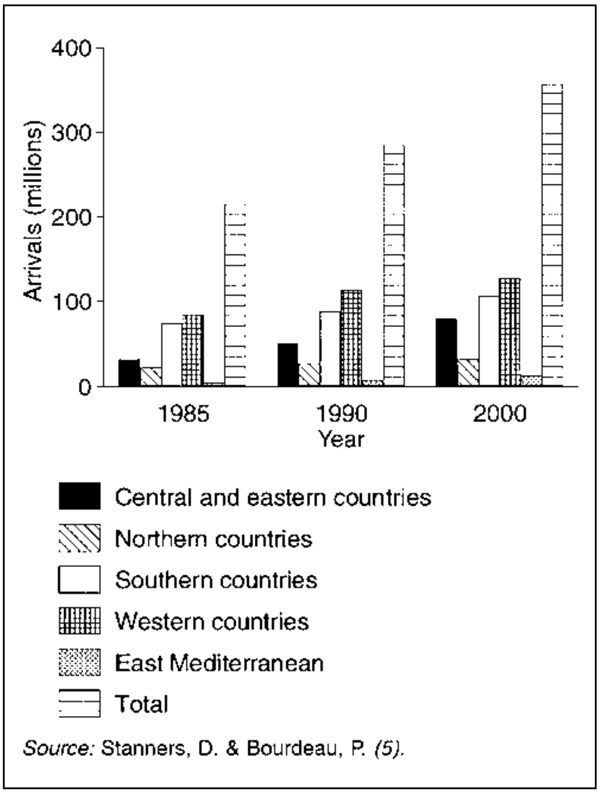


Fig. 18.6: Trends in international arrivals to different parts of the WHO European Region, 1985–2000

Effects on the environment and the health of tourists

The effects of tourism on the environment include the defacing of landscapes by developments for tourists, erosion of coastlines and mountain slopes (with increased risk of avalanche), accumulation of litter, loss of natural habitats and over-abstraction of water (Table 18.12). Host communities may suffer disruption, not least from traffic congestion and noise.

About 70% of municipal sewage in the Mediterranean region is discharged untreated, and bathing waters and local shellfish are subject to microbial contamination. Tourists visiting the Mediterranean from elsewhere in the Region are thought to be at 20 times greater risk of developing diarrhoeal illness than at home.

Trends

Most forecasts show an average rate of growth in tourism of 3.5% per year in the 1990s, reaching 380–400 million arrivals annually in Europe by 2000 (Fig. 18.6). Measures to limit environmental health effects are likely to include better monitoring and control of pollution, improvement of environmental awareness among tourists, limitation of numbers, controls on land use, establishment of protected areas, and traffic restrictions.

18.2.6 Conclusions

In all cases, the benefits from economic sectors to society and to economic development are accompanied by the potential for adverse effects on environmental health. The variation in the scale of these effects between and within the countries of the Region depends not only on the distribution of economic activities but also on the extent to which prevention or control measures are in place, as well as the characteristics of the exposed populations.

Table 18.12: Overview of major environmental impacts from tourism and recreation

Setting	Effects on environmental media				Effects on health
	Air	Water	Marine and coastal waters	Soil	
Mountains	Increased use of road transport → emissions to air → effects including local forest damage Heating needs for tourist settlements → increased emissions to air Increased energy use for ski infrastructure → emissions to air	Increased sewage and solid waste disposal (seasonal) → disposal problems Extensive pumping to supply snow-making machines → competition with other needs (such as for drinking-water)		Deforestation (resorts, access roads, skilifts, ski trails) → increased risk of avalanche Trampling and cross-country motorcycles → erosion of paths Increased road transport → land-use for car parks and new access road → land lost for other purposes	Tourism activities → loss of indigenous cultures Ski lifts and road transport → noise
Coastal areas	Increased use of road transport and aircraft → emissions to air Increased energy demand for air conditioning → emissions to air	Tourism → increased levels of untreated sewage Tourism → increased abstraction of water (very high at peak times) → potential forest fires Demand for watering coastal golf courses → potential water scarcities	Tourism (sewage, refuse from bathers) → poor bathing water quality Oil spillage from boats, antifouling preparations such as tributyltin from hulls of boats (now banned in EU) → water pollution	Tourism development pressures such as resorts, golf courses, transport infrastructure → loss of fertile coastal plains Increased road and air transport → land use for car parks and new access roads, airports → land lost for other purposes Tourism → increased solid waste disposal → more landfills (which compete with other land uses)	Tourism pressures → illegal second homes, overdependence on seasonal incomes, loss of indigenous culture (e.g. food, customs, livelihoods) Night life, beach sports (motorboats etc.), road transport → noise and disruption Increased risk of gastrointestinal infection from bathing in contaminated coastal waters or eating contaminated shellfish
Cities and heritage sites	Increased use of road transport → emissions to air, damage to buildings, congestion in historic cities (especially with coaches)	Tourism → strains on existing sewage treatment capacity		Tourism development → land lost for other purposes	Tourism pressures on resident population Tourism → increased noise

Source: Stanners, D. & Bourdeau, P. *(5)*.

In very general and over-simplified terms, the countries with established market economies in the Region have progressed further than others in controlling effects from energy and industrial sectors, but are still tackling the problems associated with intensive farming practices and the huge number of vehicles on the roads, particularly in urban areas. While the legacy of former productivity policies in the CCEE and NIS means that considerable environmental health problems related to energy and heavy industry remain, those related to intensive farming and road transport are not yet fully manifest; the potential therefore exists to avoid the damaging environmental situations that prevail in many of the western countries of the Region, and to achieve at an earlier stage the desired balance between benefits and detriments in these sectors.

Information from the World Bank [76], adapted by the Environmental Forecasting Bureau of the National Institute of Public Health and Environmental Protection (RIVM) in the Netherlands [78] and presented in Table 18.13, tends to support this overview. Disease burden is measured in disability-adjusted life years (DALYs) which take account of loss of (age-weighted) life expectancy as well as years of (weighted) disability for all possible causes of death and about 95 % of the possible causes of disability. Differences, measured in DALYs, between the environmental health burdens in the former socialist and the established market economies in the Region, indicate the health gains that could be expected from measures to reduce occupational and road transport injuries, high levels of air pollution, and microbiological contamination of food and water.

Table 18.14 illustrates an analysis carried

Table 18.13: Estimated annual disease burden (disability-adjusted life years, DALYs) from selected environment-related health problems

Environmental factor and related diseases	DALYs (millions per year)		
	Global	CCEE and NIS	European countries with established market economies
Occupational			
Cancers	79	8.6	7.9
Neuropsychiatric disorders	93	6.4	6.2
Chronic respiratory diseases	47	2.1	1.6
Musculoskeletal disorders	18	0.4	0.8
Injuries[a,b]	81	4.8	1.7
Air pollution			
Chronic respiratory diseases[c]	47	2.1	1.6
Respiratory tract cancer	4	1.5	1.4
Transport			
Motor vehicle injuries[b]	32	2.2	1.5
Food and drinking-water			
Diarrhoeal disease	99	0.2	0.1

[a] Computed by subtracting motor vehicle injuries from all unintentional injuries.
[b] No data available on percentage reduction achievable and averted burden for the CCEE and NIS and the established market economies in Europe, but globally: injuries = 20% and 16 million DALYs per year; motor vehicle injuries = 20% and 6 million DALYs per year.
[c] The percentage reduction in chronic respiratory diseases, achievable through intervention, is 2% in the CCEE and NIS and 0.5% in the established market economies (where there is substantial evidence for a relationship with a particular environment).

Sources: World Bank *(77)*; National Institute of Public Health and Environmental Protection *(78)*.

Table 18.14: Contributions by production and consumption activities to net domestic product, employment, exports and some environmental problems in the Netherlands, 1989

	Percentage contribution to economic indicators			Percentage contribution to environmental indicators				
	Net domestic product	Labour volume	Exports	Greenhouse effect	Depletion of ozone layer	Acidification	Eutrophication	Waste Accumulation
Industry	–	–	–	81	80	88	92	72
Private households	–	–	–	19	20	12	8	28
Industrial sectors								
Agriculture	4	4	6	13	0	47	85	5
Manufacturing:								
oil refineries	0	0	6	8	0	9	0	0
chemical industry	3	2	16	14	50	8	8	17
basic metal industry	1	1	3	5	0	3	0	1
other manufacturing	16	16	44	9	4	5	3	22
Electrical plants	1	1	0	28	0	10	1	1
Construction	6	8	1	1	25	1	0	21
Transport	5	5	10	6	6	12	1	13
Services and other industries	64	64	16	17	15	7	1	20
Private households								
Own transport	–	–	–	39	0	89	17	2
Other consumption	–	–	–	61	100	11	83	98

Source: de Heen, M. et al. *(79)*.

out by the Netherlands Central Bureau of Statistics of the contributions of different economic activities in the Netherlands to net domestic product (NDP), employment and exports compared with selected adverse effects on the environment [79]. The data indicate that the average contribution of each branch of industry to these particular environmental problems did not equal their contribution to NDP and employment. The exceptions were chemical and oil industries and agriculture.

While the economic benefits of activities cannot be judged solely from their direct share in NDP and employment, and the situation in one country cannot simply be extrapolated to others, Table 18.14 indicates the kind of approach that may be developed at the national level to examine the balance between the benefits and detriments of different economic activities, in order to identify priorities for action in different sectors to improve environmental health.

References

[1] Rothman, K.J. *Modern epidemiology.* Boston, Little, Brown and Co., 1986.

[2] Folinsbee, L.J. Human health effects of air pollution. *Environmental health perspectives*, **100**: 45–56 (1992).

[3] Samet, J.M. et al. Environmental tobacco smoke. *In*: Samet, J.M. & Spengler, J.D., ed. *Indoor air pollution. A health perspective*. London, Johns Hopkins University Press, 1991.

[4] *Guidelines for drinking-water quality,* 2nd ed. *Vol. 1. Recommendations*. Geneva, World Health Organization, 1993.

[5] Stanners, D. & Bourdeau, P., ed. *Europe's environment: the Dobris assessment*. Luxembourg, Office for Official Publications of the European Communities, 1995.

[6] Pershagen, G. et al. *[Residential radon exposure and lung cancer in Sweden. A nationwide case control study.]* Stockholm, Karolinska Institute, 1993 (IMM-Report 2/93).

[7] Pershagen, G. et al. Residential radon exposure and lung cancer in Sweden. *New England journal of medicine*, **330**: 159–164 (1994).

[8] *Air quality guidelines for Europe*. Copenhagen, WHO Regional Office for Europe, 1987 (WHO Regional Publications, European Series, No. 23).

[9] Ivanov, E.P. et al. Child leukaemia after Chernobyl. *Nature,* **365**: 702 (1993).

[10] Parkin, D.M. et al. Childhood leukemia following the Chernobyl accident: the European Childhood Leukemia–Lymphoma Incidence Study (ECLIS). *European journal of cancer,* **29A**: 87–95 (1992).

[11] Kazakov, V.S. et al. Thyroid cancer after Chernobyl. *Nature*, **359**: 21 (1992).

[12] Baverstock, K. et al. Thyroid cancer after Chernobyl. *Nature,* **359**: 21 (1992).

[13] *Solar and ultra-violet radiation*. Lyon, International Agency for Research on Cancer, 1992 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 55).

[14] Tomatis, L., ed. *Cancer: causes, occurrence and control*. Lyon, International Agency for Research on Cancer, 1990 (IARC Scientific Publications No. 100).

[15] Draper, G. Electromagnetic fields and childhood cancer. *British medical journal*, **307**: 884–885 (1993).

[16] Feychting, M. & Ahlbom, A. Magnetic fields and cancer in children near Swedish high-voltage power lines. *American journal of epidemiology*, **138**: 467–481 (1993).

[17] Feychting, M. & Ahlbom, A. [Cancer and magnetic fields among people living near high-voltage power lines in Sweden.] *Läkartidningen*, **89**: 4371–4374 (1992).

[18] Pershagen, G. & Simonato, L. Epidemiological evidence on outdoor air pollution and cancer. *In*: Tomatis, L., ed. *Indoor and outdoor air pollution and human cancer.* Berlin, Springer-Verlag, 1993.

[19] Dockery, D.W. et al. An association between air pollution and mortality in six US cities. *New England journal of medicine,* **329**: 1753–1759 (1993).

[20] Jedrychowski, W. et al. Case-control study of lung cancer with special reference to the effect of air pollution in Poland. *Journal of epidemiology and community health*, **44**: 114–120 (1990).

[21] Pershagen, G. Passive smoking and lung cancer. *In*: Samet, J.M., ed. *Epidemiology of lung cancer.* New York, Marcel Dekker, 1994.

[22] Browson, R.C. et al. Passive smoking and lung cancer in nonsmoking women. *American journal of public health*, **82**: 1525–1530 (1992).

[23] *Diesel and gasoline engine exhausts and some nitroarenes*. Lyon, International Agency for Research on Cancer, 1989 (IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 46).

[24] ANDERSON, C. Cholera epidemic traced to risk miscalculation. *Nature*, **354**: 255 (1991).

[25] *Health evaluation of aflatoxins in foodstuffs: report from a working group*. Copenhagen, National Food Agency of Denmark, 1989.

[26] CASTEGNANO, M. & CHERNOZEMSKY, I. Endemic nephropathy and urinary tract tumours in the Balkans. *Cancer research*, **47**: 3608–3609 (1987).

[27] LUNDBACK, B. ET AL. The prevalence of asthma and respiratory symptoms is still increasing. *In*: Lundback, B. *Asthma, chronic bronchitis and respiratory symptoms: prevalence and important determinants. The obstructive lung disease in Northern Sweden study I*. Umeå, Umeå University, 1993 (Umeå University Medical Dissertations No. 387).

[28] BURNEY, P.G.J. ET AL. Has the prevalence of asthma increased in children? Evidence from the National Study of Health and Growth 1973–86. *British medical journal,* **300**: 1306–1310 (1990).

[29] CHAN-YEUNG, M. Occupational asthma. *Chest,* **98**(Suppl.): 148S–161S (1990).

[30] WARDLAW, A.J. The role of air pollution in asthma. *Clinical and experimental allergy,* **23**: 81–96 (1993).

[31] AMERICAN THORACIC SOCIETY. Guidelines as to what constitutes an adverse respiratory health effect, with special reference to epidemiological studies of air pollution. *American review of respiratory diseases,* **131**: 666–668 (1985).

[32] SEROKA, W. & KRZYZANOWSKI, M. [Daily visits to a general practitioner and air pollution.] *Przeglad lekarski,* **41**: 433–437 (1984).

[33] SUNYER, J. ET AL. Effects of urban air pollution on emergency room admissions for chronic obstructive pulmonary disease. *American journal of epidemiology,* **134**: 277–286 (1991).

[34] DERRENIC, F. ET AL. Short-term effects of sulphur dioxide pollution on mortality in two French cities. *International journal of epidemiology,* **18**: 186–197 (1989).

[35] KATSOUYANNI, K. ET AL. Air pollution and cause-specific mortality in Athens. *Journal of epidemiology and community health,* **44**: 321–324 (1990).

[36] KRZYZANOWSKI, M. & KAUFFMAN, F. The relation of respiratory symptoms and ventilatory function to moderate occupational exposure in a general population. *International journal of epidemiology,* **17**: 397–406 (1988).

[37] ROEMER, W. ET AL. Effect of wintertime air pollution on respiratory health of children with chronic respiratory symptoms. *American review of respiratory diseases*, **147**: 118–124 (1993).

[38] FORASTIERE, F. ET AL. Effects of environment and passive smoking on the respiratory health of children. *International journal of epidemiology,* **21**: 66–73 (1992).

[39] SCHWARTZ, J. ET AL. Air pollution and acute respiratory illness in five German communities. *Environmental research*, **56**: 1–14 (1991).

[40] BRAUN-FAHRLÄNDER, C. ET AL. Air pollution and respiratory symptoms in preschool children. *American review of respiratory diseases*, **145**: 42–47 (1992).

[41] CHESTNUT, L.G. ET AL. Pulmonary function and ambient particulate matter: epidemiological evidence from NHANES I. *Archives of environmental health*, **46**: 135–144 (1991).

[42] ABBEY, D.E. ET AL. Long-term ambient concentrations of total suspended particulates, ozone and sulfur dioxide and respiratory symptoms in a nonsmoking population. *Archives of environmental health*, **48**: 33–46 (1993).

[43] SCHWARTZ, J. Lung function and chronic exposure to air pollution: a cross-sectional analysis of NHANES II. *Environmental research,* **50**: 309–321 (1989).

[44] *Respiratory health effects of passive smoking: lung cancer and other diseases.* Washington, DC, US Environmental Protection Agency, 1992 (EPA/600/6-90/006F).

[45] HASSELBLAD, V. ET AL. Synthesis of environmental evidence: nitrogen dioxide epidemiology studies. *Journal of the Air and Waste Management Association*, **42**: 662–671 (1992).

[46] MADRONICH, S. & DE GRULJI, F.R. Skin cancer and UV radiation. *Nature*, **366**: 23 (1993).

[47] VON MUTIUS, E. ET AL. Prevalence of asthma and allergic disorders among children in united Germany: a descriptive comparison. *British medical journal,* **305**: 1395–1399 (1992).

[48] VON MUTIUS, E. ET AL. Difference in the prevalence of asthma between east and west Germany: the role of atopic sensitization. *European respiratory journal*, **6**(Suppl. 17): 224S (1993).

[49] WIJST, M. ET AL. Road traffic and adverse effects on respiratory health in children. *British medical journal,* **307**: 596–600 (1993).

[50] OSTRO, B. The association of air pollution and mortality: examining the case for inference. *Archives of environmental health*, **48**: 336–342 (1993).

[51] *Indoor air quality: biological contaminants*. Copenhagen, WHO Regional Office for Europe, 1990 (WHO Regional Publications, European Series, No. 31).

[52] WICKMAN, M. ET AL. Risk factors in early childhood for sensitization to airborne allergens. *Pediatric allergy and immunology,* **3**: 128–133 (1992).

[53] WICKMAN, M. *Residential characteristics and al-*

lergic sensitization in children, especially to mites. Stockholm, Karolinska Institute, 1993.

[54] *WHO Surveillance Programme for Control of Foodborne Infections and Intoxications in Europe. Fifth report 1985-1989*. Berlin, Institute of Veterinary Medicine, Robert von Ostertag Institute, 1992.

[55] WALKER, A. Swimming: hazards of taking a dip. *British medical journal,* **304**: 242-245 (1992).

[56] *International labour statistics 1980-1991.* Geneva, International Labour Organisation, 1992.

[57] BECK, B. An update on exposure and effects of lead. *Fundamental and applied toxicology,* **18**: 1-16 (1992).

[58] THACKER, S.B. ET AL. Effect of low-level body burdens of lead on the mental development of children: limitations of meta-analysis in a review of longitudinal data. *Archives of environmental health*, **47**: 336-346 (1992).

[59] *Methylmercury*. Geneva, World Health Organization, 1990 (Environmental Health Criteria No. 101).

[60] GRANDJEAN, P. ET AL. Impact of maternal seafood diet on fetal exposure to mercury, selenium and lead. *Archives of environmental health*, **47**: 185-195 (1992).

[61] NORDIC COUNCIL OF MINISTERS. *Risk assessment of polychlorinated biphenyls (PCBs)*. Aarhus, AKA-PRINT, 1992.

[62] ROSENGREN, A. ET AL. Stressful life events, social support, and mortality in men born in 1933. *British medical journal*, **307**: 1102-1105 (1993).

[63] LINDY, J.D. ET AL. The stressor criterion and posttraumatic stress disorder. *Journal of nervous and mental diseases,* **175**: 269-272 (1987).

[64] BERTAZZI, P.A. ET AL. Ten-year mortality study of the population involved in the Seveso incident in 1976. *American journal of epidemiology,* **129**: 1187-1200 (1989).

[65] *Working group on psychological effects of nuclear accidents: report on a meeting*. Copenhagen, WHO Regional Office for Europe, 1990 (document EUR/ICP/CEH 093 (S)).

[66] BERTOLLINI, R. ET AL. Reduction of births in Italy after the Chernobyl accident. *Scandinavian journal of work, environment and health,* **16**: 96-101 (1990).

[67] TRICHOPOULOS, D. ET AL. The victims of Chernobyl in Greece. *British medical journal*, **295**: 1100 (1987).

[68] KALTER, H. & WARKANY, J. Congenital malformations. Etiologic factors and their role in prevention. *New England journal of medicine*, **308**: 424-431 (1983).

[69] JANERICH, D.T. & POLEDNAK, A.P. Epidemiology of birth defects. *Epidemiologic reviews*, **5**: 16-37 (1983).

[70] CZEIZEL, A.E. ET AL. Environmental trichlorfon and cluster of congenital abnormalities. *Lancet,* **341**: 539-542 (1993).

[71] *Fighting noise in 1990s.* Paris, Organisation for Economic Co-operation and Development, 1991.

[72] *Our planet, our health. Report of the WHO Commission on Health and Environment*. Geneva, World Health Organization, 1992.

[73] DOLL, R. Health and the environment in the 1990s. *American journal of public health,* **82**: 933-941 (1992).

[74] PERERA, F.P. ET AL. Molecular and genetic damage in humans from environmental pollution in Poland. *Nature,* **360**: 256-258 (1992).

[75] WOGAN, G.N. Molecular epidemiology in cancer risk assessment and prevention: recent progress and avenues for future research. *Environmental health perspectives*, **98**: 167-178 (1992).

[76] WORLD BANK. *World development report 1993. Investing in health*. New York, Oxford University Press, 1993.

[77] *Aquatic Environment 1993. Status of the Danish aquatic environment in 1992*. Copenhagen, Danish Environmental Protection Agency, 1994.

[78] *The environment in Europe: a global perspective 1992*. Bilthoven, National Institute for Public Health and Environmental Protection, 1992 (RIVM Report No. 481505001).

[79] DE HEEN, M. ET AL. *Integrating indicators in a national accounting matrix including environmental accounts*. Voorburg, Netherlands Central Bureau of Statistics, 1989 (National Accounts Occasional Paper No. NA-060).

Chapter 19
Conclusions and Recommendations[a]

19.1 Introduction

As stated in the Commentary to the European Charter on Environment and Health, environmental health as interpreted by the WHO Regional Office for Europe:

> includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and wellbeing of the broad physical, psychological, social and aesthetic environment, which includes housing, urban development, land use and transport.

Thus, although the possible interactions of lifestyle, nutrition and socioeconomic factors with environmental agents in determining health status are discussed in the report, these factors are not the subject of recommendations for improving environmental health.

19.2 Economic Sectors

Of the 50 Member States of the WHO European Region in November 1993, 17 could be classified as lower-middle income, 14 as

[a] Recommendations are printed in **bold type** and numbered. Priority recommendations are identified by an asterisk.

upper-middle income and 19 as high income countries. Gross domestic product per year ranges from some hundreds of millions of dollars to more than one thousand billion dollars. Differences between countries are smaller when the Human Development Index is used.

Economic growth has slowed down in recent years in the established market economies. Economic output has also sharply declined in those countries in transition from centrally planned to market economies; their earlier expectations have had to be modified. Economic pressures have led to the rapid elimination of inefficient production, but it has not been possible to replace this with new and efficient activities. Transition will be a long-term process.

Under these circumstances, achieving quantifiable environmental health results will require proper sequencing of events.

1.* The development and management needs of environment and health should be built into the overall programmes for transition in the CCEE and NIS, so that their economic transformation and development will be sustainable.

For the Region as a whole, sustainable development will require substantial changes in patterns of production and consumption.

The targets set by the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 require a balanced use of fuels with, in particular, a decrease in the use of coal and an increase in the use of gas. Several factors have to be taken into account, however: a country's natural energy resources; its desire to avoid dependence on imported fuel, especially oil; public concerns in some countries about nuclear power; and economic constraints that limit imports and the availability of capital for new power plants, for air pollution abatement equipment in existing plants, and for cleaning up the environment after years of open-cast mining of lignite coal. Thus, most countries in the western part of the Region are seeking a balanced energy supply. In many countries in transition in the eastern part of the Region, however, economic conditions require the continuing use of lignite coal, although energy demands have decreased overall with the closure of uneconomical industries.

Increased energy efficiency and conservation are crucial if optimal environmental health is to be achieved in all countries of the Region, but particularly in those with transitional economies.

2. To increase energy efficiency and conservation, the following tools should be considered: rationalization of energy prices; new regulatory systems and more strictly enforced standards; encouragement of competition; adoption of improved technology for new plants; and financial incentives.

3. Governments should try to increase public awareness of the need for energy efficiency and conservation, so as to promote the acceptance of individual as well as corporate responsibility for sustainable development.

During the present period of recession and transition, it is not possible to predict whether the CCEE and NIS will follow the pattern of the industrialized countries and move from traditional heavy industry to service types of industry.

Agricultural productivity per hectare is greater in the western part of the Region than in the CCEE and NIS, with a matching food surplus compared with a deficit. The most important factor in increasing food production has been the intensive use of agrochemicals, especially fertilizers. More intensive farming practices will probably be adopted in the CCEE and NIS.

4. The CCEE and NIS could benefit from the experience of western Europe and, by adopting land-use restrictions and strict codes of practice, avoid similar problems related to the misuse of agrochemicals.

Road transport presents a similar challenge. As soon as the economic situation improves, the number of cars in the CCEE and NIS is likely to increase rapidly.

5. To avoid an increase in road traffic acci-

dents, noise nuisance, and urban air pollution with the risk of summer-type smogs, the CCEE and NIS should adopt as preventive measures those actions that the rest of the Region is now taking to mitigate existing problems.

An increase in tourism in established tourist areas such as the Mediterranean and the Alps will aggravate existing inadequacies in drinking-water supply and safe sewage disposal. In the CCEE and NIS, on the other hand, the likely substantial development of tourism may provide a major boost to economic recovery.

Urbanization still seems to be increasing in the CCEE and NIS, though it appears to have passed its peak in the western part of the Region. Nevertheless, the depressed economic situation throughout the Region encourages people to move to larger towns in search of work. Municipalities may, as a result, have difficulty providing housing and adequate public health services.

Economic activities in the European Region are dominated by the recession, the effects of which are even more pronounced in countries undergoing transition from planned to market economies.

19.3 Environmental Health Management

The effective implementation of environmental health policies depends on:

(a) active cooperation, both vertically and horizontally, between environment and health departments and other relevant sectors of government at all levels of management;

(b) the provision of institutional frameworks and adequate multidisciplinary professional training, together with the development of the infrastructures necessary for the operation of environmental health services at all levels; and

(c) the involvement of nongovernmental organizations and the participation of an informed public in decision-making processes.

6.* Countries should develop and implement environmental health policies based on strong intersectoral cooperation. This approach should be embodied in appropriate legislation, institutional development and training.

7.* Procedures for environment and health impact assessment should be introduced throughout the Region and used at the earliest possible stage of development of policies, programmes and projects.

8.* Accurate information on environmental health issues should be made widely available, so as to achieve better understanding of the risks and to facilitate informed public participation in the development and implementation of environmental health policies.

In many countries throughout the Region, environmental health services are still developing.

9. Countries at the beginning of this process of development should consider three main areas of action.

(*a*) Strong intersectoral cooperation should be established in order to develop sound environmental health policies supported by appropriate legislation.

(*b*) Institutional structures should be developed for delivering those policies through environmental health services. These services should be suitably supported and guided by central administrations, but also have the flexibility and capacity to respond to local needs. Further, although their development should reflect local culture and traditions, they should be able to react quickly and effectively when action on environmental health issues is urgently needed.

(*c*) Training should be given to environmental health professionals and managers so they can deliver the services through the institutions that have been developed.

19.4 Economics, the Environment and Health

Considerations of environment and health should be inescapable elements of economic and social development in the Region. Market forces as they develop may ensure this: industries that do not accept the challenge of promoting environmental improvement and health gain may become less viable in a competitive world with an increasingly aware and discriminating purchasing public. Internalizing the costs of health and environmental impacts into the pricing of industrial and agricultural products could be a mechanism for encouraging economies to support sustainable development. But this needs careful monitoring to establish when these factors support improvements in environment and health, and how far overt planned intervention is necessary. Intervention may take the form of regulations or economic instruments. The latter may be incentives (such as government grants or tax reductions) or penalties (based, for example, on the principle that the polluter or the natural resource user pays).

Better information on environment, economics and health is essential for efficient investment. Important elements are, for example, how far people, companies and governments are willing and able to pay for improvements in the environment that are known to or may affect health, and how much health gain can be obtained from an investment in environmental improvements compared with the opportunity for and costs of other investments for health.

10. Consideration of which environmental health actions should be given priority should include an assessment of their value for money, in terms of the likely benefits to health compared with the costs of different options for environmental intervention. When there is public pressure for costly environmental interventions, with uncertain benefits to health, society's willingness to pay should be an important determinant of action.

11. Greater use of economic instruments (incentives or penalties) should be considered to achieve environmental improvements for health.

19.5 State of Human Health

Analysis of the health status in different countries in the Region is based largely on mortality data. Significant differences exist between the CCEE and NIS on the one hand and the rest of the Region on the other. Life expectancy is lower in the eastern part of the Region, with the highest mortality rates predominantly in middle-aged men. Premature mortality is largely due to cardiovascular and respiratory diseases and, in men, to cancer and accidents or poisoning. Lifestyle factors, particularly smoking, are more important determinants of these differences in mortality than environmental factors. Subnational data are required to identify differences in health status within countries and their causes, which may include environmental factors.

Morbidity data are less readily available, but may be important for assessing environmental impacts on health.

12.* All countries in the Region should aim to provide national and subnational mortality data. Registers of cancers and congenital malformations should be established where they do not already exist. Information on occupation, socioeconomic status, housing conditions, educational achievement and lifestyle should also be collected and made available.

19.6 The Database

There is a lack of comprehensive and comparable data needed to monitor environmental conditions and their effects on health.

13.* To achieve comparable environmental health information systems within the Region, strategies with clearly defined objectives should be adopted for comprehensive environmental health monitoring, taking into account all routes of exposure. They should be adapted to local needs but, for data to be comparable and to facilitate regional analysis, a harmonized approach must be taken to sampling, analytical and statistical procedures, quality assurance and reporting.

14.* To facilitate the monitoring of changes in health status due to environmental factors, core environmental health indicators should be developed and applied throughout the European Region.

15.* For environmental health information systems to be of practical use in decision-making, better data are needed on exposure–response relationships. This requires further epidemiological research.

19.7 Air Pollution

19.7.1 Ambient air

Many millions of urban dwellers are estimated to be exposed to levels of particulates and SO_2 in ambient air that regularly exceed the WHO air quality guidelines for Europe. Episodes of winter-type smog still occur in some cities, particularly where sulfur-rich coal is used in industry and for power generation and domestic heating. In certain populations air polluted with lead, from point sources such as non-ferrous smelters, remains an important environmental health problem.

16.* To safeguard human health, emissions should be controlled so that ambient air quality conforms with the WHO air quality guidelines for Europe.

17.* Particularly urgent action should be taken about heavily polluted areas in the CCEE and NIS and in some southern European cities. This will be greatly facilitated by practical international cooperation.

The increase in the number of vehicles on the roads continues to outstrip population growth. Many countries are already trying to limit the impact of road traffic on health. Of particular concern are emissions of lead, nitrogen oxides and volatile organic compounds (resulting in the formation of ozone and episodes of summer-type smog), noise (see p. 530) and accidents (see p. 534). Traffic still has a major effect on health, however, particularly in urban areas, and the contribution of transport sources to ambient air pollution is thought generally to be increasing. The contribution from diesel-fuelled heavy goods vehicles is very likely to increase as a result of freer trading conditions in the Region. Relatively little information is available on levels of pollutants inside vehicles.

18.* All countries should adopt measures to prevent air pollution from road traffic, such as the development and implementation of comprehensive transport policies, together with effective urban planning. Such measures should take full account of public health considerations.

19.* All countries of the Region should progressively eliminate the use of leaded petrol.

20.* Effective emission control should become obligatory in all new cars in countries that do not yet require this.

21. Data should be obtained on levels of pollutants inside motor vehicles under various conditions of operation.

Efforts to improve energy efficiency and conservation need to continue throughout the Region; reducing fuel subsidies will promote such improvement. The above measures will have the additional benefit of reducing acid deposition and the generation of greenhouse gases.

19.7.2 Indoor air[a]

Chemical, physical and biological pollutants in indoor air can have important effects on health: allergies and respiratory illnesses (particularly in children, from exposure to NO_x and environmental tobacco smoke); carbon monoxide poisoning from malfunctioning gas appliances and, possibly, aggravation of cardiovascular disorders at lower levels of exposure; and lung cancer from environmental tobacco smoke and other particulates. The risks increase where measures to prevent heat loss and/or noise disturbance reduce the rates of air exchange; and warm, damp housing conditions encourage the growth of moulds and house-dust mites, with the production of allergens.

22.* Smokers and their families should be made better aware of the effects of environmental tobacco smoke on the health of others, particularly children. Appropriate control of tobacco smoking should be introduced in indoor environments such as working and recreational environments.

23.* Adequate air exchange in buildings should not be prejudiced by energy conservation measures.

24. All gas appliances should be properly vented and maintained.

For both ambient and indoor air pollution the available data are inadequate for representative exposure assessment, or for defining exposure–effect relationships (for individual pollutants and for mixtures of pollutants). The thresholds for effects and the identities of vulnerable groups have not yet been clearly established. Thus the degree of protection afforded by the current WHO air quality guidelines for Europe is uncertain.

25. Methods should be agreed on and adopted in the Region to monitor pollutants over time and space, using appropriate quality assurance and control. The use of mobile personal monitoring techniques and biological monitoring should be encouraged, in order to obtain information on actual exposures of individuals.

26. Studies should be undertaken to establish:
(*a*) exposure–effect relationships for various ambient and indoor pollutants (including their effects on vulnerable groups); and
(*b*) the importance of individual pollutants versus a mixture of pollutants.

27. Research should be carried out to assess the role of air pollutants, including indoor biological agents, in the increasing prevalence of asthma.

[a] Radon is considered under Ionizing Radiation, p. 530.

19.8 Water Supply and Quality

The availability and quality of water are essential for the maintenance of human health. Disparities in the Region are marked: shortages of water occur in some southern and eastern countries, coverage with water supply systems is incomplete in rural areas in parts of northern and eastern Europe, and the problem of both supply and quality is more widespread in the NIS.

Leakages create a need for greater quantities of water and the use of poorer quality sources; defects in badly maintained distribution systems, as well as shortages in the water supply, can result in contamination of the network. Occasional outbreaks of acute disease are reported across the Region, as a result of microbiological contamination from sewage systems or breakdown in the treatment of drinking-water supplies. These problems are greatest in the CCEE and NIS, and are probably underreported. Waterborne, bacterial, viral (particularly hepatitis A) and protozoal diseases are important. Sporadic outbreaks of cholera have occurred recently in some parts of the CCEE and NIS. The difficulties with monitoring, pathogen identification and effective water treatment and supply are unlikely to be solved quickly.

The free supply of water is conducive to misuse and may result in the need for water treatment exceeding capacity. It may also result in inadequate funding for the maintenance of distribution systems.

28.* Urgent steps must be taken to ensure that the entire population of the Region is provided with reliable supplies of safe drinking-water.

29.* High priority should be given to preventing the microbiological contamination of drinking-water by:

(*a*) effective protection of water sources and adequate provision and maintenance of distribution networks and sewage treatment plants;

(*b*) improvement of techniques for drinking-water treatment, including disinfection for small communities; and

(*c*) development of low-cost and reliable indicators for microbiological contaminants.

Exposure to high levels of, for example, nitrate (from agricultural sources) or other chemicals (from accidental industrial releases) are known to have acute effects on health. For many substances, however, epidemiological data on the possible long-term effects on health of exposure levels are poor, and do not provide an adequate basis for assessing risks. Very little is known about the long-term effects of exposure to the mixture of substances present at low concentrations in drinking-water. Nevertheless, drinking-water sources must be protected from pollution by industrial and agricultural chemicals and municipal wastes, particularly nitrates and pesticides from diffuse sources. Many countries rely on groundwater sources, which are vulnerable to such pollution and slow to respond to remedial measures. Further, increasingly sophisticated treatment for a wide range of chemical contaminants is a less practical option for many countries than protecting drinking-water at source.

30.* Effective water resource management throughout the Region is essential in the interests of public health, and requires comprehensive surveillance and control of biological, chemical and physical contamination of surface water and groundwater.

31.* Preventive strategies should be emphasized, including land use planning (for agriculture and industry) and impact assessment.

Data on microbial and chemical contaminants in drinking-water in the Region are hard to compare. The incidence of outbreaks and of non-compliance with national standards gives some indication of the situation, but more reliable data are needed to assess where problems with drinking-water quality exist and chronic effects on health might be expected to occur. (See recommendation 13.)

19.9 Wastewater and Surface Water

The WHO European Region is characterized by densely populated cities and urban industrial areas, where surface waters can be seriously contaminated by discharges of untreated waste, and rural areas where diffuse agricultural pollution over many years has contaminated rivers and groundwater. In some places, the eutrophication of lakes and coastal waters encourages algal blooms, and the acidification of rivers and lakes mobilizes heavy metals. Contaminated surface waters may affect health directly when they are used as a source of drinking-water or for bathing; or indirectly through their impact on aquatic ecosystems, or when used to irrigate crops.

In general, a smaller proportion of the population is provided with adequate sewage treatment facilities than with safe drinking-water. In urban areas, excessive amounts of wastewater may receive too little or no treatment; if contaminated surface water is used as a source of drinking-water, more treatment is required. The exploitation of water resources in many countries is restricted because of sewage pollution.

As is the case for drinking-water, the links between exposure to contaminants in wastewater and surface water and its effects on health are hard to assess on a regional scale. Further, some countries have no effective monitoring network. The measures recommended to prevent and control pollution are also similar to those for water supply and quality.

32. Investment is required, particularly in the CCEE and NIS, to build new urban sewage treatment plants.

Measures are needed both to meet local needs and to protect international waters and enclosed seas.

33. Water quality objectives need to be defined and endorsed by all users of the same catchment area. Economic incentives should be developed.

34. Emergency response capabilities will also have to be developed (where they are not already in place) to protect surface water and groundwater should contaminants be accidentally released.

19.10 Waste

There is considerable public concern about the impact of waste disposal on the environment and health. Few studies of the effects on people's health of living near waste disposal sites have been carried out in the Region; they provide little evidence of related disease, but nuisance (particularly from odours and noise) is a serious problem that undermines wellbeing.

Technological improvements in the last 15 years, both for landfills and incinerators, mean that properly managed, modern waste disposal causes negligible population exposure and environmental health impact. As a result of decades of inappropriate waste disposal, however, and the creation of numerous "problem sites" throughout the Region, many potential environmental health hazards exist. These range from microbiological hazards associated with uncollected or uncovered disposal of municipal solid waste, to toxic hazards from uncontrolled hazardous waste disposal and contaminated industrial areas. There are particular problems in some of the NIS.

35.* Areas so contaminated by waste disposal that they are a significant potential threat to public health should be identified and appropriate measures taken for decontamination or restricted use.

36.* In some parts of the Region, abandoned military waste disposal sites require special attention because of chemical and possibly biological hazards. (See also recommendation 64 relating to nuclear materials.)

Leakages from landfill sites have contaminated soil and groundwater, and the long timescales for changes in groundwater quality and for environmental transport mean that potential future risks to health cannot be dismissed.

37. Studies should initially look at the environmental pathways of releases from such problem landfill sites, and at the resulting exposure of populations to specific agents. Studies of specific effects on health may then be warranted. Research into and development of low-technology techniques is needed to decontaminate chemically contaminated soils and potable groundwater.

The few occupational studies that have been carried out suggest that both working conditions and equipment may be inadequate to protect the health of waste disposal workers.

38. Multicentre studies of employees at different types of waste disposal plant, with proper exposure assessment, should be carried out.

Waste management practices vary widely across the Region. Incineration is increasingly used to dispose of hazardous waste, but the amounts so treated vary greatly between countries. The disposal of hazardous waste with municipal waste is still practised. Similarly, some countries operate effective waste recycling schemes but others make no provision for separating municipal wastes. A common and important problem for the future is the unsustainable growth in waste production, which is increasing at a rate that will outstrip the capacity for treatment and disposal. Waste reduction (and reduction in the proportion that is hazardous) requires an integrated programme for waste management, and involves the acceptance of joint responsibility by governments and individuals.

39.* Effective systems should be developed and maintained for the segregated collection and safe disposal of wastes, including facilities for proper treatment of hazardous waste. Incentives should be provided to encourage separation, recycling, reuse and reclamation.

40.* Waste production should be minimized, for example by promoting cleaner technology in industry and by increasing public awareness of the need to reduce domestic waste.

The successful implementation of these measures will depend on public education and information.

41.* Given the positive role that the public can play in such decisions as the siting of new incinerators or landfills, public understanding of waste disposal issues should be promoted.

The transboundary movement of hazardous waste is significant.

42. Efforts are needed to ensure commitment throughout the Region to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, in order to avoid inadequate or unregulated waste treatment and disposal taking place in countries where less strict standards and/or controls currently prevail.

19.11 Contamination of Food and Drink

The overall assessment of the impact of food contamination on health in the Region clearly identifies microbial contamination as an important environmental health issue.

Acute illness from microbial contamination is a common, widespread and growing problem in the Region, estimated to cost the medical and industrial sectors several billion US dollars annually.

Primary food production, particularly from intensive animal husbandry, is an important source of microbial contamination that can, however, occur at any stage from production to consumption. Centralized food production, storage and distribution results in the wide dissemination of contaminated food. The agent and source of an outbreak therefore need rapid identification, together with an effective communication system, so that control measures can be introduced promptly. Application of the hazard analysis and critical control point (HACCP) approach is a more cost-effective method of control than end-product inspection.

43.* The HACCP approach should be more widely adopted throughout the Region for preventing food contamination. It should cover all stages of production, processing, storage and distribution, from the farm to the consumer.

44.* Greater emphasis should be given to reducing microbial contamination at the farm. Preventive measures should cover hygiene, for example, in animal housing, feed and manure handling, and vaccination of livestock where applicable. Before new techniques for primary food production are introduced, their public health implications should be fully explored.

45. Efforts are needed to improve understanding of food hygiene by all those who handle food at all stages from production to consumption.

46. Rapid methods for detecting pathogens need to be developed for application in international trade, together with "rapid alert" communication systems.

The possible consequences for health of low levels of chemical contamination of food are uncertain; data are sparse, but no obvious effects have been demonstrated. Nevertheless, conditions exist in parts of the Region where intakes of, for example, heavy metals from mining or industrial sources may be excessive.

47. Dietary intake studies are recommended as a first priority for vulnerable groups such as infants, young children and lactating mothers living near smelters or metal mines in those of the CCEE and NIS that have identified this potential environmental health problem. Health studies may be indicated.

The assessment of the safety of food and food ingredients derived from genetically modified plants and microorganisms requires an integrated approach.

48. The proposed use and dietary significance of food from genetically modified sources, and people's potential exposure to it, should be taken into account in safety assessment.

49. In each case, critical points in the process should be identified and appropriate controls set up to ensure safety and quality.

19.12 Exposure to Selected Chemicals

Population exposure to environmental chemicals needs to be assessed, to allow the environmentally sound management of chemicals advocated by the United Nations Conference on Environment and Development in its Agenda 21. Such data are, to a large extent, lacking in the Region, and are inadequate for identifying areas where the general population is subject to high levels of exposure. Some data available for specific subgroups suggest that in certain areas exposure to, for example, heavy metals such as lead may be a potential hazard to health. Relevant health studies are in general lacking. The contribution of the various sources or media to overall exposure is also unclear.

50.* The systematic monitoring and assessment of exposure to chemicals from various media should be instituted at the national level to detect significant environmental exposures and/or possible effects on health, including that of vulnerable groups, and to define the contribution of different environmental media to overall exposure as the basis for rational control strategies.

51.* The use of chemicals or processes that are associated with significant potential hazards to health or with the formation of environmentally persistent substances should be reduced by material substitution or improved technology.

52. In the longer term, models for calculating total intake and/or target organ doses on the basis of environmental measurements need further development and validation.

53. Similarly, the design of studies to assess total human exposure to certain chemicals should be harmonized and conducted in different locations (polluted and non-polluted) in the Region, so as to provide information on representative population groups and permit the evaluation of population risks.

Although new chemicals are subjected to toxicity testing, many thousands of chemicals already in use have not yet been adequately tested. The chemicals programme of the Organisation for Economic Co-operation and Development (OECD) and the International Programme on Chemical Safety (a joint venture between WHO, the International Labour Organisation (ILO) and the United Nations Environment Programme) are organizing the systematic investigation and evaluation of existing chemicals.

54. Vigilance is recommended at the national level to detect any significant environmental

exposures and/or any possible effects on health.

Internationally harmonized mechanisms for the assessment and control of existing and new chemicals are already widely adopted throughout the Region. Their even wider adoption might be facilitated if international assistance were offered to some countries for the development of appropriate national strategies.

55. The WHO Regional Office for Europe should be ready to provide practical help if required.

19.13 Nonionizing Radiation

19.13.1 Ultraviolet radiation

There is clear evidence of a causal relationship between exposure to ultraviolet (UV) radiation and the common forms of skin cancer; the data are also compelling for malignant melanoma, but the relationship is more complex. The recent rapid increase in the number of cases of skin cancer, including melanoma, in some European countries is related to social behaviour, particularly recreational habits involving sunbathing without adequate protection of the skin. Exposure to UV radiation also probably increases the risk of developing cataracts.

56.* The public should be given clear warnings about the risks of cancer and cataracts from UV radiation and of the need, particularly for those with certain types of skin and for young children, to use protective clothing, efficient sun creams and sunglasses to limit exposure of the skin and eyes to sunlight. Health education has successfully modified behaviour in some countries, but further efforts are needed.

To date, there is little evidence that depletion of the stratospheric ozone layer in the Arctic has resulted in changes in terrestrial UV radiation levels in the European Region, but this may be due to the considerable natural variation in cloud cover and air pollution. A recent study in Toronto, however, claims that winter levels of UVB increased by more than 5 % each year from 1989 to 1993 as ozone levels were depleted, but these findings are the subject of debate. The consequences of any increase in terrestrial UV radiation levels from increasing ozone depletion are potentially great, with possible direct and indirect effects on health.

57. Member States should work together to provide UV radiation monitoring data (preferably with spectral measurements) for a range of latitudes in the Region. A regional commitment is needed to an early ban on the use of chlorofluorocarbons and similar ozone depleting agents. (See also Global and transboundary issues, p. 536.)

19.13.2 Electromagnetic fields

The public has a strong perception of the risk related to exposure to electromagnetic fields. In particular, it is widely feared that living near overhead power lines may increase the risk of a child developing leukaemia or other cancer. The epidemiological evidence on which these concerns are based, however, is inconclusive. Recent data from Sweden suggest that the associated risk is not of public health significance: one extra case of childhood leukaemia in a population of 9 million. At present there is little understanding of possible biological mechanisms involved. Adequate measures have been proposed for the protection of workers and the general public from the established effects of electromagnetic fields.

58. The question of the long-term effects of low levels of exposure to electromagnetic fields should be reviewed in a few years, once the results of ongoing epidemiological studies are available.

59. Experimental research is needed on the mechanisms of action of electromagnetic

fields at the cellular level, and on the possible relevance of some observed effects for long-term exposure.

60. In the mean time, efforts should be made to achieve a better public understanding of the risks. (See also recommendation 61.)

19.14 Ionizing Radiation

Natural background radiation contributes most to the average human exposure. About half the contribution is radon irradiation of the lung, although individual doses from radon may be much higher. Other sources, such as nuclear power production, contribute doses to the general population that are, on average, several orders of magnitude lower than total doses from natural sources. Nevertheless, the public believes that the risks from man-made sources far outweigh those from natural sources.

61. Information should be made more widely available to the public on the radiation risks from man-made and natural sources.

Certain population groups receive a higher than average exposure. Special attention should be given to (*a*) radiation workers carrying out "dirty" jobs associated with higher than average doses and/or involving exposure to actinides such as plutonium, and (*b*) those exposed to higher than average levels of natural radiation, such as miners, air crews and those living in geological areas with high radon levels.

62.* Systematic monitoring of radon levels in homes should be established in radon-prone geological areas, followed by remedial action where guideline levels are exceeded.

Actual or potential problem areas are the safety of nuclear reactors, the proliferation of nuclear material and the safe storage and disposal of high-level nuclear waste. The safety of nuclear power plants is one of the most important issues in radiation protection, and involves questions of plant design, siting, operation and maintenance, particularly staff training.

63.* International technical aid should be available for countries operating reactors whose inherent design or operational problems make them a significant potential hazard to health.

The proliferation of radioactive material that could be used for the construction of nuclear weapons is a threat of global importance. The problems entailed in the decommissioning of nuclear power plants and the destruction of atomic weapons have not yet been solved; and no country yet operates a repository for high-level radioactive waste disposal.

64.* Sites of abandoned nuclear weapons should be identified and radioactive material stored securely until appropriate facilities for disposal become available.

Past practices in radioactive waste disposal, together with routine and accidental releases and nuclear weapons testing, have resulted in severe environmental contamination in parts of the former USSR.

65.* Increased, well coordinated investigations with international support should be carried out in relevant areas of the NIS into the size and effects of the doses of radiation received by populations as a result of nuclear accidents, inadequate disposal of radioactive wastes and nuclear weapons testing.

19.15 Residential Noise

Residential noise (i.e. noise from external sources that is perceived inside dwellings) is not a health problem in the same sense as occupational noise, where hearing ability is at risk. But residential noise seriously reduces the quality of life. About 15–25% of the population of industrialized countries are exposed to levels of noise that cause serious nuisance. Road traffic noise and neighbourhood noise are the most common causes of complaint.

Residential noise also causes sleep disturbance. Preliminary evidence shows that long-term exposure to high levels of traffic noise may have specific health implications.

Most countries have comparable legislation for the control of residential noise, usually aimed at specific sources such as road, rail and air traffic. Neighbourhood noise is relatively neglected and is more difficult to control. In addition to the nuisance created for other people, hearing may be impaired in those directly exposed to loud music from personal stereo systems and discotheques.

66. Sources of neighbourhood noise should be identified and noise limits laid down in regulations. International standards for the measurement and description of such noise are needed.

67. The implementation of noise regulations should be improved. A basic requirement is better monitoring systems.

68. Since enforcement is difficult, land use and town planning measures should be applied more often. An international report on the means and results of land use and city planning as an instrument for the control of residential noise should be prepared and disseminated to responsible authorities.

69. An international system should be established for exchanging information about research into the health effects of noise, and on complaints about, regulations for and the control of residential noise.

19.16 Housing and the Indoor and Urban Environments[a]

The methods used by countries to measure aspects of the housing environment lack conformity and therefore comparability. This applies to such aspects as general housing conditions, structure and insulation, maintenance, damp, temperature, indoor pollution, home accidents, and homelessness.

70. Government departments responsible for housing should take steps to develop and use standard ways of assessing housing conditions. Countries should move rapidly towards compiling basic statistical indicators to facilitate discussion of the adequacy of the housing environment, and promotion of the health and wellbeing of the inhabitants. Ideally these indicators should be the same as, or compatible with, the WHO regional indicators for monitoring progress towards the relevant health for all targets.

Inadequate housing often contributes to ill health, and improvements must be a major element of any policy to improve environmental health conditions. Important considerations include the availability of a safe water supply and sanitation, adequate space, heating, ventilation, noise insulation, and the provision of facilities for vulnerable groups – young children, the elderly and the handicapped.

Deficiencies in sanitation are present throughout the Region. These are more pronounced in rural than in urban areas, and more common in the CCEE and NIS than elsewhere in the Region. Of the 110 million people lacking a piped water supply, 86 million are in the NIS.

71.* Priority should be given to the availability of a safe water supply and sanitation, and to the provision of facilities for special groups such as young children, the elderly and the handicapped.

Health statistics are generally inadequate for assessing the contribution of the indoor environment to the causation of various diseases such as the extent to which low indoor temperatures contribute to excess winter mortality, or the importance of low indoor air exchange rates for respiratory disease.

72.* Research is needed on the contribution of certain aspects of the indoor climate, such as cold and damp, to respiratory diseases.

[a] Indoor air quality is addressed under Air Pollution, p. 523, and radon under Ionizing Radiation, p. 530.

Accidents in the home are an important cause of morbidity and mortality, mainly involving the very young and the elderly. Data from the United Kingdom suggest that about 13 % of fatal home accidents may be caused by constructional design faults. Detailed analyses are lacking, however, and international comparisons are difficult or impossible at present. The European Home and Leisure Accident Surveillance System will be analysing data from hospitals in 11 member states of the European Union.

73.* The recording of domestic accidents and poisonings needs improving. It should include their cause, as well as factors determining their outcome, and thus help define more clearly effective measures for the prevention of both accidents and fatalities.

Beyond the individual dwelling, housing must be viewed within the broader context of the community as a whole, where adequate health care, public transport, shopping and recreational facilities, and effective control of pollution and noise are needed. Unsustainable urban development has resulted in excessive urban growth and the loss of community life in cities.

74.* Urban planning is urgently needed to rehabilitate community life within cities and their suburbs.

75. The WHO Healthy Cities project or networks should be used to promote healthy and sustainable urban development policies.

The extent of homelessness in the Region cannot be determined with any accuracy, but there does not seem to be a simple relationship to total population or estimated need for additional housing. Given the widespread recession and the related migration of workers, as well as the influx of refugees to some Member States, the problem is likely to increase in the immediate future.

76.* The scale and causes of homelessness in the Region should be investigated and the most appropriate measures for mitigation adopted.

77. In all countries of the Region, housing should be made available for those with low incomes at a cost that does not jeopardize their access to other basic necessities.

19.17 Occupational Health

Every country in the Region is committed to a policy of health and safety at work, but the availability of the necessary instruments for implementation varies substantially. Only about half of the workforce has access to special occupational health services. Improved standards of occupational health and safety benefit not just the workforce but also the economic development of a country, since there is a demonstrable relationship between overall standards of health and safety in the work environment and productivity and the quality of the end-product. From a public health perspective, occupational health services provide a unique opportunity for health promotion.

78.* The coverage, activities and competence of comprehensive occupational health services should be improved throughout the Region according to the guidance given by ILO and WHO. Adequate numbers of occupational health physicians, nurses, hygienists and other personnel should be trained for such services.

79. Training and information should be given to workers, foremen and managers on the specific health hazards at their place of work, and on methods for their prevention and control.

The relative number of workers in different types of employment differs markedly between countries in the Region. The proportion working in agriculture and industry is higher, and that in service sectors lower, in the CCEE and NIS than in the European OECD countries. In general, there is also less automation and mechanization in the CCEE and NIS. These differences mean a heavier physical workload and a higher prevalence of and exposure to all the "traditional" occupational health hazards in both the CCEE and the NIS.

The most important problems in occupational health appear to be similar throughout the Region, even in countries at different stages of development: accidents, noise, chemical hazards, ergonomic problems and psychological stress. Novel issues (such as reproductive health, new infectious hazards, and the possible impact of high technology and new processes and materials) are only partly visible at the level of national statistics. Regional comparisons, other than for fatal accidents or mortality from particular diseases, are impossible because of differences and limitations in data capture and in registration procedures. Data on working conditions and exposures are also limited.

80.* Systems for the notification, registration and reporting of occupational accidents and diseases should be developed, with coverage of all workers and the self-employed. The international harmonization of such data systems should be encouraged to facilitate analysis on a regional basis of the most important causes, thus enabling priorities for preventive measures to be established.

81.* Legislation, standards and adequate inspection should be developed in all countries of the Region for the prevention and control of health hazards at work (such as accidents, occupational diseases, physical overload, ergonomic hazards and psychological stress). They should apply to all sectors of the economy and to all employees and the self-employed. Special efforts are required to prevent workers being exposed to agents that can cause early, irreversible damage and have possible long-term effects on health.

82. Compliance with noise limits should be ensured, and the importance recognized of interactions between noise, vibration and smoking.

83. The potential hazards of new technologies should be investigated and assessed, and the results used when the introduction of such technologies is planned, with appropriate safeguards for workers.

84. The competence and activities (including epidemiological studies) of occupational health and safety services should be more widely promoted as a resource for measuring, assessing and preventing environmental health hazards.

Some of the occupational health problems emerging in Europe are clearly attributable to the present economic situation, particularly the difficulties of transition in the CCEE and NIS and the recession throughout much of the Region. The large industrial complexes of centrally planned economies had large occupational health service teams. Their replacement by smaller-scale market economy industries has weakened the resources to sustain such occupational health services. This effect is mirrored to some extent by the effects of recession elsewhere in the Region. In addition, economic migrants, mobile workers and refugees from hostilities make up cohorts of workers who are not covered by the normal occupational health services, while frequently exposed to greater risks than the stable workforce in the receiving countries. In all countries of the Region similar, smaller-scale problems exist with workers in the informal sector and in home industries. Finally, as a result of the recession, unemployment is an increasing regional problem.

85.* Special action should be taken to improve occupational health in the CCEE and NIS. Workers in agriculture and small-scale industries should be given special consideration in the development of national occupational health programmes.

86. Employers and workers in home industries and the so-called informal sector, as well as the self-employed, should be advised on the identification and management of occupational hazards. The protection of children should be particularly addressed.

87. When developing occupational health programmes for migrant and mobile workers,

including refugees, their needs for general health services should also be considered.

88. Special programmes should be developed for the unemployed to maintain their work capacity and prevent the health problems associated with unemployment.

19.18 Accidents and Man-made Disasters

Major accidents that affect the environment are a serious potential risk to health. The risks may be increased by social instability.

89.* Countries should take all the steps in siting, design, construction and operation that are necessary to prevent accidents in industrial and nuclear power plants and during transport of hazardous materials, and draw up appropriate contingency plans to deal with any accidents that may still occur.

90. People living near hazardous installations should be made aware of the potential hazards and what they would be expected to do in the event of an emergency.

Such plans will also be relevant for response to natural disasters. Similarly, the activities related to the United Nations International Decade for Natural Disaster Reduction can enhance people's preparedness to respond to technological emergencies, particularly through international cooperation to prevent and control transboundary consequences.

91. The WHO Regional Office for Europe and other relevant international agencies should help facilitate the exchange of information between Member States about accidents, preparedness and response, and promote the development of effective Region-wide early warning systems.

92. The WHO Regional Office for Europe should develop and make available advice on the recognition and management of the psychological effects of major accidents.

Accidents occurring in the home (see recommendation 73), at work (see recommendation 81) and on the road are a major cause of mortality and morbidity, notably affecting young people. Road traffic accidents cause over 350 deaths and 6000 injuries daily in the Region. The number of such accidents could be reduced and all Member States should try to achieve this.

93.* Further action is required to reduce the contributions of both the environment and personal behaviour to road traffic accidents including:

(*a*) the development of better traffic infrastructures, regular checks on the roadworthiness of vehicles, greater compliance with regulations (including those related to alcohol consumption by drivers) and the provision of adequate, alternative transport systems; and

(*b*) education and training of all road users.

Accidental poisonings occur both at work and at home. Prevention of both requires adequate information and education on potential chemical hazards, together with the adoption of measures to limit the possibility of toxic exposure.

94. Governments should ensure that:

(*a*) appropriate legislation and enforcement measures exist for ensuring the safety-in-use of chemicals on the market, appropriate labelling and the use of childproof closures where necessary, worker protection and the monitoring of occupational exposure to hazardous chemicals; and

(*b*) in the event of chemical exposure, information and therapeutic measures (including antidotes) are available to those responsible for patient care. National poison control centres should be an integral part of such a response, to provide information and advice about any chemical involved in an incident.

19.19 Environmental Exposure in some of the CCEE and NIS

Of the 50 Member States of the European Region, 22 did not have a national focal point participating in the development of Concern for Europe's Tomorrow when the environmental health protocols were distributed. Of these 22 countries, 20 provided information later: 15 of the NIS, Croatia, the Czech Republic, Slovakia, Slovenia and The Former Yugoslav Republic of Macedonia.

19.19.1 The NIS

The major environmental health problems in the NIS reflect earlier policies that gave priority to production and little or no priority to environmental health protection. The water supply is inadequate in many areas, particularly in the eastern parts of the former USSR. Water quality is impaired by poorly maintained distribution systems, the lack of or inadequate treatment facilities (including sewage) and problems of waste disposal, as well as excessive use of agrochemicals.

Large areas of the former USSR have high levels of radioactive contamination as a result of the Chernobyl accident, other radiation accidents and radioactive discharges in the south Ural region, and nuclear weapons testing in Kazakhstan.

Inadequate attention to waste disposal used to be common practice. Widespread problems have resulted from storing liquid industrial wastes in artificial ponds without insulation and from dumping solid industrial and municipal wastes on the ground. For example, mountains of industrial waste exist in the Ural region, and dumping sites in Moscow are overfilled with sludges of municipal waste.

Air pollution is a substantial environmental health problem in many areas where heavy industries are concentrated, without adequate technologies for emission control. Air pollution in the former USSR, particularly in the Russian Federation and Ukraine, is generally more severe than in polluted areas of the CCEE. The recession that has closed down the most uneconomic industries does not seem to be improving air quality to the same extent as has occurred in the CCEE, and respiratory morbidity in exposed populations is to be expected.

In general, adequate health studies of these environmental exposures are lacking, and selected epidemiological studies should be carried out.

Furthermore, the control of infectious diseases is now less effective than before. Diphtheria, hepatitis A and diarrhoeal and parasitic diseases are widespread, and outbreaks of cholera have occurred. In areas of military conflict or where ecological or industrial disasters have occurred, people may no longer have access to adequate medical care.

19.19.2 The CCEE

The environmental health problems reported by the five CCEE (all new Member States) are similar. Thus, urban air pollution is of particular concern in industrial areas of countries such as the Czech Republic and Slovenia. The pollution of water resources, including groundwaters, by industrial and agricultural wastes is a widespread problem. Consequently drinking-water standards are difficult to meet; achieving tolerable levels of arsenic and nitrates will require extraordinary efforts in Slovakia and Slovenia, for example. Improper agricultural practices have also caused serious contamination of the soil. But in the countries of the former Yugoslavia war, indirectly or directly, is the most important factor affecting the quality of life for millions of people.

95. Environmental health priorities have to be set by individual countries, and specific recommendations for action will only then be possible. Support from the international community will be needed to deal with such major problems as the provision and repair of water

distribution systems and treatment plants, radioactive contamination, and urban air pollution hot spots. Particular attention should be paid to the disaster areas affected by war, where there is threat of epidemic disease and major damage to environmental health infrastructures, and to ecological disaster areas such as around the Aral Sea.

19.20 Global and Transboundary Issues

To safeguard people's health, greater international cooperation is needed on such issues as global climate change, depletion of the ozone layer, conservation of shared water resources, control of food quality, and trade in hazardous substances, products and wastes.

Changes in energy consumption patterns in both western and eastern European countries are necessary if sustainable rates of energy production are to be achieved. A 25 % increase in electricity generation is predicted for the Region in the next 25 years.

96.* Further use of alternative energy sources should be explored, taking into account their possible environmental impacts, if growth in energy consumption is not to be accompanied by an increase in global or transboundary pollution.

97.* Implementation of the Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer should be a regional objective.

19.21 Estimated Effects on Health of Environmental Exposure

Environmental factors are just one of the known causes of disease, and are seldom the only cause of a specific health problem. This can, however, be the case with communicable, foodborne or waterborne diseases due to microbiological contamination, for example, or with the rare effects of exposure to high levels of radiation or toxic chemicals as a result of an accident. Registered occupational diseases are also usually fully attributable to environmental conditions at work.

Of the factors known to increase the risk of diseases that may be related to environmental exposure, the most important is probably tobacco smoking. It is more significant than air pollution as a risk factor for chronic obstructive airways disease and lung cancer. Smoking interacts with environmental factors and increases the lung cancer risk from exposure to asbestos and radon tenfold. The worsening trends in cardiovascular and cancer mortality noted in middle-aged men in the CCEE can be at least partly attributed to smoking. Other lifestyle factors that may interact with environmental agents include alcohol and diet. Socioeconomic factors can also affect both lifestyle and environment.

Nevertheless, exposure to environmental factors with the potential to have adverse effects on health occurs at levels of concern in the European Region. Specific conclusions and recommendations have been presented above. The most common such exposure is to levels of ambient and indoor air pollutants that exceed the WHO air quality guidelines. Hundreds of millions of people, usually in urban areas, are estimated to be exposed to such levels.

The extent of exposure to microbiological contamination of food and water is more difficult to assess than its effects on health. Several million cases are recorded annually of communicable foodborne and/or waterborne diseases. Similar acute effects of chemical contamination occur rarely, as the result of accidents. The difficulty of detecting the long-term effects of low levels of exposure, against the background rates of common diseases, is well recognized (and is relevant also, for example, to exposure to potentially carcinogenic air pollutants).

Lack of appropriate data precludes valid estimates of the extent on a regional scale of, for example, the exposure to and impact of unhealthy working conditions or of poor housing conditions, accidents or homelessness.

While it is known that, in 1990, mortality from road traffic accidents in the Region was 13.9 per 100 000 population, the contribution of environmental factors to causation cannot at present be estimated.

Unsafe industrial installations are a potential environmental health hazard, the possible scale of which cannot be estimated with any reliability. The principal need is to reduce the likelihood of an accident occurring at all stages from design to operation and maintenance.

The development of environmental health management policies and priorities requires the risks related to environmental factors to be assessed, but great uncertainty still exists in the estimation of the impact on health of environmental factors in the Region.

98. To reduce the uncertainties in risk assessment, better information on population exposure and better understanding of the links between environment and health are necessary. (See recommendations 12, 13, 14 and 15.)

19.22 Role of Economic Sectors in Environmental Health

A definition and comparison of the contribution of various economic sectors to the environmental health burden can only be achieved on a regional basis in qualitative terms. A much simplified overview suggests that the economic activities related to environmental health problems in the CCEE and NIS are mainly energy production and heavy industry. They contribute to urban air pollution and the contamination of soil and water from waste, both chemical and radioactive. The rest of the Region is confronted with the consequences of over-intensive farming and over-dependence on road transport for both passengers and freight. On the other hand, all economic activities benefit health, directly and/or indirectly, through the promotion of socioeconomic development.

99. Countries should make national assessments of the beneficial and detrimental contributions of their various economic activities to environmental health, so that they can develop appropriate priorities for interventions to achieve maximum overall improvement.

100. Research is needed to develop the methodology for costing these health benefits and detriments, as well as to assess the expected health gains in relation to the costs of intervention at source or of environmental clean-up.

This report presents the findings of a major project organized by the WHO Regional Office for Europe, one of the most comprehensive surveys on environmental health ever carried out in Europe. It will be an essential tool for decision-makers, professionals, international organizations and scientific institutions in the fields of health and environment, and will provide much needed information for medical schools, schools of public health and postgraduate institutes, as well as nongovernmental organizations, advocacy groups and the business sector concerned with environment and health.

WVG

Wissenschaftliche Verlagsgesellschaft mbH Stuttgart