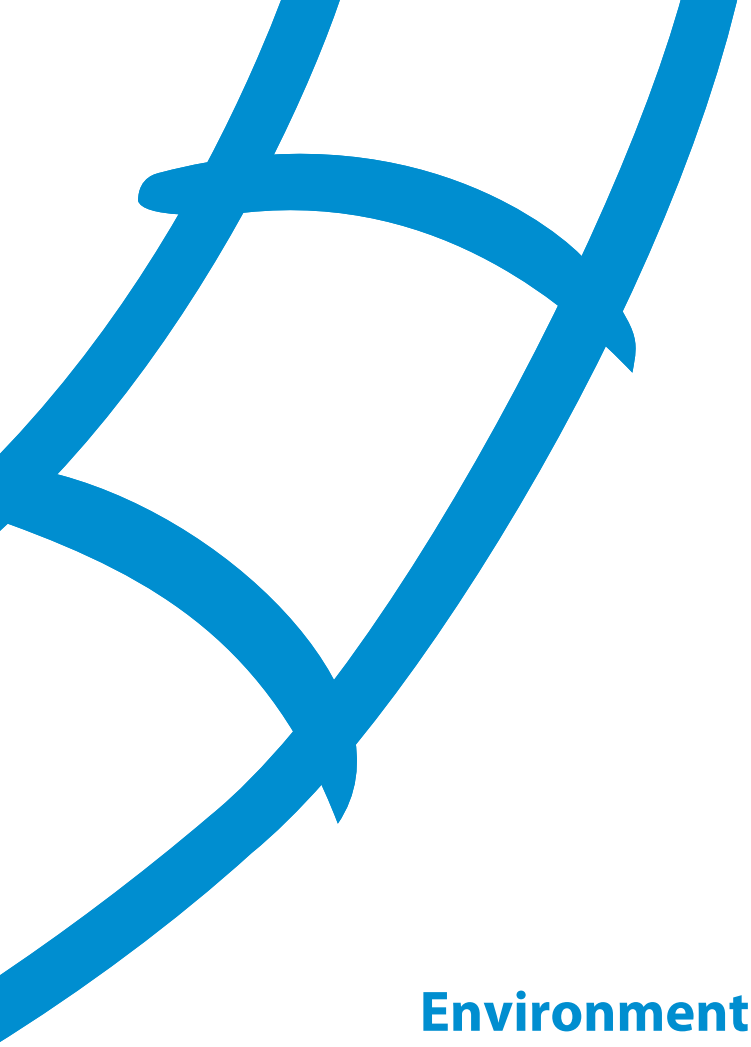
Environment and health risks: a review of the influence and effects of social inequalities



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Environment and health risks: a review of the influence and effects of social inequalities

ABSTRACT

This report serves as a background document for the policy brief on social and gender inequalities in environment and health that was prepared for the Fifth Ministerial Conference on Environment and Health (Parma, Italy, 10–12 March 2010). It provides an overview of the currently available evidence on the influences and effects of social and gender inequalities on environmental health risks.

The evidence has been compiled for six environmental health challenges (air quality, housing and residential location, unintentional injuries in children, work-related health risks, waste management and climate change) as well as for gender-related inequalities and children's exposure. Additional chapters present interventions on child-related environmental inequalities and social inequalities in environmental health risks in the Russian Federation.

Although the evidence base on social inequalities and environmental risk is fragmented and data are often available for few countries only, it indicates that inequalities are a major challenge for environmental health policies. The review confirms that people living in adverse socioeconomic conditions in Europe can suffer twice as much from multiple and cumulative environmental exposures as their wealthier neighbours, or even more. Similarly, inequalities in exposure to environmental threats have been identified for vulnerable groups such as children and elderly people, low-education households, unemployed persons, and migrants and ethnic groups. Only little evidence is available indicating that in some circumstances, well-off and advantaged social groups are more at risk.

Irrespective of developmental status, environmental inequalities can be found in any country for which data are available. Despite lack of data from many Member States of the WHO European Region, social inequalities in environmental risk must therefore be considered a public health issue for each country and the whole Region.

Keywords

ENVIRONMENTAL HEALTH
ENVIRONMENTAL EXPOSURE
SOCIOECONOMIC FACTORS
RISK FACTORS
GENDER IDENTITY
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Acknowledgements

This evidence review has been compiled by the WHO European Centre for Environment and Health (Bonn Office) and is based on three expert meetings on social inequalities and environmental risks organized in preparation to the Fifth Ministerial Conference on Environment and Health (Parma, Italy, 10–12 March 2010):

- WHO meeting on "Environment and health risks: the influence and effects of social inequalities", Bonn, Germany, 9–10 September 2009, supported by funds from the Federal Ministry of the Environment, Germany;

- "Socio-environmentally determined health inequities among children and adolescents. WHO/Health Behaviour in School-Aged Children (HBSC) Forum", Siena, Italy, 19–20 October 2009, supported by funds from the Tuscany Region, Italy and the National Health Service (NHS) Scotland;

- "Gender inequalities in environment and health", Madrid, Spain, 11–12 November 2009, organized and funded by the Observatory of Women's Health of the Ministry of Health and Social Policy of Spain.

WHO is grateful for the contributions of the authors of the individual chapters as well as the comments made by participants at these meetings.

Introduction

Social determinants of health have a strong influence on a wide diversity of health endpoints. The same is valid for the field of environmental health, as the exposure to environmental risk factors is also unequally distributed, and this unequal distribution is often related to social characteristics such as income, social status, employment and education, but also non-economic aspects such as gender, age or ethnicity. However, depending on the environmental risk and the "risk group" considered, the magnitude of inequality varies largely.

The realization of the social pattern in risk exposure has resulted in the adoption of methodologies to formally take into account these effects. Typically, the health risks depending on socioeconomic factors have a strong potential for acting as *confounders* of the parameter of interest, i.e. the association between health and the respective risk factor. Standardization techniques are applied to remove their contribution and assess the risk factor-health association independent of the influence of socioeconomic factors.

This practice has greatly contributed to better assessment of various environmental risks, and is nowadays firmly established in environmental epidemiology. However, this also reflects the strong expectation that socioeconomic factors are associated to environmental exposures. Still, complete understanding of how environmental risk factors operate in the reality of the social environment has not been reached, and would be very informative especially for designing effective policy responses.

As a first step towards better understanding of the impact of social inequalities on the distribution of environmental risks, this report presents a compilation of European evidence on the impact of social determinants on environmental risk. This report mainly draws from contributions to a background document for the WHO expert meeting on "Environment and Health risks: the influence and effects of social inequalities" funded by the Federal Ministry of the Environment, Germany (Bonn, 9–10 September 2009).[1] It incorporates additional contributions from expert meetings on social inequalities and environmental risks which were supported by funds from the Tuscany Region, Italy and the National Health Service Scotland ("Socio-environmentally determined health inequities among children and adolescents. WHO/Health Behaviour in School-Aged Children (HBSC) Forum", Siena, Italy, 19–20 October 2009)[2] and the Ministry of Health of Spain ("Gender inequalities in environment and health", Madrid, Spain, 11–12 November 2009).[3]

This review report focuses on evidence from the Member States of the WHO European Region but also recognizes key evidence from outside Europe helpful to understand the associations between social factors and environmental risk exposure. It aims at contributing towards an evidence base for addressing environmental inequalities and is one of the documents made available to the participants of the Fifth Ministerial Conference on Environment and Health (10–12 March 2010 Parma, Italy). Specifically,

[1] Further information and meeting report available from the WHO Regional Office for Europe (http://www.euro.who.int/envhealth/topics/20090706_2).
[2] Further information available from the WHO Regional Office for Europe (http://www.euro.who.int/childhealthenv/0090514_1).
[3] Further information and meeting report available from the WHO Regional Office for Europe (www.euro.who.int/gender).

it gives the scientific background details for the Ministerial Conference policy brief on social and gender inequalities in environment and health.[4]

For the preparation of the individual reports, authors were provided with a suggested framework model developed by WHO[5] to structure and decomposite the potential pathways through which social determinants and inequities could possibly affect the chain that leads from environmental conditions through environmental risk exposure and the exposure-response function to the health outcomes. The framework model (Fig. 1) suggests four major pathways:

- **arrow 1:** social determinants affect the environmental conditions of an individual and may contribute to the fact that specific individuals or population groups more often experience less adequate or potentially harmful environmental conditions.
- **arrow 2:** social determinants may directly affect exposure beyond and in addition to the exposure that is related to arrow 1 (within same environmental conditions, the "affected" population groups could still be more exposed through e.g. the mechanism of education and health behaviour).
- **arrow 3:** given the same exposure, (socially) disadvantaged groups could show more severe health effects if the social disadvantage is associated with some mechanism that modifies the effects and therefore influences the exposure-response function.
- **arrow 4:** sufficient evidence is available that social determinants affect health (what remains unclear is the relative importance of socially determined exposure to environmental risk factors).

Arrows 1 and 2 are representing the "exposure differential" – indicating the variation of exposure – and arrow 3 represents the "vulnerability differential," indicating the variability of the exposure-response function and – therefore – the vulnerability of individuals. Both differentials together would expect to explain the degree of environmental inequalities identified.

Next to the processes causing the unequal distribution of environmental risks and outcomes, the framework model identifies the institutional landscape and the respective services and actions to tackle inequalities. A variety of actors is called upon to reduce and mitigate the occurrence of environmental inequalities, be they socially determined or not. In first place, responsibility is with the environmental actors and stakeholders shaping the environmental conditions, such as actors on environment, transport, housing, occupational settings etc. However, the health sector has also a key role to play which is not reduced to the provision of care services, but also includes preventive action and environmental health services which in most cases must be based on collaboration with other sectors, shaping a common health-in-all policies approach (HIAP). Clearly, national health and welfare systems need to address the increasing problem of health inequalities, and as environmental inequalities are a major contributor to health inequalities, it is necessary to join forces with other sectors.

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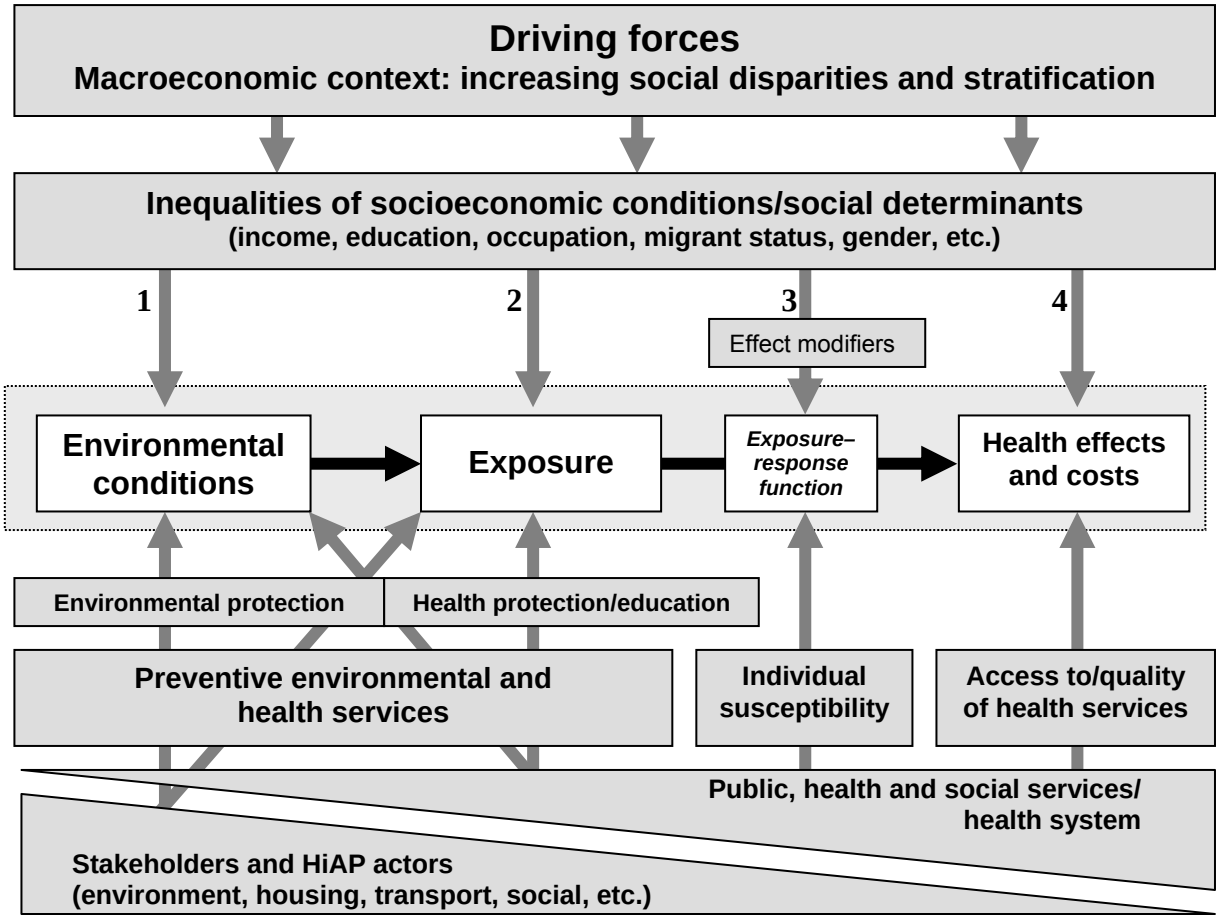
[4] Further information and policy brief on environmental and gender inequalities available from the WHO Regional Office for Europe (http://www.euro.who.int/parma2010/docs/20100201_1).

[5] WHO (2009). *Socioeconomic inequities – scenarios, recommendations and tools for action*. Copenhagen, WHO Regional Office for Europe, 2009 (http://www.euro.who.int/document/eehc/29th_eehc__bonn_edoc15.pdf).

Fig. 1. The WHO framework model on social inequalities and environmental risks



This document is structured into three categories. First, six evidence reviews on the impact of social determinants on environmental risk are presented, making the case for different environmental inequalities, and different risk groups. The first chapter, provided by Deguen (France) and Zmirou-Navier (France), deals with the inequalities in **air pollution**, focusing on ambient air. The second chapter by Fairburn (United Kingdom) and Braubach (WHO) addresses inequalities in the field of **housing and residential location**, including indoor environmental conditions as well as neighbourhood and residential effects. The third chapter, written by Laflamme (Sweden), Hasselberg (Sweden) and Burrows (Canada), presents the available evidence of the social divide in **child injuries** based on a larger WHO review project published in early 2009. The fourth chapter on inequalities related to **occupational conditions** is written by Brenner (United States) and reviews the relationship between social status and working conditions, followed by chapter five by Martuzzi (WHO), Mitis (WHO) and Forastiere (Italy) on inequalities related to **waste management**. Chapter 6 by Kovats (United Kingdom), Wilkinson (United Kingdom) and Menne (WHO) reviews the impacts of **climate change** on environmental inequalities and takes on a more forward-looking perspective.

Second, evidence reviews are presented to assess the dimension of socially triggered environmental inequalities for specific risk groups. Chapters 7–9 holistically address **environmental inequalities in children** and consist of an evidence review contributed

by Bolte (Germany), Kohlhuber (Germany), Carpenter (United States) and Tamburlini (Italy), followed by contributions from the WHO/HBSC network on interventions and actions to tackle inequities in physical activity in children (contributed by Pattison (United Kingdom (Scotland)) and Nemer (WHO)) and the abstracts of country case studies on lessons learned with physical activity-promoting interventions for children. The **gender** perspective and its reflection in environmental inequalities is described by Cantarero (Spain) and Yordi (WHO) in Chapter 10.

Third and finally, Chapter 11 presents a country profile on social inequality and **environmental health in the Russian Federation** (contributed by Boris Revich, Russian Federation) as an indication of the potential expression of environmental inequalities in Russian-speaking countries for which very little evidence seems currently available in international literature.

1. Social inequalities in health risk related to ambient air quality

Authors
Séverine Deguen
EHESP School of Public Health
France

Denis Zmirou-Navier
EHESP School of Public Health
INSERM U954 Vandœuvre-les-Nancy
Nancy University Medical School
France

Abstract

Background

Evidence of social inequalities in health is now well established in most developed countries. Environmental nuisances, including ambient air pollution, are thought to contribute to such equalities. In spite of improvements in air quality over the last decades in developed countries, air pollution remains a major investigation field and action domain for improving public health. It may still represent a strong factor of health inequalities.

There are two major mechanisms, which may act independently or synergistically, through which air pollution may play this role. Disadvantaged groups are recognized as being more often exposed to air pollution (differential exposure); they may also be more susceptible to the resultant health effects (differential susceptibility).

Review methods/data

Research articles were obtained through a literature search in the Medline database of the National Library of Medicine. We selected articles as of the end of April 2009; the more recent articles were privileged. The main keywords used to perform this literature review are “Socioeconomic Factors AND Air Pollution” AND “Health”; numerous synonymous expressions of these three keywords have been also used. This chapter will pay special attention to European studies and to children considered as a more “vulnerable” subgroup.

Results

Some European studies found that poorer people were more exposed to air pollution whereas the reverse was observed in other papers. A general pattern, however, is that, irrespective of exposure, subjects of low socioeconomic status experience greater health effects of air pollution.

Several suggested pathways and mechanisms have been identified. Housing market dynamic bias in land use decisions could explain why several populations cumulate poor socioeconomic status and poor air pollution exposure. Also, misclassification of exposures could also explain some inverse findings and asserts that true exposure of the rich may be poorly indexed by air quality measured at their week-days residence area.

Further, accumulation of environmental exposures (ambient air, indoor air, including at work and while commuting), especially among poorer populations, should be taken into account to explore more accurately the causes of health conditions. Finally, biological pathways, poorer health conditions (e.g. pre-existing chronic diseases), and presence of competitive risk factors come to be added to the list.

So far as we are aware, no European study has explored this relationship among children. Now this group might be both more exposed to environmental nuisances and more susceptible, a statement that warrants confirmation studies; also, differential childhood environmental exposures may increase health inequalities at older age.

Conclusions

The issue of exposure and health inequalities in relation to ambient air quality is complex and calls for global appraisal. There is no single pattern. Policies aimed at reducing the root causes of these inequalities could be based on urban multipolarity and diversity, two attributes that require long term urban planning.

Introduction

Evidence of social health inequalities is well established today in most industrialized countries (Kunst, 2007): globally, socioeconomically disadvantaged populations are more strongly affected by various health problems – diabetes (Dalstra et al., 2005), cardiovascular diseases (Dalstra et al., 2005), some types of cancer (Passchier-Vermeer et al., 2000; Mitchell et al., 2003), and the most severe forms of asthma (Cesaroni et al., 2003; Ellison-Loschmann et al., 2007) – than more affluent populations. Poverty and deprivation in early childhood influence both health and development in various dimensions and can have serious negative health consequences for the entire life (Hornberg et al., 2007). In spite of the numerous factors already identified, some of these inequalities remain unexplained. In light of this, it is suspected that environmental nuisances also contribute to social inequalities in health (Evans et al., 2002; Siegrist et al., 2004; O'Neill et al., 2007). Assessing how environmental exposures may partly explain social inequalities in health is today a major public health research issue.

In this context, the objectives of this report are twofold: (1) to understand how social processes may interplay with environmental nuisances and exposures; and (2) to understand why some subgroups of population experience greater illness compared with other groups.

The present review focuses on ambient air pollution. There is substantial evidence that ambient air pollution has adverse effects on human health. Many epidemiological studies conducted in the United States or in Europe have demonstrated that both short-term and long-term exposures are associated with an increase in the frequency of several health events. In spite of the improvement of air quality, air pollution remains a major investigation field and action domain for improving public health. We will pay special attention to European studies and to subgroups considered as more "vulnerable." Several epidemiological studies have identified the elderly and subjects with a pre-existing chronic cardiac or respiratory disease, congestive heart failure, and diabetes as subgroups more sensitive to the harmful effects of air pollution than the general population. This is also the case for children that may experience greater health effects due to the special sensitivity of their developing biological systems.

Review methods/data sources

Research articles were obtained through a literature search in the Medline database of the National Library of Medicine. We selected articles as of the end of April 2009. Recent articles were privileged but we referred to several key papers dealing with our topic in the 80s and 90s.

Three principal MeSH terms were used for the literature search queries: "*Europe* AND *socioeconomic factors* AND *air pollution*." Numerous synonymous expressions of these two keywords were also used, such as "*social class*, *unemployment, income*" for socioeconomic factors and "*ozone, nitrogen dioxide, sulphur dioxide, carbon monoxide, particulate matter*" for air pollution. We have also included more general expression, "*environmental justice*" and "*environmental inequity*" dealing with the socio-environmental disparities. Were excluded papers investigating only indoor air pollution and occupational or exposure to environmental tobacco smoke; papers in which air pollution exposure was measured using a proxy-indicator such as distance to high traffic roads or to industrial plants; and papers where no result was presented on either socioeconomically based *differential exposure* or *differential susceptibility.*

To complete our literature search, others databases, namely Academic Search complete, ERIS or Library, Information Science and Technology Abstract have also been consulted using the same keywords.

Literature review

1. Background

According to the literature, there are two major mechanisms, acting independently or in synergy by which environmental exposures can contribute to social inequalities in health. Among the general population, disadvantaged groups are recognized as being more often exposed to sources of pollution (Sexton, 1997; Evans et al., 2002) (exposure differential) and/or more susceptible to the resulting health effects (Sexton et al., 1993; Sexton, 1997) (susceptibility differential). The role of environmental exposures in social health inequalities can therefore only be further explored by adopting a rigorous approach that aims to improve our understanding of one and/or the other of those mechanisms by which these populations may suffer increased health effects.

In 2006, Kohlhuber et al. reminded that socioeconomic factors may impact on children's environmental health following the same two ways (Kohlhuber et al., 2006).

The following section is structured according to these two mechanisms suggested in the literature. In two distinct paragraphs we summarize the main results of epidemiological studies which are sorted by country rather than by pollutant, because ascription of the observed health effects to specific pollutants is difficult. Two tabulated appendices (Appendix 1 and 2) provide more detailed results of European studies included in this review.

As this topics has emerged relatively recently in Europe, we also review studies conducted outside Europe, notably to discuss children inequalities. Because of their number and their quality, these studies shape robust and consistent results which are useful for the reflexion about pathways and mechanisms explaining the findings.

2. Exposure differential

Cross-referencing environmental data with data on population characteristics should permit to assess whether environmental inequalities exist across populations and whether sources of pollution are concentrated more in certain areas of a territory than in others. The existence of territorial disparities in the distribution of environmental hazards or nuisances and of associated environmental exposures according to socioeconomic status would contradict the principle of "*environmental justice*" or "*environmental equity*," which states that no population group should bear a disproportionate share of negative environmental exposures.

The study of the distribution of environmental exposures between populations with different socioeconomic and demographic status originated in the United States and Canada (Brown, 1995; Neumann et al., 1998; Perlin et al., 1999; Jerrett et al., 2001; Evans et al., 2002; Morello-Frosch et al., 2002; Gunier et al., 2003; Elliott et al., 2004; Abel, 2008); later, it has spread to Europe with research mainly being carried out in the United Kingdom (United Kingdom) and Sweden (Brainard et al., 2002; Morello-Frosch et al., 2002; Mitchell, 2005; Chaix et al., 2006).

More recently, a few studies dealing with environmental inequities emerged in other countries (e.g. France (Havard et al., 2009b), Italy (Forastiere et al., 2007)). Noticeable is that, irrespective of the environmental nuisances considered, most of environmental justice studies in Europe were done on adults (Hornberg et al., 2007).

The American studies initially focused on the proximity of certain groups to polluting industries or main roadways. Income level and ethnic origin are two indicators often used in the American literature to characterize environmental inequalities. Indeed, certain ethnic minorities, particularly those with low income, are more likely to live close to main roadways carrying high volumes of traffic, to airports, polluting industry, incinerators, dumps and power stations (Rios et al., 1993a; Brown, 1995; Morrel et al., 1997; O'Neill et al., 2003; Gunier et al., 2003; Norton et al., 2007).

Studies of environmental justice in relation to air quality, actually measured or modelled, have been developed more recently. Along the last twenty years, a lot of countries have established an efficient network to monitor urban atmospheric pollution and survey air quality. A rich database of information is now available and offers studies and research opportunities. The last few years or decade have seen the development of several tools permitting ambient air concentrations and population exposures to be modelled at very fine geographic resolutions. Finally, the accessibility of geographic information systems completes the panel of tools that are available, enabling research teams to properly carry out environment justice studies dealing with air pollution.

2.1 Brief view on literature outside European countries

Most environmental justice/inequity studies concluded that the level of contamination present in the environment in which disadvantaged populations reside was higher than in more affluent areas (Jerrett et al., 2001; Morello-Frosch et al., 2002; Brajer et al., 2005). However several studies showed some inconsistent results depending to the air pollutant considered in the analysis, in particular ozone, and to the indicators used to qualify the socioeconomic level (Brajer et al., 1992; Korc, 1996; Liu, 1996; Brajer et al., 2005). Several studies (Brajer et al., 1992; Brajer et al., 2005) conducted in Los Angeles

concluded that a high level of ozone is associated with both low income and low education level whereas other studies conducted in New York and Philadelphia (Liu, 1996) found opposite results, i.e. a high level of ozone is associated with the white population and high income. From a pollution index combining (PM_{10}, NO_2, SO_2, CO and O_3 pollutants levels), a study conducted in a US cohort of pregnancy women concluded that Hispanic and African-American mothers were more than twice as likely to live in the most polluted counties compared with white mothers (Woodruff et al., 2003). In Canada, a research team working principally on the industrial area of Hamilton (Ontario) published several articles to highlight the presence of environmental inequalities. The most recent one found an association between particle concentrations and several neighbourhood socioeconomic indicators (such as income, unemployment, proportion of immigrants …) (Jerrett et al., 2001; Buzzelli et al., 2003). In New Zealand, three recent studies explored the hypothesis of environmental inequities related to air pollution. Two of them were conducted in Christchurch (Pearce et al., 2006; Kingham et al., 2007), and investigated the existence of inequities related to particulate air pollution using a panel of demographic and socioeconomic indicators (age, ethnicity, income and deprivation index). Globally, whatever the indicator used, air pollution was significantly higher in the most deprived area than in the most privileged one. Conducted at a national scale in New Zealand, a third study exhibited consistent results with the former (Pearce et al., 2008).

2.2 Focus on European countries

The majority of European studies took place in the United Kingdom. In England and Wales, McLeod et al. (2000) investigated the relationship between PM_{10}, NO_2 and SO_2, and socioeconomic indicators. They found that higher social classes were more likely to be exposed to greater air pollution, whatever the pollutants and the socioeconomic indicators they used. In contrast, Brainard et al. (2002) found that the level of NO_2 and CO in Birmingham was higher in communities with a greater proportion of coloured people and deprived classes. Several years later, in Leeds, Mitchell (2005) demonstrated social inequality in the distribution of NO_2 according to the Townsend index. Comparing the trend of NO_2 levels between 1993 and 2005, Mitchell demonstrated that the average difference between deprived and affluent communities declined from 10.6 $\mu g/m^3$ in 1993 to 3.7 $\mu g/m^3$ in 2005 as a result of city-wide improvements in air quality driven by fleet renewal. Wheeler et al. (2005) also found that air quality is poorer among households of low social class. More recently, social inequalities in NO_2 levels in Leeds were confirmed by Namdeo et al. (2008) at the detriment of poorer groups. In London, a comparison before and after the introduction of the Congestion Charging Zone showed that, although air pollution inequalities persisted, there was a greater reduction in air pollution in deprived areas than in the most affluent ones. Briggs et al. (2008) concluded that the strength of the association of the deprivation index with air pollution tended to be greater than for other environmental nuisances.

Two studies were conducted in Oslo, Norway. Using a variety of socioeconomic indicators (manual class, income, education, not owning their dwelling, living in flat and in crowded household) Naess et al. (2007) showed that the most deprived areas were exposed to higher $PM_{2.5}$ levels and revealed a clear dose–response relationship between $PM_{2.5}$ levels and the number of subjects living in flats. In contrast, no association between NO_2 levels and education or occupation was found in a cohort of Norwegian men.

Within the EXPOLIS study, environmental inequalities arising from personal exposure to NO_2 and $PM_{2.5}$ were explored in Helsinki, Finland (Rotko, 2000; Rotko, 2001). Personal levels of NO_2 decreased with a higher level of education. Much greater contrasts in exposure were observed between socioeconomic groups for men than for women, both for NO_2 and $PM_{2.5}$. While the occupational status was not correlated with $PM_{2.5}$ globally, a stratified analysis by gender showed a strong association for men only: the mean $PM_{2.5}$ exposure was about 50% lower among white-collar workers than among the other occupational categories.

Two studies conducted in Sweden brought evidence of social inequalities related to NO_2. Stroh et al. (2005) found that the strength and direction of the association between the socioeconomic status and NO_2 concentrations varied considerably between cities. In another study, children from areas with low neighbourhood socioeconomic status were shown more exposed to NO_2 both at home and at school.

We found four others European studies that explored social inequalities related to air pollution. In Rijnmond (Netherlands), according to Kruize et al. (2007), lower-income groups live in places with higher levels of NO_2 than greater income groups. In a cohort of German women, Schikowski et al. ((2008) revealed the existence of a social gradient with higher PM_{10} exposures among subjects with less than 10 years of school education than among those with longer education. Recently, an environmental justice study in the Strasbourg metropolitan Area (France) demonstrated the existence of social inequalities related to air pollution (Havard et al., 2009c). Using a French deprivation index (Havard et al., 2008), the authors found that the mid-level deprivation areas were the most exposed to NO_2. The same associations were confirmed for the other air pollutants tested in this study (PM_{10}, CO) with, as expected, inverse contrasts for O_3. Another illustration of this is that of Rome, Italy, where, contrary to many environmental justice studies, an inverse association was revealed: households of higher social class are more likely to be located in areas with high traffic emissions, and this disparity is even stronger when SES rather than income is considered. This “inverse association” appeared stronger for gases (NOx and CO) than for particulate matter (Forastiere et al., 2007).

Focus on European studies on children

In Spain, in a study, conducted 10 years ago (Garcia-Marcos et al., 1999) that compared polluted and non-polluted areas regarding SO_2 levels, the authors demonstrated that the household socioeconomic level was higher in the non-polluted area by comparison with the more polluted one. In Sweden, Chaix et al. conducted an original study on children and found that NO_2 concentrations measured both at place of residence and at school regularly increased with decreasing SES; in other terms, children from low SES neighbourhood were more exposed to NO_2 both at place of residence and at school (Chaix et al., 2006).

3. Susceptibility/vulnerability differential

The assumption according to which exposure to environmental nuisances gives rise to greater health effects among socioeconomically disadvantaged groups through differences in susceptibility has also been the subject of several studies but is still less well documented. Rios et al. (Rios et al., 1993) and Sexton et al. (Sexton et al., 1993) proposed this vulnerability hypothesis in 1993 and suggested that one important reason

was that their health had already been damaged. Such populations, because of their limited economic resources, may accumulate certain risk factors recognized as leading to the development of chronic diseases (Sexton, 1997). By this process, they would present a predisposition to the development of health conditions as a result of additional environmental risks.

Two possible routes through which air pollution exposure might result in greater effects among those in disadvantaged circumstances have been separated by O'Neill et al. (O'Neill et al., 2003): (1) susceptibility directly related to the socioeconomic position and (2) susceptibility from predisposing factors including predisposing health conditions, behaviours or traits.

Susceptibility factors include poor health status (obesity, diabetes and other chronic disease, for example), addiction (alcohol consumption, smoking, for example), multiple pollutant exposure (passive smoking, occupational exposure and indoor poor air quality) and difficulties with access to health care. Other factors have been also suggested such as psychological stress, low intake of protein, vitamins and minerals and even genetic factors. Following the WHO framework model (page 3), one could distinguish "cumulative exposure" factors on the one hand (arrow 2), whereby some subgroups might not only live in more heavily polluted areas, but also experience longer commuting time in the traffic and additional insults due to poor occupational and housing environments or to active or passive smoking, and "effect modifiers" on the other hand (arrow 3), whereby socially-related nutritional deficiencies, poor health and/or lower access to health care might result in aggravated effects of the additional stress represented by air pollution. The evidence is reviewed in the following sections.

3.1 Brief view on the literature outside Europe

To give a brief picture of vulnerability-related inequalities outside Europe, five contrasted situations are exposed: Brasilia (Gouveia et al., 2000; Martins et al., 2004), China (Chit-Ming et al., 2008; Kan et al., 2008), Canada (Jerrett et al., 2004; Jerrett et al., 2005; Charafeddine et al., 2008; Pouliou et al., 2008), the United States (O'Neill et al., 2004; Neidell 2004; Shao et al., 2008; Bell et al., 2008; Wilhelm et al., 2009) and Mexico (Romieu et al., 2004). These studies were chosen because they illustrate different findings, respectively: effect modification of air pollution by SES with poorer population/areas described as at greater risk; inverse effect modification where richer populations are reported at greater risk; absence of effect modification; and effect modification explored with two information levels combining individual and ecological socioeconomic data. Moreover, several of these papers dealt with inequalities among children which are rarely reported in Europe.

Conducted on 58 administrative districts of Sao Paulo, the study by Gouvenia et al. (Gouveia et al., 2000) investigated the association between air pollution, (SO_2, PM_{10}, CO, O_3 and NO_2), and mortality. Exploring more precisely the role of age and socioeconomic status, the authors found a slightly increased risk of mortality associated with PM_{10} among elderly people living in the most privileged areas, while Martins et al., in the same city, showed that poorer areas presented the strongest association between PM_{10} and mortality among the elderly; study design issues have been advanced as a possible explanation of these differences.

Three studies conducted in China (Chit-Ming et al., 2008; Kan et al., 2008) found that deprived socioeconomic status increased mortality associated with air pollution. More

precisely, in Shangai (Kan et al., 2008), the education level modified the effects (all-causes and cause specific mortality) of SO_2, PM_{10} and NO_2. Several pathways were pointed out by the authors to explain their finding but there was no clear evidence in favour of any single one. In Hong Kong Special Administrative Region, the effect of SO_2 on mortality was stronger in the deprived areas than in the most affluent ones, particularly for cardiovascular disease (Chit-Ming et al., 2008).The authors hypothesized that the differential of SO_2 exposure between areas might explain the differences observed in the effects but they also evoked the role of other health risk factors (poor health and nutrition for example) as being more prevalent in the socially deprived subgroups. The third Chinese study confirmed these results. However, in contrast with these findings, the data analysis from the Chinese Longitudinal Health Longevity Survey showed that elderly subjects living in more privileged urban areas were more affected by air pollution than their counterparts in more deprived one (Sun et al., 2008).

In the Hamilton-Burlington area of Southern Ontario, Finkelstein et al. (Finkelstein et al., 2003) found that effects of TSP and of SO_2 depended upon the income level. Mortality (all-causes or cardiopulmonary causes) was the highest among the low income group, beyond differences in exposure levels and advanced biological and sociological factors as possible explanations of these results. Using other neighbourhood socioeconomic indicators, Jerrett et al. (Jerrett et al., 2004) confirmed previous findings of effect modification by SES: a low education level and a high proportion of employment in manufactures modified the short-term mortality associated with the coefficient of haze (a proxy for PM) in five subdivisions of the city of Hamilton, Canada.

The study by Charafeddine et al. in the United States found that subjects living in the most affluent counties with high particulate levels were significantly more likely to report fair or poor health, compared to those in poorer counties who experience exposure to the same poor air quality. In contrast, Zeka et al., in 20 United States cities, showed stronger associations between PM_{10} and mortality for the less educated subjects (although not statistically significant). As Gouvenia et al. (Gouveia et al., 2000) in Brazil, Charafeddine et al. (2008) advanced the hypothesis of competitive risks as a possible explanation even if they could not exclude that the subjective nature of the information collected to characterize the health status could bias the results.

Studies on children

In contrast with studies conducted in the general or in adult populations, more children studies focused on health effect associated with O_3. Using the California Hospital Discharge Data, Neidell (Neidell, 2004) found that both O_3 and CO have a larger effect on asthma among low SES children, with a significant interaction for age categories 3–6 and 12–18 years. Additionally, they measured the percent change in asthma admissions between 1992 and 1998 that had resulted from changes in pollution levels over time. The declines in pollution since 1992 have decreased asthma admission in 1998 for children over 1 year from 4.6% (for the group aged 1–3 years) to 13.5% (for the group aged 3–6 years). The percentage of change in admission rates for asthma from higher pollution levels in low SES areas was estimated about 6%. In New York, Lin et al. confirmed these findings (Lin et al., 2008): children with low socioeconomic status had a greater risk of asthma admissions than other children living in areas at the same ozone level. In Mexico, Romieu et al. (2004) found no association between air pollution and

infant mortality. Nevertheless, she suggested that infants from low SES might be more susceptible to the effects of PM_{10} exposure and, by this way, were at greater risk of dying from respiratory-related causes.

3.2 Studies in European countries

This research topic is more recent in Europe than in the United States or Canada, and fewer studies have formally assessed the role of the socioeconomic status on the air pollution-health relationship. The first part of this section concerns articles which have formally tested the potential modification effect by the SES by way of stratified analyses or using interaction terms in the regression models. Table 2 summarizes this evidence and provides information on the study design of the papers, how exposure and SES were characterized, and methods used to assess effect modification and key results. The second part of this section deals with articles where socioeconomic variables were introduced as confounders.

Effect modification

In Rome, social class clearly affected the relationship between PM_{10} and mortality: the upper social classes were not as affected by the harmful effects of air pollution as those in lower social classes (Forastiere et al., 2007). Since the former were demonstrated to live in areas with higher air pollution, the authors interpreted their findings in terms of differential susceptibility. Supporting this hypothesis, they found a higher proportion of chronic diseases among the poor. They also argued that living in an area with a high level of air pollution, mainly in the city centre, did not necessarily result in greater exposure. Wealthier residents of Rome were said to spend less time by their homes than poorer social groups because they were more likely to have second residences outside the city.

In four Polish cities, Wojtyniak et al. (2001) showed a significant association between exposure to black smoke and either non trauma or cardiovascular mortality among subjects who had not completed secondary education. Significant associations between SO_2 or NO_2 and cardiovascular mortality were also present more particularly among subjects aged over 70 with education below secondary school level.

Finally, in France, five studies investigated the impact of the socioeconomic level on air pollution effects. In Bordeaux, Filleul et al. (2004) found a significant association between mortality among people over 65 and exposure to black smoke among blue-collar workers only. In the same city, however, a cohort study comparing the characteristics of people who died on days when the highest and the lowest black smoke concentrations were observed, did not found modification of the effect of air pollution on mortality by the SES. In Strasbourg, two studies explored the air pollution effects on myocardial infarction events and on asthma attacks (Havard et al., 2008; Havard et al., 2009b). Results from the former supported the hypothesis that neighbourhood SES may modify the acute effects of PM_{10} on the risk of myocardial infarction: differential susceptibility was suggested as the more plausible explanation since these most deprived populations did not live in the more polluted place. On the other hand, socioeconomic deprivation did not modify the relation between emergency telephone calls for asthma and concentrations of PM_{10}, SO_2, and NO_2, this finding was confirmed using the number of β-agonist sales for asthma.

Confounding

From the APHENA study conducted in Europe and North America (Samoli et al., 2008), the authors found that a higher percentage of unemployment was associated with a greater PM health effects in both continents. The main advanced explanation is the alleged greater susceptibility of populations with lower SES.

In Olso (Naess et al., 2007), the effect of $PM_{2.5}$ on mortality was partly explained by the neighbourhood-level indicators of deprivation, independently of individual-level deprivation. Including neighbourhood deprivation in the model diminished the strength of the association between $PM_{2.5}$ and mortality. Finally, no modification by gender was reported. Two explanations were advanced. In one hand, neighbourhood deprivation may be a distal cause mediated by more proximate factors such as air pollution; in other hand, taking into account neighbourhood deprivation level may capture confounders that explain this relationship.

Using data from the health survey for England, Wheeler et al. assessed the relationship between socioeconomic status and air pollution, and their combined effect on respiratory health (Wheeler et al., 2005). Low social class and poor air quality were independently associated with decreased lung function. No association was shown for asthma.

In Germany, Schikowski et al. investigated the contribution of air pollution in a urban area to social differences in respiratory health using data collected in the SALIA (Study on the influence of the Air pollution on Lung function, Inflammation and Aging) cohort of women from the Ruhr area aged 55 at the time of investigation (between 1985 and 1990) (Schikowski et al., 2008). They concluded that lower education women level had a higher prevalence of respiratory impairment; this association was diminished after adjustment for the five-year mean PM_{10} concentrations, particularly for FEV1 and FVC.

Studies on children

To our knowledge, no study explored, in Europe, effect modification of SES on the relationship between health and air pollution among children. In this context, the European Union funded the PINCHE network (Policy Interpretation Network on Children's Health and environment), which represents an interesting scientific platform to investigate the "Environmental exposures and children's health: impact of socioeconomic factors," title of work package number 5 of the PINCHE project. Bolte et al. (Bolte et al., 2005) identified 27 projects studying children's health, with a majority considering air pollution. The first result obtained, with still few data, suggests an inverse social gradient with increased burden of exposures and health outcomes in children of lower social status (Kohlhuber et al. 2006). The second important conclusion this study pointed out is that lack of information made it difficult to explore the effect of SES on environmental exposure and children's health in Europe, especially in eastern Europe. Enhancement of information, both in terms of availability and quality, seems a prerequisite for such studies to be effectively undertaken in Europe.

Specific key messages on children

Children need much attention; childhood environmental exposure may increase health inequalities at older age

While poverty was thought eradicated in most industrialized countries during the 1960s and 1970s, since the 1990s, childhood poverty has increased in Europe (Hornberg et al., 2007). The consequence could be a dramatic increase in incidence for several health events. It is now well documented that poverty and deprivation in early childhood influence both their health and their development and can also have adverse health consequences for their entire life. Moreover, studies on different air pollutants, exposure levels and locations suggest disproportionate health impacts for children. Follow-up studies in children are needed to assess social inequalities related to air pollution and to better understand mechanisms through which health inequalities could arise later in their life. For these reasons, much attention should be given to this major public health problem. To date, few studies have documented these two points and one first recommendation is that research projects should be undertaken following the avenue proposed by the PINCHE project. In this light, two areas of research often pursued independently in European countries have to be linked: the field of environmental epidemiology and that of social epidemiology.

Measured child poverty

Environmental justice studies focusing on children have naturally used the socioeconomic characteristics of their family to characterize their own SES level. Parental education level, income or deprivation index were more often reported as the proxy of the children socioeconomic level. Hornberg et al. (Hornberg et al., 2007) have recently stated that no consensus exists on how poverty should be measured and operationalized in such subgroups, calling for specific research

Children, a group more exposed

The contrasts in the exposure of environmental nuisances might be greater among children than among adults. Factors influencing personal exposure of children have been recently reviewed by Ashmore et al. (2009) and classified according to three micro-environments, namely school, home, and transport. Outdoor air pollution exposure tends to be more misclassified among adults population than among children because the latter are more stable within their area of residence whereas the former tend to commute from one area to another. Schools are generally located near the children residences and thus the air pollution level at school is credibly close to the home level, as demonstrated by Chaix et al (2006) in Sweden. Moreover, children with lower SES are more likely to live in homes with higher indoor air pollution, as a joint consequence of poorer insulation and indoor sources (gas stoves etc...). Finally, behaviours of children tend to increase the pollutant doses they receive compared to adults in a given air environment because children have higher inhalation rate to body weight ratio and show a greater physical activity.

For these major reasons, children may represent a particularly exposed group. Taking into account cumulative environmental exposures in children would make sense rather than considering them independently. Further methodological developments are another crucial point to enhance our ability to investigate environmental inequities and their health effects in children.

Children, a more vulnerable group

Today, it is well documented that children are more vulnerable than adults regarding several environmental hazards because of the immature development of their biological systems. Moreover, children living in poor areas seem to be more vulnerable than children living in more affluent neighbourhoods because they may cumulate chronic diseases and less healthy diet, which may give ground to synergistic effects.

Key points for gender differences

To our knowledge, gender differences in relation with air quality have never been studied among children and rarely in adults.

Some suggestions of effect modification by gender have been reviewed along the text. At this stage, it is difficult to formulate any key message on gender differences and it is rather time to set studies which should aim at investigating such interaction.

Relative impact/magnitude of inequity

In this section, we report the range of inequalities found in the literature, giving the lowest and the highest pollutant average difference estimates through SES indicators and magnitude of health risk (see more details in Tables 1 and 2)

Differences in PM or NO_2 ambient air concentrations are to date the best makers of social inequalities in exposure (where social characteristics have been measured using a panel of social indicators such as education, income or deprivation index). The following contrasts have been reported:

(i) Chaix et al. (2006) found 21.8 versus 13.5μg/m^3 for the lowest and the highest income classes respectively for NO_2 measured at Swedish children residences and 19.7 v.s.13.7 μg/m^3 for the lowest and the highest income classes respectively, measured at school location;

(ii) Neidell et al. (2004) reported average PM_{10} values by 31.85 versus 68.1 μg/m^3, and NO_2 average concentrations of 42.96 v.s.50,3 μg/m^3 among less and more deprived groups, respectively in a Californian children population;

(iii) within the Finish Expolis project, Rotko et al. (2000) found that an unemployment status increased the $PM_{2.5}$ personal exposure: $PM_{2.5}$ average exposures were equal to 41.8 among unemployed men vs 15.5 μg/m^3 for employed subjects.

Also reported below are differentials of death risk excess between social classes per 10-μg/m^3 increase in PM_{10}. In the Rome study (Forastiere et al., 2007), risk increases were 1.9% and 1.4% among people with lower income and SES compared to 0.0% and 0.1% among those with upper income and SES. Corresponding figures were 0.33% and 0.18% among the low and high education groups, respectively in a Chinese study (Kan et al., 2008). Another study in China (Chit-Ming et al., 2008) showed a significant social trend for the effect of 10 μg/m^3 of SO_2: the excess death risk (non accidental causes) was equal to 1.12% (high SES versus middle SES) and 1.38% (high SES versus low SES). Same social trends have been observed for cardiovascular mortality associated with NO_2: the difference in excess of risk was 1.03% (high SES versus middle SES) and 1.35% (high SES versus low SES). Finally, a US study (Bell et al.,

2008) found that an interquartile range increase in unemployed people was associated with a 72% [6.7; 137.2%] increase in effect estimates for ozone's impact on mortality.

Suggested pathways and mechanisms

Background

Pathways and mechanisms have been evoked in the literature review section. We propose here to capture the essential points and to illustrate briefly each one with some study results. Noticeable is that the mixed findings we describe might also result from methodological problems.

The discussion of pathways follows the four arrows introduced by the framework model in the introduction to this report.

Arrow 1 – Differential environment conditions

Residential 'segregation' may be one important reason why communities differ in their exposures. In Europe, socioeconomic disparities, notably those related to social and racial segregation, are less marked than in the US. In this context, social and economic resources (income, material living conditions, housing) are the main determinants of environmental inequalities. The housing market biases land use decisions and might explain why some groups of people suffer both from a low socioeconomic status and bad air quality at their place of residence. One reason is that the presence of pollution sources depresses the housing market and provides an opportunity for local authorities to construct council housing at low cost. Symmetrically, the presence of council housing in a given urban area tends to depress the price of land over time, encouraging the setting up of activities and facilities that generate pollution. A study conducted over a thirty-year period in the Los Angeles basin demonstrated that environmental inequities were based on deliberate localization of polluting facilities in existing minority neighbourhoods rather than on the geographical shifts of the minority population (Brulle et al., 2006).

Arrow 2 – Differential exposure

Living in a residential area with high air pollution levels does not necessary cause greater overall exposure. Affluent people are likely to have second homes outside cities and they may, therefore, spend less time at their main residence. Not taking this into account could yield exposure misclassification in that, while more affluent social categories may tend to live in central, more expensive, areas with higher pollution in some cities, their true year long exposure is probably overestimated. Conversely, subjects in deprived areas live in old dilapidated homes with poor ventilation and insulation, factors which favour the concentration of indoor pollutants. Moreover, they may be more likely to spend time close to or in the traffic, for example, working on the street rather than inside office buildings, or doing long commuting in public transport. Hence, the true daily and long term exposures of these groups are probably underestimated.

Cumulative exposure

It is well documented that poorer people are more likely to suffer from several types of environmental exposure. In the German study by Schikowski et al. (2008) the authors demonstrated that, in addition to increase in ambient air PM_{10} levels with poorer

education, the prevalence of occupational exposures and of current smoking followed the same gradient. Along the same line, Bell et al. (2008) also suggested that factors other than ambient air exposure, such as residential or occupational exposures might explain why areas with a high Afro-American population proportion and high unemployment might exhibit a greater impact of air pollution in US cities.

Arrow 3 – Differential susceptibility

Stressors, when amplified by poor resources, may directly lead to health disparities. Additionally, stressors may amplify the effects of toxicants.

Poorer health conditions

People with low SES may be more sensitive to air pollution-related health hazards because of high prevalence of pre-existing diseases. For example, Forestiere et al. (2007) raised this hypothesis to explain their results, having excluded the causal pathway of inequalities in environmental quality. They found a higher prevalence of chronic conditions such as diabetes, hypertensive diseases and heart failure in low than in high income groups. The former may receive inferior medical treatment for their conditions. They may also have more limited access to good food, resulting in a reduced intake of antioxidant vitamins and polyunsaturated fatty acids that protect against adverse consequences of particle or ozone exposure. In the particular case of infant mortality, Romieu et al. suggested that both micronutrient deficiencies and concurrent illnesses might decrease the immune response and make children more vulnerable to the adverse effects of air pollution.

Presence of competitive risk factors

The presence of competitive risk_factors in poorer areas has been advanced to explain why health risks associated with air pollution may in some instances be greater among wealthier groups (Gouveia et al., 2000; Charafeddine et al., 2008). Some authors argue that poorer populations cumulate many other risk factors that tend to increase mortality rates for other causes; a cited example is violence and substance abuse. Through this pathway, wealthier people may appear more vulnerable to air pollution as their baseline risk level is lower since they are relatively protected from other risk factors plaguing disadvantaged groups. In this context, Charafeddine et al. argued that “particulate pollution can be seen as one of the competing determinants of health” (Charafeddine et al., 2008).

Biological pathways

Concerning more precisely the poor elderly women subgroup identified in a recent French study as being more sensitive to cardiovascular risk factors, the reduction in hormonal protection following menopause has been advanced (Havard et al., 2009a). In this unfavourable context, air pollution may act as an exacerbating factor, thus generating greater health effects than in the rest of the population.

Possible solutions and countermeasures

The issue of exposure and health inequalities in relation to air ambient quality is complex and calls for a global appraisal. No single solution exists. However, two keywords should inspire policies aiming at reducing these inequalities at their very

roots. Both deal with urban planning: *multipolarity* and *diversity*. Multipolarity refers to the structure of our large metropolitan areas (or megapoles). Currently, with some variation across and within countries, the typical organization of our European cities is concentric: historical and cultural areas concentrate in the centre, where businesses and costly housing now tend to aggregate, while low cost residential areas are progressively transferred to the periphery, where large commercial malls and more traditional (often "dirty") industrial activities are also located, accessible only by private cars and duty trucks through highways and heavy traffic roads. The main characteristic of this urban organization is segregation of zones according to the type of activity they are assigned to (offices and associated workplaces, culture, green spaces and leisure, residences...) and according to the land price, which favours the creation of social "ghettos," the rich and the poor living in very different locations. In terms of sources of air pollution, this has two main consequences: more or less severe disparities in the quality of ambient air following the location of fixed sources of emissions (mainly from industries or specific services) or of traffic-related sources, on the one hand, and a pressure for long distance daily commuting between housing and job sites on the other hand, with poorer social categories forced to spend long times in the traffic or in public transport exposed to low air quality (in the traffic flow or underground). To the contrary of this concentric structure, *multipolarity* calls for urban clusters (or poles) within which one will find an array of amenities: housing, workplaces, commercial and cultural sites, hence tending to reduce the need for long distance commuting. *Diversity* is a complementary principle of multipolarity. It states that, within each pole, one should strive to give place to the widest possible variety of activities, and, most important, of social profiles of housing: places for the rich being intermingled with public and social housing. In addition to fostering solidarity across social categories, the main expected consequence of such urban design is that it will tend to reduce environmental exposure contrasts and, as a general average, the levels of air pollution. One reason, among others, is that, in general, more educated social categories tend to be more demanding and vigilant for environmental quality, a propensity that would, under this "diversity scheme" benefit the whole community.

It is easy to understand and observe that free market rules will "naturally" favour the segregated metropolitan areas pattern and that only strong national and local public policies may succeed in maintaining or re-establishing a greater mix of activities and social categories. This global vision is also consistent with the fact that in Europe, people spend a lot of time indoors, possibly reaching up to 90% of their daily life, especially in the more deprived population. This diversity scheme would prevent the crystallization of poor housing clusters, which is typically associated with poor access to good education and other cultural amenities: the further they are from the city centres, the more likely they are to be let in a marginal status. As exposed earlier, this is how inequalities in exposure to ambient air interplay with inequalities in other environmental stressors and vulnerability factors.

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Appendix 1. European studies investigating the environmental inequalities regarding air pollution exposure

Authors	Population /country	Study Design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Brainard et al.	Birmingham, England	Geographical	Annual average hourly CO and annual (hourly) NO_2	At a enumeration district scale (medium population of 496 residents): ethnicity, male unemployment, households without a car, homeowners, pensioners, social class, deprivation index (Carstairs, Jarman & Townsend)	The average CO and NO_2 emissions for districts with deprived populations are higher than in affluent ones: 2331 vs. 2112 $\mu g/m^3$ and 23.71 vs. 22.29 $\mu g/m^3$, respectively. The averages of these pollutants were also higher among districts with high proportion of blacks than among more white districts: 2919 vs. 2276 $\mu g/m^3$ for CO and 27.09 vs. 23.32 $\mu g/m^3$ for NO_2.
Briggs et al.	England	Geographical	Annual average of NO_2, PM_{10}, O_3, SO_2	Three geographical levels of analysis: super output areas (SOAs, an average of 1500 persons), wards (aggregations of SOAs, an average of 6200 persons) and districts (an average of 139 000 persons). Several indicators of deprivation: index of multiple deprivation: income, employment, education, access to housing and services	Positive correlations (varying around 0.3 and 0.2 at SOA and ward geographical scale) are found with all the air pollutants (except O_3): a high level of air pollution was associated with a high level of deprivation (inverse relation for O_3). Variation of the association strength was observed according to the geographical scale
Chaix et al.	Children aged 7–15 years, Malmo, Sweden (2001)	Multilevel	Annual average of NO_2 estimated for the points of the 100 m grid that were the closest to the building of residence and school of attendance	Annual mean of income of subjects aged 25 years or older in each residential building where children in the study lived in 2001 and in each neighbourhood of residence. The median number of people aged 25 years or older in buildings of residence was 2 and it was 1484 in neighbourhoods of residence.	Children from low SES neighbourhoods were more exposed to NO_2, both at their residence place (21.8 vs. 13.5 $\mu g/m^3$ for the lowest and the highest income classes respectively) and at school (19.7 vs.13.7 $\mu g/m^3$).
Forastiere et al.	Only residents of Rome aged 35 years and older (1998–2001)	Geographical	PM, CO, NO_x, Benzene	Estimation at census block scale (480 inhabitants on average) of a median per capita income index and a socioeconomic index (SES, including educational level, occupational categories, working-age unemployment rate, family size, crowding, and proportion of dwellings rented/owned)	Concentrations increase with the average block income level for all traffic pollutants (PM: 16.7 vs 21.7 $\mu g/m^3$, for the low income high income categories, respectively; CO: 10.4 vs 24.3 $\mu g/m^3$; NO_x: 10.4 vs 26.7 $\mu g/m^3$; Benzene: 10.7 vs 25.2 $\mu g/m^3$). Environmental inequalities are stronger using the SES index (PM: 9.2 vs 39.6 $\mu g/m^3$, CO: 6.8 vs 45.3 $\mu g/m^3$, NO_x: 11.2 vs 41.6 $\mu g/m^3$, Benzene: 7.5 vs 46.2 $\mu g/m^3$).

Authors	Population /country	Study Design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Havard et al.	Strasbourg, France	Geographical	Annual average of NO_2	At a French census block scale (2000 inhabitants in average): socioeconomic index (including 19 socioeconomic and demographic variables)	There was an association between deprivation index and NO_2 levels: the mid-level deprivation areas were the most exposed (39.6 µg/m^3) whereas the most affluent areas were the least (30.6 µg/m^3). Same relations were observed with SO_2 and $PM_{10,}$ but inverse relationship with O_3.
Kruize et al.	Rijnmond Region, Netherlands	semi-Individual	Annual average of modelled NO_2 concentrations (25 x 25 m grid)	Income	There is a significant association between income and NO_2 level: the mean of NO_2 are 37.7 and 38.2 µg/m^3 for the higher and lower income categories, respectively.
McLeod et al.	England and Wales	Geographical	NO_x,PM_{10}, SO_2	At local authority district scale and/or regional scale: social class index, population density and percentage of ethnic minorities.	The higher social classes are more likely to be exposed to greater air pollution, whatever the pollutant, the socioeconomic indicator and the model that was implemented.
Mitchell et al.	Leeds, United Kingdom	Geographical	Annual mean of NO_2	At a 200m x 200m cell level (3 600 points spaced by 200 m intervals in a grid cell pattern throughout the 144 km^2 inner box): Townsend deprivation index	A clear association between deprivation and NO_2 level: in 2005, the mean of NO_2 is around 18 µg/m^3 for the most affluent areas vs 22 µg/m^3 for the least ones.
Namdeo et al.	Leeds, United Kingdom	Geographical	Annual mean of NO_2	At the Census Output Area level: Cumulative deprivation index	Deprived population groups are disproportionately exposed to higher NO_2 level as compared to the affluent group: a scenario gives for example, 20.5 µg/m^3 vs 19.2 µg/m^3 respectively
Naess et al.	Population aged 50–74 years residing in Oslo, Norway on 1 January 1992	Multilevel	Average monthly concentrations of $PM_{2.5}$ during period 1992–1995	Social deprivation at both individual and administrative neighbourhood levels: education, household income, occupational class, ownership status of dwelling, type of dwelling and crowded households	There is a gradual increase of $PM_{2.5}$ when the proportion of subjects living in a flat increases across neighbourhoods (mean value of $PM_{2.5}$ ranging from 12.1µg/m^3 in the lowest category to 17.0 µg/m^3 in the highest).
Rotko et al.	Population aged 25–55 years, Helsinki (Finland)	Individual	48-hour exposure of NO_2	Occupational status, education level, employment status	There is an association between personal exposure to NO_2 and education level: less educated subjects have higher exposures than educated ones (mean of NO_2 equal to 26.3 and 24.4 µg/m^3 respectively). The same association is seen according to the employment status among men

Authors	Population /country	Study Design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Rotko et al.	Population aged 25–55 years, Helsinki (Finland)	Individual	48-hour exposure of $PM_{2.5}$	Occupational status, education level, employment status	There is an association between personal exposure to $PM_{2.5}$ and education level: less educated subjects have higher exposures than educated ones (mean of $PM_{2.5}$ equal to 18.98 and 13.41 $\mu g/m^3$ respectively). There is also an association between $PM_{2.5}$ and occupational status, with low exposures for white collar employees compared to other categories (mean $PM_{2.5}$ levels are 11.97 and 20.46 $\mu g/m^3$ respectively). Stratification analysis by gender demonstrates that associations persist among men but not among women. For men, unemployment dramatically increases $PM_{2.5}$ exposure (41.8 vs 15.5 $\mu g/m^3$).
Stroh et al.	Scania, Sweden		Annual average NO_2 modelled with a 250 × 250 m grid resolution	individual data: country of birth, education level	Strength and direction of the association between NO_2 and social categories varies within cities. In Malmö, subjects born in Sweden tend to live in areas with lower concentrations of NO_2 than those born in other countries. Inverse conclusions are drawn in other cities. The association between NO_2 and education ended show the same discrepancy between Malmö and the 4 other cities.
Schikowski et al.	Women aged 55 years at time of investigation, Ruhr, Germany	Semi-Individual	PM_{10}, NO_2, TSP	Education level	Women with less than 10 years of school education are more exposed to PM_{10} than those with a higher education level. No association has been found with for NO_2.
Tonne et al.	London, England	Geographical	Annual average NO_2 and PM_{10}	At census ward scale: index of Multiple Deprivation	The mean of PM_{10} and NO_2 increases from the less deprived neighbourhoods (C1, class 1) to the most ones (C5, Class 5): the mean for C1 and C5 are respectively 38.1 and 46.7 $\mu g/m^3$ for NO_2 and 25.7 and 27.5 $\mu g/m^3$ for PM_{10}.

Authors	Population /country	Study Design[a]	Air pollution variables[b]	Geographical level and SES variables	Main results
Wheeler et al.	General population aged 16–79 years, England	Semi-individual (household)	Index of air pollution combining annual average of NO_2, PM_{10}, NO_2, and Benzene estimated at a ward geographical level. The air pollution index of each participant is equal to the level of their residential ward	Social class of head of household	Environmental inequity is observed among urban households: air quality is poorer among households of low social class. There is a suggestion of inverse relationship for rural and semi-rural households.

[a] CO, carbon monoxide; NO_2, nitrogen dioxide; O_3, ozone; PM, particulate matter; PM_{10}, particulate matter with an aerodynamic diameter of up to 10 μm; $PM_{2.5}$, particulate matter with an aerodynamic diameter of up to 2.5 μm; SO_2, sulfur dioxide; TSP, total suspended particulates.

[b] Geographical: socioeconomic status and air pollution exposure were both estimated at a same geographical level; semi-individual: socioeconomic status and air pollution exposure were estimated at a individual and geographical level, respectively; individual: socioeconomic status and air pollution exposure were both estimated at a individual level; multilevel: socioeconomic status was estimated at both individual and geographical level whereas the air pollution exposure was estimated at geographical level

Appendix 2. European studies assessing the potential modification effect by the socioeconomic status on the relation health and air pollution exposure

Authors	Population /country	Health variables	Air pollution variables[a]	Geographical level and SES variables	Methods to evaluate effect modification	Main results
Filleul et al.	Residents of Bordeaux (France), population older than 65 years (1988–1997)	Non-trauma and cardiores-piratory mortality	Daily mean of BS	At individual level: educational attainment (without primary school diploma, primary school diploma, secondary validated or higher) and previous occupation (never worked, white-collar, blue-collar)	Stratified analysis and test for heterogeneity	Increase in mortality for a 10 $mg.m^3$ increment in BS concentrations Non-trauma mortality: only blue collars show a significant association: OR = 1.41 (1.05–1.90) Cardiorespiratory mortality: association is greater among subjects with high education: OR = 4.36 (1.15–16.54).
Filleul et al.	Residents of Bordeaux (France), population older than 65 years (1988–1997)	Non-trauma mortality	BS (above 90th percentile or below 10th percentile of observed ambient air concentrations)	At individual level: educational level (no school, primary without diploma, primary with diploma) and previous occupation (domestic employees and women at home, blue-collar workers craftsmen and shopkeepers, other employees, intellectual occupations)	Stratified analysis and test for heterogeneity	No effect modification according to socioeconomic indicators.
Forastiere et al.	Residents of Rome (Italy) aged 35 years and older (1998–2001)	Mortality	Daily PM_{10}	Estimation at census block scale (480 inhabitants on average) of a median per capita income index and a socioeconomic index (including educational level, occupational categories, working-age unemployment rate, family size, crowding, and proportion of dwellings rented/owned)	Interaction term in multivariate model	Effect modification of socioeconomic status on the PM_{10}-mortality association: the effect is stronger among people with lower income and SES (1.9% and 1.4% per 10 $\mu g/m^3$, respectively) compared to those in the upper income and SES levels (0.0% and 0.1% per 10 $\mu g/m^3$, respectively).

Authors	Population /country	Health variables	Air pollution variables[a]	Geographical level and SES variables	Methods to evaluate effect modification	Main results
Havard et al.	Residents of Strasbourg (France), population aged 35–74 years (2000–2003)	Myocardial infarction events	24-hour average PM_{10} concentrations	At a French census block scale (2000 inhabitants on average): socioeconomic index (including 19 socioeconomic and demographic variables)	Stratified analysis and test for heterogeneity	Significant influence of neighbourhood SES, with greater effect of PM_{10} observed among subjects living in the most deprived neighbourhoods (20.5% increase, 95%CI: 2.2–42.0).
Laurent et al.	Residents of Strasbourg (France), general population (2000–2005)	Asthma attacks	Daily air pollution indicator considered for PM_{10}, NO_2, and SO_2 was the 24-hour average concentration. Maximum daily value of the 8-hour moving average for O_3.	At a French census block scale (2000 inhabitants in average): socioeconomic index (including 19 socioeconomic and demographic variables)	Stratified analysis and test for heterogeneity	Socioeconomic deprivation had no influence on the association between air pollution and asthma attacks, whatever the pollutant.
Laurent et al.	Residents of Strasbourg (France), general population (2000–2005)	Beta-agonist sales for asthma	The daily air pollution indicator considered for PM_{10}, NO_2, and SO_2 was the 24-hour average concentration. It was the maximum daily value of the 8-hour moving average for the O_3.	At a French census block scale (2000 inhabitants on average): socioeconomic index (including 19 socioeconomic and demographic variables)	Stratified analysis and test for heterogeneity	Socioeconomic deprivation had no influence on the association between air pollution and asthma attacks, whatever the pollutant.
Wojtyniak et al.	Two group of population (1) between 0–70 years and (2) older than 70 years, Residents of Cracow, Lodz,	Non-trauma and cardiovascular mortality	BS, NO_2 and SO_2 (day of death or preceding day)	Educational	Stratified analysis and test for heterogeneity	Non-trauma mortality: significant effect of BS among the less than secondary education group in both age groups. Significant effect of NO_2 in the oldest age group and for those below secondary education only. Significant effect of SO_2 in the oldest age group and those with less than a secondary education. Cardiovascular mortality:

Authors	Population /country	Health variables	Air pollution variables[a]	Geographical level and SES variables	Methods to evaluate effect modification	Main results
	Poznan and Wroclaw (Poland)					significant effect of BS only for those with less than a secondary education in both age groups. Significant effect of NO_2 for secondary education and above, only in the oldest age group. Significant effect of SO_2 only among subjects > 70 years with below secondary education level.

[a] BS, Black Smoke; NO_2, nitrogen dioxide; O_3, ozone; PM_{10}, particulate matter with an aerodynamic diameter of up to 10 μm; SO_2, sulfur dioxide;

2. Social inequalities in environmental risks associated with housing and residential location

Authors
Jon Fairburn
Staffordshire University
United Kingdom

Matthias Braubach
WHO Regional Office for Europe, Bonn office
Germany

Abstract

Background

Housing conditions and the environmental context of settlements are very diverse and can be influenced by a large variety of social and environmental factors. As good housing and environmental quality in the residential area are in high demand, they can be sold and rented out for higher prices. Consequently, poor and less affluent population groups tend to be more often affected by inadequate housing conditions and higher environmental burden in their residential environments. However, a synthesis of the dispersed evidence on health-related housing characteristics and social status is needed to provide support for housing policies addressing social inequities.

Review methods/data

For the review, recent literature on environmental justice, housing, deprivation and environmental quality was searched in a number of health, environmental and geographical databases, and reviewed and evaluated to summarize the existing evidence on environmental inequalities in relation to housing and residential location. Social characteristics considered were income, employment, SES and gender, and the age. The review was limited to European evidence.

Results

Adequate studies were only available for few countries. Most results were identified for inequalities by income and socioeconomic status, although some limited data is available in relation to gender, age and ethnicity/migrant status.

With very few exceptions, all studies identified the poor and less affluent population groups as most exposed to environmental risks in their place of residence. Inequalities were reported for environmental risks experienced within the dwelling (such as exposure to ETS, biological and chemical contamination, noise, temperature problems and sanitary equipment) as well as the residential environment (lack of urban amenities and public safety, closeness to pollution sites or polluted areas, exposure to traffic-related pollution). Increased exposure to environmental risks within more affluent population groups were only indicated for exposure to specific compounds such as PCB, terpene and DDT.

Studies on the exposure to multiple environmental risks in the home and the residential context are rare but indicate a high environmental burden of the poor population groups.

Results and conclusions are rather consistent between the reviewed studies and indicate a strong increase in environmental risk exposure for less affluent population groups.

Conclusions

The review indicates that social status and especially low income is strongly associated with increased exposure to environmental risks in the private home or related to residential location. However, due to the variety of studies and methodological approaches as well as the lack of data for many countries, it is not possible to conclude a general assessment or quantification of the magnitude of inequality that currently is faced by the poorer population groups within the WHO European Region.

Introduction

Housing is a fundamental human right and has been identified as one of the determinants for health and quality of life. Nevertheless, housing – and its spatial context which is referred to as "residential location" in this review – is nowadays mostly a good offered on the free market. This implies that, with varying quality of housing, the price for housing also differs – both for home sales or rental. In addition, most countries offer public or social housing as an alternative for low-income groups but the quality of such housing often is limited, and there is no guarantee that all households in need of social housing can actually be covered. In consequence, the quality of housing and residential location is directly and indirectly associated with social determinants, and mostly socioeconomic parameters (such as income, purchasing power, employment status and education).

Housing conditions and health has been addressed by many governments through national reports. Since 2001, housing and health has re-emerged as a technical priority for the WHO Regional Office for Europe (Bonnefoy, 2007). Housing conditions such as e.g. lack of thermal comfort, dampness and mould, indoor air pollution, infestations, home safety, noise, accessibility and other factors all impact on health and the respective exposure varies between social groups and tenure within the population. Consequently, Howden-Chapman (2002) identified housing policy as a means of reducing inequalities in health between social groups.

The WHO model of healthy housing identifies four housing dimensions: the "home" which – if safe and intimate – provides psychological benefits and a refuge from the outside world; the "dwelling" which is the physical infrastructure of the house; the "community" which is linked to the surrounding population living there and comprises area characteristics such as education, socioeconomic status and ethnicity and finally the "immediate housing environment" such as access to green space, noise sources, accessibility and neighbourhood design.

Following this categorization, we can distinguish between the internal housing conditions and how they vary between population groups, and the external residential location in terms of environmental quality and how that may affect residents.

Different residential locations lead to different levels of exposure and therefore different levels of risk. Studies around the world show that it is often the most vulnerable or disadvantaged located in areas with poorer environmental quality (Evans and Kantrowitz, 2002; Kruize and Bouwman, 2004; Walker et al., 2003). The European Environment Agency stated that "Poorer people, immigrants, and other disadvantaged groups typically inhabit the worst parts of the city, for example near contaminated sites, and are more affected by the lack of green space and public transport services, by noise and dirty roads and by industrial pollution" (European Environment Agency 2009: 14). It is also suggested that deprived populations living in such areas are more vulnerable as they have fewer coping mechanisms for example to deal both with an unexpected event itself such as flooding (e.g. lower levels of awareness, lower levels of social capital) and the aftermath (lower levels of insurance) (Environment Agency 2007a).

Van Kamp et al. (2004) state that with regards to health, socioeconomic status related health inequalities cannot be fully explained by individual characteristics and that environmental quality needs to be taken into account. Secondly, they note that in most cases epidemiological methods simply miss the resolution that would be needed "to detect the health effects of the interaction between these social, physical and personal aspects which are often clustered and separately only results in small increases of health risks".

Gee and Payne-Sturges (2004) Stress-Exposure Disease framework illustrates that both individual factors and community factors can impact on a persons health through psychosocial stress increasing vulnerability. Community stressors can be physical e.g. noise, air quality, temperature or psychosocial e.g. fear or stress. This means that exposure needs to be considered in two ways.

a. Direct exposure to a contaminant or pollutant along a physical pathway leading to direct contact with the human body leading to ill effects i.e. standard epidemiological studies. For example, new furniture in the home could emit harmful substances, or a factory could be discharging pollutants into a water source which is used as a drinking-water supply leading to illness in the local population.

b. Exposure to a situation in the home or the neighbourhood leading to an increase in stress due to the perception of the people living there. This could for example be the announcement of a new waste or landfill site to be located in the neighbourhood or an ongoing risk such a living on an existing floodplain, or potential eviction due to problems to pay the rent.

Despite a variety of studies linking social determinants with housing and residential quality, there is no review available that describes the link between the exposure to housing-related health risks and the social status on a disaggregated level such as dwellings or households. This paper therefore aims at compiling the available evidence on the impact of social inequities on environmental risks related to housing and residential conditions. It includes associations between social status and (a) housing conditions or housing-related exposure conditions directly affected by social status (such as fuel poverty or passive smoke exposure), and (b) independent housing risks such as exposure to pollution. Only exposure variables that have been confirmed as risk factors for health were considered. However, as this review did focus on the exposure differentials, studies presenting evidence on the housing-related health outcomes were

not included. Due to the large international variation of housing parameters and social factors, the review was limited to evidence from European countries.

Review methods/data sources

Evidence on socially induced inequalities in environmental risks related to housing and residential location has been searched. In parallel, reports of national and international organizations were identified to gather evidence beyond scientifically published articles. The review was limited to European evidence.

The identification of relevant publications used a systematic approach to search in a variety of databases (PubMed, Web of Science, SWETSWISE, Annual Reviews, Google Scholar). Key words used in varying combinations were "housing", "home", "indoor" and "residential" to describe the spatial component, and "income", "socio(-)economic status", "inequality/ies", "inequity/ies", "environmental" and "risk" to describe the social gradient. However, the combination of keywords to focus on housing or residential location together with terms such as inequalities/inequities quickly reduced the number of matching studies (see Table 1).

Table 1 Examples of search terms and identified publications in PubMed

Combination of search terms	Total publications identified	Publications matching criteria
"inequalities"	225 196	Not assessed
"inequities"	1 159	Not assessed
"environmental", "inequalities"	26 510	Not assessed
"environmental inequalities"	7	1
"environmental", "inequities"	162	5
"environmental inequities"	12	1
"housing", "inequalities"	3 984	Not assessed
"housing inequalities"	0	–
"housing", "inequalities", "social"	1 971	Not assessed
"housing", "social inequalities"	32	7
"housing", "inequities", "social"	22	0
"housing", "social inequities"	0	–
"neighbourhood", "social inequalities"	58	9
"neighbourhood", "social inequities"	3	0
"residential", "social inequalities"	13	1
"residential", "social inequities"	0	–

NB: the search was restricted to articles related to humans only.

The most frequent reasons for not including studies in the review were: (a) the evidence was based on non-European data; (b) the study only referred to "deprived" housing and did not indicate specific housing or residential risk factors; (c) the study did not report on the distributions of risk by income or SES categories.

It is likely that this review fails to cover some of the existing evidence. Some papers known to the authors and used in this review were actually not identified during the literature search at all as they were not primarily published as inequality-driven papers. The same accounts for reports by governments or international organizations which provide a significant share of the evidence, but are not accessible through literature search programmes.

Empirical evidence

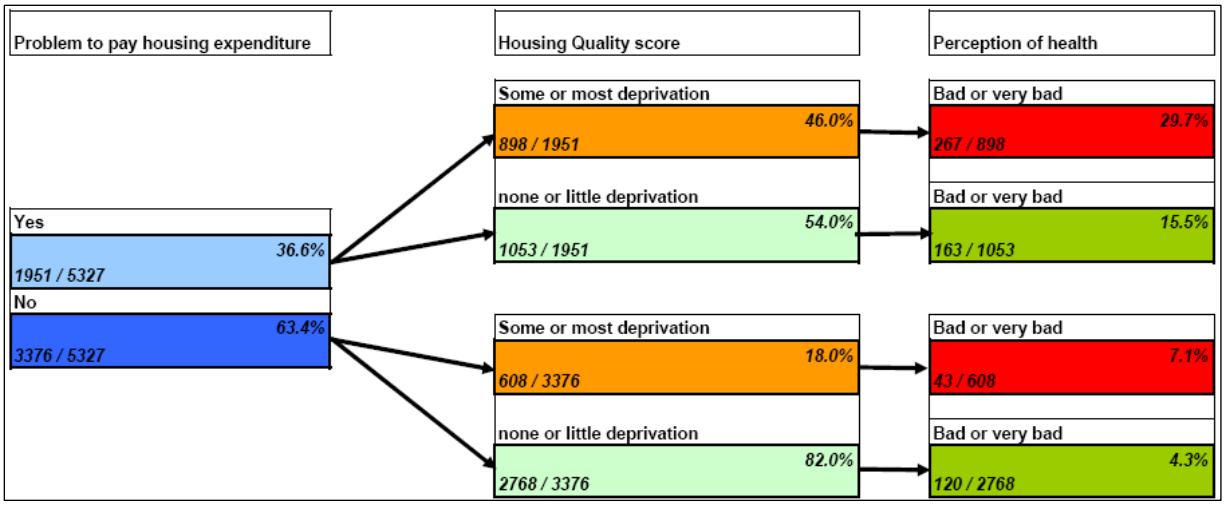
The review showed that many studies dealing with social inequalities related to housing and residential conditions focus on ecological level analysis of neighbourhoods by social deprivation level and often fail to deeper investigate environmental inequalities – especially those related to the dwelling. For each environmental risk factor related to housing and residential location, only few studies or reports were identified that provided insight into the social gradient of risk exposure. Such evidence is available only for few countries, with Germany and United Kingdom being the main contributors. In parallel, there is a scarcity of evidence on specific environmental risks such as e.g. sanitation (no peer-reviewed publication matching the criteria was identified), while for home safety and injuries no data was actually identified at all.

A) Housing and indoor environmental conditions

Housing conditions are a fundamental determinant of health and well-being, but are not equally distributed. The largest cause of inequality in housing quality is definitely the socioeconomic status associated with income and economic resources. Consequently, the European Foundation for the Improvement of Living and Working Conditions (2008) states that: "Not surprisingly, there is an association between household income and experience of inadequate housing, stronger in the NMS [new Member States] and CC3 [candidate countries] than in the EU15." WHO data based on data collection in eight European cities further confirms that inadequate housing conditions are linked to lower levels of self-rated health for all income and SES-groups, but that the association is much stronger for poor households than for the well-off households as indicated by figure 1 (WHO, 2007; Braubach and Savelsberg, 2009). Also, inadequate housing conditions are associated with risk factors such as mould, crowding, indoor pollution and noise especially for low income-households.

While it has long been acknowledged that the poorest people tend to live in the worst housing conditions, there are still large gaps in understanding the relationship between housing and health (Bonnefoy, 2007; Bonnefoy et al., 2007). The difficulty arises from the sheer number of possible contributing factors to any illness, and difficulties in measuring the probable exposure and even specifying the disease under investigation. Additional complexity is brought by the fact that for poor housing, there usually is a multiple exposure to several housing-related risk factors. However, there is little research on the health impact of such cocktail exposure to combined housing problems, and very few studies are available (Evans and Marcynyszyn, 2004). Therefore, the following review of evidence is structured by individual risk factors, acknowledging that in many cases the described inequality may only be one of several challenges faced by the affected households, individuals or population groups. A short section addressing the available evidence on multiple housing exposures is provided at the end of this chapter.

Fig. 1. Housing affordability, housing quality and health



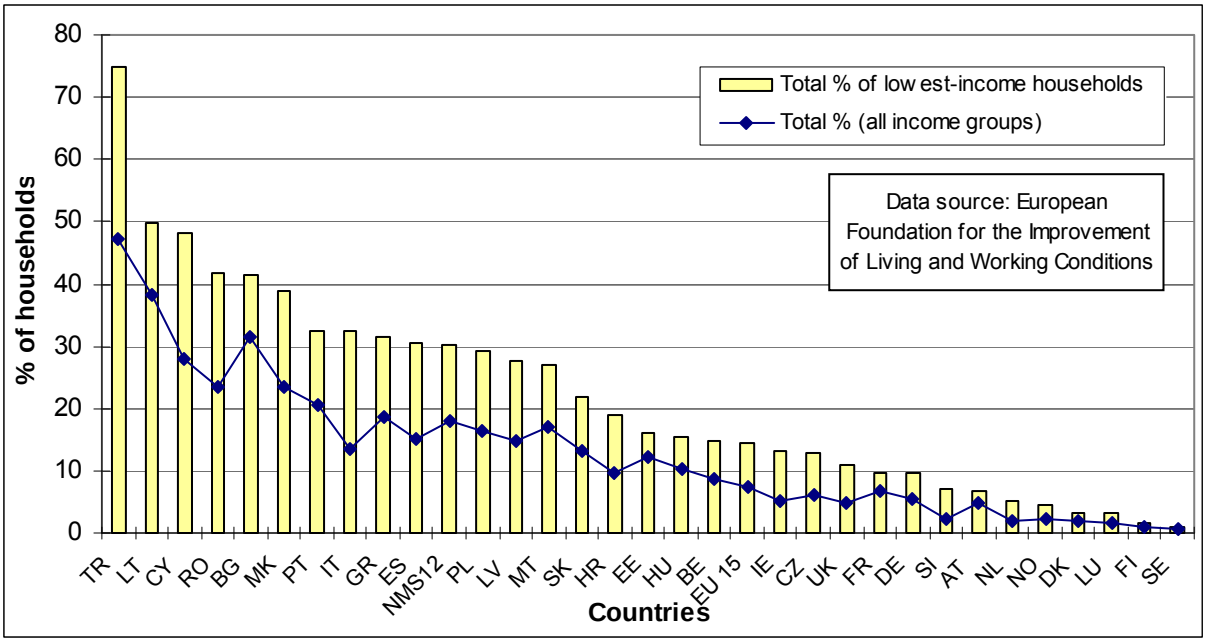
Fuel poverty and thermal comfort

Healy (2003) examined excess winter deaths between 1988 and 1997 in 14 EU countries and it illustrates the previous points well. He examines the number of possible factors linked to excess winter mortality e.g. health care expenditure, environment and lifestyle, income distribution, building standards, per capita GDP, education and how they vary between countries. Portugal records the highest level of premature winter deaths, 28% above the average mortality rate (8800 deaths). High levels are found in Spain (21%, 19 000 deaths), Ireland (21%, 2000 deaths), England (19%, 31 000 deaths), Wales (17%, 1800 deaths) and Italy (16%, 27 000 deaths). Finland, Germany and Netherlands suffer far less from winter mortality. Those countries with the poorest housing in terms of thermal efficiency demonstrate the highest level of excess winter mortality.

In-depth research undertaken in the United Kingdom showed that excess winter mortality is much stronger expressed in residents of cold homes than warm homes (Wilkinson et al., 2001). Estimations for the relative contribution of inadequate housing conditions range from 20 up to 50%.

More recent data from the European Quality of Life Survey (EQLS) by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2007) shows that for the affordability of home heating, still large income-related inequalities exist within as well as between countries (Fig. 2).

Fig. 2. Households who cannot afford keeping their home adequately warm (2007)



Note: lowest income is defined as bottom 25% of the population by income

Irrespective of the absolute level of this problem, nine out of 31 countries – old and new EU members – indicate that this problem is twice as frequent for households in relative poverty (defined as below 60% of national median income).[6]

In general terms, affordability of heating is a major problem in eastern European cities, affecting more than 40% of all low-SES households (WHO, 2007). Buzar (2007) describes the problems of fuel poverty in the Czech Republic (4–11% of the population) and the former Yugoslav Republic of Macedonia (up to 60% of the population). In relation to housing standards, he notes that "On the whole, income-poor households are also energy-poor... However, the problem is also present among pensioners and families with young children, who may be at risk by virtue of their housing circumstances. In this case, the emergence of energy poverty can be attributed, in part, to the poor energy efficiency of residential buildings, and the high daily energy needs of such households." (p. 238). Similarly, a UNDP report on energy, environment and poverty in Serbia and Montenegro (UNDP, 2004) indicated that the burden of cold and energy-related poverty is disproportionally affecting the low-income households, 27% of which are limiting the heating to only be used in selected rooms.

Thermal risks also arise from heat-waves when houses accumulate the heat and cannot cool down during night. Data from the 2003 heat-wave in Paris showed that the highest heat exposure categories were found in the most deprived areas while similar results were not found for the rest of the country due to less heterogeneity in deprivation (Rey et al, 2009). Further studies from the heat-wave in France in 2003 (which caused approximately 15 000 deaths in France and mostly affected old people) present strong evidence on the protective value of adequate housing conditions and identifies housing-related risk factors (Table 2) together with the Odds Ratio indicating the increased risk

[6] Data tables from the EQLS are added in Appendix 1 for selected variables.

for heat-related mortality (Vandentorren et al., 2006). A principal risk factor was building age, as buildings built before 1975 have less amenities (e.g. no private toilet) and bad insulation quality. Well insulated buildings consequently provided a protective effect.

Table 2. Housing impacts on all-cause mortality OR in elderly during the French heat-wave, 2003

Housing parameter	Mortality Odds Ratio
Building older than 1975	OR 1.8 (CI 1.1–2.9
Living on the top floor of a building	OR 2.3 (CI 1.3–4.1)
Bedrooms directly under roof	OR 2.2 (CI 1.3–3.7)
Good insulation (versus bad insulation)	OR 0.4 (CI 0.3–0.7)
Number of windows/50m^2	OR 1.2 (CI 1.03–1.4)
Number of rooms	OR 0.85 (0.72–0.99)

Although the published data do not directly provide information on the social characteristics of the affected persons, it shows that elderly people in low-quality housing are most vulnerable to heat-wave mortality.

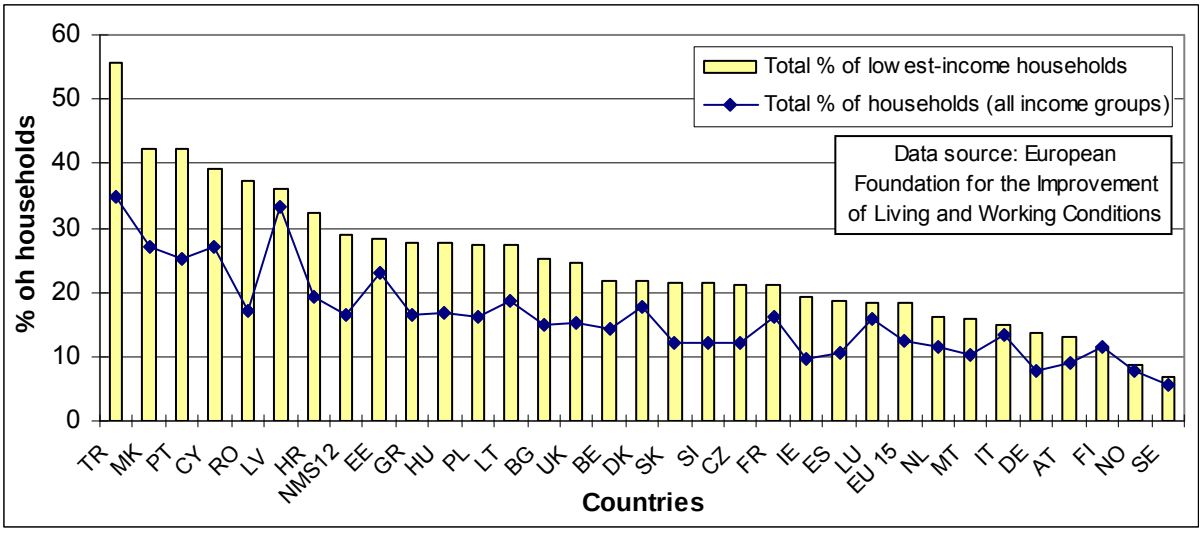
Building conditions, dampness and mould

In the EU15 18% of households in the lowest quartile have damp or leaks compared to 9% in the highest quartile; in the 12 new Member States the figures are 29% in the lowest quartile and 8% in the highest quartile (Eurofound, 2008). With the exception of the three Scandinavian countries Sweden, Norway and Finland, poor households are more exposed in every country (Fig. 3). The biggest problems of dampness are faced by low-income households in Poland (57% reporting dampness or leaks) and Romania (45%). For Serbia and Montenegro, the problem of dampness is strongly related to affordability of heating: 48% of households using coal and wood for heating reported dampness problems versus 14% of households benefitting from district heating systems (UNDP, 2004). Dampness in particular leads to the growth of spores and moulds in the house creating poor indoor air quality.

Poortinga et al. (2008) in Wales found that lower socioeconomic neighbourhoods were more likely to have poor housing conditions (such as condensation, damp, cold or mould) and that the reporting of housing problems was significantly associated with self-rated health. Those reporting one housing problem were 27% more likely, and those reporting two or more housing problems were 24% more likely to report poor health.

Macintyre et al. (2003) in Scotland found that housing tenure could explain 5.4% of self assessed health and 5.4% of depression after having controlled for age, sex and marital status and found that provision of gardens and other amenities substantially reduced the percentage variance in each health measure explained by tenure. However the link between tenure and health is unlikely to be consistent across Europe. In the United Kingdom renting is often associated with poverty or lack of resources and the United Kingdom has a relatively small share of private renting compared to many European countries.

Fig. 3. Households having a problem with damp or leaks in walls or roof in their accommodation (2007)



Note: lowest income is defined as bottom 25% of the population by income

Pevalin et al. (2008) investigating housing and long term health effects showed that an increase in housing problems was associated with an increase in self reported health problems in the over 50s. These effects are on mental health well-being and are 1/5 of the effect due to separation/divorce.

Problems with crowding were more than three times more frequent for households in relative poverty in Bavaria (Bolte and Fromme, 2008a). According to data from the European Quality of Life Survey (Eurofound, 2007), 23.2 of all EU27 households considered to belong to the lowest income group report problems with shortage of space in their dwelling, while this is only reported by 14.6% of the households considered the highest-income households. However, the data shows that the overall problem of shortage of space is bigger in the new Member States, but the inequality is less strong as around 22% of the high-income households report shortage of space as a housing problem.

Indoor air and environmental quality

A review carried out by Bunge and Katzschner for the German Federal Environment Agency (Umweltbundesamt, 2009) identified housing factors for which an increased exposure is found for households with low social status. The findings indicate that such environmental inequalities exist for closeness ETS exposure; for benzene exposure in indoor air of children's bedrooms, and for child blood lead levels. On the other hand, there are a number of exposures that are more frequently found in well-off households, such as PCB-levels in children's blood; terpene concentrations in indoor air; and DDT-levels in house dust samples.

Data from the German national children and environment study indicate that household chemicals which pose potential health threats (e.g. disinfectants; indoor sprays; detergents etc.) are more often and more frequently used by households with low social status (Seiwert et al., 2008). However, chemical compounds for pest control (moths, ants, etc.) are more often applied by households with high social status. This shows that

households with different social background tend to accept (or are not aware of) different types of exposure, although they could be harmful to the residents.

A rising concern is the use of solid fuels for heating and cooking, which is especially frequent in the Eastern countries but also is an alternative energy source for low-income households in more developed countries (Braun-Fahrländer, 2004). The UNDP report on energy use in Serbia and Montenegro (UNDP, 2004) identified the use of lignite coal – known as a serious risk factor for indoor air pollution – as more common in the housing stock inhabited by less affluent population groups. In homes heated with coal and wood, increased exposure to carbon monoxide, benzene, particulate matter and formaldehyde were identified.

Passive smoking and ETS exposure in the private home are one of the major concerns for the health of children and cannot be dealt with by smoking bans as in public places. Studies from various European countries identified significant social inequities for environmental tobacco smoke (ETS) exposure (Adamek et al., 2007; Bolte et al., 2009; Dell'Orco et al., 1995; Umweltbundesamt, 2009; Vardavas et al., 2007), with children in low-income households being exposed about twice as much (Umweltbundesamt, 2009).

German data based on pre-schoolchildren indicate that a number of social determinants (such as low educational level, unemployment, low income levels, migrant status and single-parent households) commonly shape the frequency of home smoking and consequently the degree of child ETS exposure (Bolte and Fromme, 2008b). The strongest associations were reported for low education of the parents (OR 3.9). In addition, the study also assessed ETS exposure in cars and indicated that – for low education of the parents, the OR value (5.0) was even higher than for home ETS exposure. Within households with smokers, a similar social gradient was identified when looking at the existence of informal agreements and "home smoking policies" between household members: in households of low educational level, unemployed households, poor households and migrant households, less smokers exclusively smoked outside the dwelling (balcony, terrace etc.).

Data on environmental exposures and health outcomes in German pre-schoolchildren in North-Rhine Westphalia (Rauchfuss et al., 2008) indicates that households of lower social status are exposed to significantly higher exposures to particles (TSP, Total Suspended Particles) due to the location of their homes close to trafficked roads, and are affected by less adequate housing conditions. These results are especially expressed in households with migration background.

Home safety and injuries

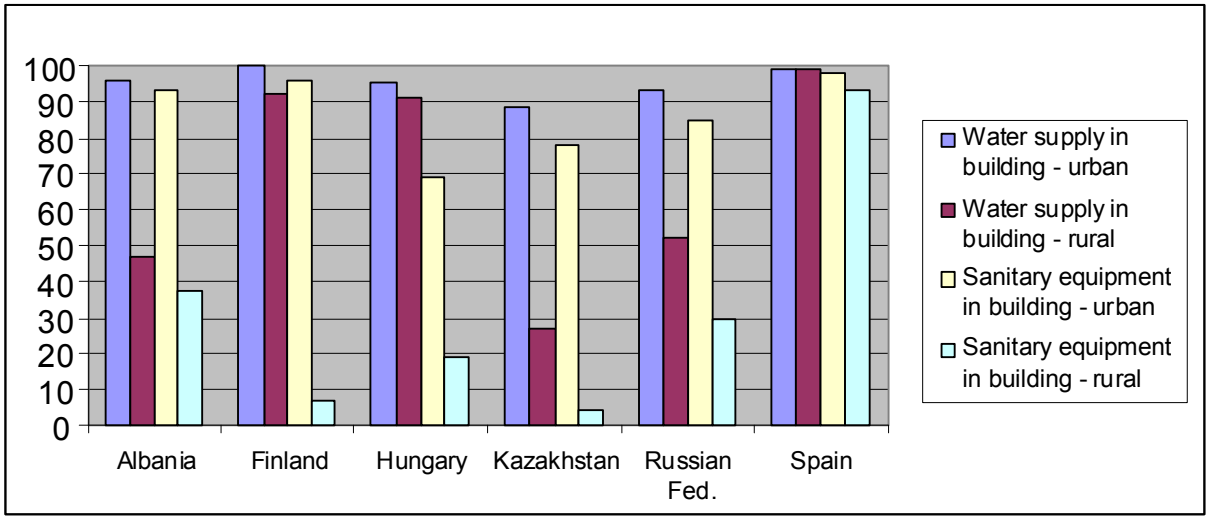
Injuries are a major cause of mortality in the WHO European Region, and data from a variety of countries show that home accidents are the most relevant accident setting with sometimes more injuries than the transport sector. It is known that home injuries are leading to health problems and disabilities especially in the elderly population (EUNESE). However, next to this age-related evidence, no data could be found for the social patterns of home injuries. Still, studies point at the fact that inadequate housing conditions (non-functional equipment, small kitchen work space, broken floor, stairs and windows, noise exposure etc.) are associated with higher injury risks (WHO, 2007; Braubach & Heuberger, 2008).

Water and sanitation

Although water and sanitation is a key requirement for healthy housing, there is little information available on the inequalities of its supply and adequacy. Research from high income countries does not deal with it as no problems are expected, and research for low income countries on this topic is rarely published internationally. Therefore, data was almost exclusively found in relation to international databases and monitoring programmes.

The Joint Monitoring Programme of WHO and UNICEF shows the urban-rural variations of water and sanitation supply, but it does not provide population or person-based data (UNICEF/WHO, 2008). Still, water supply coverage in urban areas is most often very high or 100% and even in rural areas, water supply is often a given. However, when looking at the existence of household connections for water supply and sanitary equipment, urban-rural variations are still extreme in some countries of the WHO European Region as figure 4 shows.

Fig. 4. Household connections for water and sanitation in selected countries (2004)

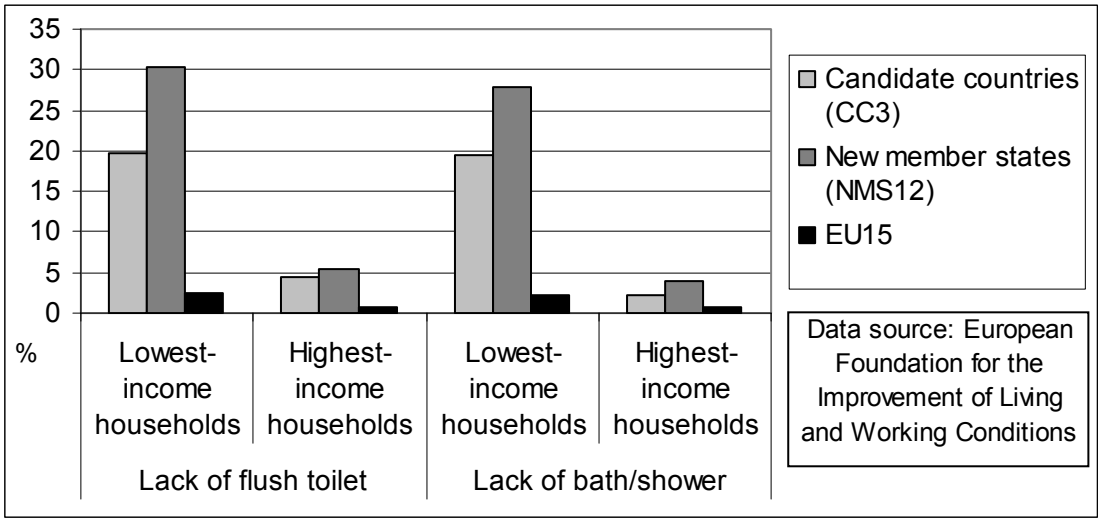


Source: Joint Monitoring Programme (http://www.wssinfo.org/en/welcome.html).
Data for 2004. Water supply and sanitary equipment related to « improved » water and sanitation conditions. NB - only systems connected to the private building / dwelling are counted.

Data from the European Quality of Life Survey (Eurofound, 2007) indicate that the lack of a toilet for the private use of the household is still an issue for the poorer population groups (Fig. 5). This is valid for both the EU15 countries (0.7% for highest and 2.5% for lowest income groups) and the new Member States (5.4% and 30.4% respectively). The biggest problems are faced by Romania, where already 11.2% of the highest income group reports such a problem, and 68.8% of the lowest income group is affected. However, for the EU15, the problem rate for the lowest income groups can also go as high as 3.9% (United Kingdom), 4% (Netherlands), and 5.3 (Greece).[7]

[7] Data tables from the European Quality of Life Survey are added in Appendix 1 for selected variables.

Fig. 5. Lack of sanitary equipment by household income (2007)



Note: lowest income is defined as bottom 25% of the population by income

B) Outdoor environments and residential location

The strongest and most consistent link found in terms of residential location is between deprivation and ambient air quality (see parallel review by Deguen and Zmirou-Navier). However England, Scotland, France, Germany, Netherlands, all provide detailed distribution studies which have explicitly looked at the link between social groupings and residential location for other environmental factors. eastern Europe also has some preliminary evidence. While the number of such studies is few they do provide clear evidence that quite stark inequalities exist in the countries that have been studied so far.

Neighbourhood quality, safety and physical activity

In a survey of people aged over 65 in the United Kingdom, Bowling et al. (2006) found that perceptions of problems in an area (noise, crime, air quality, rubbish litter, traffic, graffiti) were also predictive of poorer health and also noted that few studies have included perceptions of the neighbourhood with regards to health and deprivation. Similarly, Curtice et al. (2005) found in Scotland that those who reported a higher level of street incivilities i.e. poor local environments (litter, dog faeces, graffiti, dumped cars and fridges) also reported higher levels of anxiety and depression (23% compared to 13% in areas with lower incivilities). Poortinga et al. (2008) working in Wales found that those from a lower socioeconomic background were more likely to report litter, noise and poor neighbourhood quality and found a clear association between neighbourhood deprivation and self-rated health. The association between neighbourhood deprivation and self rated health was substantially reduced after adjusting for individual socioeconomic status, but remained statistically significant. Chaix (2009) reviewed 40 studies that had researched coronary heart disease or cardiovascular disease and neighbourhood characteristics. He found that a significant number of them reported an increased risk for residents of socially deprived areas after controlling for individual socioeconomic characteristics.

The European Quality of Life Survey (Eurofound, 2009) used six measures of environmental quality to measure perception across 27 European countries; noise, air pollution, lack of access to green space, quality of drinking-water, crime/violence, and

litter or rubbish in the street. In Italy 83% of the population were dissatisfied with two or more of these neighbourhood conditions, in Bulgaria 82% and Poland 79%. The populations of the 12 new Member States were most likely to have multiple complaints about their neighbourhood; while the least dissatisfied nations are the Netherlands, Austria, Germany and the Nordic countries. However, within national distributions there is only a marginal expression of inequalities (Eurofound, 2007), as for the EU27 the exposure difference between total population and low-income groups was almost non-existent. Those inequalities identified – represented by exposure differences of few percents only – are mostly originating from the 12 new Member States.

It is possible that these low variations are caused by the fact that the national figures merge urban and rural areas, for which many studies have shown that there are major differences in problems such as air pollution, noise exposure, safety perception and green spaces and clean. It could well be expected that – if the data was broken down by income groups and urban-rural variation – inequalities may be much more expressed.

Shenassa et al. (2006) using the LARES data across eight European cities found a link between perceived safety (associated with litter, graffiti, etc) and occasional exercise. This is important for two reasons; firstly increasing exercise and physical activity is a key method for preventing ill health and disease (particularly coronary heart disease and cardio vascular disease and some cancers) especially among existing sedentary populations, secondly the results suggested that health promotion strategies can target residential areas without needing to identify specific persons. Similarly, Ellaway et al. (2005) established linkages between unpleasant residential areas (based on measures of perceived lack of safety and lack of greenery) and reduced levels of physical activity in the residing population. Finally, lower levels of public green areas have been found for low-income neighbourhoods in the Rijnmond region in the Netherlands (Kruize and Bouwman (2004); Kruize et al. (2007)).

Air quality and noise

Much of the environmental justice literature deals with the unfair distribution of air pollution, mostly in urban settings. Further details are provided by Chapter 1 on air quality by Deguen and Zmirou-Navier.

Bolte and Fromme (2008a) provide evidence on the association of relative poverty and inadequate living conditions in Bavaria, Germany. Exposure to traffic was significantly increased (highest increase found for occurrence of traffic jams). Consequently, poor households indicated a higher level of noise exposure, but also reported less access to green areas in their neighbourhood and increased air pollution. However, the authors offer an interesting comparison of urban and rural differences for the described inequalities, suggesting that environmental inequality is more strongly expressed in urban areas due to the overall increase of environmental burden.

Similar findings were provided by Rotko et al. (2001) using Expolis data for Helsinki, which indicated a significant association between NO_2 levels and several factors including home location, housing characteristics and traffic volume near the home. For men only, the Expolis Helsinki data showed that unemployment strongly increased the $PM_{2.5}$ personal exposure ($PM_{2.5}$ average exposure of 42µg/m^3 for unemployed vs 16µg/m^3 for employed men) (Rotko et al. 2000).

A review of evidence (Umweltbundesamt, 2009) identified residential environment exposures for households with lower social status and summarized that – next to increased noise exposure – there is an increased environmental risk for air pollution from traffic sources, but also for closeness to businesses such as gas stations or print companies.

In Germany, Kohlhuber et al. (2006) examined perceived exposure to noise pollution among a range of different social characteristics such whether the person was non-German nationality, East German, income and education levels. They found that environmental exposures were unequally distributed particularly with regards to economic differences. Self rated health was associated with perceived environmental exposure independent of housing conditions. The noise results show a clear gradient between income and perceived exposure indicating inequalities in the whole income distribution. This result was similar to earlier work by Hoffman et al. (2003) which found that people with lower socioeconomic status often lived nearer main roads with high traffic noise and felt more annoyed by traffic noise.

One interesting aspect of the Kohlhuber et al. (2006) study is that there were no actual measures of noise exposure, the assumption being that perceived exposure was a good proxy for subjective exposure. Some evidence suggests that different social groups perceive the same objective noise level differently (Hoffman et al., 2003), with higher social status groups feeling more highly exposed than lower status groups.

Noise exposure in residential areas is a key problem especially for urban settings and largely related to street traffic noise. Data from the German Health Survey 1998 showed that exposure to highly trafficked roads is about twice as frequent for persons working in low-skill jobs or with a low income when compared to persons with high-skill jobs or high incomes. Similar results are obtained by Braun-Fahrländer (2004) for Switzerland, stating that noise exposure is highest in lower social classes and regularly exceeds the Swiss limit value of 65dB(A). In addition, the Swiss data shows that 65% of the households with lowest SES live in areas with industrial activities where background noise levels are around 7dB(A) higher than in residential areas.

Kruize and Bouwman (2004) summarized in their research work that in the Dutch Rijnmond region, lower levels of income reduced the chance of noise exposure levels below 50 dB(A). An exception was found for aircraft noise where a higher level of income was associated with an increased exposure to aircraft noise (Kruize et al., 2007). Finally, Brainard et al. (2002) studying Birmingham, England found that black populations were more likely to be exposed to higher levels of noise and that night time noise was significantly elevated in deprived communities.

Industrial pollution siting

The siting of Integrated Pollution Control (IPC) sites has been examined for England (Walker et al., 2003; Walker et al., 2005). Use was made of Index of Multiple Deprivation 2000 which had been released at ward level (ca. 10 000 mean pop) to classify the population into 10 deciles. The results are illustrated in Table 3 and indicate a strong inequality faced by the most deprived wards.

There are five times as many authorizations in the most deprived decile wards (decile 1), compared to the least deprived (decile 10), which represents a special dimension of

inequality as it is unfair and avoidable. Consequently, this situation does represent an environmental inequity. Regarding residential location, there are five times more people living within 500m of a site in decile 1 compared to decile 10.

Table 3. Authorizations for IPC sites and population distance to IPC sites by ward deprivation

Decile	Total population (2001)	Population living within 500 m of an IPC Site (2001)		Authorizations of IPC sites 1991–2001	
	(Million)	Total	%	No.	%
1 - Most deprived	4.944	162 948	20.1	231	16
2	4.954	124 390	15.4	226	15
3	4.94	136 445	16.9	248	17
4	4.948	106 566	13.2	173	12
5	4.948	84 763	10.5	125	9
6	4.953	47 973	5.9	121	8
7	4.938	38 314	4.7	122	8
8	4.955	39 429	4.9	101	7
9	4.952	37 764	4.7	71	5
10 - Least deprived	4.96	30 342	3.8	49	3
Total	49.491	808 933	100	1467	100

In general terms, IPC sites are also more clustered in deprived areas than in more wealthy areas. IPC sites in deprived areas on average produce greater numbers of emissions and present a greater potential pollution hazard, as indicated by the Agency in authorization scores. They also produce more 'offensive' pollutants in deprived areas which are likely to have an impact on the day-to-day quality of life for people living nearby. Levels of PM_{10} emissions to air from IPC sites were disproportionately high in more deprived wards and to a lesser extent also emissions of NO_2, the latter also being confirmed by Kruize et al. (2007) for the Netherlands when looking at poorer income groups.

The Environment Agency (2007c) examined waste management and policy in England and carried out a more detailed analysis than was possible in 2003. Results showed again that such sites were concentrated in the most deprived areas. The exception were landfills sites which had been decreasing in numbers for years and now appeared to be bias against the least deprived, however the total numbers affected by landfills was a very small proportion of people affected by all waste sites. Similar studies in other countries have also found an unequal distribution of these types of sites. Laurian (2008) found that towns in France with high proportions of immigrants were more likely to host hazardous sites even after controlling for size and income, Kruize and Bouwman (2004) and Kruize et al. (2007) identified that in the Dutch Rijnmond region, waste sites were more frequently built in neighbourhoods populated by low-income groups and in Scotland Fairburn (2005) found a strong social gradient in the sitng of IPC sites as well (see case study box below).

Varga et al. (2002) speak of a lack of moral, political and financial support for research into environmental justice in eastern Europe. One of the other reasons why there is a lack of distribution studies in eastern Europe is also be because of a lack of basic data (Pellow et al., 2005) on race as well as environmental quality. Smith (2004, p. 32) concurs:

> Countries like Poland and Hungary have thousands of abandoned and in-use landfills – and many more illegal dump sites. Environmental monitoring agencies are ill-equipped to collect data on toxic leakages for all of these sites, and few show the desire to provide that kind of information to the concerned public.

Discrimination against Roma communities in central and eastern Europe is illustrated by Steger (2007). Siting of Roma settlements on or near waste sites, floodplains, lack of provision of basic utilities including clean running water are all documented as being significant problems for many Romas. In Hungary it was found that 15% of Roma settlements were within 1km of an illegal waste dump and 11% were within 1k, of animal carcass disposal sites (Gyorgy et al., 2005). Systematic discrimination against the Roma populations through the citizenship laws in the Czech Republic (O'Nions, 1999) would have prevented them from having access to environmental decision-making processes and information.

Polluted river environments and flooding

The issues of river water quality and river environments (Environment Agency, 2007b) is a difficult topic to consider and as the review makes clear a direct casual link between deprivation and river water quality is extremely difficult to establish. The small amount of literature that does exist is often anecdotal and postulated. However the study in the United Kingdom did find that poor quality rivers were concentrated in deprived areas, a result similar to findings in Scotland (Fairburn 2005 – see case study box below).

In 2007 the Environment Agency in England published a series of reports entitled Addressing Environmental Inequalities. This series made use of both improvements in socioeconomic data availability and individual household location to provide extremely detailed analysis for all of England. There was no pattern for fluvial floodplains (Environment Agency, 2007a). However, it did find that people at risk of sea flooding were overwhelmingly those experiencing social and economic deprivation and as such risk management would need to be adjusted to take account of this. The report discussed the social impacts of flooding and their social differentiation between groups. For example, levels of flood awareness were lower in lower socioeconomic groups. Health impacts will be more extensive in neighbourhoods already characterized by poor health and such health impacts can be considerable (Reacher et al., 2004). Impacts on policy include a need to take a differentiated approach to communication and to consider the issues of flood resilience. Werrity et al. (2007) found similar results and outcomes for flood victims in Scotland.

Case study Scotland

Fairburn et al. (2005) reported on all of Scotland using individual household location classified according to the Scottish Index of Multiple Deprivation. The topics were ambient air quality, industrial pollution (IPC sites), derelict land, river water quality, landfill sites, quarry and open cast sites and woodlands. For industrial pollution, derelict land and low river water quality there was a strong relationship with deprivation (see table 3). People in the most deprived areas are far more likely to be living near to these sources of environmental impact than people in less deprived areas and that there is a clear social gradient sown by the data.

Scotland has an extremely detailed annual survey of derelict land (the Scottish Vacant and Derelict Land Survey). The table below details the different levels of population exposed between the social groups in Scotland. Exposure to contaminants from derelict can happen through wind blown particles especially in dry summers or through people recreating in such areas as well as the visual impact on neighbourhood perception.

Landfills and quarries and open cast sites in Scotland display little evidence of a relationship between deprivation and population proximity. At a national scale there was no evidence to suggest that deprived populations were more likely than others to live near to landfill sites. For quarries and open cast sites only when populations in rural areas were examined separately did a tendency against more deprived areas becomes evident.

People living in deprived areas were less likely to live near to areas of woodland. However, for areas of new woodland the analysis shows that there has been a tendency in planting towards deprived populations, suggesting that policy may be redressing this overall imbalance.

Scottish population living close to derelict land, IPC sites and polluted rivers

Decile	Total Population	Population within 600 m of derelict land	%	Population within 500 m of IPC sites	%	Population within 600 m of rivers classified as C or D	%
1 – Most deprived	505 775	340 045	67.2	422 564	83.5	129 752	25.7
2	506 808	267 125	52.7	387 929	76.5	88 247	17.4
3	506 064	219 564	43.4	336 369	66.5	83 760	16.6
4	506 082	170 656	33.7	277 154	54.8	79 393	15.7
5	506 596	155 380	30.7	251 672	49.7	70 623	13.9
6	505 966	144 472	28.6	218 421	43.2	67 010	13.2
7	505 930	135 568	26.8	208 505	41.2	61 453	12.1
8	506 157	125 781	24.9	219 250	43.3	57 022	11.3
9	506 485	93 659	18.5	200 501	39.6	61 778	12.2
10 – Least deprived	506 148	70 180	13.9	150 251	29.7	67 799	13.4
Scotland	5 062 011	1 722 431	34.0	2 672 615	52.8	766 839	15.1

Assistance from state actors can also be selective, in a case in eastern Europe while non Roma families were moved out of flooded areas the Roma were left there (Open Society, 2001). In another flooding case study in Slovakia 45 of the 47 people who died were Roma, living on a shanty town in Jarovince (Steger, 2007).

Multiple exposure to risk factors

Evans and Katrowitz (2002), and Gee and Payne-Sturges (2004) make the point that most studies focus on a single environmental risk factor and advocate examining multiple impacts arising from living in suboptimal environments. Few studies were found that answered to this request, one of which is an US-based publication by Evans and Marcynyszyn (2004) where evidence is presented for New York, showing that low-income children are more exposed to cumulative housing problems (crowding, noise, housing problems) than children from middle-income households.

The European Quality of Life Survey carried out in 2007 across the EU 27 Member States finds that home ownership varies hugely across Europe. Home ownership accounts for about 75% of the tenure type in the new Member States compared to ca. 40% in the EU15 countries. However the overall quality of housing is better in the EU15 than in the 12 new Member States. Six measures of housing quality were used in the study; inadequate space; rot in windows, doors or floors; damp or leaks in walls or roofs; lack of an indoor flushing toilet; absence of a bath or shower; and no place to sit outside. In Latvia and Romania, more than 40% of the population had at least two of the housing problems compared to 6% in Sweden (Fig. 6). Main problems identified are especially lack of sanitation amenities (main problem for Romania but also for the three Baltic countries), shortage of space (highest in the Baltic countries as well as Turkey) and dampness (most expressed in Cyprus, Latvia, Former Yugoslav Republic of Macedonia and Turkey) (Eurofound, 2009).

Fig. 6. Accumulated problems with the accommodation by country (2007)

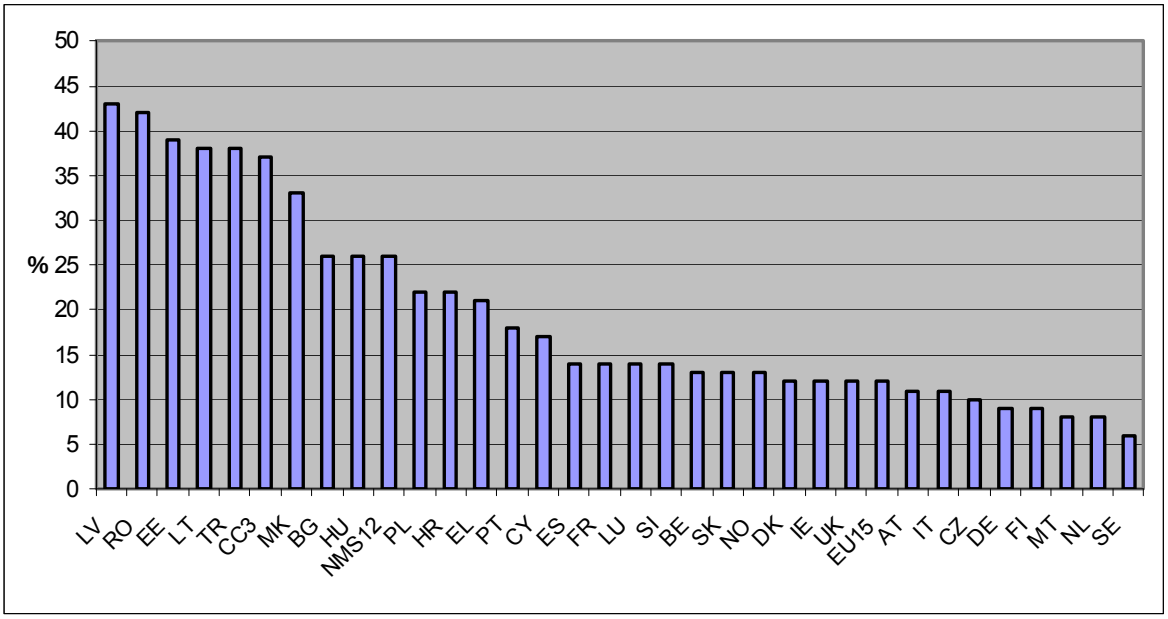


Table 4 shows – for the EU15, the 12 new Member States and the three candidate countries (Croatia, the former Yugoslav Republic of Macedonia and Turkey) – the distribution of the four major accommodation-related problems in relation to household income, indicating that there is a strong impact of income on the quality of housing conditions (Eurofound, 2007).

Table 4.Accommodation problems by household income (2007)

	Shortage of space		Damp and leaks		Lack of flush toilet		Lack of bath/shower	
	Lowest income house-holds	**Highest income house holds**	**Lowest income house-holds**	**Highest income house-holds**	**Lowest income house-holds**	**Highest income house-holds**	**Lowest income house-holds**	**Highest income house-holds**
EU candidate countries (CC3)	49.6%	18.1%	53.5%	15.4%	19.7%	4.4%	19.4%	2.2%
New member States (NMS12)	27.9%	21.8%	28.8%	7.9%	30.4%	5.4%	27.9%	3.9%
Old member States (EU15)	21.7%	12.2%	18.3%	9.1%	2.5%	0.7%	2.2%	0.8%

Note: lowest/highest income is defined as bottom/top 25% of households by income

Deteriorating housing conditions in eastern Europe were recently identified by the UNECE (2009, page 15), reporting that: "Many of the post-socialist countries have seen a growing "slumification" of their housing stock, as well as alarming trends towards informal settlements with self-made low-quality low-energy-efficient shelters."

Bonnefoy et al. (2007) reports on a Pan-European survey into housing and health in eight cities across Europe. The LARES study shows a social gradient for a wide range of housing inadequacies all of which are linked to negative health impacts; examples include crowding, poor heating, leaking roofs, perceptions of poor indoor air quality, and levels of mould growth. Multiple exposures to poor housing factors showed the strongest association with poor health outcomes (Fig. 7) as indicated by Braubach and Savelsberg (2009).

Few studies have even attempted to assess cumulative or multiple impacts of residential location due to the complexity and difficulty of doing so (Environment Agency, 2007d) however a couple of studies have given some simple indicators (Fairburn et al., 2009; Kruize and Bouwman, 2004). Fairburn et al. (2009) and Fairburn and Smith (2008) provide a method to enumerate the number of multiple impacts (such as risk of flooding, poor air quality, proximity to waste sites) occurring in local neighbourhoods for South Yorkshire (Table 5) illustrating that the poorest areas were subject to most impacts.

Fig. 7. Self-rated health and housing problems (mould growth, bad indoor air quality or cold in winter) by income group

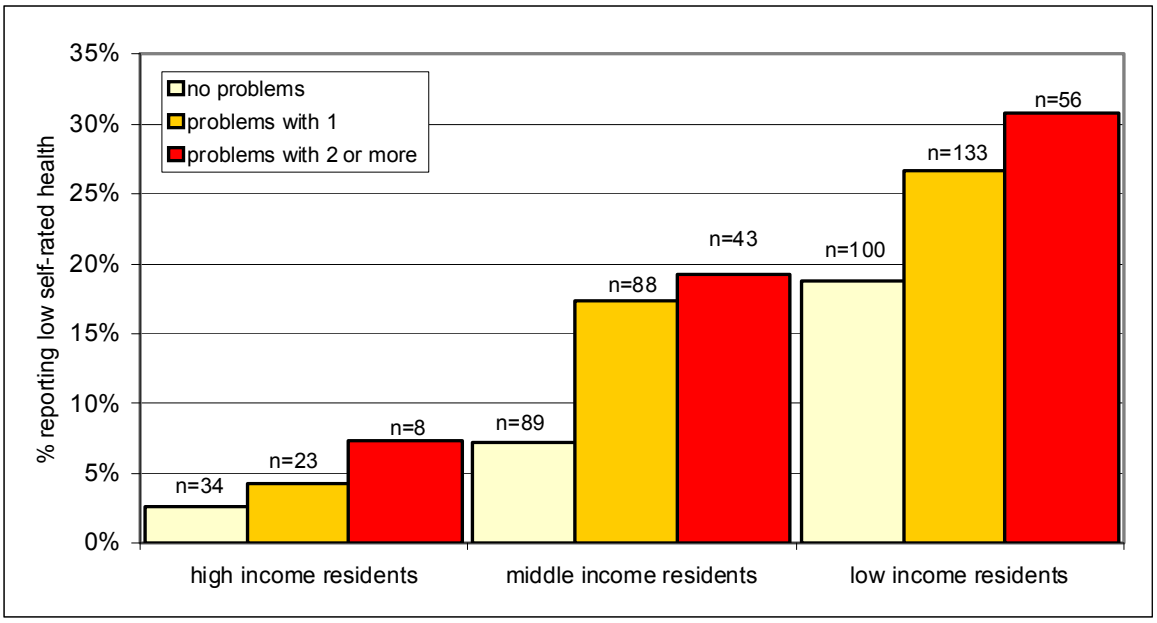


Table 5. Percentage of households experiencing multiple impacts by decile in South Yorkshire

Decile	Population	No Impacts	Single Impact	Multiple Impacts total	Multiple Impacts counted: 2	3	4	5–9
Poorest – 1	287 560	10.5	21.5	68.0	*21.3*	*18.4*	*10.6*	*17.7*
2	212 770	16.4	27.6	55.9	*16.7*	*18.1*	*11.3*	*9.9*
3	160 770	10.5	32.2	57.3	*18.6*	*17.7*	*16.1*	*4.8*
4	112 600	16.0	30.0	54.0	*29.5*	*17.2*	*3.5*	*3.8*
5	130 100	15.3	33.3	51.4	*26.9*	*14.1*	*5.7*	*4.7*
6	124 900	17.4	39.1	43.5	*24.6*	*9.6*	*6.6*	*2.7*
7	82 440	24.5	41.7	33.9	*22.8*	*3.9*	*4.7*	*2.5*
8	70 580	27.7	41.9	30.5	*20.4*	*3.4*	*6.4*	*0.4*
9	51 110	34.5	42.5	23.0	*17.8*	*5.0*	*0.2*	*0.0*
Wealthiest – 10	32 340	72.6	17.0	10.4	*9.9*	*0.5*	*0.0*	*0.0*
Total	**1 265 170**	**17.6**	**30.8**	**51.6**	***21.4***	***14.1***	***8.6***	***7.6***

Specific key messages on children and gender

Inequalities in children

As part of the PINCHE study, Bolte and Kohlhuber (2005) reviewed the link between the impact of socio economic factors on environmental exposure and the health of children in Europe. Environmental justice was used as a key concept in the study to examine the unequal distribution of environmental burden and health risks across social groups. They key results were:

- a lack of information in general (especially peer review articles) on these issues in Europe and especially in eastern Europe;
- based on the fragmentary evidence available, in most cases there was an inverse social gradient with increased burden (exposures, health disturbance) in children of lower socioeconomic status.

These key messages match well the overall conclusion that can be made for children based on this review, which can be categorized into three statements.

1. The main cause of inequality of housing and residential location affecting children is related to the social status, and mostly the income and the economic resources of the households. These resources largely shape the quality of the dwelling as well as the quality of the residential context, and therefore become the main mechanisms for unequally distributed children exposure. The socioeconomic mechanism seems to be the major link but may to an uncertain degree be associated with other characteristics such as ethnicity, gender, educational status etc. However, the influence of these factors cannot be assessed with the available evidence.
2. In most of the cases, low social and economic resources of their families are associated with increased children's exposure to inadequate housing and residential conditions (such as noise, indoor and outdoor air pollution, crowding, and to some extent lack of access to green spaces). In less developed countries, water and sanitation concerns become fundamental as well. However, there are some examples showing that the burden of unequal distributions is not by default to the disadvantage of the poor population subgroups, as some exposures (especially in relation to indoor contamination) tend to be more frequent for high-income households. Nevertheless, the overwhelming proportion of relatively increased exposures is definitely faced by the poor.
3. Almost all described exposure situations relate to the building and the neighbourhood, where children are affected as all other household members although – depending on behaviour, time spent at home etc. – some variation in exposure can be possible. However, there is one exposure dimension for which children can be considered the major risk group: exposure to passive smoking. Such exposure does not derive from building or neighbourhood conditions but is exclusively related to health behaviour and risk awareness of the households. Evidence suggests that – as for most other environmental inequalities – the children of low-income households tend to be more exposed as well.

Gender-related inequalities

Evidence on gender-related inequalities in relation to housing and residential location is scarce. This may be because housing and residential location conditions – seen from physical and infrastructural perspective – tend to be the same for male and female residents. Variations and inequalities therefore may be rather caused by perception and values (which is difficult to quantify) or through socioeconomic mechanisms that may be linked to more general gender inequalities in national societies. Beyond mentioning the few identified gender-sensitive findings, it is thus not possible to generate more strategic conclusions.

Evci et al. (2006) found that among the elderly in Turkey, women were more likely to have accidents in the home (1.26 times higher than men) which is linked to them spending more time in the home than men.

Shenassa et al. (2006) found a significant difference between men and women across eight European cities in terms of their perception of safety in the urban environment and as such their propensity to be physically active. The results indicated that female residents were more constrained in their physical activities than male residents. However, the perception of inadequate safety may also produce other constraints, such as a reduced frequency of going out when it is dark.

The data collected by the European Quality of Life Survey (Eurofound, 2008) offers the opportunity to categorize housing and residential environment information by gender. However, there is no consistent pattern of disadvantage as depending on the country and the respective variable, male and female exposure is very diverse. The data tables providing EQLS data (Appendix 1) for selected variables indicate these variations.

Identification of relative impact associated with the most frequently used social factors/inequity determinants: the magnitude of inequity

Walker et al. (2003), Fairburn et al. (2005) and Fairburn et al. (2009) provide fairly simple quantitative methods to detail information about the number of people exposed or living in proximity to good or poor environments provided access to data is available. However, the amount of people exposed and the inequality varies widely depending on the environmental factor under consideration and the country or area under consideration.

Lack of thermal comfort continues to kill thousands of people every year across the WHO European Region. Investing in energy efficient measures would provide multiple benefits not only for the health of the population, but also as a means of addressing climate change and providing local employment in such areas. The challenges of doing this are not technological as most of the technology is already well understood. The problems are particularly severe in eastern Europe and look set to worsen given the rising energy costs, increasing deterioration and lack of investment in the housing stock. These problems overwhelmingly affect the poor which in many countries are almost twice as often facing such problems (Eurofound, 2007). Together with the heat-wave of 2003 in Europe, the data demonstrates that inadequate housing can lead to deaths due to both heat and cold with the old particularly vulnerable.

Poor housing is directly related to incidences of poor health which is unsurprising given the length of time people are indoors; it can lead to multiple physical ailments as well as problems of mental well-being. The impact of the residential location is almost certainly less than that of the house, but has been shown to be statistically significant and predictive of health in several studies particularly when multiple as opposed to single exposures are considered.

Siting of industrial pollution sites has been shown to be inequitable in those countries in which it has been analysed. In Scotland the population in the poorest decile is three times more likely to be nearer such a site than those in the richest decile; in England the figure is six times more likely and both countries have a clear social gradient for such sites. Uneven distribution of such sites against the poor has also been shown in the

Netherlands and France. However many in the environmental justice field would argue that policy should not be about re-distributing such sites to even out imbalances, but to change methods of production, utilization and disposal to eliminate the need for such sites over time. Note that these figures are for some western European countries, we have little idea of the situation in the former Communist countries particularly with regards to the siting and toxicity of any historic waste sites.

In summary, there is a diversity of inequalities that can be found in many countries and studies. Depending on the country or respective study, the variable considered, and the population risk group defined, the magnitude of inequality varies a lot. Therefore, it would be inappropriate to try and extrapolate an overall assessment of the magnitude of environmental inequality for housing and residential conditions; however as we have shown it is generally the poorest groups who are experiencing the worst housing conditions and undesirable residential locations.

Suggested pathways and mechanisms for the impact of social factors on inequality

The discussion of pathways follows the four arrows of the framework model in the introduction section of this report.

Arrow 1 – Environmental conditions

The review identified clearly that there is a social gradient affecting the quality and adequacy of housing and residential environments. Main evidence exists for the socioeconomic mechanism as the environmental disadvantages are usually – with very few exceptions only – faced by less affluent population subgroups. Much less evidence is available on other social determinants such as gender, age and ethnicity. Examples of the association between poverty and inadequate or harmful environmental conditions include the following.

- In England, larger numbers of deprived populations are situated on tidal floodplains with an increased risk of flooding compared to other higher income groups (Environment Agency, 2007a).
- In Germany, noise and air pollution are more often experienced by low-income households which is usually related to a less adequate dwelling location close the heavy traffic (Umweltbundesamt, 2009).
- In the new EU Member States, almost 30% of the low-income households were not having adequate water and sanitation supply compared to around 5% in high-income households (Eurofound, 2007).

Arrow 2 – Increased exposure

Although the largest proportion of inequality in relation to housing and residential locations is probably explained by the mechanism above (unequal environmental conditions), there are still some mechanisms that affect the exposure irrespective of the environmental context.

- There are lower levels of flood awareness in deprived populations in England (Environment Agency, 2007a) and as such they are not as well prepared for flood events as other groups also living on the floodplains.

- German data has shown that irrespective of housing conditions, the exposure of children to passive smoking/ETS is strongly increased in poor households and migrant households (Umweltbundesamt, 2009)

Arrow 3 – Effect modifier

In specific cases, exposure may lead to different outcomes for different population groups, and social determinants may play a role in this variation. For housing and residential location, it seems difficult to identify such effect modifiers; two examples are given below.

- In the case of flooding, poor households often have less adequate insurance schemes (Werrity et al., 2007) which puts them at high economic risk when their dwelling is flooded and in need of expensive repair work.
- For houses in radon-prone areas, the habit of indoor smoking – which is much more frequent in low-income population groups – acts as a strong catalyst for radon-related health impacts (Darby et al., 2005)

Possible solutions and countermeasures

A first and possibly most fundamental recommendation is provided by the report of the Commission on the Social Determinants of Health (WHO, 2008), which identified the improvement of daily living conditions as a priority as well as addressing the unfair distribution of resources and power. This position advocates not only that poverty and social status differences in societies need to be tackled; it very clearly identifies the need to disconnect the current association between being poor and being disadvantaged.

In more detail, the recommendation to improve daily living conditions suggests to:

> Improve the well-being of girls and women and the circumstances in which their children are born, put major emphasis on early child development and education for girls and boys, improve living and working conditions and create social protection policy supportive of all, and create conditions for a flourishing older life. Policies to achieve these goals will involve civil society, governments, and global institutions. (WHO, 2008, p. 2).

Renovation of the existing housing stock will continue to be the main focus for action at the household level, but increases in the supply of public housing and increases in the replacement of existing stock also need to be considered. New houses need to be subject to much tougher building codes to prevent many of these housing problems occurring in the first instance and to avoid the problems of later trying to retrofit features. However, a major political challenge will be to offer quality housing for prices affordable to especially poorer population so that they can benefit from healthy housing.

There needs to be much stronger links between local municipalities and the health service providers to tackle poor housing together; and states may want to consider switching resources from health service providers to local municipalities to provide more of a focus on preventive as opposed to curative policy measures. Local municipalities are far more capable of dealing with structurally poor housing compared to health providers as long as they have the resources to do so.

Nationally housing should be considered as a determinant of health and thus an asset to the society influencing productivity and requiring running investment, maintenance and improvement.

Evidence is available for a neighbourhood effect on health which means that policy-makers can tackle some of these problems at an ecological level which is easier than dealing with issues at the level of the individual. Thomson (2008) admits there is little likelihood of empirical validation for healthy urban policy, but that we need to rely on the strong links demonstrated between socioeconomic deprivation and health as a justification for such policy. A more realistic assessment is also needed as to what area based interventions can achieve, particularly with the high levels of in and out migration which occur in many deprived areas.

Greater use needs to be made of spatial planning to avoid the build up of multiple exposures to poor environments and ghettoization/isolation of neighbourhoods. Integrated regional planning should consider the impacts of any new facilities and developments to check that they won't increase existing inequalities. Publication of multiple impact maps and other data should be used to stimulate conversations in the regions particularly around the issue of local unwanted land uses (LULUs). If undesirable facilities such as waste and other sites can no longer be dumped on poor areas it may start to move the debate towards changing methods of production and consumption.

Compensation should be considered for those communities which have shouldered a heavier environmental burden up until now. The Forward Scotland 'Environmental Justice Fund' launched by a Scottish Government agency in 2007 provides a good example of a policy designed to at least compensate for past environmental inequities. £2 million was made available for communities to bid into and a key part of the grant is used to engage local people in the decision-making processes surrounding the local environment.

In terms of administration and data collection far more could be achieved if data was reported at a localized level, recorded with a geo-spatial tag and made freely and easily available to the public and researchers alike. This would allow both monitoring of trends to examine if policy was working and provide the raw data to allow greater quantification of any health impacts.

Basic knowledge about the spatial pattern between environmental quality and social groupings has not been done for most countries. Primary research needs first to be carried out to investigate whether inequalities exist.

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Appendix 1. Data tables on housing inequalities by age, gender and income

Here are selected data tables from the 2nd European Quality of Life Survey (EQLS) carried out by the European Foundation for the Improvement of Living and Working Conditions (Eurofound); and data from the Eurostat survey "Statistics on Income and Living Conditions" (SILC).

Both Eurofound EQLS and Eurostat SILC data were collected in 2007. Further details on the EQLS – beyond housing and residential conditions – is provided by Chapter 9 contributed by Eurofound.

Overview of tables

1. Lack of an indoor flushing toilet in the accommodation; by gender, age and income (EQLS)
2. Lack of a bath or shower in the accommodation; by gender, age and income (EQLS)
3. Damp or leaks in walls or roof in the accommodation; by gender, age and income (EQLS)
4. Ability to keep the home adequately warm; by gender, age and income (EQLS)
5. Shortage of space in the accommodation; by gender, age and income (EQLS)
6. Heavy financial burden due to the housing costs; by different household compositions (SILC)
7. Households having problems with pollution, grime or other environmental problems (due to traffic and industrial activities) (SILC)

Data from the EQLS also comprises other environmental domains such as exposure to violence and crime; noise; low quality of drinking-water; air pollution; and lack of green spaces. However, largest inequalities were found for the more objective and "purchase-power-related" housing problems listed above. For the non-listed problems, the inequalities are less expressed and also are difficult to analyse as they depend on perception and problem awareness which may be stronger within households and individuals of higher social status. As well, in some areas (such as noise, water and air quality, perception of safety) the urban-rural difference may also have an impact that cannot be assessed.

All EQLS data can be obtained directly from the EQLS web site at http://www.eurofound.europa.eu/areas/qualityoflife/eqls/eqls2007/results.htm

Data from the SILC does also cover a number of environmental dimensions (such as noise, damp, dark dwellings, thermal comfort, housing size, sanitation) which can be analysed and categorized by a variety of social determinants, mainly household composition. SILC is an annual survey and therefore, updated data can be expected frequently.

All SILC data can be obtained directly from the Eurostat web site http://epp.eurostat.ec.europa.eu/portal/page/portal/living_conditions_and_social_protection/data/database

Do you have a problem with lack of an indoor flushing toilet in your accommodation?									
Data source: European Foundation for the Improvement of Living and Working Conditions (EQLS), 2007									
Country	**Gender**	**Yes**		**Country**	**Age**	**Yes**		**Country**	**Income**	**Yes**
AT	Male	0.6		AT	18–34	0.6		AT	Lowest	1.8
	Female	0.3			35–49	0.4			Low	0.7
	Both	0.4			50–64	0.4			High	0.3
BE	Male	2			65+	0.5			Highest	0.2
	Female	2.7		BE	18–34	2.7		BE	Lowest	4.6
	Both	2.4			35–49	1.9			Low	4
BG	Male	22.8			50–64	1.7			High	1.2
	Female	27.3			65+	3.2			Highest	0.8
	Both	25.2		BG	18–34	19.7		BG	Lowest	54.6
CY	Male	1.1			35–49	22.4			Low	35.9
	Female	1.1			50–64	27.2			High	21.7
	Both	1.1			65+	33.7			Highest	9
CZ	Male	4.1		CY	18–34	0		CY	Lowest	3.9
	Female	2.3			35–49	0.9			Low	0.9
	Both	3.2			50–64	0.3			High	0.2
DE	Male	2.1			65+	4.8			Highest	0
	Female	1.9		CZ	18–34	1.2		CZ	Lowest	3.7
	Both	2			35–49	3.3			Low	4.4
DK	Male	1.4			50–64	3.3			High	3
	Female	1			65+	6.7			Highest	0.7
	Both	1.2		DE	18–34	0.9		DE	Lowest	2.1
EE	Male	13.2			35–49	1.6			Low	1
	Female	14			50–64	3.1			High	1.6
	Both	13.7			65+	2.6			Highest	1.5
GR	Male	3.1		DK	18–34	2.7		DK	Lowest	4.9
	Female	1.1			35–49	0			Low	1.1
	Both	2.1			50–64	0.5			High	0.2
ES	Male	0.2			65+	1.6			Highest	0.1
	Female	1.6		EE	18–34	4.4		EE	Lowest	18.9
	Both	0.9			35–49	15.1			Low	20.1
FI	Male	1			50–64	16.7			High	12.6
	Female	2.2			65+	22.6			Highest	5.7
	Both	1.6		GR	18–34	0.6		GR	Lowest	5.3
FR	Male	0.8			35–49	1.4			Low	0.2
	Female	0.4			50–64	3.2			High	1.4
	Both	0.6			65+	4.1			Highest	0.5
HR	Male	4.3		ES	18–34	0		ES	Lowest	1.3
	Female	3.6			35–49	1.7			Low	0
	Both	3.9			50–64	0			High	0
HU	Male	7.1			65+	2.2			Highest	0
	Female	7		FI	18–34	1.2		FI	Lowest	2.2
	Both	7.1			35–49	1.6			Low	1.8
IE	Male	2.3			50–64	1.4			High	1.7
	Female	2.8			65+	2.5			Highest	0.8
	Both	2.6		FR	18–34	0.8		FR	Lowest	0.9
IT	Male	0.5			35–49	0.1			Low	0.5
	Female	0.7			50–64	0.6			High	0.7
	Both	0.6			65+	0.8			Highest	0.7
LT	Male	22.2		HR	18–34	1.6		HR	Lowest	10
	Female	21.6			35–49	4.6			Low	3.9
	Both	21.9			50–64	4.8			High	1.4
LU	Male	4.2			65+	5.3			Highest	1.6
	Female	2.3		HU	18–34	5.5		HU	Lowest	16.2
	Both	3.2			35–49	5.8			Low	8.9
LV	Male	20.6			50–64	6.9			High	5.2
	Female	18.3			65+	11.7			Highest	2.5
	Both	19.3		IE	18–34	3.4		IE	Lowest	5.5
MK	Male	13.3			35–49	2.9			Low	2.7
	Female	12.3			50–64	1.9			High	1.2
	Both	12.8			65+	0.8			Highest	1.1
MT	Male	0.6		IT	18–34	0.3		IT	Lowest	3.8
	Female	1			35–49	0.7			Low	0
	Both	0.9			50–64	0.6			High	0
					65+	0.8			Highest	0
NL	Male	0.4		LT	18–34	21.9		LT	Lowest	38.5
	Female	1.3			35–49	21.9			Low	30.1

Do you have a problem with lack of an indoor flushing toilet in your accommodation?									
	Both	0.9		50–64	16.6			High	18
NO	Male	3.2		65+	27.9			Highest	8.6
	Female	3.1	LU	18–34	3.6		LU	Lowest	1.3
	Both	3.1		35–49	2.4			Low	3.6
PL	Male	6.8		50–64	1.7			High	1.7
	Female	7.8		65+	6			Highest	3.3
	Both	7.3	LV	18–34	18.5		LV	Lowest	27.6
PT	Male	0.8		35–49	20.7			Low	22.5
	Female	1		50–64	20.5			High	11.6
	Both	0.9		65+	17.7			Highest	11.4
RO	Male	34.4	MK	18–34	13.9		MK	Lowest	29.1
	Female	35.4		35–49	12.5			Low	12.7
	Both	34.9		50–64	7.8			High	5.6
SE	Male	1.5		65+	18.4			Highest	3.9
	Female	0.8	MT	18–34	0		MT	Lowest	0
	Both	1.1		35–49	0.8			Low	0.9
SI	Male	2.1		50–64	1.4			High	0.8
	Female	1.5		65+	1.7			Highest	0
	Both	1.8	NL	18–34	0.5		NL	Lowest	4
SK	Male	4.9		35–49	0			Low	0
	Female	3		50–64	0.8			High	0.3
	Both	3.9		65+	3.1			Highest	0
TR	Male	8.9	NO	18–34	3		NO	Lowest	1.8
	Female	12.1		35–49	3.7			Low	4.2
	Both	10.5		50–64	3.1			High	3.1
UK	Male	1.5		65+	2.5			Highest	2.2
	Female	1.7	PL	18–34	6.2		PL	Lowest	15.6
	Both	1.6		35–49	6.2			Low	9.7
EU 15	Male	1.2		50–64	6.1			High	4.2
	Female	1.3		65+	13			Highest	2.9
	Both	1.3	PT	18–34	0.6		PT	Lowest	3.4
NMS12	Male	14.2		35–49	0.5			Low	2
	Female	14.8		50–64	1.2			High	0
	Both	14.5		65+	1.5			Highest	0
			RO	18–34	31.7		RO	Lowest	68.8
				35–49	27.5			Low	51.4
				50–64	34.2			High	22.3
				65+	52.1			Highest	11.2
			SE	18–34	0		SE	Lowest	1.9
				35–49	1.5			Low	1.1
				50–64	1.4			High	0.9
				65+	1.9			Highest	1.1
			SI	18–34	1.1		SI	Lowest	2.8
				35–49	2.5			Low	2.6
				50–64	1.8			High	0.3
				65+	1.6			Highest	0
			SK	18–34	2.9		SK	Lowest	12.8
				35–49	3.9			Low	3.5
				50–64	3.9			High	2.1
				65+	6.4			Highest	2.2
			TR	18–34	9.8		TR	Lowest	20
				35–49	10.9			Low	8.6
				50–64	11.7			High	6.8
				65+	10.9			Highest	4.7
			UK	18–34	2.5		UK	Lowest	3.9
				35–49	0.8			Low	1.8
				50–64	0.8			High	1.4
				65+	2.3			Highest	0.6
			EU 15	18–34	1		EU 15	Lowest	2.5
				35–49	1			Low	0.9
				50–64	1.3			High	0.9
				65+	1.9			Highest	0.7
			NMS12	18–34	12.4		NMS12	Lowest	30.4
				35–49	12.2			Low	20.9
				50–64	13.8			High	10.4
				65+	22.7			Highest	5.4

EU 15: EU members before 2004 - NMS12: New EU member states after 2004

Do you have a problem with lack of a bath or shower in your accommodation?									
Data source: European Foundation for the Improvement of Living and Working Conditions (EQLS), 2007									
Country	**Gender**	**Yes**		**Country**	**Age**	**Yes**		**Country**	**Income**	**Yes**
AT	Male	0.9		AT	18–34	0.7		AT	Lowest	1.3
	Female	0.7			35–49	0.6			Low	1
	Both	0.8			50–64	0.4			High	0.6
BE	Male	3.3			65+	1.8			Highest	0.9
	Female	2.8		BE	18–34	3.5		BE	Lowest	5.9
	Both	3			35–49	2.6			Low	5.5
BG	Male	10			50–64	2.9			High	1.5
	Female	13.4			65+	3.1			Highest	1.2
	Both	11.8		BG	18–34	8.1		BG	Lowest	35.9
CY	Male	0.8			35–49	9.1			Low	16.8
	Female	0.5			50–64	12.7			High	4.7
	Both	0.7			65+	19.3			Highest	2.6
CZ	Male	2.4		CY	18–34	0		CY	Lowest	3.5
	Female	1.7			35–49	0.9			Low	0
	Both	2			50–64	0.2			High	0.2
DE	Male	1.9			65+	2.4			Highest	0
	Female	1.4		CZ	18–34	0		CZ	Lowest	2
	Both	1.6			35–49	1.9			Low	2.7
DK	Male	1.8			50–64	1.8			High	2.4
	Female	1.2			65+	6.4			Highest	0.4
	Both	1.5		DE	18–34	0.7		DE	Lowest	0.5
EE	Male	17			35–49	2.1			Low	1.2
	Female	17.3			50–64	2.2			High	1.8
	Both	17.2			65+	1.5			Highest	1.3
GR	Male	2.6		DK	18–34	2.3		DK	Lowest	3.1
	Female	1.4			35–49	0.6			Low	1.8
	Both	2			50–64	1.5			High	2.1
ES	Male	0.2			65+	1.9			Highest	0.7
	Female	2.5		EE	18–34	8		EE	Lowest	24.8
	Both	1.4			35–49	20			Low	26
FI	Male	1.5			50–64	17.8			High	13.6
	Female	2.9			65+	26.8			Highest	9.9
	Both	2.2		GR	18–34	1.4		GR	Lowest	3.5
FR	Male	1.1			35–49	0.2			Low	0.4
	Female	1			50–64	3.2			High	1.2
	Both	1			65+	3.8			Highest	0
HR	Male	4.7		ES	18–34	0.8		ES	Lowest	4.1
	Female	4.5			35–49	1.2			Low	1.2
	Both	4.6			50–64	1.1			High	0
HU	Male	5.7			65+	2.7			Highest	0
	Female	5.9		FI	18–34	1.2		FI	Lowest	2.9
	Both	5.8			35–49	3			Low	1.8
IE	Male	2.5			50–64	1.4			High	3
	Female	5.2			65+	3.4			Highest	1.5
	Both	3.9		FR	18–34	0.9		FR	Lowest	1.5
IT	Male	0.4			35–49	0.8			Low	1.3
	Female	1			50–64	1.1			High	0.9
	Both	0.7			65+	1.4			Highest	0.6
LT	Male	18.1		HR	18–34	1.5		HR	Lowest	10.7
	Female	20.8			35–49	4			Low	4.5
	Both	19.5			50–64	5.3			High	2.3
LU	Male	4.3			65+	8.9			Highest	2.3
	Female	2.6		HU	18–34	5.1		HU	Lowest	11.5
	Both	3.5			35–49	4.6			Low	9.8
LV	Male	21			50–64	5.1			High	5
	Female	20.6			65+	9.7			Highest	1.3
	Both	20.8		IE	18–34	5.8		IE	Lowest	8.5
MK	Male	7.4			35–49	2.6			Low	6.6
	Female	9.9			50–64	2.6			High	1.7
	Both	8.7			65+	3.3			Highest	1.1
MT	Male	0.8		IT	18–34	0.5		IT	Lowest	3.8
	Female	1.1			35–49	0.6			Low	0
	Both	1			50–64	0.8			High	0.2
					65+	0.8			Highest	2
NL	Male	0.9		LT	18–34	18.3		LT	Lowest	35.4
	Female	0.8			35–49	20.8			Low	23.1

Do you have a problem with lack of a bath or shower in your accommodation?									
	Both	0.9		50–64	12.6			High	17.9
NO	Male	4		65+	27.6			Highest	6.6
	Female	2.6	LU	18–34	3.6		LU	Lowest	0.8
	Both	3.3		35–49	2.9			Low	2.8
PL	Male	7.4		50–64	1.3			High	1.1
	Female	8.2		65+	6.8			Highest	3.3
	Both	7.9	LV	18–34	16.9		LV	Lowest	33.3
PT	Male	0.8		35–49	22.7			Low	21.8
	Female	1.5		50–64	22			High	15.3
	Both	1.1		65+	23			Highest	11.2
RO	Male	32.8	MK	18–34	8.7		MK	Lowest	19.1
	Female	35.1		35–49	9.7			Low	8.5
	Both	34		50–64	5.3			High	4.6
SE	Male	2		65+	11.7			Highest	1.9
	Female	0.4	MT	18–34	0		MT	Lowest	0.6
	Both	1.2		35–49	0.8			Low	2.1
SI	Male	1.7		50–64	1.7			High	0.8
	Female	0.8		65+	2			Highest	0
	Both	1.2	NL	18–34	0		NL	Lowest	2.7
SK	Male	2.3		35–49	0.8			Low	0.9
	Female	1.7		50–64	0.7			High	0.6
	Both	2		65+	2.5			Highest	0
TR	Male	7.8	NO	18–34	4		NO	Lowest	3.2
	Female	12.9		35–49	2.3			Low	5.1
	Both	10.4		50–64	3.6			High	2.5
UK	Male	1.2		65+	3.4			Highest	2.8
	Female	1.9	PL	18–34	5		PL	Lowest	15.4
	Both	1.5		35–49	7.1			Low	11.6
EU 15	Male	1.2		50–64	8.1			High	4.5
	Female	1.5		65+	14.6			Highest	2.9
	Both	1.4	PT	18–34	0		PT	Lowest	3.8
NMS12	Male	12.6		35–49	1.2			Low	3.2
	Female	13.6		50–64	1.6			High	1.1
	Both	13.1		65+	2.4			Highest	0
			RO	18–34	30.1		RO	Lowest	68.1
				35–49	27.6			Low	47.2
				50–64	33			High	21.2
				65+	51.3			Highest	7.8
			SE	18–34	1.1		SE	Lowest	1.4
				35–49	0.6			Low	1.1
				50–64	1			High	0.6
				65+	2.2			Highest	2.4
			SI	18–34	1.1		SI	Lowest	2.8
				35–49	1.1			Low	3
				50–64	1.1			High	0
				65+	1.7			Highest	0.2
			SK	18–34	2.4		SK	Lowest	6.2
				35–49	1.7			Low	2.2
				50–64	1.7			High	0
				65+	1.8			Highest	2
			TR	18–34	9.6		TR	Lowest	20
				35–49	10.9			Low	12.8
				50–64	12			High	5.4
				65+	9.9			Highest	2.3
			UK	18–34	2.7		UK	Lowest	2.3
				35–49	0.9			Low	3.6
				50–64	0.5			High	1.8
				65+	1.8			Highest	0
			EU 15	18–34	1.2		EU 15	Lowest	2.2
				35–49	1.2			Low	1.6
				50–64	1.3			High	1.2
				65+	1.8			Highest	0.8
			NMS12	18–34	10.5		NMS12	Lowest	27.9
				35–49	11.3			Low	19
				50–64	12.6			High	8.8
				65+	21.6			Highest	3.9

EU 15: EU members before 2004 - NMS12: New EU member states after 2004

Do you have a problem with damp or leaks in walls or roof in your accommodation?										
Data source: European Foundation for the Improvement of Living and Working Conditions (EQLS), 2007										
Country	**Gender**	**Yes**		**Country**	**Age**	**Yes**		**Country**	**Income**	**Yes**
AT	Male	9.8		AT	18–34	6.9		AT	Lowest	13
	Female	7.3			35–49	7.1			Low	7.9
	Both	8.5			50–64	12.2			High	6.4
BE	Male	11.3			65+	8.6			Highest	8.9
	Female	15.1		BE	18–34	16.2		BE	Lowest	21.9
	Both	13.2			35–49	15.1			Low	15.3
BG	Male	11.1			50–64	11.8			High	9.5
	Female	14.8			65+	8.5			Highest	10.3
	Both	13.1		BG	18–34	11.6		BG	Lowest	25.2
CY	Male	24.5			35–49	12.6			Low	19.9
	Female	28.5			50–64	13.3			High	8.6
	Both	26.6			65+	15.3			Highest	6.4
CZ	Male	10		CY	18–34	23.8		CY	Lowest	39.1
	Female	12.4			35–49	30			Low	32.6
	Both	11.3			50–64	25.9			High	24.7
DE	Male	6			65+	27.3			Highest	11.2
	Female	7.3		CZ	18–34	10.4		CZ	Lowest	21.1
	Both	6.6			35–49	10.8			Low	12.7
DK	Male	16.7			50–64	10.5			High	6.5
	Female	17			65+	14.8			Highest	8.1
	Both	16.9		DE	18–34	9.8		DE	Lowest	13.8
EE	Male	21.1			35–49	8.9			Low	4.7
	Female	25.1			50–64	3.5			High	4.8
	Both	23.3			65+	3.5			Highest	7.2
GR	Male	15.4		DK	18–34	27.8		DK	Lowest	21.9
	Female	16.8			35–49	17.9			Low	22.9
	Both	16.1			50–64	12.8			High	14.8
ES	Male	8.8			65+	6.2			Highest	11.9
	Female	15.6		EE	18–34	22.1		EE	Lowest	28.3
	Both	12.3			35–49	25.4			Low	15.4
FI	Male	9.9			50–64	28.2			High	27.1
	Female	12.1			65+	17.2			Highest	20.8
	Both	11.1		GR	18–34	16.3		GR	Lowest	27.7
FR	Male	15			35–49	13.3			Low	20.1
	Female	15.5			50–64	14.6			High	12.4
	Both	15.2			65+	21.2			Highest	5.8
HR	Male	19.4		ES	18–34	13.1		ES	Lowest	18.5
	Female	16.9			35–49	9.1			Low	11.1
	Both	18.1			50–64	9.3			High	7
HU	Male	14.1			65+	18.6			Highest	6.2
	Female	17.3		FI	18–34	11.4		FI	Lowest	11.5
	Both	15.8			35–49	11.4			Low	14.9
IE	Male	8.1			50–64	12.1			High	9.5
	Female	8.8			65+	8.9			Highest	10.7
	Both	8.5		FR	18–34	20.8		FR	Lowest	21.1
IT	Male	7.1			35–49	17.3			Low	19.7
	Female	9.3			50–64	11.1			High	14.8
	Both	8.3			65+	10			Highest	9.3
LT	Male	15.9		HR	18–34	13.3		HR	Lowest	32.4
	Female	19.7			35–49	19.4			Low	18.6
	Both	18			50–64	20.9			High	13.6
LU	Male	13.1			65+	19.9			Highest	12.4
	Female	15.5		HU	18–34	17.6		HU	Lowest	27.7
	Both	14.3			35–49	14.2			Low	20.8
LV	Male	32.8			50–64	14.8			High	11.5
	Female	31.4			65+	16.2			Highest	6.6
	Both	32.1		IE	18–34	10.5		IE	Lowest	19.2
MK	Male	27.9			35–49	8.1			Low	6.8
	Female	23.4			50–64	4.9			High	7.3
	Both	25.6			65+	9			Highest	5.5
MT	Male	10.3		IT	18–34	8.8		IT	Lowest	14.9
	Female	12.6			35–49	7.5			Low	17.5
	Both	11.5			50–64	7.3			High	7.9
					65+	9.4			Highest	13.1
NL	Male	9.8		LT	18–34	17.2		LT	Lowest	27.3
	Female	13.1			35–49	16.7			Low	20

Do you have a problem with damp or leaks in walls or roof in your accommodation?										
	Both	11.5			50–64	18.7			High	14.3
NO	Male	7.9			65+	20.4			Highest	12.9
	Female	7.8		LU	18–34	14		LU	Lowest	18.4
	Both	7.8			35–49	15			Low	17
PL	Male	13.3			50–64	15			High	15.7
	Female	16.6			65+	12.7			Highest	12.7
	Both	15		LV	18–34	32.6		LV	Lowest	36.2
PT	Male	19			35–49	40.1			Low	36.7
	Female	25.4			50–64	26.3			High	33.6
	Both	22.3			65+	27.2			Highest	26
RO	Male	13.7		MK	18–34	21.2		MK	Lowest	42.3
	Female	16.9			35–49	28.3			Low	29.6
	Both	15.4			50–64	25.6			High	24.4
SE	Male	6.5			65+	31.1			Highest	11.4
	Female	6		MT	18–34	8.5		MT	Lowest	15.8
	Both	6.3			35–49	9			Low	6.7
SI	Male	8.3			50–64	12.5			High	10.1
	Female	14.5			65+	19			Highest	8.1
	Both	11.5		NL	18–34	15.1		NL	Lowest	16.3
SK	Male	11.8			35–49	14.5			Low	13.4
	Female	7.4			50–64	10.3			High	7.5
	Both	9.5			65+	2.2			Highest	9
TR	Male	31.1		NO	18–34	11.1		NO	Lowest	8.8
	Female	37.2			35–49	9.2			Low	7.7
	Both	34.1			50–64	5.3			High	7.7
UK	Male	11.5			65+	4.1			Highest	7.1
	Female	13.6		PL	18–34	12.3		PL	Lowest	27.4
	Both	12.6			35–49	17.4			Low	17.4
EU 15	Male	9.9			50–64	16.3			High	11.5
	Female	12.2			65+	15.4			Highest	8.2
	Both	11.1		PT	18–34	17.5		PT	Lowest	42.2
NMS12	Male	13.4			35–49	21.6			Low	23.6
	Female	16.3			50–64	22.5			High	24.5
	Both	14.9			65+	30.7			Highest	10.2
				RO	18–34	16.6		RO	Lowest	37.4
					35–49	14			Low	19.7
					50–64	11.3			High	6.9
					65+	20			Highest	4.8
				SE	18–34	13.2		SE	Lowest	6.7
					35–49	5.4			Low	4.6
					50–64	3.1			High	9.4
					65+	2.5			Highest	1.2
				SI	18–34	9.3		SI	Lowest	21.4
					35–49	14.1			Low	10.3
					50–64	11.4			High	8.2
					65+	10.9			Highest	8
				SK	18–34	10.3		SK	Lowest	21.5
					35–49	7			Low	12.7
					50–64	9.7			High	6.1
					65+	12.3			Highest	8.6
				TR	18–34	30.8		TR	Lowest	55.5
					35–49	38.9			Low	38.4
					50–64	35.2			High	29.1
					65+	34.6			Highest	15.8
				UK	18–34	15.3		UK	Lowest	24.6
					35–49	18.3			Low	12.6
					50–64	8.5			High	10.5
					65+	5.7			Highest	13
				EU 15	18–34	13.7		EU 15	Lowest	18.3
					35–49	12.2			Low	12.5
					50–64	8.4			High	9.3
					65+	8.9			Highest	9.1
				NMS12	18–34	14		NMS12	Lowest	28.8
					35–49	15.4			Low	18.3
					50–64	14.4			High	10.4
					65+	16.8			Highest	7.9

EU 15: EU members before 2004 - NMS12: New EU member states after 2004

Can you afford keeping your home adequately warm if you want it?									
Data source: European Foundation for the Improvement of Living and Working Conditions (EQLS), 2007									
Country	**Gender**	**No**		**Country**	**Age**	**No**		**Country**	**Income**	**No**
AT	Male	3.8		AT	18–34	2.1		AT	Lowest	6.7
	Female	3.7			35–49	4			Low	3.3
	Both	3.7			50–64	5.8			High	5.4
BE	Male	6			65+	3			Highest	4
	Female	7.5		BE	18–34	8.1		BE	Lowest	14.7
	Both	6.8			35–49	6.3			Low	11.2
BG	Male	28.9			50–64	5.9			High	6.2
	Female	31.9			65+	6.7			Highest	2
	Both	30.5		BG	18–34	24		BG	Lowest	41.5
CY	Male	27.4			35–49	29.8			Low	33.6
	Female	26.5			50–64	28.4			High	30.9
	Both	26.9			65+	42.7			Highest	19.4
CZ	Male	4		CY	18–34	16.1		CY	Lowest	48.1
	Female	6.2			35–49	30.9			Low	28.9
	Both	5.1			50–64	31.2			High	23.4
DE	Male	5.1			65+	36.2			Highest	10.8
	Female	5.1		CZ	18–34	2.4		CZ	Lowest	12.8
	Both	5.1			35–49	3.5			Low	5.4
DK	Male	1.7			50–64	6.7			High	4.3
	Female	2.3			65+	10.5			Highest	1.5
	Both	2		DE	18–34	6.5		DE	Lowest	9.5
EE	Male	9.1			35–49	5.1			Low	6
	Female	13.4			50–64	5.2			High	3.5
	Both	11.5			65+	3.5			Highest	3.4
GR	Male	14.8		DK	18–34	1.1		DK	Lowest	3.3
	Female	21			35–49	2.5			Low	2
	Both	18			50–64	2.4			High	0.8
ES	Male	8.1			65+	1.9			Highest	1.5
	Female	13.6		EE	18–34	11.8		EE	Lowest	16.2
	Both	10.9			35–49	10.2			Low	12.2
FI	Male	0.4			50–64	11			High	14.1
	Female	1.6			65+	13			Highest	5.7
	Both	1		GR	18–34	12.9		GR	Lowest	31.4
FR	Male	6.1			35–49	12.6			Low	17.4
	Female	5.7			50–64	21.9			High	18.2
	Both	5.9			65+	28.5			Highest	7.3
HR	Male	7.5		ES	18–34	10.1		ES	Lowest	30.6
	Female	9.6			35–49	8.7			Low	12.7
	Both	8.6			50–64	13.1			High	11.5
HU	Male	7.5			65+	13			Highest	6
	Female	11.5		FI	18–34	0		FI	Lowest	1.5
	Both	9.6			35–49	0.3			Low	1.6
IE	Male	3.9			50–64	0.7			High	0.6
	Female	4.2			65+	3.6			Highest	0.3
	Both	4.1		FR	18–34	6.4		FR	Lowest	9.7
IT	Male	8.3			35–49	6.3			Low	9.5
	Female	9.6			50–64	6.4			High	4.4
	Both	9			65+	4			Highest	2.8
LT	Male	36		HR	18–34	3.6		HR	Lowest	18.9
	Female	41.5			35–49	6.8			Low	7.9
	Both	39			50–64	7.9			High	6.2
LU	Male	0.8			65+	19.4			Highest	5.5
	Female	2.8		HU	18–34	8.2		HU	Lowest	15.5
	Both	1.8			35–49	8			Low	7.7
LV	Male	13.6			50–64	9			High	11.1
	Female	17.1			65+	15			Highest	6.8
	Both	15.5		IE	18–34	6.2		IE	Lowest	13.2
MK	Male	25.2			35–49	3.1			Low	1.6
	Female	23			50–64	1.8			High	2.5
	Both	24.1			65+	3.7			Highest	3.1
MT	Male	17.8		IT	18–34	7.2		IT	Lowest	32.4
	Female	17.2			35–49	10			Low	10.4
	Both	17.5			50–64	7.8			High	4.6
					65+	11.1			Highest	6.3
NL	Male	1.8		LT	18–34	36.6		LT	Lowest	49.9
	Female	2.1			35–49	34.3			Low	41.7

Can you afford keeping your home adequately warm if you want it?									
	Both	1.9		50–64	43.1			High	35.9
NO	Male	1.7		65+	45.7			Highest	24.8
	Female	2.5	LU	18–34	1.8		LU	Lowest	3.2
	Both	2.1		35–49	2.2			Low	2.1
PL	Male	13.2		50–64	0.5			High	0.6
	Female	19.9		65+	2.6			Highest	0
	Both	16.7	LV	18–34	14.2		LV	Lowest	27.6
PT	Male	13.9		35–49	14.1			Low	14
	Female	21.5		50–64	18.6			High	9.8
	Both	17.9		65+	15.9			Highest	7.8
RO	Male	19.7	MK	18–34	21.6		MK	Lowest	39
	Female	23.9		35–49	29.2			Low	27.2
	Both	21.9		50–64	23			High	17.8
SE	Male	0.4		65+	21.6			Highest	10.4
	Female	1	MT	18–34	12.8		MT	Lowest	27
	Both	0.7		35–49	17.8			Low	20.7
SI	Male	2.8		50–64	23.2			High	11.9
	Female	1.8		65+	17.2			Highest	8.3
	Both	2.3	NL	18–34	2		NL	Lowest	5.1
SK	Male	11.1		35–49	1.8			Low	1.7
	Female	9.6		50–64	2.7			High	1.4
	Both	10.3		65+	1			Highest	0
TR	Male	41.1	NO	18–34	1.6		NO	Lowest	4.4
	Female	50.4		35–49	2.8			Low	2.4
	Both	45.8		50–64	2.2			High	1
UK	Male	3.8		65+	1.6			Highest	0.8
	Female	5	PL	18–34	10.1		PL	Lowest	29.2
	Both	4.4		35–49	14.9			Low	16.9
EU 15	Male	6		50–64	22.2			High	13.1
	Female	7.4		65+	25.1			Highest	6.7
	Both	6.7	PT	18–34	12.8		PT	Lowest	32.6
NMS12	Male	14.8		35–49	14.2			Low	26.1
	Female	19.2		50–64	22.5			High	10.8
	Both	17.1		65+	25.8			Highest	12.8
			RO	18–34	20.1		RO	Lowest	41.9
				35–49	15.1			Low	30.4
				50–64	23			High	15.7
				65+	33.4			Highest	5.6
			SE	18–34	0.2		SE	Lowest	0.9
				35–49	1.8			Low	1
				50–64	0.7			High	0.4
				65+	0			Highest	0
			SI	18–34	1		SI	Lowest	7.1
				35–49	2.7			Low	0.8
				50–64	3			High	0.7
				65+	2.9			Highest	0.8
			SK	18–34	8.4		SK	Lowest	21.9
				35–49	9.8			Low	14
				50–64	12.8			High	9.4
				65+	12.7			Highest	7.9
			TR	18–34	41.8		TR	Lowest	74.8
				35–49	48.8			Low	52.1
				50–64	50.6			High	39.6
				65+	48.9			Highest	22.9
			UK	18–34	4		UK	Lowest	11
				35–49	5.4			Low	4.5
				50–64	4			High	1.8
				65+	4.2			Highest	2.2
			EU 15	18–34	6.5		EU 15	Lowest	14.5
				35–49	6.6			Low	7.7
				50–64	7			High	4.7
				65+	7.1			Highest	3.3
			NMS12	18–34	13		NMS12	Lowest	30.3
				35–49	14.4			Low	19.5
				50–64	19.6			High	14.8
				65+	25.3			Highest	7.6

EU 15: EU members before 2004 - NMS12: New EU member states after 2004

Do you have a problem with shortage of space in your accommodation?									
Data source: European Foundation for the Improvement of Living and Working Conditions (EQLS), 2007									
Country	**Gender**	**Yes**		**Country**	**Age**	**Yes**		**Country**	**Income**	**Yes**
AT	Male	15.9		AT	18–34	28		AT	Lowest	35.6
	Female	16.5			35–49	15.7			Low	17.9
	Both	16.2			50–64	11.1			High	8.6
BE	Male	13.4			65+	5.8			Highest	3.2
	Female	13.5		BE	18–34	23.3		BE	Lowest	17.6
	Both	13.4			35–49	17.8			Low	10.9
BG	Male	26.3			50–64	5.6			High	15.5
	Female	28.2			65+	3.6			Highest	12.8
	Both	27.3		BG	18–34	40.4		BG	Lowest	27.3
CY	Male	19.6			35–49	33			Low	15.8
	Female	20.4			50–64	20.8			High	21.5
	Both	20			65+	9.5			Highest	29.7
CZ	Male	11.9		CY	18–34	23.3		CY	Lowest	26.8
	Female	10.4			35–49	29.6			Low	21.2
	Both	11.1			50–64	10.5			High	17.2
DE	Male	13.1			65+	9.6			Highest	9.6
	Female	11.6		CZ	18–34	14.4		CZ	Lowest	13.9
	Both	12.3			35–49	15.2			Low	14.6
DK	Male	14.7			50–64	6.8			High	10.1
	Female	17.8			65+	5			Highest	12.1
	Both	16.3		DE	18–34	19.4		DE	Lowest	17
EE	Male	27.7			35–49	15.2			Low	13.9
	Female	24.6			50–64	7.9			High	9.5
	Both	26			65+	5.5			Highest	6.9
GR	Male	19.5		DK	18–34	21.3		DK	Lowest	25
	Female	22.6			35–49	26.5			Low	19
	Both	21.1			50–64	8.9			High	11.6
ES	Male	15.6			65+	4.6			Highest	12.8
	Female	18.2		EE	18–34	38		EE	Lowest	24.7
	Both	16.9			35–49	31.9			Low	25.3
FI	Male	17			50–64	18.2			High	22.6
	Female	17.7			65+	9.1			Highest	29.5
	Both	17.3		GR	18–34	19.9		GR	Lowest	27.6
FR	Male	16.3			35–49	26.3			Low	18.8
	Female	18.6			50–64	21.7			High	24.5
	Both	17.5			65+	15.9			Highest	15.3
HR	Male	19.3		ES	18–34	22.8		ES	Lowest	22.9
	Female	19.8			35–49	16.9			Low	22
	Both	19.6			50–64	13.6			High	14
HU	Male	24			65+	11.2			Highest	9.5
	Female	27.1		FI	18–34	27.2		FI	Lowest	24.4
	Both	25.7			35–49	19.7			Low	15.4
IE	Male	15.7			50–64	11.5			High	18.5
	Female	17.7			65+	9.2			Highest	16.9
	Both	16.7		FR	18–34	23.5		FR	Lowest	19.3
IT	Male	16.4			35–49	28.2			Low	21.6
	Female	16.8			50–64	10.5			High	22.1
	Both	16.6			65+	3.7			Highest	14.5
LT	Male	30.1		HR	18–34	17.3		HR	Lowest	22.7
	Female	29.1			35–49	24.9			Low	21
	Both	29.5			50–64	21			High	18.2
LU	Male	11.1			65+	13.7			Highest	19.1
	Female	13.4		HU	18–34	34.7		HU	Lowest	29.9
	Both	12.3			35–49	32.8			Low	17.3
LV	Male	31			50–64	18.8			High	28.6
	Female	34.3			65+	9.2			Highest	22.6
	Both	32.8		IE	18–34	19.9		IE	Lowest	30.2
MK	Male	27.7			35–49	23			Low	13.6
	Female	29.7			50–64	9.5			High	14.9
	Both	28.7			65+	6.4			Highest	16.3
MT	Male	8.8		IT	18–34	22.5		IT	Lowest	24.4
	Female	10.6			35–49	20.2			Low	18.2
	Both	9.7			50–64	12.6			High	14.5
					65+	9			Highest	15.9
NL	Male	12.3		LT	18–34	37.4		LT	Lowest	33.6
	Female	17			35–49	37.7			Low	25.4

Do you have a problem with shortage of space in your accommodation?									
	Both	14.7		50–64	21.2		High	27.3
NO	Male	12.6		65+	13		Highest	32.8
	Female	19	LU	18–34	18.6	LU	Lowest	20.7
	Both	15.8		35–49	14.3		Low	12.7
PL	Male	28.3		50–64	7		High	10.3
	Female	27.7		65+	5.8		Highest	1.1
	Both	27.9	LV	18–34	41.8	LV	Lowest	26.5
PT	Male	18.3		35–49	37.3		Low	31.8
	Female	17.2		50–64	31.7		High	32.5
	Both	17.7		65+	15.1		Highest	37.6
RO	Male	23.5	MK	18–34	33.1	MK	Lowest	37.6
	Female	21.4		35–49	29.8		Low	27.2
	Both	22.4		50–64	25.2		High	26
SE	Male	15.6		65+	21.4		Highest	22.1
	Female	12.1	MT	18–34	10.4	MT	Lowest	8.8
	Both	13.8		35–49	12.3		Low	9.6
SI	Male	14		50–64	9		High	4.8
	Female	18.3		65+	5.7		Highest	6.2
	Both	16.2	NL	18–34	19.2	NL	Lowest	24.7
SK	Male	13		35–49	20		Low	19.2
	Female	12.2		50–64	9.2		High	10.3
	Both	12.6		65+	6.2		Highest	8.3
TR	Male	27.5	NO	18–34	26	NO	Lowest	20.3
	Female	38.5		35–49	21.7		Low	13.7
	Both	33		50–64	7.8		High	16.8
UK	Male	21.9		65+	2.2		Highest	10.1
	Female	20.8	PL	18–34	35.1	PL	Lowest	36.6
	Both	21.3		35–49	36.1		Low	27.7
EU 15	Male	16.2		50–64	19.2		High	23.8
	Female	16.7		65+	13.4		Highest	23.3
	Both	16.5	PT	18–34	17.4	PT	Lowest	17.5
NMS12	Male	23.9		35–49	24.9		Low	22.1
	Female	23.7		50–64	15.6		High	19
	Both	23.8		65+	11.3		Highest	15.9
			RO	18–34	33.4	RO	Lowest	21.4
				35–49	24.5		Low	21.1
				50–64	12.7		High	23
				65+	11.3		Highest	19.2
			SE	18–34	23	SE	Lowest	19.3
				35–49	18.9		Low	14.6
				50–64	5.5		High	12.2
				65+	6.2		Highest	9.6
			SI	18–34	22	SI	Lowest	16.8
				35–49	23		Low	13
				50–64	8.5		High	19.9
				65+	6.6		Highest	17.4
			SK	18–34	17.8	SK	Lowest	15.7
				35–49	15.5		Low	11.7
				50–64	5.6		High	11.6
				65+	4.2		Highest	14.9
			TR	18–34	31.8	TR	Lowest	52
				35–49	33.9		Low	36.8
				50–64	38.3		High	22.4
				65+	27.6		Highest	17.8
			UK	18–34	25.9	UK	Lowest	27.9
				35–49	27.2		Low	27.7
				50–64	19.2		High	26.4
				65+	9.4		Highest	19
			EU 15	18–34	22.4	EU 15	Lowest	21.7
				35–49	21		Low	18.9
				50–64	12		High	16.1
				65+	7.5		Highest	12.2
			NMS12	18–34	31.9	NMS12	Lowest	27.9
				35–49	29.5		Low	22
				50–64	16		High	22.3
				65+	10.7		Highest	21.8

EU 15: EU members before 2004 - NMS12: New EU member states after 2004

Households with heavy financial burden due to the housing costs

Data source: EUROSTAT (SILC), 2007

Country	% of single female house-holds		% of single male house-holds		% of single parent with dependent children		% of house-holds with two adults with three or more dependent children		Total% of households without dependent children		Total% of households with dependent children		Total% of all house-holds	
	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh
AT	23	15	30	10	39	28	35	16	26	11	31	15	29	13
BE	42	34	46	30	55	47	54	28	43	25	52	29	47	27
CY	74	64	68	43	88	80	89	80	75	64	88	72	80	69
CZ	39	26	49	19	58	41	65	32	45	18	53	22	51	20
DE	30	21	29	18	40	36	42	30	28	17	38	25	32	21
DK	15	7	14	8	21	18	21	8	11	5	16	7	12	6
EE	43	32	31	17	52	36	39	20	41	20	40	16	40	18
ES	60	51	45	39	80	70	78	61	60	47	63	51	62	49
FI	20	21	21	15	52	44	42	27	21	14	40	24	27	19
FR	37	28	31	22	59	43	45	32	37	22	50	30	45	26
GR	46	37	31	22	55	45	40	28	37	27	43	30	40	28
HU	53	36	53	30	59	50	55	43	52	29	51	34	51	32
IE	20	16	28	18	55	42	44	24	22	14	47	24	37	21
IS	12	10	18	11	14	19	11	10	11	8	12	11	11	10
IT	64	58	61	46	73	65	76	62	65	52	78	61	72	56
LT	46	39	40	27	57	35	33	26	42	28	37	24	39	26
LU	60	37	63	29	59	51	66	39	61	31	66	38	65	35
LV	57	47	37	25	51	32	48	36	50	30	41	23	46	26
MT	36	24	41	21	48	42	32	29	30	22	42	32	37	28
NL	17	14	23	15	48	41	22	12	18	10	29	15	24	13
NO	14	9	11	6	9	13	19	5	11	4	10	5	11	5
PL	65	49	59	36	72	58	60	49	60	40	57	39	57	40
PT	41	30	30	20	47	41	38	27	33	20	39	24	36	22
RO	52	53	50	41	76	62	60	52	48	39	53	40	51	40
SE	8	9	13	8	28	23	24	12	11	5	22	10	16	8
SI	54	40	55	35	63	51	43	31	51	30	48	30	50	30
SK	57	45	61	37	57	47	64	37	62	35	67	35	66	35
UK	20	18	28	18	50	44	42	34	23	16	45	29	34	23
EU15	37	28	33	23	51	43	51	33	38	26	53	34	46	30
NMS10	54	42	53	31	63	50	58	44	54	33	55	35	55	34

Poor households are defined as households in relative poverty, i.e. with an income below 60% of the national median income.

Households having problems with pollution, grime or other environmental problems (due to traffic and industrial activities)

Data source: EUROSTAT (SILC), 2007

Country	% of single female house-holds		% of single male house-holds		% of single parent with dependent children		% of house-holds with two adults with three or more dependent children		Total% of house-holds without dependent children		Total% of households with dependent children		Total% of all house-holds	
	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh	Poor hh	All hh
AT	7	10	12	8	19	12	6	9	12	8	9	8	10	8
BE	17	18	29	19	22	17	30	19	19	17	23	18	21	17
CY	21	22	20	18	22	22	19	23	27	25	17	26	23	26
CZ	16	16	12	13	19	18	29	21	18	15	21	19	20	17
DE	29	26	30	25	26	27	39	19	26	23	25	21	26	22
DK	10	9	22	12	33	16	19	7	13	9	17	7	14	8
EE	21	23	17	17	25	25	23	26	20	25	26	28	23	26
ES	12	14	8	9	20	19	15	14	14	15	17	17	16	16
FI	16	19	13	15	28	18	9	11	12	15	13	13	12	14
FR	21	18	16	14	23	21	14	14	17	17	19	16	18	17
GR	14	21	10	18	34	25	8	14	12	18	16	19	15	19
HU	16	16	9	15	15	16	13	14	14	14	13	13	13	13
IE	7	8	5	9	9	8	23	11	7	9	15	10	12	9
IS	11	14	14	16	18	15	12	8	10	13	14	9	12	11
IT	19	22	22	21	23	23	13	17	19	22	21	20	20	21
LT	12	15	8	11	22	24	13	13	10	15	16	16	14	15
LU	16	16	23	15	41	27	19	17	15	16	20	16	18	16
LV	34	39	14	24	41	36	31	40	28	32	41	40	35	37
MT	37	38	31	31	31	33	33	30	34	36	37	34	36	35
NL	25	16	19	16	18	19	6	11	16	14	15	13	15	14
NO	11	10	9	8	12	8	8	6	10	8	10	7	10	8
PL	13	15	7	12	18	18	12	13	10	13	12	13	11	13
PT	22	25	12	20	34	28	28	28	21	22	25	22	23	22
RO	11	16	11	18	36	31	18	19	9	17	18	19	15	18
SE	4	8	6	8	5	7	4	7	6	7	5	7	5	7
SI	22	23	17	20	26	27	10	15	20	22	21	19	21	20
SK	19	16	6	14	11	16	27	21	19	18	21	18	20	18
UK	10	11	15	12	12	15	10	11	12	13	13	13	12	13
EU15	20	19	20	17	20	20	16	14	18	18	19	17	18	17
NMS10	17	17	9	13	20	19	16	15	14	15	15	16	15	15

Poor households are defined as households in relative poverty, i.e. with an income below 60% of the national median income.

3. The social inequalities in health risks related to unintentional injuries among children

Authors
Lucie Laflamme, Marie Hasselberg
Karolinska Institute
Sweden

Stephanie Burrows
Institut national de santé publique du Québec
Canada

Abstract

Background

Injuries are not only one of the major causes of premature death but also one of the causes of childhood mortality with the steepest social gradient. A great deal of research has been produced on socioeconomic disparities in injury but reviews are few. This review summarizes the current state of knowledge regarding socioeconomic differences in unintentional injuries among children.

Review methods/data

The material used was extracted from the information gathered in a recent review addressing the socioeconomic divide in both unintentional and intentional injuries among both children and adults. Studies conducted inside and outside the WHO European Region and published in the medical and public health literature since 1990 were considered. For the current review, those studies related to childhood injury mortality and morbidity were selected – and updated – and split up into the following causes: all causes aggregated, fall, traffic, burns, and drowning and recreational injuries (about 80 scientific articles). A distinction is kept between studies according to whether they were conducted inside or outside the WHO European Region.

Results

Traffic-related injuries are by far the most studied injury cause, followed by falls and recreational injuries. The studies, though numerous, come from a few high income countries and the evidence at hand is therefore mainly representative of some types of governments, economies, and forms of social stratification. These studies very often show that children from low socioeconomic status and from less affluent areas tend to sustain – or die from – injury to a greater extent than others. This applies to most causes of injury and for several settings (e.g. home, work, transport). While little is known regarding the nature of the mechanisms lying behind those differences, a variety of individual and contextual ones might come into play. These may vary by cause of injury, sex and age group of the child and the setting in which the injury occurred.

Conclusions

Unintentional injuries are a threat to children's health and development and their socioeconomic divide is neither irreversible not unavoidable. Both safety-for-all initiatives and targeted prevention measures are required to combat this health threat. Promoting safe practices and the use of safety equipment is only one of several possible approaches. It cannot be regarded as a substitute to reducing differential exposure to environmental hazards and reduced differential consequences of injuries by greater access to care.

Introduction

In the WHO European Region, injuries account for 9% of deaths and 14% of ill health. The most common causes of mortality and morbidity for children aged from 0 to 19 years in the Region are road traffic crashes, drowning, poisoning, fires and falls, which altogether contribute to the annual 42 000 injury deaths and to the 70 million hospitalizations and emergency department visits in the Region (Sethi et al., 2008).

As is the case for many other health outcomes, childhood injuries are unevenly distributed between countries (Sethi et al., 2006) and, within countries, between socioeconomic groups. In fact, injuries constitute not only one of the major causes of premature death and disability in the Region but also one of the causes of childhood mortality with the steepest socioeconomic gradient (Sethi, 2008; WHO, 2008; Fukuda et al., 2005; Martikainen et al., 2003; Shkolnikov et al., 1998). In the face of this divide, one wonders whether downward trends in global rates of fatal injuries noticed in rich countries, including several European ones (Morrisson et al., 2000a; 2000b; UNICEF, 2001), benefit to the same extent members of all socioeconomic groups in those countries. One must also ask whether upward trends observed in European countries undergoing dramatic socio-political transitions, several of which are middle income countries, accentuate pre-existing socioeconomic disparities. In fact, if safety has improved globally but the safety divide remains – or is worsening (Edwards et al., 2006) – health and safety policies and strategies may need to be revisited and considered in the light of their disparity-reduction potential.

Besides being a threat to collective health targets, health and safety inequity is unfair to individuals. Indeed, poorer chances of survival and poor health, when generated by social processes to the detriment of the less well off impede basic human rights (Kawachi et al., 2002; Whitehead & Dahlgren, 2006a; 2006b). Further, health inequities in general and inequity in injury in particular are neither unavoidable nor irreversible (Laflamme, 1998; Laflamme 2001; Laflamme & Diderichsen, 2000; Engström, 2003; Hasselberg, 2004; Whitehead and Dahlgren 2006a; 2006b). There are eloquent sectoral examples of passive safety dealing with physical exposures and showing for instance that tackling material deprivation in the home through better housing conditions (Berfenstam, 1979; 1995), modifying or isolating hazards in workplaces (Menckel & Kullinger, 1996) or modifying the traffic environment (Berfenstam, 1979; Jones et al., 2005; Tester et al., 2004) can do much to "level up" safety differentials between members of different social groups.

A great deal of research has been produced on socioeconomic disparities and injury. Reviews are available, among which there are a few on childhood injuries, but these

focus on specific injury causes or circumstances (Laflamme & Diderichsen, 2000; Birken & Macarthur, 2004; Reading e al., 2005). This review presents an inclusive overview of the current state of knowledge regarding socioeconomic differences in unintentional injuries among children by considering studies published in the medical and public health literature that address the leading causes of both fatal and non-fatal injuries. A distinction is made between studies according to whether they were conducted inside or outside the WHO European Region (including both EU and non-EU countries).

The aim of the review is to highlight the main features of the knowledge at hand, to clarify where it comes from, and to examine whether European studies obtain results that are similar to those from other parts of the world. An additional aim is to propose avenues for prevention through the identification of key mechanisms and the presentation of measures that can help reduce injuries and combat socioeconomic disparities.

Socioeconomic inequality in violence and injury occurrence and consequences arises because people are variously disadvantaged according to socioeconomic group due to one or several of the following, each referring to one specific type of prevention:

- differing opportunities for safety (e.g., some face higher structural risks and have fewer chances of avoiding injuries); ***Primary prevention***
- differing opportunities to avoid risk (e.g., some are at greater circumstantial risk due to limited chances to compensate for – or cope with – danger and avoid injury); ***Secondary prevention***
- differing access to/use of medical care (for treatment and for rehabilitation) ***Tertiary prevention***

Review methods/data sources

The material used for this new review was extracted from that gathered in a recently published review addressing the socioeconomic divide in unintentional and intentional injuries and among both children and adults (Laflamme et al., 2009). The review encompassed studies conducted inside and outside the WHO European Region and all those published in the medical and public health literature since 1990 were considered.

Original research articles that examined socioeconomic disparities in injury risk across socioeconomic groups were then obtained through a literature search in the databases of SafetyLit and the National Library of Medicine's Medline. For the former database, all studies included under "social disparities" were examined for relevance. For the latter database, English, French, Swedish and Danish language studies published between January 1990 and June 2006 were identified using the keywords "injury or injuries or accident or accidents" in conjunction with "educational status or education or social class or socioeconomic status or occupation or income or social position or socioeconomic position or socioeconomic context or social context or deprivation or socioeconomic factors or socioeconomic characteristics or residence characteristics or neighbourhood." Additional studies were also identified from the reference lists in selected articles and in those of the reviews listed above.

The current review selected all studies – from any country – related to childhood injury mortality and morbidity and used the same databases to update the literature search until December 2008 (about 70 scientific articles). Any study concerning children aged up to 19 years and including denominators and testing for significance or providing confidence intervals was dealt with regardless of the strength of its design and the effort made to control for confounding factors. So that injuries as motor-vehicle driver (motorcycles and automobiles) could also be assessed, for this specific cause the upper age limit was extended to include youth up to 24 years. In all instances, to be included, studies were required to examine the relationship between socioeconomic status (SES) and injury at an individual- or area-level as the primary research question. Studies merely controlling for SES were excluded.

The studies were split into the following causes/circumstances: all causes aggregated, fall, traffic, burns, poisoning, and sports/recreational injuries. Except for the latter circumstances, the order followed corresponds roughly to the decreasing importance of the causes treated in the burden of childhood injury mortality and morbidity. Note that we found only one study from the Republic of Korea considering drowning injuries separately that met our inclusion criteria and those results are not reported herein.

Empirical evidence

As mentioned above, the review is not restricted to findings from European countries or countries from the European Community. When presenting the evidence however, we make a distinction between the results of studies from European countries and those from other countries. The main aim is to indicate whether the results tend to go in the same direction or, rather, differ in some ways. Table 1 presents a summary of findings from the studies conducted in European countries, split by cause/situation. Several studies examined all injuries aggregated, while considering various severity levels/indicators or injury sites (e.g. home). Even injuries sustained in the traffic environment have been much studied in European countries. Other injury causes e.g. falls, poisoning, and burns are covered to a very limited extent. Several studies paid attention to several injury causes or focused on specific injury sites or body parts and they are referred to wherever appropriate.

The studies, though numerous, come from a few high income countries and the evidence at hand is therefore mainly representative of some types of governments, economies, and forms of social stratification. In addition, for most injury causes, rather than being conducted at the individual level (using measures such as maternal or paternal occupation, education, class or income, household economy) many studies were conducted at the area level (using measures such as neighbourhood deprivation, percentage of low income household, percentage of unemployed). While study designs of that kind are regarded as weaker than one conducted at the individual level, it should be noted that modification of the environment (by e.g. eliminating, modifying, or separating sources of danger) in which children live is regarded as a very powerful and effective measure for primary injury prevention (Sethi et al. 2008; Laflamme et al. 2009).

Table 1. Summary of studies and findings from European countries based on injury cause/situation and design

Injury cause	Country	Results
All injuries – various severity measures		
Individual level	Czech Republic (1); Denmark (1); Finland (1); United Kingdom (2)	Studies examining all causes aggregated are conducted almost exclusively in the north of Europe. Most of them consider children in rather wide age categories and nearly all aggregate boys and girls. With the exception of one Finnish study on adolescent self-reported minor injuries, all studies show an association between socioeconomic status and injury, to the detriment of children from less well off families and neighbourhood.
Area level	United Kingdom (11)	
Multilevel	United Kingdom (2) Sweden (1)	
Fall injuries		
Individual level	Sweden (1)	Fall-related studies are relatively few, are exclusively from northern Europe and yield mixed results. In Sweden, associations are found when falls are disaggregated in subgroups (e.g. fall from height and from playground equipment) and children split into different age groups. In Ireland, a strong association was found between economic deprivation and injury rate, particularly for falls from heights among children aged 0–12 years.
Area level	Sweden (4) United Kingdom (3)	
Traffic injuries		
Individual level	Sweden (10); United Kingdom (4)	European studies on road traffic injuries are many and all come from northern Europe. Both individual and area level studies show that low socioeconomic position is associated with an increased risk of being injured in traffic as e.g. pedestrian (most often studied), bicyclist or car occupant. Studies that distinguished various age groups indicate that socioeconomic differences may vary with increasing age.
Area level	Greece (1); Ireland (1); Sweden (3); United Kingdom (8)	
Multilevel	Sweden (1)	
Burns		
Individual level	Denmark (1); United Kingdom (1)	Most studies on burns and house fires aggregate boys and girls. In England and Wales, despite downward trends in overall rates, inequalities remain for death from house fires. In all instances, studies show a strong inverse association between socioeconomic status and burn/scald injuries.
Area level	Sweden (1); United Kingdom (3)	
Poisoning		
Individual level	Denmark (1); United Kingdom (1)	Studies from northern Europe reveal that poisoning among young boys and girls is one of the causes of injuries with the steepest socioeconomic differences.
Area level	Sweden (1); United Kingdom (2)	
Sports/recreational injuries		
Area level	Sweden (2)	These studies often treat boys and girls separately and indicate some – but not consistent – association between area deprivation and leisure time injuries.

All causes – various severity levels or measures

Studies on child and adolescent injuries all causes aggregated have been conducted almost exclusively in the north of Europe (United Kingdom, Ireland and Scotland, Sweden, Finland, Denmark) and America (United States of America and Canada). Most of them consider rather wide age categories and nearly all aggregate boys and girls. In Europe, with the exception of one Finnish study on adolescent self-reported minor

injuries (Mattila, 2004), all studies show an association between socioeconomic status and injury, to the detriment of the less well off. This applies to individual level studies on injury mortality in infants (Czech Republic; Bobak et al., 2000), dental injuries among 14-year-olds (Newham, London; Marcenes & Murray, 2001; 2002), unintentional home injuries in Danish children aged 0–14 years (Laursen et al., 2008) and mortality and morbidity for injury and poisoning during the first ten years of life of children from Oxfordshire and West Berkshire (Petrou et al., 2006). It also applies to area-based studies (all from the United Kingdom) on femoral fractures (Bridgman et al., 2004), fatal head injuries (Williamson et al., 2002), traumatic brain injuries – fatal or not (Hawley et al., 2003), hospitalizations (Hippisley-Cox et al., 2002; Lyons et al., 2003), emergency department attendance (Brown et al., 2005; Silversides et al., 2005; Haynes et al., 2003) and school-related injuries (Latif et al., 2002). With the exception of one Australian study (Poulos, 2007), similar findings are reported from non-European studies (except one from Australia (Poulos, 2007) considering either fatal injuries or a combination of severe and fatal injuries (United States of America; Durkin et al., 1998; Pomerantz et al., 2001) or various severity levels separately (United States of America; Marcin et al., 2003; Canada; Brownell et al., 2000).

For a given population, the association between an area's material deprivation and injury is stronger for more severe injuries (Hippisley-Cox et al., 2002; Kendrick & Marsh, 2001). This holds true for specific injury mechanisms (Hippisley-Cox et al., 2002; Lyons et al., 2003; Silversides et al., 2005).

Three multilevel studies have been conduced in Europe and they yield different results. A first one from Norwich (United Kingdom; Reading et al., 1999) on preschool injuries of various severity levels indicates that much of the variation in injury rates is accounted for by individual level attributes (i.e. male sex, young maternal age, number of elder siblings and distance from hospital), with a smaller but independent influence of living in a deprived neighbourhood. Similar results emerge in the county of Avon (United Kingdom; Reading et al., 2008) when considering injuries requiring medical attendance or of any severity among children of the same age (0–5 years). By contrast, a Swedish study covering children aged 0–14 years and based on injuries requiring hospitalization, both unintentional and intentional ones, indicate that children in the most deprived neighbourhoods exhibit significantly higher odds of injuries even after controlling for individual level demographic and socioeconomic attributes.

Non-European individual-based studies also consider various severity levels, including dental injuries (Nicolau et al., 2001; Marcenes et al., 2001). Some studies reveal strong associations between socioeconomic status and injuries (Canada; Gilbride et al., 2006; China; Chen et al., 2005; Bangladesh; Giashuddin et al., 2009), while others do not (Brazil; Nicolau et al., 2001). Some cases of inverted relationships are noted for dental injuries among children 12 years old (Brazil; Marcenes et al., 2001).

In Canada, a multilevel study on medically treated injuries and hospitalizations among Canadian adolescents yields mixed results but in general, lower SES is associated with increased risk for hospitalization (and injuries from fights) whereas no associations are identified for medically treated injuries (Simpson et al., 2005). In the Republic of Korea, considering children aged 0–5 years, a study indicates that both individual-level and area-level socioeconomic position influenced the risk for childhood fatal injuries (Kim et al., 2006).

Falls

Studies on the socioeconomic patterning of fall-related injuries are relatively few. Nearly all are from Europe. As is the case for studies conducted all injuries aggregated or by severity levels, all studies except three Swedish ones (Laflamme & Reimers, 2006; Reimers & Laflamme, 2004; 2008) examined socioeconomic disparities for boys and girls combined. A Swedish national study including four age groups (0–4, 5–9, 10–14, 15–19 years) found no significant association between household socioeconomic status and fall injuries, whatever the age group (Engström et al., 2002). Still in Sweden, but in Stockholm County more specifically, an area-based study also reports no association between area material deprivation or socioeconomic status and children's hospitalization for fall-related injuries (Reimers & Laflamme, 2005). When falls are split into various categories and children into different age groups (Reimers & Laflamme, 2004), socioeconomic deprivation of the living area is associated with many types of falls among young children (0–5 years) but in different manners: protective effects (about 30%) are observed for falls at the same level (the largest diagnosis) and from heights, while aggravating effects are reported for falls from items of furniture (about 34%). No association is found with falls from playground equipment. Among older children (6–15 years), protective effects were observed for several types of fall injuries except falls on the same level, where the surplus risk among the better-off is about 30%. Lower risks among children from affluent areas are found for falls from playground equipment, falls from trees and sports-related falls. In a later study, it was also observed that education and economic assets of the living area has no effect on hospitalizations for falls on the same level among pre-adolescent and adolescent boys but did among girls. More recently, for adolescent boys and girls in the age groups 10–14 and 15–19 years, it was observed that the association between area economic deprivation and fall injuries had markedly changed over time among girls aged 15–19 years, from being protective in the early 1990s (1993–1995) to being aggravating in the early 2000s (2003–2005) (Reimers & Laflamme, 2008). No such changes are observed among younger girls or among boys of both age groups; associations were weak in both time periods.

In Ireland, a strong association was found between economic deprivation and injury rate, particularly for falls from heights among children aged 0–12 years (Silversides et al., 2005). In Wales and Trent, strong socioeconomic gradients were observed in the young (0–14 years; Lyons et al., 2003; Hippisley-Cox et al., 2002).

In a recent Canadian area-based study (*Quebec;* Gagné & Hamel, 2009), the only non-European one, it was observed that hospitalization in children aged 0–14 years is not associated with both dimensions of deprivation.

Traffic injuries

By far the most studied cause of health disparities in the child injury field are road traffic injuries and most of these studies are from European countries (England, Greece, Ireland, Spain, Sweden, the Netherlands, United Kingdom). Earlier reviews can be found in Laflamme and Diderichsen (2000) and Towner and colleagues (2005).

Area-based studies from Europe have dealt with various categories of road users but above all pedestrians and cyclists (other categories are car passengers, motorcyclists and car drivers). All studies show an inverted relationship between affluence of the living

area and injuries (Edwards et al., 2008; Adams et al., 2005; Coupland et al., 2003; Reimers & Laflamme, 2004; Hippsley-Cox et al., 2002; Graham et al., 2005; Elmén &Sundh 1994; Lyons et al., 2003; Moustaki et al., 2001; Kendrick, 1993; Bentham, 1986; Silversides et al., 2005). One of these observed that the association between increased deprivation and pedestrian casualties in England was stronger among children than among older age groups (Graham et al., 2005). Children in deprived areas had up to a four times higher risk for pedestrian injuries than children in more affluent areas. Many additional studies from the United Kingdom support this finding (Dougherty et al., 1990; Kendrick, 1993; Hippisley-Cox et al., 2002; Coupland et al., 2003; Adams et al., 2005; Lyons et al., 2003). In addition, it appears that even though child injury deaths have decreased in most socioeconomic groups over the last twenty years, the clear inequalities in injury deaths between children in different socioeconomic groups remain, particularly for pedestrians (Edwards et al., 2006). Similar findings have been reported in Greece where less wealthy towns had a twofold excess of pedestrian injuries compared to wealthier ones (Moustaki et al., 2001), and in Sweden (Stockholm) where poor areas had approximately 90% higher risk than the most affluent areas for pedestrian injuries but not for bicycle injuries (Reimers and Laflamme 2004) and motor-vehicle related injuries (Reimers et al., 2008). However a multilevel study from the same area showed that contextual socioeconomic attributes of the living area were significant for injuries sustained as motor-vehicle riders but not for injuries as pedestrians or bicyclists (Laflamme et al., 2009).

As is the case for area-based studies, all individual level studies from Europe (Edwards et al., 2006; Roberts, 1997; Roberts & Power, 1996; Hasselberg et al., 2001; Engström et al., 2002; Engström et al., 2003; Laflamme et al., 2002; 2004; Hasselberg & Laflamme, 2003; 2004; 2005; Murray, 1998; Zambon & Hasselberg, 2006a; 2006b) but one (Pless et al., 1989) showed that children from better-off households or families are at less risk for road traffic injuries. A Swedish national study observed that household socioeconomic position affected road traffic injuries throughout childhood, adolescence and young adulthood when considering the education or socioeconomic group of the parents. By contrast, disposable income of the household had less importance in late adolescence and young adulthood than during childhood (Hasselberg et al., 2004). Also, as opposed to the area-based studies from the United Kingdom (Hippsley-Cox et al., 2002), only small socioeconomic differences were observed among child pedestrians (Hasselberg et al., 2001). An additional study confirmed this result and also observed that socioeconomic gradients increased with increasing age (0–4, 5–9, 10–14 and 15–19 years) and were greater when children came into contact with motorized vehicles than when they travelled as pedestrians or cyclists (Laflamme & Engström, 2002).

Nine studies from outside Europe were found, seven of which were based on area level data (Turrell & Mathers, 2001; Dougherty et al., 1990; Durkin et al., 1994; Joly et al., 1989; Brownell et al., 2002), one on individual-based measures (Roberts et al., 1995) and one had a multilevel design (Myoung-Hee et al., 2007). Four of these studies treated pedestrian injuries separately and found a strong relationship between socioeconomic characteristics, both at an area and individual level, and the rate of pedestrian injuries (Gagné & Hamel, 2009; Poulos et al., 2007; Durkin et al., 1994; Roberts et al., 1995).

Gender-specific results

Although boys are more often injured in traffic than girls, whether socioeconomic patternings are similar between boys and girls – or whether they differ between categories of road users and setting – is unclear. An area-based study from Greece indicates that boys are disproportionately disadvantaged regarding pedestrian injuries when they reside in less wealthy towns (Moustaki et al., 2001). By contrast, a Canadian study found larger socioeconomic differences in traffic injuries (with regard to both morbidity and mortality) for girls than for boys (Dougherty et al., 1990). Swedish studies, on the other hand, found a similar social patterning for both sexes (Laflamme & Eilert-Petersson, 2001; Hasselberg et al., 2001).

Burns

Studies on burns and house fires have been conducted both within and outside Europe and in most of them results for boys and girls were aggregated. Individual level studies are less common and two of them are from Europe (Edwards et al., 2006; Laursen et al., 2008). Focusing on childhood injury mortality over time for the whole of England and Wales, a first study considered various causes and compiled rates by employment status in the family (class) for three different time periods (Edwards et al., 2006). In spite of downward trends in overall rates, inequalities remained for death from house fires, among others. Compared with children from families with the best occupational status, those from less favourable ones had a 37.7 times higher death rates due to exposure to smoke, fire and flames. A Danish national study on unintentional home injuries observed higher differences between income groups for both burns and scalds from hot water, tea or coffee than for other injury causes (Laursen et al., 2008). The risks were respectively 1.9 and 2.4 times higher in the lowest-income group than in the highest-income group. Still at the individual level but from outside Europe, one study from Peru observed that low income and crowding are associated with increased risk of child hospitalization for burns of various types and that better maternal education had a protective effect (Delgado et al., 2002). This latter result is consistent with a study from the United States of America on house fires resulting in at least one fatality among children less than five (Scholer, 1998) that shows an association between lower maternal education and a more than threefold increase in fatal fire events.

Area-based studies from Europe have been conducted both in the United Kingdom and in Sweden. One dealt with burns and smoke inhalation in secondary care in Lancashire and South Cumbria and showed an increase in hospital admissions with increasing social deprivation (Rajpura, 2002). A second from Trent (1992–1997) found that hospital admission for injury and injury of high severity increases with socioeconomic deprivation; with gradients more marked for the 0–4 than 5–14 years and for injury mechanisms like burns and scalds (Hippisley-Cox et al., 2002). A third study from Belfast North and West found a strong association between economic deprivation of the living area of children aged 0–12 years, particularly for burn/scalds (Silversides et al. 2005). A fourth one from Stockholm found that, for children aged 0–15 years, a higher concentration of people with low SES increased the risk of burns/scalds (Reimers & Laflamme, 2005).

In the same vein, one area-based study conducted in Dallas (Texas) considered residential fire-related deaths in children aged 0–19 (Istre et al., 2002) and found that injuries occurred predominantly among the youngest ages (< 5 years) and in poor

neighbourhoods. Studies on hospitalization for burns in children aged 0–14 years conducted in New South Wales (Australia; Poulos et al., 2007) and in Quebec (Canada; Gagné & Hamel, 2009) also reveal strong associations between area deprivation and the risk of burn injury. Even in Cape Town (South Africa), an area-based study found that poor housing conditions, socioeconomic barriers and child dependency were associated with children's (0–12 years) burns in a graded fashion (Van Niekerk et al., 2006).

Poisoning

Studies on poisonings are very few, most are from the North of Europe and all show strong associations between socioeconomic disadvantage and children poisoning. They do not treat boys and girls separately. A recent study aggregating mortality and morbidity for unintentional injuries and poisonings during the first ten years of life of children from Oxfordshire and West Berkshire (United Kingdom; Petrou et al., 2006) shows that social class gradients do persist during those years. In Denmark, a national study on unintentional home injuries observed significant differences between income groups for poisonings (Laursen et al., 2008). Area-base studies lead to similar results as those conducted at the individual level. The multicause study from Trent mentioned above (Hippisley-Cox et al., 2002) found that the occurrence of poisoning increased with area-based socioeconomic deprivation. Groom and colleagues (2006) have more recently observed that hospital admissions rates for unintentional poisoning among children aged 0–4 years were 2–3 times higher among children in the most deprived wards of East Midlands (United Kingdom) than those in the least deprived. It was also observed that gradients were particularly steep for benzodiazepines, antidepressants, cough and cold remedies and organic solvents. The multicause study from Stockholm (Reimers & Laflamme, 2005) found that a higher concentration of people with low socioeconomic status – but not low material deprivation – was associated with poisoning among children aged 0–15 years.

Studies on injury hospitalizations in children aged 0–14 years conducted in New South Wales (Australia; Poulos et al., 2007) and in Quebec (Canada; Gagné & Hamel, 2009) also reveal strong associations between area deprivation and poisonings.

Sports/recreational injuries

The studies addressing recreational and sports injuries are those where boys and girls are most often treated separately; they often consider older children and have been conducted mainly outside Europe. An individual-based study from North America found inverted relationships with lower socioeconomic status both among boys and girls 12–19 years (Canada; Potter et al., 2005) and children 6–17 years (United States of America; Ni et al., 2002). In the latter study, differences between socioeconomic groups were observed not only in magnitude but also in kind: for children from not poor families, most injury episodes occurred in sport facilities; for those from poor/near poor families, most occurred outside the home.

Area-based studies from outside Europe report either no association with hospitalization for sports-related injury among children and adolescents aged 5–19 years (Australia; New South Wales; Lam, 2005) or, to the contrary, a consistent positive association between percentage of people living below the poverty line at census tract level and emergency department treated recreational injuries in various age categories of 0–19 year olds – and for both boys and girls (Canada; Ontario; Falker et al., 2000). By

contrast, a multilevel study among Canadian adolescents (Simpson et al., 2005) found that higher socioeconomic status was associated with increased risk for sport/recreational injury.

Indications of association between area deprivation and leisure time injuries are found in the Swedish study on fall injuries conducted in Stockholm County (Laflamme & Reimers, 2006). In this study no association between material deprivation of the living area and hospitalization for falls from playground equipment was found among young children (0–5 years). Among older children (6–15 years), protective effects were found for falls from playground equipment, falls from trees and sports-related falls. In a study on socioeconomic differences in the injury hospitalization for those causes most common among adolescent boys and girls (10–19 years) respectively (Reimers & Laflamme, 2004) a protective effect of low (but not average) economic and educational assets was observed among boys for sports-related falls and among girls for horseback riding injuries.

Specific key messages on children

There are disparities in several environments, but the traffic environment is most studied

Although there is an abundant literature on socioeconomic differences in childhood injuries, the whole injury panorama is unevenly covered. Injuries sustained in the road traffic environment have been extensively covered – and the bulk of the evidence indicates that children from less affluent backgrounds are at greater risk as pedestrians, cyclists, and car riders at all ages. Disparities in those injuries occurring in and around the home (e.g. falls, burns, and poisonings), often sustained among younger children, are far less researched, but there is supportive evidence that they too may be over-represented among children from less affluent backgrounds.

Lower status – greater risks

Socioeconomic differences in childhood injuries appear to be common, both when all injuries are aggregated and when specific causes or circumstances are considered. Differences arise not only as regards injury mortality but also various severity measures (e.g. hospitalization, emergency department visits, long bone fractures, head injuries).

Disparities at all levels of morbidity

Socioeconomic differences arise for various injury severity measures (e.g. hospitalization, emergency department visits, long bone fractures, head injuries). Some – but not all – studies indicate that the more severe the injury, the greater the socioeconomic differences. This has been observed for causes of injury like traffic, poisoning, burns and also for several settings (e.g. home, work, transport).

Variation with age or setting?

Not only does the injury panorama vary with increasing age of the child but this may also be the case with the magnitude of the socioeconomic disparities. From among the studies reviewed, relatively few considered various age categories and there is no

consistent age and type of injury pattern within and across countries. Most often, wide age groups were presented (e.g. 0–15, 0–19 years) but when narrower categories were considered, various patterns emerged according to age. For instance, for some injury causes – and settings – socioeconomic disparities increased with increasing age (e.g. road traffic injuries as car riders and drivers in Sweden; Laflamme & Engström, 2002). For other causes and in other settings, disparities were relatively constant (e.g. admission for fall-related injury and injury of high severity in Trent; Hippisley-Cox et al., 2002).

In other words, the manner in which socioeconomic disparities fluctuate with increasing age is not only a matter of individual development. Indeed, children are often injured when doing what we want them to do – or when doing things that all children do. The likelihood of them being injured then is very likely to be influenced by the surrounding environment. Child pedestrian injuries for instance are associated with a very strong social gradient in the United Kingdom (area based study) and with a non-existent one in Sweden (individual based study). This takes us to our next point.

Few countries contribute evidence

The evidence is mainly representative of some types of countries (governments and economies) and does not encompass many forms of social stratification. Within Europe, the bulk of it stems from high-income countries and, most often, countries from the North.

One description does not fit all

Despite considerable socioeconomic disparities in injuries of various kinds, it ought to be underlined that not all children from lower socioeconomic status or deprived areas get injured. And not all injured children come from a deprived family or environment. As an example, in a study on injuries among small children (3 months to 3 years), it was noticed that more than half of those children residing in a deprived ward did not have a medically attended injury and more than 90% did not have a hospital admission. On the other hand, 60% of children who had a medically attended injury and 40% who had a hospital admission did not live in a deprived ward (Kendrick & Marsh, 2001).

Gender-related socioeconomic disparities under researched

A vast majority of the studies reviewed treated boys and girls in an aggregated manner. It is very likely that, as explained by some authors (Engström et al., 2002; Hasselberg et al., 2003), although there are considerable gender differences in the risk for children and adolescent to sustain an injury, there are no obvious reasons why socioeconomic affiliation would have different impact of the risk distribution of boys than girls. It is possible that the age of the child matters in this respect but empirical evidence on this is lacking.

Relative impact/magnitude of inequity

As mentioned above, the association between children's socioeconomic status and injury varies in magnitude depending on the age of the child, the injury cause and severity level, and the setting. But considerable differences – and striking gradients –

have been observed for both mortality and morbidity studies. Some examples are presented below.

In England and Wales for instance, where child injury deaths have fallen over the years in most socioeconomic groups, children from families with no adult in paid employment are at excess risk: those have a nearly fivefold excess risk (RR = 4.7) of fatal pedestrian injuries compared to children from families with an adult in paid employment (Edwards et al., 2006). In Greece, children residing in less wealthy towns run almost double the risk of having pedestrian injuries compared with children living in wealthier towns (Moustaki et al., 2001). A survey in Trent (United Kingdom) showed that children in the most deprived areas had a nearly 4 times higher risk for pedestrian injuries compared to children in the most affluent ones (Coupland et al., 2003; Hippisley-Cox et al., 2002). Finally, Swedish national studies showed that the injury risk of young pedestrians and cyclists are 20–30% higher among the children of manual workers than those of intermediate and high level salaried employees. Socioeconomic differences increase for injuries involving motorized vehicles (70–80%; Hasselberg et al., 2001).

Perhaps the most spectacular figure is that observed by in a study on childhood injury mortality over time for the whole of England and Wales where one can see that, in spite of downward trends in overall rates, inequalities remained for death from house fires, among others. Compared with children from families with the best occupational status, those from less favourable ones had a 37.7 times higher death rates due to exposure to smoke, fire and flames (Edwards et al., 2006).

It is important to bear in mind that comparisons between studies are difficult for structural and operational reasons. As the social stratification differs from one country to another and, with it, the distribution of material and social advantages, the size of the gap between groups is not constant over countries. Also, across studies, the manner in which socioeconomic position and material deprivation are operationalized varies considerably both in the measures used and the scales or number of categories used for similar measures.

Suggested pathways and mechanisms

The discussion of pathways follows the four arrows introduced by the framework model in the Introduction.

Arrow 1 – Differential environment conditions

One likely explanation for the safety divide is that the higher injury rates for children – and older people – from less affluent areas or families are merely reflection of rather systematic differences in living, commuting and working conditions (compositional differences). It has been proposed that an adequate response to this process of social stratification would need to be at a societal level (Erskine, 1996; Diderichsen et al., 2001; Whitehead & Dahlgren, 2006b). There are recent examples of social interventions aiming at improving (women's) social position (Pronyck et al., 2006) or social mobility as a policy response (Fauth et al., 2004) that are of great interest as they indicate quite strong protective effects on injuries (mainly intentional).

It is worth noting that part of the reduced risks of pedestrian injuries among Swedish children finds an explanation not only in traffic safety measures but also in employment policies (for both men and women), child care services, and the availability of parks and playgrounds (that significantly reduce the time they spend in the traffic environment). Indeed, as explained elsewhere (Laflamme et al., 2009), at the national level, the safety of unprotected road users as pedestrians and cyclists has long been on the agenda of the Swedish transport sector and low mortality and morbidity rates have been achieved through "safety-for-all" measures (Whitehead & Dahlgren, 2006). It is therefore possible that the absence of contextual differences in Stockholm County is a reflection of those systemic and infrastructural counter-measures historically valued and widely implemented (Laflamme et al., 2009). Consequently, the presence of contextual attributes putting pedestrians and cyclists at risk may not vary significantly across parishes (e.g. traffic separation or traffic-calming measures). Furthermore, even policies from other sectors may help to reduce inter-parish differences in exposure. We refer here to equity-oriented policies, like those related to e.g. child access to recreational environments (other than the street) and limited distance to and from school for all, that reduce both child exposure to traffic and variability across living areas.

Should the phenomenon find an explanation within the areas themselves, targeted interventions and interventions based on either environmental or educational actions may constitute effective policy responses (see below). There are strong reasons to believe that – over and above family attributes – the environment in which children from less affluent families and areas live and develop is intrinsically more hazardous than the one where their affluent counterparts do (Reading et al., 2005).

Arrow 2 – Differential exposure

The concept of differential exposure refers to being unequally exposed to various extraneous sources of danger that can be found in one's environment, such as living, playing, commuting and learning circumstances (Laflamme, 1998; 2001). When exposure is high, the likelihood of injuries occurring is increased due to one or several of the following mechanisms: more elements of the surroundings can be harmful, the consequences of making mistakes may be more immediately injurious, and injury avoidance is not a primary and conscious aim of all instances (in particular but not exclusively in the very young).

Exposure is not only to be measured in the number of hazards but also in the duration of exposure. Van Beeck (1991) in the Netherlands showed that an important part of the influence of sociodemographic factors on bicycle injury mortality could be attributed to differences in the use of bicycles. A longitudinal American study considering sports participation and moderate-to-vigorous physical activity (MVPA) in adolescents also showed that for both genders, participation in organized sports and weekly hours of MVPA were positively associated with socioeconomic status (Walters et al., 2009). It also revealed that on average, MVPA decreased between high school and young adulthood for both genders and across socioeconomic groups. It was suggested that increased dependence on organized sports for MVAP may be insufficient to meet the needs of young people following high school, especially for those of low socioeconomic status.

Also, the explanation proposed to explain the lower risk of young cyclist injuries in less affluent areas of Stockholm (Sweden) (Reimers & Laflamme, 2004) and urban Canada (Doughtery et al., 1990) is that cyclists – more than pedestrians – have a greater possibility to move outside their own residential area, and thereby to be less exposed to hazards from their own immediate environments.

From another perspective, greater disparities with increasing injury lethality are very likely to find an explanation in both level of exposure and differences in access to post-trauma or pre-hospital care).

Arrow 3 – Differential susceptibility

The concept of differential susceptibility links the existence of safety differences between people to their social affiliation (Laflamme, 1998; 2001; Kawachi et al., 2002; Braverman et al., 2005). Theoretically, related (dis)advantages may be regarded as either inherited (i.e. genetic predisposition) or under the influence of class attributes (e.g. educational, material, and influential assets).

In the public health sector, this mechanism is often attributed to differences in knowledge and practice and therefore efforts are deployed to provide "people at risk" with information likely to change their safety practice. Although some studies indicate this might be the case (Lerner et al., 2001; Shinar et al., 2001; Leveque et al., 2004; Mock et al., 2002; Kendrick & Royal, 2003; Farley et al., 2003), there is an interesting body of knowledge on childhood injuries, mainly in the home, suggesting that the problems faced by people from deprived groups may not be exclusively – or above all – attributable to deficiencies in knowledge and practice (Jan et al., 2000; Ribas et al., 2006; Evans & Kohli, 1997; Hapgood et al., 2000; Kendrick & Marsh, 1998; DiGuiseppi et al., 1999a; 1999b; 2002).

Affordability, readability and power of influence have been documented as substantial barriers to the uptake of safe practice in economically and socially deprived groups. Affordability as a barrier to the adoption of safe practice has been identified in a variety of studies addressing home safety (Colver et al., 1982; Wortel & de Geus, 1993; Sparks et al., 1994; Hsu & Scott, 1991; Evans & Kohli, 1997) and safety in the traffic environment (e.g. cycle helmets, child restraint in cars). Readability of safety instructions has been stressed in research from the traffic sector. Studies show that safety instructions (e.g. the installation of safety seats) often target a much too high education level (Wegner & Girasek, 2003). Further, as far as skill improvement is at stake (e.g. swimming, driving), offering and multiplying opportunities to acquire those skills may be an important contribution to reduce susceptibility. Lack of power and means of influence on their living, commuting or working circumstances is a common denominator for most people from less favourable social positions. It has been proposed that empowerment should enable poor people to influence their situation and allow for the setting of priorities and choice of means to be based on their understanding and local expertise (Brock & McGee, 2002). Whenever applicable, the voice of specific groups should be heard (e.g. children, parents) (Aynsley-Green et al., 2000).

Possible solutions and countermeasures

Health inequities in general and inequity in injury in particular are neither unavoidable nor irreversible (Laflamme, 1998). Let us add that, for health targets to be reached and sustained, not only are health-for-all policies and interventions required but even equity-oriented ones are imperative, both within and outside the health policy domain (Whitehead & Dahlgren, 2006a; 2006b). Equity-oriented measures may build on initiatives aimed at narrowing the safety divide between the worse- and better-off or on focusing on people or neighbourhoods in poverty only (see Laflamme et al., 2009a; 2009b).

Given that injuries are the leading cause of death and disability among children worldwide and in the WHO European Region, abatement strategies likely to lead to a reduction of injury risks for all children can only be welcomed. Numerous interventions for the prevention and control of violence and injuries have been evaluated and promoted as effective. These are listed in various reports, including a few published by the WHO during the past years: one being specific to road traffic crashes (WHO, 2004), others concerning the prevention of both unintentional (WHO, 2007) and child and adolescent injuries (WHO, 2008; Sethi et al., 2008). Let us stress that few evaluations have been conducted thus far that assess whether those interventions are equally effective in all socioeconomic groups (or areas) or if they help reduce differences between those groups.

Legislation, regulation and enforcement

The prevention and control of injuries is significantly aided by – sometimes a pre-condition for – well defined and enforced legislations and regulations. Well anchored legislations have a strong potential not only to improve safety for all but even to narrow down the safety divide. We refer here to safety-oriented legislation that determines minimum standards and conditions under which several activities or tasks cannot be performed (e.g. during leisure time and sports, on the road). There are also legislations that impose safe behaviours and practices that would not be adopted by all on a voluntary basis only (e.g. car restraints, bicycle helmet use, alcohol consumption). A Canadian study looking at the effectiveness of cycle helmet legislation for children concluded that helmet legislation is effective in increasing helmet use by all children and particularly those in low-income areas (Parkin et al., 2006).

Engineering, equipment, and product safety

For risk reduction, engineering and product development are obvious resources. Referring to Haddon's ten strategies (1980a; 1980b), it is a matter of 'modifying', 'isolating', 'separating' or 'eliminating' the sources of danger. Considering the traffic environment as an example, differential exposure to hazards may be addressed by countermeasures ranging from modifications of the environment itself (e.g. traffic separation, traffic calming) to improvements in the functioning of public transport systems. Interestingly, interventions of the latter kind may have positive effects on other factors as well. It is possible that a well functioning public transport system contributes to an increase in individual and collective security (see the Boston example in Wise et al., 1985). Likewise, better lighting in outdoor environments (e.g. streets, parks, tunnels) may have a beneficial effect on the prevention of both injuries and violence.

To minimize the consequences of injurious events, the development of safe equipment and products has much to offer (Towner et al., 2005). One early example of safe products is flame-resistant nightdresses. While not preventing injuries from occurring, these products limit their consequences and have proven to significantly contribute to the reduction of fatal injuries – for members of all groups. The same applies to the legislation and enforcement in England regarding the maximum sizes for paracetamol and aspirin pack sizes. This limits the maximum number of tablets bought per purchase, and includes warnings on the packs about the danger of overdose (Hawton, 2005). It is estimated that this change in legislation may have prevented approximately 200 deaths in the three years since it was implemented (Hawton et al., 2004).

Maintenance

To achieve positive and long-lasting effects from environment and product changes on injuries, maintenance is an essential component. There is an eloquent example from a playground survey conducted by Suecoff and colleagues (1999) who compared playground hazards in high- and low-income neighbourhoods randomly selected from the nine New York City community districts (park design hazards, equipment maintenance hazards, and equipment hazards relating to fall injuries). They observed that approximately one of two parks were located in low-median-income districts and contained 98 (53%) of the total play areas. High- and low-income playgrounds did not differ significantly in the amount or type of equipment, mean fall injury hazards per play area, or mean park design hazards per play area. Yet, significantly more hazards per play area were identified in the low-income group compared with the high-income group.

Increased passive safety

There are eloquent sectoral examples of passive safety dealing with physical exposures and showing that tackling material deprivation in the home through better housing conditions (Berfenstam, 1979; 1995), or modifying the traffic environment (Berfenstam, 1979; Jones et al., 2005; Tester et al., 2004) can do much to "level up" safety differentials between members of different social groups. Traffic calming has shown to be associated with absolute pedestrian injury reduction and also in relative inequalities in the child pedestrian injury rate (Jones et al., 2005).

Vision Zero approach

Even system-oriented programmes putting forward Vision Zero, as is the case for instance in the Swedish road traffic environment, contribute to the reduction of severe consequences; and do so in an inclusive manner. Vision Zero is an approach to road safety endeavours founded on the premise that no one should be killed or seriously injured in a collision within the transport system. Increased car-crash safety (e.g. air bags) and traffic-calming measures are strategies implemented in accordance with that vision.

Community-based prevention programmes

Community-based approaches intend to tackle the safety level of communities by combining strategies like behavioural and environmental changes, in some instances together with enforcing legislation and subsidies. Community-based interventions have

not always been rigorously evaluated, so assessments of their impact and outcome are not necessarily available. Reviews indicate that community-based prevention may significantly contribute to normative changes in targeted populations, in particular when child safety practice is at stake (Klassen et al., 2000). Programmes can be effective at increasing some safety practices (e.g. car restraint and cycle helmet wearing) but not all (e.g. reducing adolescent drinking and driving). It is unclear whether they can help to reduce injury risk levels.

Should community-based approaches be adopted, one must keep in mind that success may be conditional on stakeholders' involvement, the adaptation of the programme to community needs and the use of several strategies grounded in a theory of behavioural change (Klassen et al., 2000; Farley, 2003).

Home safety education and home visit programmes

Home safety education and visit programmes have aimed at promoting safe practices in the home and also for the prevention of both unintentional and intentional injuries. Several programmes have been evaluated and meta-analyses have been conducted. A series of them, focusing of childhood unintentional injuries and including 80 programmes (Kendrick et al., 2007), reveal that home safety education is effective in influencing the uptake of a range of safe practices, including for example, safe hot tap water temperatures, functional smoke alarms or storing medicines and cleaning products out of reach. Evidence is lacking however as to whether home safety education programmes reduce rates of thermal injuries, poisoning or injuries in general. Interestingly, whether those interventions are less effective in families where children are at greater risk was not a consistent finding.

According to a recent meta-analysis (Kendrick et al., 2009), when targeted specifically towards families with small children in disadvantaged areas such interventions addressing the barriers of cost and needing help to fit equipment may reduce inequalities in several practices (e.g. stair gate use) but not all (e.g. functioning smoke alarms).

In principle, one could presume that the more a given intervention targets the source of danger or the risk itself, by eliminating, separating, isolating or modifying it (passive safety), the better its potential to level up the safety of the less privileged and narrow down the divide between groups. Conversely, the more an intervention relies on the adoption of safe practice (active safety) in otherwise difficult living, commuting or working conditions, the less likely its potential to function among deprived individuals and communities and thereby to reduce the safety divide (for a recent illustration of this concerning the use of safety products in the home environment, see Stone et al., 2007; for various strategies concerning child pedestrian injuries, see Bishai et al., 2003; and for paediatric burn prevention, see Van Niekerk, 2007).

Creating attractive places for recreation

The traffic environment is often conceived by adults for adults. Because of that, it may be hazardous and unfriendly for children. The fewer off-street play areas that are offered, the more the street environment becomes not only an area for traffic but also one for recreation. The Harlem Injury Prevention Program is an example of a successful programme aiming at reducing paediatric pedestrian injuries by means of creating

attractive alternatives for children to being in the traffic environment (Durkin et al., 1999). Besides an educational component (traffic safety education implemented in classroom settings in a simulated traffic environment and theatrical performances in community settings) and the distribution of cycle helmets (linked to cycle safety clinics), the program included the construction of new playgrounds, the improvement of already existing playgrounds and parks, and a range of supervised recreational and artistic activities for children in the community. During the programme, a reduction of 45% in the incidence of traffic injuries among school age children was observed.

Social support

Not only an improved physical environment but also a cohesive social environment can play an important – compensatory – role in combating differential exposure. This occurs when parents accompany their children to school or a group of children travel to school together (school buses), just to take an example of collective strategies for injury control.

Community development and neighbourhood-based approaches aimed at changing social and cultural behaviour and attitudes of adults and children have an important and instrumental role to play in injury control and safety promotion. Yet, as pointed out by others, these would reduce, but not replace, the need to narrow the social and economic disparities between rich and poor if we are to reduce inequalities in child injury (Reading et al., 2005).

Allocation and location of post-trauma care

Prompt and efficient pre-hospital care can help to reduce the severity of consequences of serious injuries (WHO, 2007). It is clearly evident that post-trauma care can play a determinant role for reducing injury mortality and morbidity differentials.

Concluding remarks

The contribution of injuries to social-health differentials in childhood is considerable in very many countries, and prognoses show that their importance is on the increase. Yet, socioeconomic differences in wealth need not be reflected in differences in safety. For health targets to be reached and sustained, both safety-for-all and equity-oriented policies and strategies are imperative. These can be initiated by the health sector but they are likely to require multisectoral commitments and concerted actions.

The know-how in injury prevention and control has much to offer to the achievement and maintenance of living conditions favourable to health and safety for all. Although imperative, reducing inequalities in injury risks and in the benefits of prevention will not be achieved without facing major ethical issues. Undeniably, it will have to be orchestrated while respecting historical, political, geographical and cultural differences; the implication being that no strategy of intervention or means of prevention will be universal.

One can wonder how the current economic crisis will impact on the socioeconomic distribution of injuries and the answer to this question is no simple one. The driving forces may have both protective and aggravating effects, sometimes even protective

ones on adult injuries and aggravating ones on children injuries. It is known for instance that unemployment periods are accompanied by reductions in road-traffic injuries among adults, a reduction that is mainly explained by lower commuting needs. Yet, a study from California shows that an economic decline in metropolitan areas may also coincide with increases in infant mortality due to unintentional injuries (Bruckner, 2008), an observation associated among others with disturbed parental supervision.

An additional preoccupation related to care and rehabilitation following an injury is an expected reduction in insurance rates. Unemployment is indeed associated with preoccupying reductions in the number on insured motorists and it might as well be the case even for house owners and tenants.

Extrapolating on the above, one can expect that less societal investment in safety in the form of e.g. built-in safety, routine maintenance and reparation, and accessible trauma care will put additional responsibility on individuals who are already under pressure.

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4. Social inequities in working environment and work-related health risks

Author
M. Harvey Brenner, Ph.D.
University of North Texas
Johns Hopkins University
United States of America
and
Berlin University of Technology
Germany

Abstract

Background

The fundamental finding, relevant from the 1840s to the present day, is that the occupational skill level of workers is strongly related to their age-standardized mortality rates. Occupational 'skill-level' (i.e. 'status' or grade) is one dimension of socioeconomic status (SES), whereas both education and income levels are highly correlated with occupational status. SES, as a consolidated phenomenon, is a principal source of inequality in morbidity and mortality. The question is: which of the three main components of SES is the primary causal factor in SES that influences differential mortality rates – occupation, education or income. There are insufficient methodologically precise studies to answer this question up to now. However, there is evidence that occupational skill-level can influence injuries, infections, and chronic disorders through physical and psychosocial mechanisms.

Review methods/data

A literature search was conducted via Google Scholar on working conditions/ occupational health from 1990 to the present to identify studies that explicitly focus on the relation of those phenomena to SES as identified by education and income level, unemployment, immigration, ethnicity, gender and child labour.

Results

Although the research literature indicates that occupational skill level is strongly inversely related to morbidity and mortality rates and that, separately, both education and income have been shown to relate in a similar manner inversely to health status measures, that research literature has not as yet been able to distinguish the independent contribution of occupation, income and education on population health status. Eleven high quality studies were found in an attempt to unravel this problem and observed strong inverse relations between morbidity, mortality and grade of employment (measure of economic status); community group status; low job control; high job demands; low economic rewards in both genders but to a lesser degree in women. It is clear however that education, income, unemployment, immigration, ethnicity and child labour are all strongly related to low occupational skill-level and morbidity and mortality rates.

Conclusions

In the literature on socioeconomic status in relation to health, the skill-level attributed to different occupations has been linked to the exposure to deleterious working conditions, with the greatest exposures found among the least skilled (i.e. comparing professional, managerial, skilled, semi-skilled and unskilled occupational grades). Mechanisms of these relationships include exposure to physical, chemicals and microbiological toxins, as well as lack of worker autonomy leading to psychosocial stress.

Education, income, immigration, ethnicity and gender influence the determination of which populations obtain low-skilled occupations and are exposed to environmental risks.

Viewed macro-economically, technological development and economic growth are main sources of occupational structure and health. The international recession portends potential damage to occupational and environmental health through losses in employment and income, and loss of financial capacity to protect worker health based on use of new technology.

Introduction

Since 1841 in England and Wales, the British Registrar General's decennial Report estimated morality rates according to occupation, with the mortality subclassified by age, sex and diagnosis on death. This formulation begun under William Farr, thought to be the founder of modern epidemiology, brought two basic concepts into the field of medical demography. The first is that occupational status was the fundamental element in socioeconomic status or, what was then referred to as 'social class'. The second is that it was possible to describe multifactoral causes of illness and mortality, based largely on the occupational classification of the deceased (Susser et al., 1975).

The fundamental finding, relevant to the present day, is that the occupational skill level of workers is strongly related to their age-standardized mortality rates: the lower the occupation skill-level of a specific occupation, the greater the probability of a relatively high standardized mortality rate. Occupational skill level has been the traditional rank-order designation of socioeconomic status in epidemiology in the United Kingdom. It specifies the formal level of technological skill and authority over other workers (i.e. managerial skills) required to perform at a given ordinal level (or grade) in the employment hierarchy of economic or government organizations. From the mid-19th to the mid-20th century this basic principle was understood to prevail in northern European countries and the United States. The fundamental assumption was that there were attributes (physical, environmental, infectious, microbiological, etc.) that were characteristics of the occupations themselves which represented the link between occupational skill level and many illnesses (which were understood to be "occupational" illnesses or diseases).

In the 1950s in the United States, and thereafter in northern European countries, more elaborate concepts of socioeconomic status (SES) began to be used in epidemiology. These included, in addition to occupational status, both occupational level and income level. Sociologists and other social scientists were able to confirm that, indeed, occupational skill-level was one dimension of SES, whereas both education and income levels were highly correlated with occupational status. The new paradigm went beyond

occupational status, to include SES in general, with the most pervasive finding in epidemiology, namely that socioeconomic status as a consolidated phenomenon is a principal source of inequality in morbidity and mortality. The question began to be raised, however, as to which of the three components was the primary causal factor in SES in influencing differential mortality rates – occupation, education or income. There are insufficient methodologically precise studies to answer this question up to the present time. However, there is evidence that occupational skill-level can influence infectious and chronic disorders through multiple mechanisms: (1) working conditions and specific infectious, chemical or other agents, ergonomics, work intensity or speed; (2) stresses related to low income or low job status, e.g. high work demands, low employer control over the work process, inadequate wages and benefits, alcohol and tobacco abuse associated with stressful work; (3) relatively low education levels minimizing knowledge of work safety and health, diets and behavioural risks and limited access to health care systems.

Review methods/data sources

The literature since 1990 on working conditions/occupational health has been culled to find those studies that explicitly focus on the relation of those phenomena to SES as identified by education and income level. On the basis of a search using Medline supplemented Google Scholar, 11 major studies of high methodological quality have been found.

The discussion below reviews the findings of 11 studies published between 1990 and 2009 on working conditions affecting health and the socioeconomic implications thereof. The participants were company employees or participants in national health studies, e.g. the British Whitehall Study and the Finnish Kuopio Ischaemic Heart Disease Risk Factor Study. The countries involved in these studies were France, Germany, Finland, Scotland and the United Kingdom.

A second literature review, using Google Scholar supplemented by the database at the University of California, Berkeley Library, identified the most recent quantitative studies over 1990–2005 dealing with the relations between occupational skill level (or ‘status’) and the following socioeconomic variables: educational level, income, immigration, ethnicity, gender and child employment. An attempt was made to emphasize European studies, but, where these were lacking, North American studies were also included.

A final literature review was performed for the topic Unemployment and Health based on Medline for 1990–2009 and, before 1990, based on published reviews. These largely involved European studies but included those from the US where these were frequently quoted in the literature – especially the national-level studies of the 1970s and 1980s.

Empirical evidence (literature review) on the contribution of occupational status and working conditions to SES–health relation

The research literature has been clear for the last century and a half in England and Wales, and in other industrialized countries since the Second World War, that occupational skill level is strongly inversely related to morbidity and mortality rates. This is the case for the great majority of diagnoses and especially for working age

populations, and seems to be stronger for men than for women. In addition, separately, both education and income have been shown to relate in a similar manner inversely to health status measures. Further, it is well established that educational level and income level, as well as immigrant status and minority ethnicity are correlated with occupational skill level of employees. As the studies below indicate, however, the relatively unique contribution of occupational skill level or working conditions to the link between socioeconomic status and health has yet to be determined. In other words, the research literature has not as yet been able to distinguish the importance of the occupational skill level, education, income, and other social determinants of socioeconomic status as to their independent impact on population health status. The studies below are among the most advanced, methodologically, in the literature from 1990–2009, which attempt to unravel this problem.

North et al. (1993) studied short and long-term spells of sickness/absence in low and high grade employees (grade of employment was used as a measure of socioeconomic status). A strong inverse relation between grade of employment and sickness absence was evident. Men in the lowest grade employment had rates of short and long spells of absence 6.1 (95% confidence interval 5.3 to 6.9) and 6.1 (4.8 to 7.9) times higher than those participating employees in the highest grade of employment. For women the corresponding rate ratios – 3.0 (2.3 to 3.9) and 4.2 (2.5 to 6.8) – were similar but to a lesser degree. Risk factors such as smoking and alcohol consumption and work characteristics (low levels of control, variety and use of skills, work pace, and support at work), low levels of job satisfaction, and adverse social circumstances outside work (financial difficulties and negative support) accounted for about one third of the grade differences in sickness absence.

The study participants are from 20 civil service departments in London, specifically, 6900 male and 3414 female civil servants aged 35–55 years. This population was from The Whitehall study of British civil servants, which started in 1967 and showed a steep inverse association between social class (assessed by grade of employment) and mortality from a wide range of diseases. After 10 years of follow up those in the highest grades of employment had about one third the mortality of those in the lowest grades. The limited data available suggest there are also substantial socioeconomic differences in morbidity, but these differences remain largely unexplained. The Whitehall II study examined a new cohort of 10 314 civil servants between 1985 and 1988 to explain socioeconomic gradients in morbidity and mortality. In addition to the established risk factors included in the first Whitehall study, the second study has documented differences by grade of employment in work characteristics, social support, and health related behaviours. This paper specifically describes and explains the observed grade differences in sickness absence.

Information on grade of employment was obtained by asking participants to give their civil service grade at the time of the baseline survey. On the basis of salary, the civil service identifies 12 nonindustrial grades which, in order of decreasing salary, consist of seven “unified grades”, senior executive officers, higher executive officers, executive officers, clerical officers, and clerical assistants and office support staff. Unified grade is used by the civil service to refer to the combination of administrative grades (previously known as permanent secretary, deputy secretary, under secretary, assistant secretary, senior principal, and principal) and professional or technical staff with equivalent salaries. Similarly, the remaining professional or technical staff are combined

with administrative grades on the basis of salary. There was a steep increment in salaries between grade categories from an annual salary in 1987 of £18 020–62 100 in category I to £3060–6790 in category 6. However, most of the civil servants in the top category were at the lower end of the pay scale, with 82% of men and 83% of women in category 1 earning £18 020–27 065. Nevertheless, there appears to be a significant gap in salaries between grades.

Smith et al. (1998) studied 27 worksites in Scotland looking at education (early termination of schooling) and occupation social class (manual work). For all cause of death groups, men in manual social classes and men who terminated full time education at an early age had higher death rates. Cardiovascular disease was the cause of death group most strongly associated with education, while the non- cardiovascular non-cancer category was the cause of death group most strongly associated with adulthood social class.

Occupational social class was coded according to the Registrar General's classification and treated at six levels for analysis by social class alone and at four levels—I and II; III non-manual; III manual; IV and V—for analyses in which both social class and education were included. Age at leaving full time education was categorized as 12–14; 15–16; 17–18, and 19+. Mortality from all causes and from broad cause of death groups show clear increases from the non-manual to the manual social classes (Table 1). Similar gradients are seen according to education (Table 2).

Table 1. Age-adjusted 21-year death rates according to social class (per 10 000 person years)

Mortality	**Social class**						**Trend**
	I	***II***	***IIIN***	***IIIM***	***IV***	***V***	
All cause							
No. of deaths	156	242	293	530	334	84	
Death rate	101.1	110.0	139.5	153.0	152.6	170.5	*P*=0.0001
All CVD							
No. of deaths	65	138	155 2	73	172	38	
Death rate	48.0	66.8	79.8	86.4	87.7	78.7	*P*=0.0001
All cancer							
No. of deaths	64	68	91	166	109	25	
Death rate	41.7	35.4	52.7	57.4	57.8	60.1	*P*=0.005
Non-CVD, non-cancer							
No. of deaths	27	36	47	91	53	21	
Death rate	21.0	20.2	26.8	32.4	30.7	59.1	*P*=0.0001

Table 2. Age adjusted 21-year death rates according to age at leaving full time education (per 10 000 person-years)

Mortality	**Age at leaving full-time education (years)**				**Trend**
	19+	**17–18**	**15–16**	**12–14**	
All cause					
No of deaths	96	150	397	996	
Death rate	100.8	112.8	129.3	148.5	*P*=0.0001
All CVD					
No of deaths	40	81	212	508	
Death rate	47.5	66.7	75.0	83.9	*P*=0.0001
All cancer					
No of deaths	36	47	125	315	
Death rate	38.9	39.6	47.4	54.4	*P*=0.004
Non-CVD, non-cancer					
No of deaths	20	22	60	73	
Death rate	24.0	17.8	23.4	32.5	*P*=0.009

Marmot et al. (1997) studied participants from the British Whitehall II Study. The largest contribution to the socioeconomic gradient in CHD frequency was from that of low controls at work. After adjusting for a wide variety of factors, newly reported CHD in the lowest grade of employment was reduced from ratios of 1.5 to 0.95 in men, and from 1.47 to 1.07 in women. Much of the inverse social gradient in CHD incidence can be attributed to differences in psychosocial work environment.

Employment grades were grouped into three categories: Unified Grades 1–7 (administrators in Whitehall I), executive officers, and clerical and office support staff. Professional grades were classified with the equivalent administrative or executive grade. Job control was measured by a self-completed questionnaire at phase 1. Fifteen items deal with decision authority and skill discretion, and these were combined into an index of decision latitude or control. The analyses given here show that, low control is related to employment grade, and appears to account for much of the grade difference in CHD frequency in both men and women. Taken together, these results support the hypothesis that low control is involved in the process that links socioeconomic status with CHD.

Sexton et al. (1993) states that by improving our ability to identify, evaluate, prevent, and/or reduce risks for all members of society, environmental health research can contribute directly to fair and equitable protection. Further, Adler et al., 2002 explains that SES underlies three major determinants of health: health care, environmental exposure, and health behaviour and that reducing SES disparities in health will require policy initiatives addressing the components of SES (income, education, and occupation) as well as the pathways by which these affect health.

Lynch et al. (1997) studied Finnish men from the Kuopio Ischaemic Heart Disease Risk Factor Study to determine Carotid Atherosclerosis progression, plaque height and thickness as related to work demands and rewards (income). Men who had jobs with high demands and low economic rewards had significantly greater progression of plaque height and thickness than men with low-demand, high-income jobs. Risk factor adjustments, workplace resources, social support, and employment status made no

difference in these findings. The relationship between job demands and health should be understood in a broad framework of interacting economic conditions, social circumstances, and behaviours that cascade over the life course and may ultimately contribute to socioeconomic inequalities in morbidity and mortality.

Steptoe et al. (2003) studied the British Whitehall II Study participants to determine stress based on blood pressure/heart rates and cortisol outputs over a working day. SES was indexed by grade of employment. Cortisol concentration was greater in lower than higher grade men but was more elevated in higher than lower grade women. Differences remained significant after adjustment for age, time of awakening, smoking, and alcohol intake. Socioeconomic differences in blood pressure and cortisol may reflect stress-related activation of biological pathways that contribute to variations in disease risk. The differences found were in grade of employment and gender.

Lynch et al. (1997) studied Finnish workers to determine if there was an association between workplace conditions and the risk for all-cause and cardiovascular mortality and myocardial infarction differed by SES. Men who reported high demands, low resources, high income; or high demands, high resources and low income; or low demands high resources and low income found elevated all-cause and cardiovascular mortality. Elevated myocardial infarctions were found only for men with high demands, low resources and low income. Results did not differ by level of workplace social support or employment status.

The findings are consistent with the effort-reward imbalance model proposed by Siegrist, which suggests that the imbalance between high job demands (e.g. excessive supervision of time schedules, troublesome supervisors, troublesome fellow workers, job responsibility, poorly defined tasks and responsibilities, risk of accidents, risk of unemployment, irregular work schedules, and the mental strenuousness of work) and high psychological immersion in work roles and low economic and psychosocial rewards is associated with poor health outcomes. One interpretation of these results is that over time, the effects of poor working conditions and low economic reward (i.e. low resources assessed with questions asking participants to rate statements concerning the degree to which their work was interesting, allowed them to use their skills and capabilities, allowed them to feel composed and competent, was enjoyable and was meaningful) lead to feelings of hopelessness and depression, poorer behavioural and biological risk factor profiles, and higher levels of morbidity, which contribute to increased mortality risk. This study has shown that jobs with higher demands are more prevalent in low-SES groups. In addition, low-SES groups have fewer educational and economic resources with which to gain better jobs over time, and so may have greater exposure to poor working conditions over the life-course.

Kuper et al. (2002) studied Whitehall II participants under high efforts and few rewards in employment settings. Psychosocial work environment, as defined by high efforts expended in relation to few rewards reaped, was hypothesized to increase the risk of future poor health outcomes. A high ratio of efforts in relation to rewards was related to an increased incidence of all CHD and fatal CHD/non-fatal myocardial infarction during follow up, as well as poor physical and mental functioning. Effort-reward imbalance may be particularly harmful with respect to CHD risk among those with low social support at work or in the lowest employment grades. High efforts is defined as

putting great effort into work performance; rewards are the positive gains the employee receives in return for his/her work effort.

Geyer et al. (1999) studied German workers employed or employed before retirement classified by their last occupational status (semi skilled/unskilled, skilled manual, skilled non manual, intermediate occupations/professionals). German employees showed marked social gradients in terms of all-cause mortality. Socioeconomic status was not determined individually, but on the basis of regional origin by assigning the status predominant in a certain area. The authors found the highest mortality rates in communities where lower status groups made up the highest proportion.

Marmot et al. (1995) studied British questionnaire and sickness absence data from the first phase of the Whitehall II study to investigate the degree and causes of the social gradient in morbidity and mortality. A strong inverse relation between the grade of employment (measure of socioeconomic status) and sickness absence was observed. Men in the lowest grade had rates of sickness absence six times higher than those in the highest grade. For women the corresponding differences were two to five times higher. In general, the longer the duration of absence, the more strongly baseline health predicted rates of absence. Additionally, job satisfaction was strongly related to sickness absence with higher rates in those who reported low job satisfaction. The participants were from London offices of 20 civil service departments. Participants included 6895 male and 3413 female civil servants aged 35–55 years. Analysis was conducted on 88% of participants who had complete data for the present analysis.

Relation of occupational status (and working condition) to other SES indicators

We now identify a series of recent studies which point to the link between occupational skill level and other major socioeconomic factors, educational level, income level, immigration and ethnicity.

Education – general findings

Higher education is related to higher occupation levels – this is gender and region-specific and economic mobility is a factor.

Michels (2009) used a very large set (150 000 random cross-section of adult individuals) of labour market data from the US Census Bureau, covering 2001 and 2002 to analyse the determinants of hourly wage rates across the entire US population. Two important factors increase the hourly wage rate; workers can increase their education level, become more productive within their current occupation, and get paid more or workers can move from their current occupation to a new, higher paying one, however, regional-specific, the full wage benefits of increased education only occur if it is combined with a shift to a higher paying occupation.

Ehrenreich (2007) showed a direct and gradient relationship between the highest income and highest education attainment (regional and gender effect) – there was mobility up and down the economic ladder over time, but to lesser degree in some periods e.g. 1970–80s and 1980–90s and mobility across countries (United Kingdom, US, France, Canada, Denmark) with the US (with an egalitarian political tradition) not as mobile as

many countries (more mobility moves families out of poverty from generations more quickly).

Income – general findings

In periods of rapid change and globalization, income is positively related to higher grade occupations.

Andersen et al. (2005) determined that occupational grade on the risk of myocardial infarction (MI) is mediated by income with different aspects of income taken into account. Hazard ratio for unskilled workers as compared with executive managers was reduced from 1.55 to 1.42 after adjustment for household income indicating that low incomes in unskilled workers produce increased health hazard ratios.

Philippon et al. (2008) indicated that financial jobs before the 1930s and after the 1980s increased due to finance deregulation and corporate activity increasing the demands for skills in financial jobs. Financial jobs were relatively skill intensive, complex, and highly paid until the 1930s and after the 1980s, but not in the interim period

Immigration – general findings

Foreign-born workers are employed in a broad range of occupations; nonetheless, overall and in particular, illegal immigrants, are given the lowest-level occupations and lowest wages, benefits and working conditions.

Chiswick (2007) conducted empirical analyses based on the 2000 US Census, One Percent Public Use Microdata Sample containing information on 509 specific occupational categories within 23 major occupational groups and limited to males age 25 to 64 years. About one-half of the increase in earnings associated with formal education occurs through entrance into higher-paying occupations for both the native born and the foreign born though most of immigrants' human capital results in them being channelled into relatively low-paying occupations.

The work of Bloch et al. (2009) is an interactive article that illustrates where US workers come from and for which specific jobs: business and technical professions; health, education and service professions; hospitality, maintenance and personal services; and construction, manufacturing and other labour listing the top 20 occupations for each country of origin. Results indicate regional effects in types of jobs taken by specific population groups.

Elliott et al. (2008) reports that most non-white natives and all immigrant groups experience an unexplained penalty in terms of attaining employment in the higher paid occupations (professionals, managers and associate professionals). South Asian immigrants are 25 percentage points more likely to be employed in the higher paid occupations, while Black immigrants are 16 percentage points more likely to be employed in the lowest paid jobs.

Camarota (1999) reports that immigration has dramatically increased the supply of unskilled workers in the United States and 31 percent of the high school dropouts in the labour market were immigrants. The poverty rate for immigrants is 50 percent higher than that of natives, with immigrants accounting for one in seven persons living in

poverty though at the highest level of education, immigrants tend to be slightly more educated than natives, with 10 percent of immigrants holding a graduate or professional degree compared to 8 percent of natives.

Lerougetel (2008) stated, regarding immigrant status "there are those who, although they work, can't produce work documents or pay slips, because they have always worked, often for decades, in illegal situations, in the most terrible conditions of exploitation."

Ethnicity – general findings

Societal structures stratify along ethnic and immigrant lines by giving lower level occupational roles to immigrants and minority-ethnic groups (overrepresented in lowest-paying occupations and underrepresented in better-rewarded occupations).

Elliott et al. (2006) explains the relatively poor earnings performance of non-white migrants and non-white natives. Relative to white natives the occupational segregation effect is virtually zero for non-white natives, favourable to white immigrants and unfavourable to non-white immigrants.

Landale et al. (1990) showed that men from Northern and western Europe heritage gained occupationally from the incipient flow of migrants from Southern and eastern Europe.

Eargle et al. (2006) uses the two-stage ordinary least squares regression to estimate the models. Preliminary results indicate that ethnic differences do exist in the way that industrial and occupation structures impact employment hardship and poverty levels.

Lian et al. (1998) review how Canadian society was stratified along ethnic lines where those of other ethnic groups were willing to accept lower level occupational roles and as a result, "immigration and ethnic affiliation" have been important factors in the formation of social classes in Canada.

Specific key messages on inequities in children and gender-related inequities

General findings on gender

Gender segregation in the private sector is greater than in the public sector The share of women in an occupation is still one of the largest contributors to the gender wage gap. While women have almost reached parity with men in terms of their share of the workforce, they are not near parity in their earnings.

Webb (2009) compares employment restructuring, gender, and occupational change in Japan, Sweden, the United Kingdom, and the USA, since the 1980s where in each country the shift towards services has further concentrated men's dominance of employment in extractive and transformative industries. It is argued that gender and markets are mutually constitutive; their evolution is not pre-given but subject to political choices informed by history and culture (socialdemocratic, egalitarian, liberalized labour market values and policies).

Mora et al. (2003) found that gender segregation in the private sector is 14% larger than in the public sector in 1977 and 32% larger in 1992. During the 1977–1992 period, gender segregation in the public sector remains basically constant but increases by 15% in the private sector.

Boraas et al. (2003) used the US Current Population Survey (CPS) data to estimate the relationship between wages and the concentration of females within occupations and found that the relationship was negative, even after controlling for worker and job characteristics – the share of women in an occupation is still one of the largest contributors to the gender wage gap because they are the adverse consequences of occupational "crowding." Industry on the other hand was found to have the largest effect on the relationship, primarily because predominately male industries, such as construction and manufacturing, pay higher wages – particular industries pay more than others, and results show that these industries, on average, have higher concentrations of men.

Solberg (2005) in the US review of the literature finds that occupational assignment plays a major role in the distribution of wages and hence it may influence the existence and measurement of the gender pay gap – the occupational crowding by gender model says that an excess supply of women in "female" jobs depresses wages for otherwise equally productive workers. One mechanism for gender segregation is that agents have imperfect information about their probability of success and base career choices on prior beliefs about these probabilities hence gender differences in preference play a role in gender differences in occupation.

Burchell (2007) has been collecting data since 1990 on developments pertaining to working conditions – the latest of these surveys, the fourth European Working Conditions Survey (EWCS), across 31 countries in Europe reports on women more frequently switching to part-time employment or are less able to work the long hours typically expected for promotion to senior or managerial positions. The 'horizontal' segregation into different types of jobs occurs but also 'vertical' segregation where women are generally underrepresented in the higher level, better-paid managerial and senior positions in organizational hierarchies and occupational career ladders and overrepresented in low-paid jobs that is, women are disproportionately employed in low-paid jobs – there is labour market gender segregation.

General findings on children

Low income children are exploited in low-level working positions.

Rizzini et al. (1999) reports that one of the main reasons for high rates of school drop-out and retention in Brazil, in addition to the lack of adequate education infrastructure, is the need for children and youth to work; many low income children and youth in Brazil are frequently compelled to forgo school attendance to support themselves and their families. Chronic poverty in Brazil and in the rest of Latin America has had a direct impact on children e.g. in 1989 the richest 10 percent of the population controlled 51.3 percent of total income, while the poorest 20 percent of the population had access to just 2.1 percent of total income (World Bank, 1997).

Committee on the Health and Safety Implications of Child Labour, National Research Council and Institute of Medicine (1998) reports that, the jobs that poor and minority

young people have tend to be in more dangerous industries where for example the standards are much less restrictive for children and adolescents working in agriculture than for those employed in non-agricultural jobs. The committee developing guiding principles for working youth believes that these principles form the basis for ensuring that the work performed by children and adolescents will be safe and healthful yet there is not much information on subpopulations of young people, such as those who are disabled, poor, or members of minority groups and information on the quality of the work in which young people engage is also lacking; criteria and surveillance systems are needed as children are permitted to work many more hours and at younger ages in agricultural than in non-agricultural workplaces; one of the most dangerous industries in the country.

Horrell et al. (1995) found that in early industrialization the number of children working, and the number working in factories both increased, while the age at which children started work decreased which is related to changes in household structure where older children were gaining independence earlier, leaving younger siblings to augment family incomes. There are longer-term implications for the sexual division of labour as the effects of labour market changes differed for girls and boys.

Forastieri (2002) reports that despite the current legislation regarding child labour, there is a wide gap between law and practice. There are a large number of countries that have adopted legislation that excludes certain sectors or branches of economic activity such as agriculture and certain categories of workers in the informal sector e.g. domestic services thus many remain unprotected – in particular, child workers.

Unemployment and health

Unemployment is an important risk factor to mortality and morbidity – especially if the unemployment is of long duration (Tausky et al., 1967/68; 1994; Hallsten et al. 1999; Kasl et al., 2002). Brenner (in press) reviewed European Commission studies dated 1998–2004 examining the time-series relations between mortality and economic growth and unemployment. These studies covered the 15 original European Union countries and the United States over the period 1960–2000 (Brenner, 1979; 1982; 2000; 2002) and are extensions of original work done in the 1970s and early 1980s (Brenner 1984, 1985). Short-term positive relationships between unemployment and mortality are also seen within a year following increased unemployment rates. In a pooled cross-sectional study of metropolitan areas of the US, with a lag of two years following increased unemployment, and inclusion of poverty and income inequality as control variables, the standard positive relation was found for heart disease, stroke and homicide (Merva et al., 1996; 1999), which is consistent with the findings of virtually all epidemiological studies in Europe and North America over the last thirty years (Kasl, 2002). In another pooled cross-sectional study of the US, based on US states, without any lags and without the usual epidemiological controls, these inverse relations were not replicated (Ruhm, 2000). Some of the more prominent of the European studies are (Arnetz et al., 1991; Brenner SO et al., 1987; Hallsten et al., 1999; Martikainen et al., 1996; Linn et al., 1985; Morris et al., 1994; Jin et al., 1995; Moser et al., 1986). Over the past decade, several European studies have been concentrating on the impact of firm restructuring with downsizing – i.e. loss of jobs. The studies have uniformly found increased unemployment to be related to increased morbidity and mortality. (Martikainen et al., 2007; Kivimäki et al., 2008; Virtanen et al., 2005; Bambra et al., 2009).

Theodossiou (2009) in a technical report to the European Commission (Brenner, 2009a) reviewed the empirical literature and identified unemployment as a key socioeconomic determinant of health, particularly for men. However, unemployment does not only affect unemployed individuals but also their spouses and children. Andreeva and Laurijssen (2009 in Brenner, 2009), investigated how restructuring often harms so many individuals, families and communities (Kivimäki et al., 2000). Globalization, and associated restructuring places extreme pressure on adaptation of affected workers, families and communities. Poorly educated males suffer the most under the pressure of restructuring. Mobility, too, is critical to adaptation. Rapid restructuring is a fact of life for modern, industrialized, highly interconnected, technologically innovative societies (Johnson et al., 1996).

A hypothesis that needs testing is the belief that negative impacts of restructuring on workers' health are proportional to the length of the economic downturn. Prolonged recessions have been accompanied by an increase in unhealthy behaviours. Downsizing is another aspect of today's labour market which can introduce negative changes for those who remain employed, such as heavier workload, unsafe working conditions, physical hazards, and job insecurity (Campbell et al., 2006; Pepper et al., 2003; Noer, 1993; Gallo et al., 2006a; 2006b; Couch, 1998). Massive reorganization and restructuring, performed in a socially unrecognized, chaotic and poorly communicated manner is likely to cause more harm (Price et al., 2002; Ferrie et al., 2007;Vahtera et al., 2009) while managerial wisdom and preparedness can influence health outcomes.

Brenner (2009a) identified the principal external factors that are thought to have a major influence on the restructuring process; they include globalization, technological change, government policies and management style. Potential effects that could economically harm key segments of the employed population include: deindustrialization, downsizing, outsourcing, offshoring and delocalization. There is an impact of unemployment on diminished health and increased mortality; as well, the restructuring of industry – which has become quite common in the past 20 years – typically involving job loss, with or without recession, would also lead to higher illness and mortality rates. Recessions or near recessions, have a relatively slow economic growth (Schultze, 2004; Milani et al., 1996; Stiglitz, 2003; Neutel, 2006; Storrie, 2006).

Identification of relative impact associated with the most frequently used social factors/inequity determinants: the magnitude of inequity

Education, occupational prestige, and income level are fundamentally related to occupational-skill level. Since the 19th century occupational skill level has been the basic measure of 'social class' in the United Kingdom This social class concept, in turn, is the grounding of the British Registrar General's report on occupations and mortality. This is one of the founding documents in epidemiology begun by William Farr in England and Wales, 1839, the originator of epidemiology (Susser et al., 1975). Following this measure of occupational skill level, the classic relation to mortality has been in continuous use for the United Kingdom

In Table 3 below a strong gradient with regard to occupational skill level is found for men (age 20–64, Great Britain) where the standardized mortality rate ratio (SMR, SMR all population equals 100) increases from 66 for social class I (professional etc. occupations) to 165 for social class V (unskilled occupations). Such a social gradient

can also be found for single women (age 20–59, Great Britain) where the social class I SMR equals 75 and increases to an SMR of 117 for social class V single women. It can also be seen from these numbers that the social gradient is much more pronounced for men than for women.

Table 3. Population and deaths by social class, occupation group and unit for men, women and single women, with all cause SMRs for men and single women

Men aged 20-64 (Great Britain)			Occupation		All women aged 20-59 (England and Wales)		Single women aged 20-59 (Great Britain)		
Population (10%) in 1981	Deaths in 1979-80, 1982-83				Population (10%) in 1981	Deaths in 1979-80, 1982-83 (observed)	Population (10%) in 1981	Deaths in 1979-80, 1982-83	
	Observed	SMR						Observed	SMR
1,502,667	**337,099**	**100**	**All persons**		**1,244,558**	**112,023**	**210,992**	**14,987**	**100**
1,456,233	326,573	99	All occupied and retired		774,292	36,156	177,065	10,209	81
			Social class						
83,400	10,808	(66)	I	Professional etc, occupations	8,815	402	3,784	200	(75)
325,073	56,535	(76)	II	Intermediate occupations	169,327	8,304	45,814	2,409	(68)
160,459	33,370	(94)	IIIN	Skilled occupations (non-manual)	292,711	12,140	71,950	3,603	(80)
503,648	116,218	(106)	IIIM	Skilled occupations (manual)	59,863	3,822	13,817	1,125	(111)
232,124	69,415	(116)	IV	Partly skilled occupations	163,238	8,833	26,834	2,306	(107)
85,071	36,574	(165)	V	Unskilled occupations	51,329	2,384	3,268	465	(117)
19,235	1,902	(123)		Armed Forces	1,288	30	849	21	(74)
47,223	1,751	(18)		Inadequately described	27,721	241	10,749	80	(10)
46,434	10,526	(128)		Unoccupied	470,266	75,867	33,927	4,778	(205)

Source: Office of Population Censuses and Surveys: Occupational mortality. The Registrar General's decennial supplement for Great Britain, 1979–80, 1982–83. Series DS No.6. Part I. Commentary. London: Her Majesty's Stationary Office (1986)

Suggested pathways and mechanisms for the impact of social factors/inequity, reflecting the suggested model

The mainstream labour economics and economic growth literatures assume that the level of technology of a society – heavily based on its ability to finance economic development – is the foundation of the occupational structure at any point in a country's history. For this research the outstanding question is whether such factors as education, income, immigration, ethnicity, gender, etc. influence which individuals will fill the different economic positions (made possible by the state of technology). There is considerable evidence that persons with low education, immigrant status, minority ethnicity, and from families with low income and occupational prestige are far more likely to take on relatively low occupational-skill jobs. Obviously this is because, in competitive labour markets, the most educated and acculturated will be selected for the highest-level positions. Nevertheless, this 'purely competitive' labour market paradigm is somewhat flawed in that discrimination based on age, gender, ethnicity, religion, nationality and immigrant status are often used to select employees regardless of education, or ability to do specific jobs.

Causal arrows specifying mechanisms

The discussion of causal factors follows the four arrows introduced by the framework model in the introduction chapter.

Arrow 1 – Environmental influences of working conditions/occupation

The occupational health literature contains a profusion of studies linking specific toxic environments to occupational illnesses (e.g. Koh, 2002). The issue for this review is that virtually none of these studies identifies the socioeconomic context as an explanatory factor. An exception to this principle, based on ecological studies, is that income, education and other social determinants of SES are known to influence where people will live – and thus the extent to which they are exposed to environmental toxins. This research literature is often cited under the rubric 'environmental justice.' Part of the problem is that environments toxic to occupational health are based on the technological characteristics of individual firms. In particular, firms that are economically weak (especially small firms) are typically financially unable to invest in intricate health and safety monitoring or in the modernization of technology which would enable adherence to optimal health and safety standards. Unfortunately, the research literature does not yet contain occupational health studies in which the environments of individual firms are explored.

Arrow 2 – Working conditions/Occupation as exposure

Again, the literature contains a great many studies of specific toxins, ergonomic problems, chemical and biological risks in the work environment – and these are usually tied to specific occupations. However, hardly any studies could be found since 1990 which also identified the origins of working conditions/occupations with specific socioeconomic groupings (income, education, immigration).

Arrow 3 – SES as modifier of working conditions/occupations in relation to health

Here again, we confront the fact that the literature as yet has rarely combined separate analyses of education and income in studies of the effect of working conditions on health. Nevertheless, this causal arrow points to very significant future research. It would be important to know how the education and income of low-skilled workers act to modify the main effect of dangerous or monotonous working conditions on health. It is possible, for example, that in themselves low education and income – which are correlated with occupational skill level – are risk factors for alcohol abuse. In that case, e.g. the pathological alcohol consumption could, in turn, exacerbate the potential for accidents in the work of low-skilled machinists.

Possible solutions and countermeasures

The literature indicates two fundamental problems concerning occupational status and working conditions as they involve both illness-mortality and other aspects of socioeconomic status such as education and income, unemployment, immigration, ethnicity, gender and child employment. The first problem is that there is a heavy burden of occupationally related illnesses in the lowest-skill occupational categories, namely semi skilled machine operators and unskilled labourers who work in industries that either produce or require contact with physical materials or environmental hazards. For these situations, the traditional remedies are basic to occupational health and safety, meaning limitation of exposure to these health risks. However, it must be kept in mind that the firms that are able to invest in the technology that will minimize these

occupational risks must be sufficiently well financed to introduce the appropriate new technology.

At the same time, while financing is necessary, it will help only if there is a commitment of the management of the firm. Obviously, commitment is especially crucial precisely because technological modification is likely to be costly. This problem of commitment introduces the equally important requirement for societal norms and values and legal systems to be consistent with the vigorous promotion of environmental and occupational health. In this situation the role of government leadership, social dialogue, the trade unions, international trade agreements and ILO conventions rise to immediate prominence. Similarly, the importance of implementing the WHO Global Plan of Action on Worker's Health (2007) should be prominently mentioned.

The second major problem in the work environment – which has implications for stress-related illness – is worker autonomy with respect to the allocation of tasks and control over the work process. To a large degree this problem is moderated in countries whose political philosophy involves humanitarian management methods and considerable social protection of workers. In recent decades, it is argued that this problem of lack of worker autonomy might have become much more serious in that computer-based mechanisms for surveillance of employees and their productivity have become more routine and sophisticated. While there has been considerable scholarly writing on this subject, it seems that it will be essentially managerial training in business schools and political attitudes among employers that will need to be changed before significant progress is observed in this area.

As a general matter, the most powerful factor that can act to improve both problems is based on continued, sustainable economic growth. Such long term growth is the basis for financing of new technologies that can minimize physical and environmental occupational health and safety hazards. It is, of course, the central factor which can reduce unemployment rates in a period of international recession. In the context of rapid technological change and globalization, moreover, there is a marked reduction in the quantity of labour that is engaged in manufacturing or contact with physically hazardous materials in advanced industrialized societies. In addition, over the long term, there is evidence that countries with the most robust social welfare and protection systems are also, usually, the countries with the highest income per capita and the greatest attention to the needs of autonomy on the part of employees. Further, to the extent that countries wish to elevate the wage levels or education of their workers, this too usually requires financing in the context of a growing economy. While this conclusion with respect to economic growth is empirically justified, in general, it will appear controversial to some. For example, social inequities and the gradient of health inequities in China has been aggravated even if economic growth has been substantial in recent decades. The implication is that the role of government, in the context of democratic social dialogue, becomes especially important. And, as indicated above, the role of trade unions, international trade agreements, ILO conventions, the WHO Plan of Action on Worker's Health (2007) should be given special emphasis.

In the situation of the current international recession, all theses suggestions as to financing of technology and the promotion of more autonomous work environments, as well as the reduction of physically hazardous work, comes to a point of crisis. In the face of decreased economic growth rates, the large scale failure of many firms, and

greatly increased unemployment rates, it will be difficult for governments and firms to find the financial means to support the policies that are heavily endorsed by the social partners – unions especially – as well as the ILO and WHO (Brenner, 1979; 1987a; 1987b; 1996). Governmental and international organizations must emphasize the priorities for occupational and environmental health precisely because they are especially at risk in a time of strained government budgets for surveillance and major damage to small and medium-sized businesses (SMEs) where these problems are the most pressing (Moeller, 1997).

In fact, the international recession is likely not only to reduce national health care budgets, but also income and employment levels for major segments of European populations for the next several years. This destabilization of the work process may well have important damaging effects on the health and longevity of working populations. It is urgent that governments find the means and the policy to improve worker and family protection as well as retraining for positions that will become available as the recession retreats. The recession has had the most damaging effect on the least skilled, least educated and the lowest earning populations. There is a moral imperative to safeguard the health and well-being of the low socioeconomic occupational groups, since the national health burden will be the largest for these populations (Brenner, 2009).

The one area of policy that nearly all mainstream epidemiologists and labour economists agree on is the importance of improving and increasing levels of education. As pointed out, education is a prime factor in socioeconomic status and would be essential in allowing workers subject to unemployment either through recession or restructuring to find new fulltime work with equitable wages and benefits. Education of the general population – especially in the framework of 'lifetime learning' – is also understood to be a significant contributor to economic growth (as an element in human capital theory). Finally, enhanced education with respect to health information has the potential of making employees and management more sensitive to environmental and occupational risks, and the significance of health and safety regulations for length and quality of life (Dahlgren et al., 2006; Dollar et al., 2004; Moeller, 1997).

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5. Inequalities, inequities, environmental justice in waste management and health

Authors
Marco Martuzzi and Francesco Mitis
WHO Regional Office for Europe, Rome Office
Italy

Francesco Forastiere
Local Health Authority Rome E
Italy

Abstract

Background

The scientific evidence on the waste exposure-related health effects is not univocal. Epidemiological studies on populations living nearby landfills and incinerators do not demonstrate that exposure to waste causes cancer and reproductive outcomes. Socioeconomic factors have been considered, mainly as confounders, in few studies only. Differential exposure to waste by socioeconomic status (SES) is often documented, but its health implications and the possible modification of effects are not well known.

Review methods/data

Grey and peer-reviewed literature was reviewed starting from the 1980s, from Europe and the United States. Grey literature was searched using Google Scholar and obtaining key references listed in the peer reviewed articles.

Results

United States literature provides consistent indications that waste facilities are disproportionally located in areas with more residents from ethnical minorities or low-income classes. Similar results were found in European studies: international and national projects, studies by research agencies and nongovernmental organizations (NGOs) have shown that hazardous sites are located mainly in areas were more deprived people live. In eastern Europe there is anecdotal evidence on Roma people, ethnical minorities and refugees living close to hazardous waste sites. In studies considering health effects (mainly from Europe), risks are estimated with standardization for SES, typically using deprivation indices (DI). Such standardization always decreases risks for several cancers and reproductive outcomes. Effect modification is not investigated in these studies.

Conclusions

Evidence indicates that more deprived populations tend to live close to hazardous sites and to be more exposed to their emissions. This pattern results in corrections, towards the null, to the estimates of the health risks. Given that: (i) not all the studies analysed SES; (ii) SES is considered in several studies but unadjusted estimates are not published; (iii) often adjustment is made together with other confounders and SES effect

is not distinguishable, and (iv) in no case interactions between SES and waste exposure were studied, it seems important to address some further questions and investigate if disadvantaged people are more vulnerable, i.e. risks differ in different social groups living in the same area. Notwithstanding these open questions, public health officers and decision-makers should identify and develop waste management policies to minimize their potential health impacts and their unequal distribution, through participatory processes where the interests of all stakeholders are taken into consideration.

Introduction

Despite the lack of univocal evidence on the health implications of current waste management practices, there are concerns over the health effects of different waste management options, including landfilling, incineration, disposal of health care and other hazardous waste. Given the growing production of waste, policy-makers are increasingly confronted with the necessity of developing more capacity to safely dispose of waste. European case studies on health effects of landfills and incinerators were reviewed by the WHO Regional Office for Europe in an international workshop (Mitis & Martuzzi, 2007). With regards to waste landfills, some evidence exists on adverse effects on reproductive outcomes and cancer (somewhat stronger for the former), but is not sufficient to establish the causality of the association. However, in consideration of the large proportion of population potentially exposed to landfills in many European countries and of the low power of the studies to find a real risk, the potential health implications cannot be dismissed. With regards to incinerators the evidence is, overall, not conclusive to establish the occurrence and magnitude of risks. As in landfill studies, increases in relative risk are difficult to detect because they are generally caused by long-term low-level exposures to multiple agents. Studies pointing to an increase in soft tissue sarcomas and non-Hodgkin's lymphomas support a possible etiologic role of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8 T4CDD) emitted by old-generation incinerators. Against several uncertainties in the available data, the WHO expert group reaffirmed the importance of the EU's waste management hierarchy, favouring the minimization of waste production, followed by the reuse of goods, then value recovery through recycling and composting, finally incineration and landfilling, preferably with energy recovery.

Given the increasing use of incineration technology in many European countries, and the intense debate about alternative waste management strategies, more information regarding the health implication of waste–related exposures is desirable if health-friendly waste policies are to be articulated. First, further insights on health effects of landfills and incinerators are likely to be gained only from studies that consider exposure pathways and biomarkers of exposure and effect, and compare waste-related exposures with those due to other sources of pollution. Second, there is a need to investigate these possible effects in conjunction with other environmental hazards, as concurrent exposures (for example to mixtures of chemicals, or to agents or risk factors of different nature) can result in synergistic health effects. In particular, it is of interest to consider how health effects of waste may take place in combination with other powerful health determinants depending on lifestyle and the social environment. Third and lastly, it is important to clarify how the population distribution of waste related exposures (how uneven and skewed, how unequal and inequitable are such exposures) affects the policy response, its effectiveness and acceptance, and how these aspects can be taken into account more systematically in the policy-making cycle.

The present contribution is dedicated to the role of socioeconomic differences and environmental justice on the potential health burden due to exposure to hazardous waste facilities. We examine the evidence that socioeconomic factors have a confounding effect; in particular how strong is the evidence that most deprived communities are more exposed to waste–related contaminants. We address this question in the following section; later we examine how these gradients, where observed, can influence the risks for several health endpoints. Finally, we discuss the implications of these inequalities.

Review methods/data sources

Grey and peer-reviewed literature was reviewed from the 1980s. Keywords or references in the titles to "waste," "health effects," "socioeconomic factors," "inequities," "environmental justice," "congenital anomalies" and "mortality" were used to search Medline. All the pertinent European studies were selected. With regard to United States studies, given the large amount of literature dealing with social differences on the residence near waste facilities, only the most significant studies were chosen and commented. Grey literature was searched with the same criteria using Google Scholar and looking at the key references listed in the peer reviewed articles to identify NGO reports and studies published by other Agencies. Some of the data reported are on still unpublished reports (INTARESE EU project and part of the Campania study).

Residence near waste facilities: unequal and inequitable

The characteristics and main findings of the identified studies are summarized in Appendix 1.

Empirical evidence from Europe

One of the first studies to analyse the disproportionate location of industrial facilities (including some large waste sites) was carried out by Friends of Earth (1999). It was documented that in England and Wales the poorest families (reporting average household incomes below £5000) were twice more likely to live near a polluting factory than those with incomes over £60 000 and that almost two-thirds of the most polluting industrial facilities were located in areas of below average income. The areas with the most polluting factories were reported to have average household incomes almost £1500 (or 9%) lower than those where there are no such factories while the effects were more severe in areas characterized by the presence of multiple factories.

Another Friends of Earth study (2004) analysed the correlation between socioeconomic deprivation index and localization of solid waste incinerators, showing that 50% of the operating municipal waste incinerators in England were located in the 10% most deprived wards. These results were consistent with those published later by Walker (2003), who showed that waste sites were disproportionally located in the more deprived areas.

A study by Elliott et al. (2001) showed that: "the area within 2 km of the 9565 landfill sites tended to be more deprived than the reference area: 34% (versus 23%) of the population were in the most deprived tertile of Carstairs score (Carstairs & Morris, 1989) (36% for special waste sites)".

A pilot study in the north-western England (Damery et al., 2007) considered the potential association between socioeconomic deprivation and location of waste facilities. Findings showed that more deprived populations were more likely to live closer to waste sites than the less deprived. As to the residence close to the landfills, an opposite result was found. This result was consistent throughout 25 years of licensing approval but showed that the sites with the highest potential impacts were not located close to the most deprived population. However, it was found that deprived population were "more likely to be living near to facilities which have not complied with the conditions of their permit (license) at least once".

A national study on environmental inequalities in France on the distribution of environmental burdens tested the hypothesis that poor and immigrant communities are disproportionately exposed to environmental risks. Eight types of hazardous sites (industrial and nuclear sites, incinerators, waste management facilities) and the socioeconomic characteristics of populations were associated at the *commune*, or town, level for all 36 600 French towns. The results of the spatial regression analyses showed that towns with high proportions of immigrants hosted more hazardous sites, even controlling for population size, income, degree of industrialization of the town and region (Laurian, 2008).

In the EU project "Integrated Assessment of Health Risks of Environmental Stressors in Europe" (INTARESE), an integrated approach for the health impact assessment of landfills and incinerators on the population living in the surroundings has been applied in three European countries: Italy, United Kingdom and Slovakia (Forastiere et al., 2008). Waste disposal sites were identified and geocoded through a geographic information system (GIS). In Italy, England and Wales and Slovakia 619, 121, and 165 municipal urban solid waste landfills and 40, 11, and 2 waste incinerators were respectively considered. Population data by socioeconomic level, by using national socioeconomic deprivation indices, have been considered at census tract level across the three pilot countries.

Italy and England and Wales present a direct relationship between belonging to a more deprived social class and living in the surroundings of waste facilities under exam (Table 1). For landfills, in Italy the 26.1% of population living within 2 km from the plant belongs to the most deprived social class and the 13.3% to the most affluent class; in the United Kingdom 20.1% of population living within 2 km from the plant belongs to the most deprived social class and the 2.5% to the most affluent class. An inverse relationship was observed in Slovakia, with 12.1% of the most deprived class living close to the landfills opposed to the 24.2 of the less deprived groups. As to incinerators, In Italy 24.9% of population living within 3 km from the plant belongs to the most deprived social class and the 12.6% to the most affluent class; in England and Wales the distribution is even more skewed: 55.4% of population living within 3 km from the plant belongs to the most deprived social class and only 3% to the most affluent class. Again, an opposite relationship was observed in Slovakia, where the distribution is skewed towards a higher social class: only 2.5% of population living within 3 km from the plant belongs to the most deprived social class and 55.6% to the most affluent class. The authors explained that is due to the urban location of the incinerators, where most affluent Slovakian people live.

Table 1. Characteristics of residents living close to waste facilities* in Italy§, Slovakia and England 2001

	Italy	Slovakia	England and Wales	Italy	Slovakia	England and Wales
	Landfills			*Incinerators*		
Number of sites	619	165	232	40	2	11
Population within 2 km	1 350 852	328 869	1 425 350	1 060 569	16 409	1 203 208
Most affluent population (I group,%)	13.3	24.2	2.5	12.6	55.6	30.
II group	15.0	24.7	17.9	15.1	2.4	6.3
III group	22.4	22.6	18.7	21.0	9.8	12.5
IV group	23.0	16.4	19.1	24.2	29.6	22.8
Most deprived population (V group,%)	26.1	12.1	20.1	24.9	2.5	55.4
Missing information (%)	0.0	0.0	21.7	2.2	0.2	0.0

* 2 km from municipal urban solid waste landfills; 3 km from waste incinerators.
§ 118 landfills were geocoded, for population of 257 513. Socioeconomic data were then extrapolated to 619 landfills.
Source: adapted from Forastiere et al., 2008.

The results of European Collaborative Study of Residence near Hazardous Waste Landfill Sites and Risk of Congenital Malformations (EUROHAZCON) (Dolk et al., 1998), a multisite study that considered 21 landfills in Belgium, Denmark, France, Italy and United Kingdom, suggested "no overall evidence that socioeconomically more deprived communities live near to landfill sites."

In a study carried out around a Welsh landfill the relationship between socioeconomic status and distance from the landfill was characterized by most affluent people living closer the site (average Townsend deprivation score of 1.92 in the exposed wards compared to a more deprived score of 2.28 in the unexposed ones) (Fielder et al., 2000).

In a recent study, cancer mortality and congenital anomalies of populations living in 196 municipalities of the provinces of Naples and Caserta (Campania Region, southern Italy) were investigated (Martuzzi et al., 2009). The study area was characterized by more than 20 years of waste mismanagement (with the involvement of organized crime), including uncontrolled waste disposal, release of toxic substances and illegal waste burning. A positive association was found at municipality level between a waste exposure indicator, built around 227 waste facilities sites (138 of which were illegal) and socioeconomic status, described through a deprivation index (Cadum et al., 1999). The spatial distributions of the waste exposure indicator and of the deprivation index were similar, and a positive correlation was observed (r=0.30) (Martuzzi et al., 2009).

Research on environmental justice and on unequal distribution of environmental hazards and benefits has grown, in the recent years, in the countries of central and eastern Europe. It has been documented that hazardous sites and illegal waste disposal activities are disproportionally located in the working-class areas, as in Hungary with illegal asbestos disposal (Varga, Kiss & Ember, 2002), and in communities of ethnic or national minorities, predominantly the Roma (gipsy) populations (Steger, 2007, Varró et al., 2001), whose camps are settled, most of the times, on (or near) contaminated sites.

The Hungarian National Public Health and Medical Officers' Service reported, for example, that 15% of the 767 Roma colonies identified in Hungary, for a total of 3 million persons, are within 1 km of illegal waste disposal sites, and 11% within 1 km of animal carcass disposal sites (Ungváry et al., 2005). As observed in a recent study (Harper, Steger & Filcak, 2009, pp 12–13), Roma-settled areas:

> are vulnerable to being designated sites for both formal and informal environmentally problematic projects and activities (e.g., the location of a new landfill or illegal waste dump) as well as being ignored when it comes to infrastructure developments or improvements (e.g., public water system and/or sewage treatment). Additionally, as new development plans are underway, one of the first stages may be to shift the Roma from centrally located (and increasingly valuable) areas to other places on the periphery where opportunities, resources, and services can be scarce.

In addition, European national minorities are more at risk of environmentally-based discrimination because they are more likely to be object of political and governmental changes, to be regarded as "second class" citizens or to live in enclaves, in deprived zones along the borders or in refugee camps (Brown, V. J., 1999, Varga, 2000). That happened, for instance, near the dismissed chemical plant of Durres (Albania): its hazardous waste was not cleaned up and thousands of refugees displaced from the war in Kosovo[8] were resettled in the abandoned chemical plant site (Steger, 2007).

Finally, besides differential levels of exposure to waste-related contaminants by socioeconomic levels at local or national level, inequalities in exposure might take place at the international level, through the transfer of related hazards from one country to another. This can take place both as a result of illegal shipment (Cleary, 1997, Zsak a boltjat: Nemet szemet Magyarorszagon [Waste for sale: German garbage in Hungary], 2007), that is of growing relevance in some countries of central and eastern Europe (European Environmental Agency, 2007, European Topic Centre on Resource and Waste Management, 2008), and as a consequence of environmental disasters. This was the case in Romania with the 2000 cyanide spill in the river Tisza (following the collapse of a dam of an artificial lake used as a dump of residues of gold extraction); large quantities of cyanide and other contaminants were dispersed from Romania to Hungary and to the Danube basin (The Regional Environmental Centre for Central and Eastern Europe, 2000).

Empirical evidence from the United States

A considerable part of the available evidence comes from studies conducted in the United States. Compared to the European data, there are some important differences, notably:

1. a different approach to measuring socioeconomic status, based on variables such as income, rather than on composite indices, as done in European studies, built combining information on several domains, such as social class, education, unemployment, housing, family structure etc; and
2. a greater emphasis on the comparison of different ethnic groups.

[8] In accordance with Security Council resolution 1244 (1999).

The early United States studies were prompted by the concerns of civil activists on the disproportionate location of landfills in predominantly black communities (Bullard, 1990). As stated by Taylor, the correlation between race, socioeconomic deprivation and residence influenced several outcomes such as a higher likelihood of being exposed to environmental hazards (Taylor, 2000), the disproportionate impacts of environmental processes and policies (for example, different clean up rate (Lavelle & Coyle, 1992, Margai, 2001)), lower civil penalties for law violation (Lavelle & Coyle, 1992)), the targeting and siting of noxious facilities in more deprived communities (Taylor, 2000) and inequalities in the delivery of environmental services such as rubbish removal (Taylor, 2000).

A study conducted in Houston (Bullard, 1983) on the location of waste facilities found a skewed distribution, with less affluent population subgroups living in the surroundings of the facilities: while only 28% of the population in Houston was black, 75% of waste incinerators and 88% of landfills were located in predominantly black areas. Similar conclusions were made in a review of the evidence on "environmental racism" (Mohai & Bryant, 1992). A statewide study in North Carolina (Norton et al., 2007) found that the presence of a solid waste facility was 2.8 times greater in census block groups with more than 50% people of colour compared with census block groups with less than 10% people of colour, and 1.5 times greater in census block groups with median house values less than US$ 60 000 compared with census block groups with median house values more than US$ 100 000. Among block groups that did not have a previously licensed solid waste facility, the probability of a new one being licensed was 2.7 times higher in census block groups with more than 50% people of colour compared with census block groups with less than 10% people of colour.

These results are consistent with those by Faber and Krieg (2002): in their study of 368 communities of Massachusetts, in which population was classified by social class and racial composition, a score rating the severity of each type of hazardous facility or site (such as municipal incinerators, resource recovery facility, demolition landfill, up to a total of 17 different types of environmentally hazardous sites and industrial facilities) was given to identify a cumulative exposure of population to hazardous sites. After controlling for the size of the community and the severity of the site, landfills (including incinerator ash landfills, demolition landfills, illegal sites, sludge landfills, tyre piles and transfer stations), ecologically hazardous sites and facilities were found to be disproportionately located and concentrated in communities of colour and working-class communities.

The first United States national assessment, carried out by the United Church of Christ Commission for Racial Justice (United Church of Christ Commission for Racial Justice, 1987), found correlations between black residence and presence of hazardous waste sites in the surroundings, at zip code (postcode) level; analysing the location of 415 hazardous waste sites, 60% of African Americans and Latinos in the United States were estimated to live in communities characterized by the presence of illegal or abandoned toxic dumps. It was argued that communities with one hazardous waste site had twice the percentage of people of colour as those with none, and that percentage tripled if there were two or more waste sites. Race was considered a stronger predictor of the presence of toxic dumps than other variables, such as household income, the value of homes and the estimated amount of hazardous waste generated by local industry.

A first revision of this national assessment was published in 1994: following seven years of interventions, the situation for minority communities was found to have worsened, with black people 47% more likely than white people to live near these potentially hazardous facilities (Goldman & Fitton, 1994). It was concluded that race and poverty were the two most critical determinants for the location of commercial hazardous waste facilities in the United States (including hazardous waste generators of all sizes across Massachusetts (Spence, 1995)).

The findings of these studies were criticized by several authors (Anderton et al., 1994, Been, 1994, Oakes, Anderton & Anderson, 1996) who questioned the study design; in a review of 42 studies (Bowen, 2002) did not find consistent evidence of environmental inequity.

To determine if research indicated the presence of unequal exposure, Brown (1995) reviewed these first studies. His paper assessed whether there were race and class differentials in (i) exposure to toxic hazards, including the presence of hazardous waste sites and facilities (landfills, incinerators, Superfund sites); (ii) regulations, ameliorations and cleanups, including record of decisions and cleanups at National Priority List (NPL) sites; and (iii) regulatory actions, as measured by assessed fines for environmental pollution. He concluded that "the overwhelming bulk of evidence supports the "environmental justice" belief that environmental hazards are inequitably distributed by class, and especially race."

In 2007 the last update of the national assessment was published (Bullard et al., 2007). The authors stated that "racial and socioeconomic disparities persist in the distribution of the nation's commercial hazardous waste facilities" and that their unequal distribution was increasing. Poverty rates in the host neighbourhoods are 1.5 times greater than non-host areas (18% versus 12%); similarly, neighbourhoods with clustered facilities had disproportionately higher poverty rates. Similar figures were also found out at national, regional, state and metropolitan level.

These results were supported by those obtained in the most recent study (Kearney & Kiros, 2009): an analysis on social and economic variables within one mile of 71 NPL or Superfund sites in Florida. Logistic regression and GIS techniques were used to analyse the differences in race/ethnicity composition and socioeconomic factors between census tracts with or without NPL. The study concludes that "the percentages of Blacks ($OR = 5.7$, $p < 0.001$), the percentage of Hispanic/Latino ($OR = 5.84$, $p < 0.001$), and percent employed in blue collar occupations ($OR = 2.7$, $p < 0.01$) were significant predictors of location of NPL facilities." In addition, other socioeconomic variables, traditionally associated to poor socioeconomic status, such as percentages of renter occupied housing, foreign born, and houses lacking plumbing facilities were higher in host compared to non-host tracts.

Several studies in the United States analysed the historical processes from which environmental injustice was originated. Ringquist (1997) proposes two main reasons that could explain this process: first, urban planning had been deliberately unbalanced and waste sites were localized in more deprived areas because of discrimination or of lack of political power from the less affluent communities; second, there was a demographic transition after the plants were built, with affluent people leaving the area and poorest subgroups moving in because of a decreased housing value. The second

mechanism was supported by some authors (Been (1994) and Callewaert (2002)) but not by others: in Los Angeles County, differential siting was found to matter more than differential patterns of residential moving after the site was built (Pastor et al. (2001)). It is unclear whether gradients are created by allocation of hazardous sites differentially towards socially disadvantaged areas, or, conversely, by differential patterns of in- and out-migration after creation of the sites. While this debate has its importance in terms of developing appropriate policy process for site allocation, this does not affect the occurrence of adverse health effects.

Specific key messages on (a) inequities in children and (b) gender-related inequities

The review did not identify any specific evidence in relation to children and/or gender.

Exposure to waste and socioeconomic factors: compounded effects

Many of the studies above, especially from Europe, document a pattern where deprived people are overrepresented in the vicinity of waste treatment facilities. In some of these studies, in addition, it is observed that differential health effects – notably mortality, congenital anomalies, low birth weight – are associated with socioeconomic factors. These associations are described below.

Several studies were performed in United Kingdom on all congenital anomalies (Elliott et al., 2001, Elliott et al., 2009), Down syndrome (Jarup et al., 2007) and cancer (Jarup et al., 2002) in population living near landfills. In the most recent study on congenital anomalies and landfill density, risks were standardized by socioeconomic status, presence of a congenital anomalies registry and maternal age. After adjustment for these factors, risks decreased for all the anomalies under study: all anomalies, hypospadias and epispadias, neural tube defects, cardiovascular defects and abdominal wall defects. With the exception of abdominal wall defects the major changes from the unadjusted to the adjusted risks were found in the areas with the highest special waste sites density. Similar results were found analysing only non-special or unknown waste sites density. Comparison of the combined top three categories of landfill density with the unexposed group produced an excess of hypospadias and epispadias for special waste sites (Elliott et al., 2001).

In the study by Jarup et al. (2007) a decreasing risk of Down syndrome with increasing levels of socioeconomic deprivation was observed (one of the few reversed associations to be found); however, adjustment for socioeconomic status resulted in a marginal correction of the estimates of the risks from landfills.

In the study on cancer and residence near the landfill sites (Jarup et al., 2002), adjustment for socioeconomic status decreased the risk estimate for bladder cancer, which however remained significantly in excess. The same trend was observed when analysis was applied only to hazardous sites but, in this case, the adjusted risk for bladder cancer lost the statistical significance.

In the first article published from the EUROHAZCON study (Dolk et al., 1998) a positive association was reported between socioeconomic status and non-chromosomal congenital anomalies close to United Kingdom landfill sites, while the same trend was not observed in the other European sites.

A second report of the EUROHAZCON multisite study (Vrijheid et al., 2000) further analysed the associations between socioeconomic factors non-chromosomal and chromosomal congenital anomalies. The risk for non-chromosomal anomalies increased with increasing socioeconomic deprivation: the risk in the most deprived group was 40% higher than in the most affluent quintile. The same applied to some non-chromosomal anomalies subgroups such as anomalies of cardiac septa (182%) and digestive system anomalies (253%). An impact measure was also estimated: if the rates observed in the most affluent group prevailed in the whole exposed population, the 18% fewer anomalies would have occurred.

In the study carried out in Campania a positive association was observed between mortality for various cancer causes and both waste exposure and socioeconomic factors. For both sexes, mortality risk estimates unadjusted by socioeconomic deprivation were much higher than adjusted ones, as shown in Table 2. Risk estimates were markedly corrected across the five levels of waste exposure, and so were estimates of linear trends. The only exception was stomach cancer in men.

Table 2. Waste exposure, socioeconomic status and mortality outcomes in Campania region*

Mortality	***Excess risks by waste exposure group***										***Trend***	
	I	***II***		***III***		***IV***		***V***			
Cause of death – Men		**Un adj**	**Adj§**	**Un adj**	**Adj**	**Un adj**	**Adj**	**Un adj**	**Adj**	**Un adj**	**Adj**
All causes	1	**9.2**	**5.4**	**6.9**	**7.9**	**7.1**	**3.9**	**13.6**	**9.2**	**2.2**	**1.7**
All cancers	1	**9.3**	**4.2**	3.2	**5.6**	**9.3**	**4.9**	**11.0**	4.1	**2.2**	**1.5**
Lung cancer	1	**11.4**	**5.5**	4.2	6.4	**11.1**	6.1	**14.0**	6.7	**2.7**	**1.9**
Liver cancer	1	0.1	9.2	12.7	**20.6**	7.0	0.7	**35.5**	**19.3**	**5.6**	**4.3**
Stomach cancer	1	1.5	3.0	0.1	2.8	**17.0**	**19.4**	16.2	15.7	**5.0**	**5.2**
Bladder cancer	1	**17.3**	11.7	11.0	6.4	10.8	7.1	4.6	4.1	0.8	0.7
Kidney cancer	1	4.4	2.8	4.3	0.6	8.5	14.9	7.6	16.7	3.0	4.0
Soft tissues sarcoma	1	10.6	9.8	7.2	20.4	23.6	31.0	18.7	25.0	3.1	3.9
Non-Hodgkin lymphoma	1	**24.2**	9.4	29.8	25.4	18.7	6.8	2.8	3.7	2.3	1.3
Other cancers	1	**9.1**	**4.7**	2.4	4.3	**7.6**	3.3	6.2	0.3	1.4	0.7
Cause of death – Women											
All causes	1	**3.1**	1.7	**7.2**	**8.1**	**5.6**	**4.8**	**14.4**	**12.4**	**2.6**	**2.4**
All cancers	1	**9.8**	**5.1**	2.3	2.4	**6.7**	3.6	**10.0**	**6.6**	**1.6**	**1.0**
Lung cancer	1	**63.8**	**45.4**	10.2	14.4	14.1	5.6	**22.7**	9.4	0.2	2.3
Liver cancer	1	3.5	9.3	5.0	9.1	13.6	9.6	**39.5**	**29.1**	**7.3**	**6.6**
Stomach cancer	1	8.1	8.3	2.3	6.4	1.0	2.2	10.7	16.7	2.1	2.6
Bladder cancer	1	17.9	7.7	6.5	12.7	3.2	2.8	17.3	16.7	2.8	3.3
Kidney cancer	1	19.2	6.9	2.4	11.2	8.7	3.4	36.2	19.1	3.8	1.7
Soft tissues sarcoma	1	4.3	7.7	76.0	84.1	35.2	33.6	4.2	0.3	7.8	8.3
Non-Hodgkin lymphoma	1	9.8	10.1	3.3	3.5	15.9	19.7	2.1	0.2	1.8	1.6
Other cancers	1	**7.4**	3.5	1.3	1	5.2	2.3	6.3	3.7	1.1	0.7

* In bold, statistically significant risks are reported (95% CI)
§ Risks adjusted by socioeconomic status. Risks not adjusted are unpublished data.
Source: Martuzzi et al., 2009

In a study in the New York state near PCB-contaminated (i) Superfund sites, (ii) NPL sites and (iii) the Six Areas of Concern (Baibergenova et al., 2003), the risk of giving birth to a low-birth-weight and to a very low-birth-weight baby was investigated. Positive associations were observed between having a low-birth-weight baby and (i) low levels of income and (ii) mother's educational level less than (or equal to) high school while only a low-income level was associated to having a very low-birth-weight baby.

In the United States, a study by Orr et al. (2002) was carried out considering only ethnic minorities (black/African American, Hispanic/Latino, American Indian/Alaska Native, and Asian/Pacific Islander), and found a positive association between a range of anomalies and residence in the census tracts near the NPL hazardous waste sites. The largest association was found between potential exposure and neural tube defects (odds ratio (OR) = 1.54, 95% confidence interval (CI) = 0.93–2.55), particularly anencephaly (OR = 1.85, 95% CI = 0.91–3.75). The strongest association between birth defects and potential exposure was among American Indians/Alaska Natives (OR = 1.19, 95% CI = 0.62–2.27). This study design, however, does not allow a comparison with the effects in the majority population.

Waste and health: same risk for everyone?

The evidence summarized in the two sections above indicates that there is a tendency in poorer, less educated, disadvantaged people or ethnical minorities (highly correlated characteristics) to live closer and be more exposed to waste treatment facilities of any kind; and, in addition, that when adverse health effects due to such proximity are detected, these are compounded (usually multiplicatively) with the effects, also adverse, of social disadvantage. This pattern may occur for other localized source of environmental pollutants, but is not systematically documented.

Some questions arise naturally.

- Are disadvantaged people, besides being disproportionally exposed to waste-related environmental risk, also more vulnerable to its impacts?
- Do risks differ in different social groups living in the same exposed place, and if so, to what extent?
- In other words, is there an interactive, synergistic relationship between the adverse health effects of waste exposure and of the disadvantaged social environment, or conversely does the proportionality assumption hold?

The available information on the health effects of waste facilities by social groups, needed to address these questions, is limited, for several reasons:

1. not all the studies carried out to evaluate the potential associations between exposure to waste facilities and health outcomes have considered socioeconomic status;
2. in some studies, socioeconomic-adjusted risks are estimated but unadjusted risks are not published, and a comparison between the two, which allows an assessment of the relative importance of social factors, is not possible;
3. in some cases risks are adjusted not only for socioeconomic status but for other factors (for example, maternal age or presence of a dedicated registry in studies of

congenital anomalies) and only final adjusted risks are published, and no distinction can be made between different factors and confounders;

4. crucially, in no cases are interaction effects between socioeconomic factors and waste exposure tested and reported.

For waste and health as well as for many other cases in environment and health, these questions are central; answers to them would not only shed light on the nature of the interrelationship between the social and the physical environment, they would also allow the identification of more effective strategies to prevent or reduce the impacts.

The lack of evidence on these questions reflects an attitude, in epidemiological research, to consider risk factors from different domains in isolation, by assuming independent effects. There are also substantial difficulties in estimating the joint effects of different risk factors, for example low power to estimate interactive effects, given the high collinearity between environmental exposures and deprivation. This is one facet of environmental justice: different risk factors, such as environmental contamination, social disadvantage, unhealthy lifestyles are often observed to insist on the same subgroups. This makes the assessment of the interplay between these different factors difficult, and represents an important reason to consider inequalities (in exposure and in health outcomes) as *inequities*. Other relevant considerations in terms of equity include the following.

- While a certain degree of inequalities are inevitable, at least a part (arguably a substantial one) of the observed inequalities is preventable. Exposure inequalities can and must be reduced by appropriate measures of mitigation and abatement of emissions from potential sources. This includes not only established noxious agents (for example, particulate matters, persistent organic pollutants, heavy metals) but also emissions interfering with residents' quality of life (for example, odours, noise). Health inequalities can and will be reduced, by such abatement measures, and will be further countered by primary prevention and health promotion initiative undertaken in conjunction.
- It is possible that people who bear the most part of the adverse impacts from waste disposal activities (in terms of health and well-being) produce less waste. This might occur, for example, when residential exposures are disproportionately distributed towards population strata with lower income, lower purchasing power, and lower rates of consumption of material goods. There are examples, in other domains, where this unfair, negative correlation between benefits and negative impacts, is obvious (for instance, greenhouse gas emission at global level) and similar mechanisms may take place at more local level too.

Currently, both of these dimensions of environmental justice are, by and large, speculative. Data and evidence to assess the extent of these inequities would be highly informative.

A way forward

Numerous studies in Europe and in the United States have documented that disadvantaged communities often suffer disproportionately from the impact of waste facilities. Several questions are unresolved that should be addressed with the collection of targeted data and research. Uncertainties include the presence and magnitude of environmental different waste-related risks (depending on type of facility, different

agents, joint effects of multiple risk factors), the possible synergistic effects with the social environment, the extent to which inequalities are preventable, and the degree to which benefits and adverse impacts are differentially distributed in the population. However, while these knowledge gaps are being filled, public health professionals should contribute to the identification and development of waste management policies that minimize health impacts and inequalities. In the words of Mohan (2006, pp. 912–913):

> Health inequalities should be one of the key considerations when developing waste management strategies or when conducting HIAs of waste sites. If waste management installations are to be located in an area, every effort should be made to mitigate any potential adverse health effects. […] Every effort should also be made to ensure that the local community enjoys any potential benefits from waste management.

For waste management as well as for other domains, a direct participation of the health sector in the decision-making process is desirable. Participatory processes are necessary to achieve fairer policies, where the interests of all stakeholders are taken into consideration. In view of the various limitations hampering our ability to characterize all risks, policy decisions on new facilities and remediation schemes should be inspired by a precautionary approach (Faber & Krieg, 2002), where equity is put at the centre of the debate.

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Appendix 1. Residence near waste facilities: summary of the reviewed studies

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
Bullard	Solid waste sites and the Houston black community	United States	Multi	Solid waste landfills and incinerators	Ethnicity	Although blacks made up only 28% of the Houston population in 1980, 75% of waste incinerators and 88% of landfills are located in predominantly black neighbourhoods	Yes
Bullard	Dumping on Dixie: race, class and environmental quality	United States	Multi	Landfills	Ethnicity	Higher likelihood of exposure to environmental hazards for blacks (overall assessment from review).	Yes
Margai	Health risks and environmental inequity: A geographical analysis of accidental releases of hazardous materials	United States	Multi	Releases of hazardous materials	Income Ethnicity	Areas of high-impact from accidental releases of hazardous materials are characterized by a large proportion of families below the poverty line, Hispanics, and other minorities.	Yes
Lavelle	Unequal protection: the racial divide in environmental law	United States	Multi	Clean up of Superfund toxic sites Punishment of polluters	Ethnicity	White communities see faster action, better results and stiffer penalties than communities where blacks, Hispanics and other minorities live. This unequal protection occurs whether the community is wealthy or poor.	Yes
Norton	Race, wealth, and solid waste facilities in North Carolina	United States	Multi	Solid waste facilities	Ethnicity Median house values	Solid waste facilities are disproportionately located in communities of colour and low income	Yes
Faber	Unequal exposure to ecological hazards: environmental injustices in the Commonwealth of Massachusetts	United States	Multi	Environmentally hazardous sites and facilities – developed a means for measuring and ranking cumulative exposure for communities	Ethnicity Income	Ecologically hazardous sites and facilities are disproportionately located and concentrated in communities of colour and working-class communities	Yes

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
United Church of Christ Commis-sion for Racial Justice	Toxic wastes in the United States: a national report on the racial and socioeconomic characteristics of communities with hazardous waste sites	United States	Multi	415 commercial waste facilities operating under the US EPA hazardous waste management system	Ethnicity Property values Income	Ethnicity is a more significant predictor of where commercial toxic waste facilities are located in the US than several measures of income and property values; areas with communities hosting the greatest number of hazardous facilities also have the highest composition of minority residents	Yes
Goldman	Toxic wastes and race revisited: an update of the 1987 report on the racial and socioeconomic characteristics of communities with hazardous waste sites	United States	Multi	415 commercial waste facilities operating under the US EPA hazardous waste management system	Ethnicity Property values Income	Situation for minorities worsened during the 7 years from the first report: the percentage of minorities sharing zip codes with hazardous waste facilities increased by 6%	Yes
Bullard	Toxic Wastes and Race at Twenty 1987–2007	United States	Multi	Hazardous waste facilities	Ethnicity Income (poverty rates)	Significant racial and socioeconomic disparities persist in the distribution of the nation's commercial hazardous waste facilities	Yes
Anderton	Environmental equity: the "demographics of dumping"	United States	Multi	Facilities for treatment, storage, and disposal of hazardous wastes	Ethnicity	No significant differences between the racial or ethnic composition of census tracts containing waste facilities and those that did not	No
Oakes	A longitudinal analysis of environmental equity in communities with hazardous waste facilities	United States	Multi	Facilities for treatment, storage, and disposal of hazardous wastes	Ethnicity Income	No stark evidence of environmental inequity or disparate impact. Compositional change in host communities may best be explained by general population trends	No

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
Been	Locally undesirable land uses (LULU) in minority neighbourhoods: disproportionate siting or market dynamics	United States	Multi	LULU	Income Ethnicity	LULU's presence in a neighbourhood can cause property values to fall, and that decline in turn changes the demographics of the neighbourhood. Market dynamics play a major role in determining the demographics of host neighbourhoods and therefore should be taken into account in the structure of any remedy for disproportionate siting	Yes
Bowen	An analytical review of environmental justice research: what do we really know?	United States	Multi	Several	Income Ethnicity	Empirical foundations of environmental justice are weak and do not allow identification of patterns of uneven distributions and their health effects on minority, low-income, and other disadvantaged communities (overall assessment from review of 12 studies)	No
Brown	Class, and environmental health: a review and systematization of the literature	United States	Multi	Proximity to known hazard Regulations, ameliorations and clean up Regulatory actions Proximity to prospective hazard	Ethnicity Income	The overwhelming bulk of evidence supports the "environmental justice" belief that environmental hazards are inequitably distributed by class, and especially ethnicity (overall assessment from review)	Yes
Kearney	A spatial evaluation of socio demographics surrounding National Priorities List sites in Florida using a distance-based approach. International journal of health geographics	United States	Multi	71 National Priorities List or Superfund sites	Ethnicity Socioeconomic indicators (blue/white collars occupation)	The percentages of Blacks (OR = 5.7, $P < 0.001$), of Hispanic/Latino (OR = 5.84, $P < 0.001$), and of employed in blue collar occupations (OR = 2.7, $P < 0.01$) were significant predictors of location of NPL facilities	Yes

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
Pastor	Which came first? Toxic facilities, minority move-in, and environmental justice	United States	Multi	Toxic storage and disposal facilities	Ethnicity Income Home value Median rent Education Occupation Housing	Disproportionate siting matters more than disproportionate minority move in the area under study	Yes
Friends of the Earth	Pollution injustice and the geographic relation between household income and polluting factories	United Kingdom	Multi	Industrial facilities registered under the Integrated Pollution Control framework (polluting factories)	Household income	The analysis shows that poorer people in England and Wales are more likely to live in close proximity to a potentially polluting factory than richer people. It also shows that the relationship is stronger with increasing numbers of factories in an area	Yes
Friends of the Earth	Incinerators and deprivation. Briefing.	United Kingdom	Multi	Municipal waste incinerators	Socioeconomic index of multiple deprivation	The results show that operating incinerators are predominately found in the most deprived wards in England	Yes
Walker	Environmental quality and social deprivation	United Kingdom	Multi	Waste sites included in the Integrated Pollution Control regime	Socioeconomic index of multiple deprivation	Sites are disproportionately located in more socially deprived areas. Compared to other industrial sectors, the waste sector shows the most marked propensity for sites to be located near to deprived populations	Yes
Damery	Addressing environmental inequalities: waste management	United Kingdom	Multi	5435 operational waste sites (796 in the North West).	Socioeconomic index of multiple deprivation	In North-western England, more deprived populations are more likely to be living nearer to waste sites than the less deprived, except in the case of landfill sites where it is the least deprived populations who are more likely to live nearby	Yes for waste sites; Negative for landfills
Elliott	Risk of adverse birth outcomes in populations living near landfill sites	United Kingdom	Multi	9565 landfill sites	Carstairs deprivation index	The area within 2 km of the landfill sites tend to be more deprived than the reference area: 34% (versus 23%) of the population are in the most deprived tertile of Carstairs score (36% for special waste sites)	Yes

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
Laurian	Environmental injustice in France	France	Multi	Eight types of hazardous sites (industrial and nuclear sites, incinerators, waste management facilities) for all 36600 towns	Income Immigrant communities	Towns with high proportions of immigrants host more hazardous sites, even controlling for population size, income, degree of industrialization of the town and region	Yes
Foras-tiere	Health impact assessment of waste management facilities in three European countries	United Kingdom, Italy, Slovakia	Multi	905 urban solid waste landfills and 53 incinerators	Socioeconomic deprivation index	A direct relationship was found between low social class and residence near waste facilities in Italy and United Kingdom, and an inverse relationship was found in Slovakia	Yes (United Kingdom, Italy) Negative (Slovakia)
Dolk	Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study	Five European countries	Multi	21 landfills	Socioeconomic deprivation index	No overall evidence that socioeconomically more deprived communities live near to landfill sites	No
Fielder	Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis	United Kingdom	Single	1 landfill	Socioeconomic deprivation index	Most affluent people were found to be living closer the site	Negative
Martuzzi	Cancer mortality and congenital anomalies in a region of Italy with intense environmental pressure due to waste	Italy	Multi	227 legal (89) and illegal (138) waste sites	Socioeconomic deprivation index	A positive association was found at municipality level between a waste exposure indicator and socioeconomic status: more deprived people are more likely to live close the waste sites.	Yes

First author	Title	Location	Multi vs single site	Facility type/ variable used	Socioeconomic variables used	Main result	Gradient found? *
Vargas	The lack of environmental justice in central and eastern Europe	Hungary	Single	asbestos disposal site	Occupation	Working class people were found to be living closer the site	Yes
Steger	Making the case for environmental justice in central and eastern Europe	Countries of Eastern and central Europe	Multi	Hazardous sites and illegal waste disposal activities	Ethnicity	Hazardous sites and illegal waste disposal activities are disproportionally located in communities of ethnic or national minorities, predominantly the Roma (gipsy)	Yes
Harper	Environmental justice and Roma communities in central and eastern Europe	Countries of Eastern and central Europe	Multi	Hazardous sites and illegal waste disposal activities	Ethnicity	Hazardous sites and illegal waste disposal activities are disproportionally located in communities of ethnic or national minorities, predominantly the Roma (gipsy)	Yes
Ungváry	Roma colonies in Hungary – Medical care of children and hygienic conditions	Hungary	Multi	Illegal disposal sites Animal carcasses disposal sites	Ethnicity	15% of the 767 Roma colonies identified in Hungary, for a total of three million persons, are within one km of illegal waste disposal sites, and 11% within one km of animal carcass disposal sites	Yes

6. Social inequalities in environmental risks associated with global climate change

Authors
Sari Kovats & Paul Wilkinson
London School of Hygiene and Tropical Medicine
United Kingdom

Bettina Menne
WHO Regional Office for Europe, Rome office
Italy

Abstract

Background

Climate change is a complex environmental problem that acts over large spatial and temporal scales. Some warming has already occurred, but the majority of impacts are anticipated to occur in the future as the rate of warming increases. In the absence of studies that directly observed the impacts of climate change in the recent past (or project impacts into the future), the attribution of health impacts to climate change must be indirect. And the impact of inequalities must be inferred from a wide range of evidence.

Review methods/data

The main substance of the background paper is the review of evidence for inequalities in current climate-related health effects, these include: heat effects, cold effects, floods and wildfires. Some health outcomes do not have a clear current climate component, but they may be affected by future climate change. Therefore, we also briefly reviewed the evidence for current inequalities in health effects for the following exposures/outcomes:

- water, sanitation, hygiene
- vector-borne diseases
- foodborne diseases
- air quality

An addition issue is the implications of policies responses to climate change for environment and health risks (mitigation and adaptation policies). We briefly review the range of potential policies and evidence for their positive or negative effect on reducing inequalities.

Results

Inequalities in current climate-related effects

There is an emerging literature on the epidemiology of heat-related mortality and morbidity. Several papers have looked at socioeconomic determinants of heat related mortality but there is no evidence of difference in risk by population income group. The elderly are most affected by hot weather, but there is little evidence for effects on children.

Cold effects are addressed in the background paper on housing.

Flood exposure (flood risk) is not evenly distributed within or between countries. In some countries, such as the United Kingdom, coastal flood risk greater in low income groups. Elderly are most at risk of flood death.

For other potential impacts of climate change, health problems associated with lack of water, sanitation and hygiene demonstrate the greatest inequalities between countries. Evidence is limited on inequalities within countries/populations.

Adaptation policies (to address climate change) may reduce or increase inequalities. Evidence for the impact of related interventions is limited –but some transport interventions have been shown to reduce inequalities in exposures.

Conclusions

Climate change will have clear regional differences within the WHO European Region. Due to the lack of detailed studies or assessments on future or past impacts, projections of future impacts on inequities depend upon a range of assumptions. Differences in the capacity to adapt to climate change may increase inequalities, for example with heat-related mortality. It is therefore important that equity issues are considered for planning mitigation or adaptation policies, strategies and measures.

Introduction

Climate change is a complex environmental issue that will exacerbate many of the current environmental hazards in Europe. Unlike the other environment risks considered in this background document, the exposures (and health effects) have not yet occurred. Climate change is also considered a cross cutting theme as it will have a wide range of effects, and acts to exacerbate current inequalities in environmental health risks.

Climate change and health has been a focus of interest by WHO Europe since 1999 (Menne, 1999; Kovats et al., 1999). The Sixty-first World Health Assembly in 2008 recognized the potentially serious implications of climate change for human health (WHO, 2008; WHO Executive Board, 2008).

Issues of equity have been central to the arguments for mitigating climate change. The distribution of impacts across the world is one of the five “reasons for concern” identified by the Intergovernmental Panel on Climate Change (IPCC) (Smith et al. 2008). High-income countries are responsible for the greatest cumulative greenhouse gas emissions whereas low income countries are likely to suffer the worst impacts of climate change. This responsibility (of the polluter) is explicit within the United Nations Framework Convention for Climate Change as a commitment of high-income countries to support the least developed countries to address climate change (adaptation).

Little work has been done on quantifying likely future impacts on health. The global burden of disease study estimated the number of deaths due to climate change in 2000 (compared to 1961–1990 baseline climate). The distribution of attributable deaths is inversely related to per capita carbon emissions (Patz et al., 2005).

In addition to global inequity, climate change also raises questions of inter-generational equity – but this will not be considered further in this paper.

What is climate change?

The world's climate is changing. Globally, the rate of warming over the past 50 years (0.13 °C per decade) is nearly twice that of the past 100 years. The global mean temperature increase from the period 1850–1899 to 2001–2005 is 0.76 °C. In Europe, the warming trend has been +0.90 °C for 1901–2005 period. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) concluded that most of the warming since 1950 has been due to human actions. The global atmospheric concentration of carbon dioxide (the main greenhouse gas) increased from a pre-industrial value of 280 ppm to 379 ppm in 2005 – and is now approaching 390 ppm. This concentration far exceeds the natural range (estimated from ice cores) over the last 650 000 years (180–300 ppm).

It is important to distinguish between *climate change* and *climate variability*. *Climate change* is defined as a statistically significant departure from either the prior mean state of the climate or its variability, and persisting for an extended period (typically decades or longer) (IPCC, 2007). Climate change may be due to natural internal processes within the climate system, or external forces. The latter includes anthropogenic changes in the composition of the atmosphere and changes in land use. In this paper we use the term climate change to mean anthropogenic climate change caused by fossil fuel burning and other human activities.

Review methods

Climate change is large scale phenomenon, only apparent over large spatial scales, and over long time scales (decades or longer). It is therefore difficult to undertake empirical studies. In addition, it is relatively new concern for public health and the relevant evidence base is not yet established.

There are three main types of research study that can be reviewed with respect to climate change- with important differences in methods:

- present – learning, from observational studies, about the sensitivity of health outcomes to variations in climate and weather exposures;
- recent past – detection and attribution of changes in population health due to observed anthropogenic climate change; and
- future – scenario-based assessments of future health burdens, to estimate how climate change will affect health over coming decades.

With respect to the last category, few studies assessed the full chain of risk from climate change to health impacts and none have so far looked at inequalities in the health outcomes. Heat-related health effects by age group are the only exception.

There are very few studies of observed climate change impacts – the detection and attribution of health effects to observed climate change. Therefore, in this paper, we focus on the first types of study. We review the evidence of health impacts of a climate-

related health effects. Assumptions must then be made about whether these relationships will hold in the near term (over the next few decades).

Geographical scope

This review addresses the countries in the WHO European Region. Europe has a range of climates and will experience important differences in impacts in terms of rates of warming and changes in precipitation patterns. Therefore, we used the regional classifications for Europe used in the IPCC Fourth Assessment Report chapter on Europe (Alcamo et al., 2007) as displayed in Table 1: north, Atlantic, central, Mediterranean and east.

Empirical evidence by topic

This part of the review is restricted to epidemiological studies of current effects of weather/climate by health outcome/topic and effect modification by income group or other group (age). Studies of climate-related exposures in indigenous populations (such as in Arctic areas) were not reviewed due to lack of time.

Table 1. Summary of main expected impacts of climate change related to extreme weather events in Europe, assuming no adaptation (modified from Alcamo et al., 2007)

Sectors and systems	**Impact**	**Area**				
Water resources	Floods	↓↓	↓↓	↓↓	↓	↓↓↓
	Water availability	↑↑	↑↑	↓	↓↓↓	↓↓
	Water stress	↑↑	↑↑	↓	↓↓↓	↓↓
Coastal and marine systems	Beach, dune: low-lying coast erosion 'coastal squeeze'	↓↓↓	↓↓↓	**n/a**	↓↓	↓↓
	SLR- and surge-driven flooding	↓↓↓	↓↓	**n/a**	↓↓	↓↓↓
Property insurance	Flooding claims	**??**	↓↓	↓↓	**??**	**??**
	Storms claims	↓	↓↓	↓↓	**??**	**??**
Ecosystems	Fires	↑↑	↓	↓	↓↓↓	↓↓
Human health	Heat-related mortality/morbidity	↓	↓↓	↓↓	↓↓↓	↓↓
	Cold-related mortality/morbidity	↑	↑↑	↑↑	↑	↑↑↑
	Health effects of flooding	↓	↓↓	↓↓	↓↓	↓↓
	Food safety/Water-borne diseases	↓	↓	↓	↓↓	↓↓

Note: ↓ Red arrow indicates a negative impact. ↑ Blue arrow indicates a positive impact.

Heat-related health effects

Heat-waves have a significant impact on mortality and this is greater than the reported number of deaths or cases certified as due to classical heat illness. The excess mortality in Europe associated with the heat wave and hot summer of 2003 was 35 000 deaths in western European countries and 15 000 in France, the country most affected by the Heat-waves (Robine et al., 2008).

Elderly people are most at risk of heat-related mortality. Vulnerability to heat in old age occurs because of intrinsic changes in the regulatory system. Epidemiological studies of heat-related mortality show a larger effect in the elderly, with the risk increasing with increasing age above approximately 50 years old. However, children and babies also have limited ability to thermoregulate and are potentially at risk of dehydration and heat stroke. Three deaths in children from heat stroke occurred in France during the heat-wave in 2003 (Pascal et al., 2005) and one death was reported in the 2006 heat-wave (Empereur-Bissonnet et al., 2006).

Most studies of heat related mortality have used a time series approach. Other designs have also been used to assess modification of heat effects. The case-only approach has been used to quantify the effect of several risk factors but does not given an indication of the overall effect (Armstrong, 2003; Schwartz, 2005). Several case-control studies have also been undertaken on heat-wave events in Chicago (Semenza et al., 1996) and Paris (Vandentorren et al., 2006). These studies used live controls, and therefore may also be estimating factors that determine the risk of death per se, rather than the determinants of a heat-related death. Stratifying daily mortality series by subgroup can also be used to investigate effect modification (Gouveia et al., 2003; Hajat et al., 2007). However, the number of subgroups that can be investigated using this method is normally quite limited.

A review of the health effects of Heat-waves in Europe found no strong evidence of differences in risk between high and low income groups. No information on Heat-wave deaths in the homeless have been found but such populations are likely to be affected based on evidence from the United States of America. These studies are summarized in Table 2.

Table 2. European studies that compared heat-wave mortality by socioeconomic status

Population Event	Methods	Results	Reference
Rome, Italy 2003 heat-wave	Analysis of deaths registration data: 1094 excess deaths during three heat-wave periods	Excess mortality 5.9% in highest SES group compared to 17.8% in lowest SES group, compared to 23% excess in total. Possible confounding by age.	(Michelozzi et al., 2004)
Italy: 4 cities Bologna, Milan, Rome, Turin 2003 heat-wave	Case crossover design- for mortality. OR for dying on day with AT = 30 °C compared to 20 °C	Pooled results (all cities). In all adults (over 35), lowest 20 centile of income – difference not statistically significant.	(Stafoggia et al., 2006)

Population Event	Methods	Results	Reference
Barcelona, Spain June– August 2003	Multivariate Poisson regression. All deaths (> 20 years). Compared mortality rates in summer 2003 with mortality rates in previous summers (1998–2002). SES indicator was educational level, available via record linkage to Municipal Census.	No clear pattern of effect of SES within age-sex groups. Excess (number of heat-attributable deaths) greatest in low education group. Analysis using small area indicators found no effect of SES.	(Borrell et al., 2006)
France, 2003 heat-wave	Compared mortality in 2003 with the number of deaths observed from August to November 2003 in France was compared to mortality rates 2000 to 2002	The mortality of widowed, single and divorced subjects was greater than that of married people.	(Fouillet et al., 2006)

Occupational heat stress

Occupational health effects of heat are also important. Reviews for the US indicate that workers in the agricultural sector and construction are most at risk. Evidence from the France heat-wave of 2003 also indicated deaths from heat stroke in several workers, including truck drivers and horticultural workers. There is some evidence that migrant workers may be more at risk.

Cold related health effects

Climate change is likely to reduce the burden of cold mortality and morbidity in Europe (Langford and Bentham, 1995; Department of Health, 2002). The determinants of cold-related mortality are often linked to inadequate home heating. It is important to note that vulnerability to cold-related mortality and morbidity varies substantially between populations. The United Kingdom, for example, appears to have a larger seasonal fluctuation in mortality than many other countries of continental Europe and Scandinavia, despite the fact that it has relatively mild winters. Other countries with high rates of 'excess' winter mortality in Europe are Portugal and Spain (Healy, 2003). However, extreme cold weather only really occurs in northern Europe – so the impact of cold spells is mostly restricted to this region. There is some evidence of inequalities in the impact of cold spells as homeless people are at risk. Most exposures are in young adults however.

Wildfires

A wildfire is any uncontrolled, non-structure fire that occurs in the wilderness, forest, or bush. Fires are closely related to extreme climatology (temperature, drought) (Vazquez et al., 2002). Studies in Europe have shown that, in fact, a few (large) fires account for most of the burned area. Forest fires have been increasing, and in some areas, part of it has been due to changes in climate. Thus in south-western Europe, there is good

evidence that the increase in fires is due to climate change. There is good evidence that climate change will increase the risk of fires in Europe.

A review of the literature on fire events found very little information from Europe. There are several papers on the effect of biomass smoke on respiratory outcomes (hospital admissions) from the United States (Delfino et al., 2009) and Australia (Hanigan et al., 2008) but we found only one study from Europe (Greece) which is in press (Anatalis et al.).

There are clear geographical differences in risk with the hotter drier areas in southern Europe being most at risk. Further, these natural disasters particularly affect rural areas. Due to the lack of information on wildfire distribution or impacts, we found no published information on the populations most affected.

Flooding and health

Flooding is one of the most widespread of climatic hazards and poses multiple risks to human health, yet there has been little systematic research work on health outcomes and the means by which health systems respond to those risks. There are no studies that estimate the future health burden from flooding associated with climate change. A recent review of the epidemiological literature has described the range of health effects: drowning, injuries, mental illness, and infectious diseases (Ahern et al., 2005). In Europe, the burden of infectious diseases from floods is relatively low and therefore no major outbreaks have been associated with recent flood events, due to the relatively high standard of infrastructure.

Flood risk maps can be used to determine population at risk of flooding. The Joint Research Centre, Italy, has mapped (river) flooded areas in Europe, and the flood risk in terms of the economic damage due to direct contact with water and the number of people affected. However, these data have not yet been used in Europe to look at equity or vulnerability issues other than intercountry comparisons. Further, disasters databases report all cause mortality and have no information on age, sex or socioeconomic status of the person affected. One national study was found in the published literature. A spatial analysis in England and Wales linked the population in indicative floodplains with census data showed no clear differential by income in flooded populations (Fielding and Burningham, 2005). Further work by the United Kingdom Environment Agency on mapping populations at risk of flooding found that low income groups were disproportionately at risk of coastal flooding (the opposite is true for river flooding).

Water/Sanitation

Please see the background document on children. There is very limited published evidence, despite the clear disparities between high and low income countries within the European Region.

Outdoor air pollution

Climate change may increase background ozone levels in Europe. However, the results from atmospheric chemistry models are inconsistent. For information on environmental and health inequalities please see paper in background documents.

Foodborne disease

Bacterial gastrointestinal infections are sensitive to ambient temperature. Incidence may be affected by warmer summers. However, incidence is declining in many countries. One study in Denmark found that incidence was generally higher in higher income groups (Simonsen et al., 2008).

Vector-borne diseases

Some vector-borne diseases may change their range within Europe (e.g. leishmaniasis, tick-borne encephalitis). It is unlikely that "tropical" diseases such as malaria or dengue would become re-established in western Europe if control measures are maintained, but the risk of localized (autochthonous) outbreaks of malaria may increase.

The most important vector-borne disease in western Europe is tick-borne encephalitis (TBE), which has been increasing in recent years in central and eastern European countries. This is due to a range of factors including changes in human behaviour, changes in agricultural practices, and increased unemployment. Sumilo et al. (2008) found an association between the increased incidence of TBE and poverty indices.

Policy implications

It is important the equity issues are included in decision-making so that policies for climate change do not increase inequalities in health (O'Neill et al., 2009). This is an emerging area of research. So far there have no systematic reviews of the available policies and evidence regarding the interventions is limited.

Adaptive responses to climate change may not reduce health inequities because self-interested adaptation by those populations with most resources could increase the health gap (Friel et al., 2008). Adaptation policies for health are only just beginning to be developed. However, it is adaptation outside the health sector that is of concern, for example:

- water resource management: increased use of untreated or partially treated water wastewater;
- housing: increased use of air conditioning (or other space cooling) will likely increase the inequalities in heat-related mortality.

Mitigation policies have potential to reduce or increase inequalities:

- transport: congestion charge intervention showed most benefit in most deprived group (Tonne et al., 2008);
- energy: increased energy costs will disproportionately affect poorer households.

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7. Environmental inequalities among children and adolescents. A review of the evidence and its policy implications in Europe

Authors
Gabriele Bolte & Martina Kohlhuber
Bavarian Health and Food Safety Authority
Germany

David O. Carpenter
University at Albany, State University at New York
United States of America

Giorgio Tamburlini
Institute for Maternal and Child Health (IRCCS) Burlo Garofolo and Centre for the Health of the Child
Italy

Abstract

Background

During the past decade, the impact of socioeconomic inequalities in the living environment and in exposure to environmental pollution has increasingly been recognized as a major contributing factor in the production of health inequalities. Likewise the awareness of the importance of children's environmental health has been increased. Consequently, protecting children from undesirable environmental exposures by taking socioeconomic conditions into account has been identified as a policy priority area in Europe.

This review aimed to identify and discuss environmental inequalities among children and adolescents in Europe.

Review methods/data

A systematic literature search was conducted in various databases. Further sources for information were reports by WHO, EU and other organizations and drafts of topical review papers prepared 2009 as working documents for the WHO expert meeting.

Inclusion criteria for publications were: data from Europe, published since 2000, age group 0–18 years, socioeconomic factors considered as influencing factors, not merely as confounder.

Results were summarized according to the conceptual model that socioeconomic factors may impact on environmental health by the pathways exposure variation and effect modification.

Results

Most of the available evidence documents that a low socioeconomic position is associated with an increased exposure of children/adolescents to inadequate housing and residential conditions and less opportunities for physical activity. On community level

hazardous waste sites and illegal waste disposals are disproportionately often located in more deprived areas. Socially disadvantaged children are more likely to be exposed to mainly traffic-related air pollution, noise, lead, and environmental tobacco smoke. Scientific data on the impact of socioeconomic factors on water pollution/sanitation and on occupational exposures/working conditions of children and adolescents in Europe are lacking. There is clear evidence that children from low socioeconomic position and from less affluent areas tend to sustain or die from injury to a greater extent than others.

For most topics and exposures reviewed here there were no studies investigating the modification of the exposure-response function by socioeconomic factors.

Due to a variety of methodological approaches and studies on one hand and lack of data for many topics and countries on the other hand it was not possible to quantify the magnitude of environmental inequalities among children and adolescents in Europe.

Conclusions

Though patterns of environmental inequalities may vary across populations and countries, the overall pattern based on the available fragmentary data is that children living in adverse social circumstances suffer from multiple and cumulative exposures, are more susceptible to a variety of environmental toxicants and often lack environmental resources or access to quality health care to reduce the health consequences of environmental threats. Action is needed along the whole causal pathway of the social divide in environmental hazards with priority to policy measures aiming at removing socially determined differences in environmental conditions.

Introduction

At the start of the 21st century, all European countries are faced with substantial inequalities[9] in health within their populations. People with lower levels of education, occupation and/or income tend to die at a younger age, and to have a higher prevalence of most types of health problems (Mackenbach, 2006; Marmot et al., 2008). These health inequalities are one of the main challenges for public health throughout Europe, and there is a great potential for improving average population health by eliminating or reducing the health disadvantage of lower socioeconomic groups (Mackenbach et al., 2007). In recent years it became apparent that an increasing number of children are socially disadvantaged not only in poor societies but also in rich countries in Europe and that those social inequalities are widening. Social and economic policies have a determining impact on whether a child can grow and develop to its full potential and live a flourishing life; or whether its life will be blighted (Commission on Social Determinants of Health, 2008).

The precise ways in which the social determinants of health operate is an area of considerable research interest. While the general relationship between social factors and health is well established, the relationship is not precisely understood in causal terms (Kelly et al., 2007). It can be assumed that the pathways of influence are likely to be

[9] In this review the term ‘inequalities’ is used for mere description of socioeconomic differences in environment and health between groups of people without any further valuation. The term ‘inequities’, which is used in the section on policy implications, refers to those inequalities that are avoidable or can be redressed and are assumed to be unjust (WHO, 2009).

complex. In a common framework of interpretation socioeconomic factors are regarded as distal causes with their effects mediated by more proximal causes such as material living conditions, psychosocial factors, health-related behaviour, and access to health and social services (Bolte & Kohlhuber, 2005).

During the past decade, the impact of socioeconomic inequalities in the living environment and in exposure to environmental pollution has increasingly been recognized as a major contributing factor in the production of health inequalities (Evans & Kantrowitz, 2002; Brulle & Pellow, 2006; O'Neill et al., 2007). Basically, socioeconomic factors may impact on environmental health in two ways (Bolte & Kohlhuber, 2005; Kohlhuber et al., 2006).

First, exposure to environmental burdens (environmental "bads") as well as access to environmental benefits and resources ("goods") may differ according to socioeconomic position (exposure variation/exposure differential). Disadvantaged communities often face greater likelihood of exposure to ambient hazards. From a global perspective, the concept of exposure variation can apply to communities where those at a perceived disadvantage – whether due to their socioeconomic position, gender, ethnicity, immigration status, lack of land ownership, geographical isolation, political power, or other characteristics – puts them at disproportionate risk for being exposed to environmental hazards.

Second, given a certain level of harmful environmental exposure, socioeconomic factors may modify the health effects by influencing individual's vulnerability (effect modification/susceptibility differential). Factors such as nutrition, existing medical conditions, and access to health care, to transportation or to resources (e.g. fresh foods) have been suggested to be vulnerability factors that link social conditions with environmental hazards. These vulnerability factors characterize differential preparedness and differential ability to recover from exposure to environmental hazards. Psychosocial stress has been proposed to be a key component. When not counterbalanced by resources, place-based and individual-level stressors may lead to increased vulnerability to environmental exposures (Gee & Payne-Sturges, 2004; Morello-Frosch & Shenassa, 2006).

WHO has further expanded this conceptual model by distinguishing within the pathway 'exposure variation' between socioeconomic variation in environment conditions and socioeconomic differences in exposure (WHO Regional Office for Europe, 2009). In this framework model on the influence and effects of environmental inequalities, socioeconomic differences in exposure may occur due to mechanisms of education and health awareness. For example, having a gas heater at home does not necessarily lead to relevant exposure if operated correctly. Another example is that living in an urban area with high levels of air pollutants does not necessarily mean greater exposure to these air pollutants. Forastiere et al. (2007) argued for the situation in Rome that though people with a higher socioeconomic position lived more often in areas with higher air pollution, their exposure may not be higher because they were more likely to have second houses outside the city and spend less time in their urban neighbourhood.

This basic conceptual model of the relationship between socioeconomic position, environmental quality and health is assumed to be valid globally. It has to be underlined that environmental inequalities have several dimensions: inequalities among population

groups within a country or urban area, inequalities across countries, and inequalities between generations (EEA & WHO Regional Office for Europe, 2002).

Awareness of the importance of children's environmental health has been increasing during past years. The study of the burden of disease attributable to environmental factors among children and adolescents in Europe showed that large proportions of deaths and DALYs are attributable to the selected environmental factors outdoor and indoor air pollution, inadequate water and sanitation, lead exposure, and injuries with pronounced differences between European subregions (Valent et al., 2004).

Consequently, protecting children from undesirable environmental exposures has been identified as a policy priority area in the Declaration and Children's Environment and Health Action Plan for Europe (CEHAPE) adopted at the Fourth Ministerial Conference on Environment and Health held in Budapest in 2004 (WHO Regional Office for Europe, 2004a, 2004b). CEHAPE states: "children's exposure to environmental hazards is influenced not only by the state of the physical environment but also by socioeconomic conditions and individual and group behaviour" (WHO Regional Office for Europe, 2004b). Therefore the CEHAPE recommends poverty reduction in terms of policies addressing the multidimensional aspects of poverty among children as one effective action for protecting children's health.

The joint report of the European Environment Agency and the WHO Regional Office for Europe (2002), a review of evidence on children's health and environment, pointed to the growing evidence throughout Europe that the most disadvantaged groups, and children and pregnant women among them, suffer from the worst environmental conditions. It seems to be a common pattern that poor children are confronted with widespread environmental inequalities in terms of accumulation of multiple environmental risks (Evans, 2004). The cumulative risk of exposure due to substandard housing and insufficient physical structure and infrastructure of the immediate environment can contribute both directly and indirectly to a variety of adverse health outcomes (Hornberg & Pauli, 2007).

However, major gaps still remain in the knowledge of the magnitude and distribution of the environmental burden of disease and of environmental inequalities among the young (WHO Regional Office for Europe, 2005a).

Based on the assumption that environmental factors and socioeconomic factors are inextricably intertwined, the impact of socioeconomic factors on environmental exposures and children's health in Europe has recently been reviewed within the EU-funded network PINCHE (Policy Interpretation Network on Children's Health and Environment) (Bolte & Kohlhuber, 2005; Kohlhuber et al., 2006). PINCHE focused on the four themes indoor and outdoor air pollution, carcinogens, neurotoxicants, and noise. Key results were that there was a lack of information to evaluate and quantify the effect of socioeconomic factors on environmental exposures and children's health in Europe, especially eastern Europe. The common pattern based on the available fragmentary data was, that in most cases there is evidence of an inverse social gradient with increased exposures and health disturbances in children of lower socioeconomic position. For a child, living in circumstances of low socioeconomic position is a proxy for multiple environmental exposures.

The unique vulnerability of children and adolescents

"Children" is a term commonly used to describe individuals from birth until puberty, while adolescence is from puberty to age 18 or 20. But there are many different developmental stages over this period of time, and these differences must be recognized in evaluating vulnerability. Exposure during the development of an organ system is likely to result in more harm and less reversible harm than comparable exposure later in life (Makri et al., 2004; Selevan et al., 2005). While growth and development occurs over this full age range, it occurs more rapidly during the prenatal period and in the early years of life, and because organ systems are developing more rapidly at this period the vulnerability is greater than in older adolescents.

There are several factors that must be considered when approaching the issue of social inequalities with regard to children.

The first is that children, by virtue of the fact that their organ and systems are still developing, are more vulnerable in general than are adults to environmental exposures (windows of vulnerability (EEA & WHO Regional Office for Europe, 2002)). As a consequence, they suffer from health consequences that have no counterpart in adult life.

Second, children are more frequently exposed than adults to a variety of environmental toxicants. As is well known, very young children breath more air, drink more water and eat more food per unit of body weight than does an older child or an adult, and thus the intake of toxicants from the same environment can be quite higher in young children compared to older children or adults (Landrigan & Garg, 2005). Young children also tend to have a living area closer to the ground or floor, resulting in a somewhat different exposure to some air pollutants or to contaminated soil than that in a large, upright person.

Third, children's metabolic pathways, especially in fetal life and in the first months after birth, are immature. Thus children's ability to metabolize, detoxify, and excrete environmental agents differs from that of adults (Landrigan et al., 2004).

Fourth, early exposure gives time enough for long latency agents to produce adverse health effects: this is typically the case for cancer (Soffritti et al., 2008), or to produce early modifications that lead later to health disturbances such as respiratory disease (Vonk et al., 2004) or hypertension (Barker et al., 2002; Hardy et al., 2003).

Finally, children are less aware of the risk and have less control over their environment than adults.

Thus, social inequalities impart a disproportionate elevation in hazard to deprived population groups at all ages, but again this is particularly true for children from poor households and deprived communities. The peculiar vulnerability of children to environmental agents acts by multiplying the effects of social inequalities.

Aims

The starting point of this review were the results of previous reviews indicating major gaps in knowledge, especially a lack of information to evaluate and quantify the effect

of socioeconomic factors on environmental exposures and children's health in Europe (e.g. Bolte & Kohlhuber, 2005, 2008).

This review therefore aimed to identify and discuss social inequalities in children's environment and health in Europe by re-evaluating the current evidence base for environmental inequalities among children and adolescents in Europe.

The term "inequalities" is used for mere description of socioeconomic differences in environment and health between groups of people without any further valuation. The term 'inequities', which is used in the section on policy implications, refers to those inequalities that are avoidable or can be redressed and are assumed to be unjust (WHO Regional Office for Europe, 2009).

Key issues were housing/built environment, air pollution, water pollution, waste, and unintentional injuries.

Though this review concentrated on the period from birth until adulthood, it is acknowledged that the prenatal development is an important critical window for exposures (Selevan et al., 2000). Specifically, the aims were:

- to summarize the evidence on the aforementioned key issues given in peer-reviewed publications, international reports, and in the drafts of topical review papers prepared 2009 for a WHO expert meeting;
- to summarize the evidence on diverse socioeconomic indicators;
- to summarize the evidence on the magnitude of environmental inequalities among children and adolescents;
- to identify mechanisms how social inequalities in environmental exposures and health effects develop;
- to identify the most affected social groups;
- to identify specific settings where unequal distributions of environmental risks occur;
- to discuss the policy implications using a public health approach.

Review methods/data sources

This chapter gives a short overview of the methods and summarizes the evidence on environmental inequalities among children and adolescents in Europe. The literature for this review was retrieved from three sources:

1. a systematic literature search of reviews and original articles published in peer-reviewed journals;
2. international reports by WHO, EU and other organizations; and
3. the drafts of topical review papers prepared in 2009 for a WHO expert meeting.

Systematic literature search

A systematic literature search was conducted in May 2009 in the Medline database, in Science Citation Index, Current Contents, SocINDEX and PsychINDEX. In the Medline

database the search was conducted with the MeSH Terms “socioeconomic factors” AND “environmental pollution” OR “housing” OR “accidents” OR “lead.” Furthermore the keywords “sanitation,” “waste,” “environmental justice” and “social justice” were searched in all fields. To exclude articles regarding adults, search was always conducted with the MeSH Terms “child,” “child, preschool,” “infant” and “adolescent.”

Current Contents, Science Citation Index and PsychINDEX were searched with the keywords “child” AND “socioeconomic” OR “social” AND “environment.”

SocINDEX was searched with the keywords “child” AND “environmental pollution” OR “environmental justice” OR “environmental exposure.”

Thus, the literature search focused on the two basic mechanisms exposure variation and effect modification by socioeconomic position. It searched specifically neither for social inequalities in children’s health nor for policy papers or intervention studies.

Gender inequalities in environment and health are already discussed in another chapter of this review document (see Chapter 10).

Screening of abstracts

Abstracts were further evaluated by using the following inclusion criteria:

- original studies conducted in Europe (including Israel and countries of the former USSR) or reviews;
- English language, published since 2000;
- age group 0–18 years (children and adolescents);
- socioeconomic differences in children’s environmental exposures or environmental health at an individual- or area-level must be described in the abstract; mere inclusion of indicators of socioeconomic position as potential confounder in analyses or the description of the sociodemographic characteristics of the study population was not sufficient;
- exposures: outdoor and indoor air pollution including environmental tobacco smoke, lead, noise, housing/built environment (also impact of built environment on physical activity), water pollution, waste and other environmental exposures. In addition: unintentional injuries (e.g. road traffic accidents, poisoning, drowning, injuries due to fire or falls).

In total, 674 abstracts were eligible for further evaluation after the first screening of the publications identified by the initial systematic literature search. After evaluation of the abstracts, 134 publications remained for further analysis. An overview of the literature search and the results is given in Appendix 1.

Reports

Major reports published by WHO, EEA or other institutions since 2000 were collected in May 2009 based on search of these institutions’ web sites. Inclusion criteria for reports were:

- published since 2000;

- thematic focus on children's (environmental) health in Europe or health inequalities or environmental conditions/exposures;
- published in English.

One exception was made by inclusion of the report *Socioeconomic factors and environmental exposures in Germany* (Bolte & Kohlhuber, 2008) in order not to exclude all the evidence published in German only. A list of all reports considered for this review is given in Appendix 2.

Topical review papers

Drafts of topical review papers prepared 2009 as working documents for the WHO expert meeting on environmental inequalities were obtained from WHO in July 2009. These review papers covered ambient air quality (Chapter 1 of this review document), housing and residential location (Chapter 2), unintentional injuries (Chapter 3), the working environment (Chapter 4) and waste management (Chapter 5).

The evidence of social inequalities in children's environment and health given in these review papers was extracted.

Empirical evidence on social inequalities in children's environmental conditions in Europe

The following sections are structured according to the two basic mechanisms exposure variation by socioeconomic factors (exposure differential) and effect modification by socioeconomic factors (susceptibility differential).

Housing and built environment as an overall topic

Housing and built environment are a cross-cutting issue comprising aspects such as quality of housing (e.g. temperature, ventilation, dampness, moulds, vermin), indoor air pollution (due to heating and cooking), outdoor air quality, noise exposure, water quality, flooding, proximity to waste sites, lack of green space, road safety and crime, community cohesion, access to facilities and factors encouraging physical activity. Poor housing conditions are strongly correlated with disadvantaged socioeconomic position and therefore housing is often used as a proxy for the socioeconomic position (Chaudhuri, 2004).

The built environment and housing conditions can have a significant impact on health and health inequalities. According to the Commission on Social Determinants of Health (2008:4), "communities and neighbourhoods that ensure access to basic goods, that are socially cohesive, that are designed to promote good physical and psychological well-being and that are protective of the natural environment are essential for health equity".

Exposure variation

Most of the studies on housing in several countries demonstrated that poor and less affluent population groups are most exposed to environmental risks within the private home (e.g. biological and chemical contamination, temperature problems, sanitary equipment) as well as within the residential context (e.g. closeness to polluted areas, lack of urban amenities and public safety, neighbourhood incivilities such as litter)

(Chapter 2). Especially in eastern Europe deteriorating housing conditions were observed.

Specific data on children for some of these housing issues are given elsewhere in this review and have been summarized before in the report for the EU project PINCHE (Bolte & Kohlhuber, 2005).

A recent review of the evidence on environmental inequalities in Germany confirmed this overall pattern of more adverse housing conditions in socially disadvantaged (Bolte & Kohlhuber, 2008). For example, single oven heating, crowding, damp housing and living near roads with heavy traffic was associated with a lower socioeconomic position in several cross-sectional studies in school beginners (du Prel et al., 2005, 2006; Bolte & Fromme, 2008).

Social differences were repeatedly reported for biological indoor pollutants such as allergens and endotoxin in house dust. However, the results are mixed. Whereas exposure of children to the cat allergen Fel d 1 seems to be higher in families with a low socioeconomic position, exposure to the dust mite allergen Der f 1 seems to be more common in families with a high socioeconomic position (Chen et al., 2007; Bolte & Kohlhuber, 2008). The dust mite allergen Der p 1 is known to be positively correlated with dampness in homes. Since studies from several countries indicated that dampness in homes is more common in case of a lower socioeconomic position, social differences of exposure to Der p 1 are likely, too.

In the United States, there is evidence that homes in high-poverty areas, families with a low income or with a low maternal education are more likely to have high levels of cockroach, rat and mice allergens but lower levels of dust mite allergens (Bolte & Kohlhuber, 2005). However, the housing conditions in Europe are quite different between the countries and when compared to the United States.

Data from Germany indicated that parents with a lower socioeconomic position felt more often impaired by a lack of accessible green space in their living environment in both urban and rural settings (Bolte & Fromme, 2008).

The evidence from industrialized countries (not further specified for children) suggests that opportunities for physical activity are often determined by individual socioeconomic status as well as the socioeconomic determinants in the neighbourhood where people live. Socially disadvantaged people and those who live in neighbourhoods of lower socioeconomic status (deprived areas) may have limited opportunities for physical activity (WHO Regional Office for Europe, 2007).

A study in the Netherlands showed that children's physical activity was associated with certain modifiable factors of the built environment such as proportion of green space, residential density or general rating of activity-friendliness of the neighbourhood (de Vries et al., 2007).

Fear of traffic can be a powerful deterrent to parents' allowing their children to walk or cycle to school or play outdoors, especially in deprived areas, because poorer children are more likely to live in urban areas with poor road safety and high-speed traffic (WHO Regional Office for Europe, 2006).

Characteristics of the built environment such as heavy traffic in residential areas and living in segregated marginalized neighbourhoods shorten the radius within which children can be active and reduce the activities in their living space. Resources such as parks, green areas and free playing areas which encourage physical activity and so indirectly influence health behaviour and status are rare in sociostructurally disadvantaged residential areas, and when available, quality is usually low (Hornberg & Pauli, 2007).

Ellaway et al. (2007) showed that in Glasgow, Scotland, more play areas per total population as well as per child were in deprived districts as measured by the Carstairs index (containing crowding, unemployment, social class and car ownership). This result also contrasts with data on sporting facilities in Glasgow. However it is not clear whether the playgrounds in deprived areas are enough to compensate for a probable lack of private gardens in the more affluent areas. Also the quality of the playgrounds was not assessed in depth.

A recent review on built environment and health inequalities in United Kingdom argued that "a main issue is the lack of space for children to play as they get older with a concentration on environmental problems in the surrounding areas and a sense of insecurity on streets, in parks and play areas" (Power et al., 2009:8).

There is some evidence in Europe that ethnically marginalized children tend to live, play and go to school in more environmentally hazardous areas. This has been described especially for central and eastern Europe (Hajioff & McKee, 2000; Steger, 2007), but also for example for five camps of Roma people in Italy in terms of conditions such as overcrowding, stagnant water in the camp, use of wood burning stoves and insufficient sanitation like lack of access to water and toilets (Monasta et al., 2008).

Chapter 2 of this review document summarizes the evidence on housing inequalities among children by giving three key messages.

1. The main cause of inequality of housing and residential location affecting children is related to the social status, and mostly the income and the economic resources of the households.
2. In most of the cases, low social and economic resources of their families are associated with increased children's exposure to inadequate housing and residential conditions (such as noise, indoor and outdoor air pollution, crowding, and to some extent lack of access to green spaces). In less developed countries, water and sanitation concerns become fundamental as well. However, there are some examples showing that the burden of unequal distributions is not by default to the disadvantage of the poor population subgroups, as some exposures (especially in relation to indoor contamination) tend to be more frequent for high-income households. Nevertheless, the overwhelming proportion of relatively increased exposures is definitely faced by the poor.
3. Almost all described exposure situations relate to the building and the neighbourhood, where children are affected as all other household members although – depending on behaviour, time spent at home etc. – some variation in exposure can be possible.

Effect modification

There have been no studies identified which investigated the modification of the exposure-response function in terms of housing/residential location and health outcomes by socioeconomic factors among children and adolescents in Europe.

Indoor air quality: the case of environmental tobacco smoke

Exposure variation

The evidence on social inequalities in children's exposure to environmental tobacco smoke (ETS) in Europe published until 2004 has been summarized within the EU project PINCHE (Bolte & Kohlhuber, 2005), consistently indicating across several countries that social disadvantage is associated with a higher or rather more frequent prenatal and postnatal exposure of children to ETS.

More recent studies further support this finding: A study on 245 schoolchildren in Liverpool, United Kingdom, showed that a low socioeconomic status of the household was a risk factor for childhood ETS exposure (Delpisheh et al., 2006). A low parental educational status was associated with a higher prevalence of children's ETS exposure at home in a study with 1737 preschool children in Tyrol, Austria (Horak et al., 2007).

In Germany, ETS exposure is more frequent among socially disadvantaged children (review of the evidence published until 2007 and including results of the German Environmental Survey 2003–2006 (GerES IV) for Children: Bolte & Kohlhuber, 2008). Two recent studies provided more data: In a cross-sectional study on 968 preschool children living in a restricted area of North Rhine-Westphalia, Germany, Hoffmann et al. (2009) found that more children from underprivileged social groups, characterized by low parental educational attainment, foreign nationality or immigration background, unemployment and relative poverty, were exposed to ETS. Low parental education, unemployment, low household equivalent income, non-German nationality and single-parent family were independently associated with children's ETS exposure at home in two surveys of 12 422 preschool children conducted 2004–2006 in three urban and three rural areas in Bavaria, Germany (Bolte & Fromme, 2009).

Many studies reviewed here used questionnaire data and parental reports on smoking habits in the child's home which may be biased. However, studies in several European countries using human biomonitoring to assess exposure more objectively (e.g. measurement of cotinine) confirmed that social inequalities in children's exposure to ETS are widespread.

Effect modification

There have been no studies identified which investigated the modification of the exposure–response function in terms of ETS exposure and ETS-related health outcomes by socioeconomic factors among children and adolescents in Europe.

Water/sanitation

Exposure variation

The WHO report on children's health and environment (WHO Regional Office for Europe, 2005b:15) summarized that:

> biologically contaminated water causes a range of waterborne diseases. A variety of known viruses, bacteria and parasites can contaminate drinking-water and cause gastrointestinal diseases in infants and young children. Mortality and morbidity due to waterborne gastrointestinal diseases – mainly those that cause diarrhoea – are still high in countries and communities where a substantial proportion of the population lacks access to clean water and proper sanitation. This is the case in many countries in the European Region, particularly in south-eastern Europe, the Caucasus and central Asia, and for a significant number of disadvantaged minority groups in other countries in the Region.

The search for the keyword "sanitation" gave mainly papers on the fluoridation of water and children's dental health which were not included in this review. No literature was found that studied the topics water and sanitation in connection with socioeconomic position in a general population in Europe. Only one study has been identified on health problems in small disadvantaged minority groups like Roma children living in camps in Italy with lack of water and insufficient sanitation (Monasta et al., 2008).

Effect modification

For the topic water/sanitation there are no studies on effect modification by socioeconomic positions.

Waste

Exposure variation

As with the topic water and sanitation there were no studies identified by the systematic literature search. Reports (Pye et al., 2008; WHO Regional Office for Europe, 2005a) and Chapter 5 of this review document by Martuzzi et al. summarized from European data that deprived population groups are more likely to live near waste sites and waste incinerators. On community level hazardous sites and illegal waste disposals are disproportionately often located in more deprived areas. Although there are no data specifically on children, it seems likely that this is also true for children.

According to Martuzzi et al. (Chapter 5 of this review document) the evidence:

> indicates that there is a tendency in poorer, less educated, disadvantaged people or ethnical minorities (highly correlated characteristics) to live closer and be more exposed to waste treatment facilities of any kind; and, in addition, that when adverse health effects due to such proximity are detected, these are compounded (usually multiplicatively) with the effects, also adverse, of social disadvantage.

Ethnic minority groups such as Roma communities in central and eastern Europe have been shown to live more often on or near waste sites, floodplains, and suffer from lack of provision of basic utilities including clean running water (Steger, 2007; Steger & Filcak, 2008).

Effect modification

Effect modification, that is interaction between socioeconomic factors and waste exposure, has not been tested and reported (see Chapter 5). Therefore the question whether disadvantaged people, besides being disproportionally exposed to waste-related

environmental risk, are also more vulnerable to its impacts cannot be answered until now.

Chemicals: the case of lead

The protection of children against toxic chemicals in the environment is a major public health challenge (Landrigan et al., 2004), but scientific evidence on the relationship of socioeconomic position and exposure to chemicals is scarce in Europe. Therefore we included only a preliminary section on lead in this review.

Exposure variation

Only a few studies on lead exposure and health outcomes in children like cognitive ability and development in east and central Europe could be reviewed within the PINCHE project (Bolte & Kohlhuber, 2005). A reason may be that probably environmental lead poisoning is not an issue in the western European countries any more, hence there is lack of any data on environmental lead exposure. Another reason may be that data on lead exposure have been published in the national language only; this may be the case in France, for example. In some central and eastern European countries lead exposure may still be of concern and pose higher public health concern compared to western countries due to poorer maintained environment, worse housing conditions and lower socioeconomic position. For example, a study in the Ukraine demonstrated significantly increased blood lead levels in children of fathers who worked in manual labour jobs. Risk factors for high blood lead levels were father's occupation and maternal smoking indoors (Friedman et al., 2005).

Overall recent reviews of data in Europe showed that children from families living in adverse housing conditions or with lower socioeconomic position have higher blood lead levels (Bolte & Kohlhuber, 2005, 2008). In accordance with this, the European Environment and Health Information System (ENHIS, 2007) mentioned poor housing quality and poor socioeconomic position as one of other determinants of higher blood lead levels in children. However, single studies or certain populations may give conflicting results. For example, a study in Swedish adolescents found no social differences in serum and blood lead levels (Barany et al., 2002).

Effect modification

Bellinger (2008) stated in a review that children growing up in disadvantaged circumstances showed lead associated developmental deficits at lower blood or tooth lead levels than more advantaged children. Also the deficits were of greater magnitude in disadvantaged children and these children were less able to compensate or recover from lead associated neurodevelopmental deficits. Reasons for this effect modification might be co-exposures to other chemicals, genetic and epigenetic processes, nutrition, stress and stimulation by the social environment.

Noise

Exposure variation

Apart from the literature already reviewed within the PINCHE project (Bolte & Kohlhuber, 2005) and in the recent review for Germany (Bolte & Kohlhuber, 2008), no further more recently published studies were identified by the systematic search for this review.

In accordance with the fact that socially disadvantaged families tend to live more often near busy roads, noise annoyance due to traffic is often higher in people with a lower socioeconomic position (Bolte & Kohlhuber, 2008). The German Environmental Survey 2003/06 (GerES IV) for Children demonstrated that socially disadvantaged children aged 8–10 years felt more often annoyed by road traffic noise than children in higher socioeconomic position (Babisch, 2009). Moreover, besides social inequalities in noise annoyance there are social inequalities in exposure to noise: A recent study in Germany showed for children living in Munich that there is an association between relative poverty and high traffic noise exposure estimated by noise maps (Kohlhuber et al., 2009). A report from the Transport, Health and Environment Pan-European Programme (THE PEP) stated for the Netherlands that low-income groups had to deal with more than average with high noise exposure (above 65 dB(A)) and lived less than average in quit areas (below 50 dB(A)) (WHO Regional Office for Europe & UNECE, 2004).

A few papers were published on noise exposure, annoyance and school performance in schoolchildren around Heathrow Airport in West London (Haines et al., 2001, 2002; Bolte & Kohlhuber, 2005). The samples of children were matched by social deprivation but descriptive results showed that children from high-noise schools were more likely to be non-white and to speak another language than English as first language at home. The proportion of children from manual social class households and deprived households were also slightly higher in the high-noise schools.

Effect modification

Stansfeld et al. (2000) pointed out that health effects of environmental or domestic noise may be influenced by socioeconomic factors like deprivation, housing conditions and the relationship with neighbours.

The RANCH study on road traffic and aircraft noise exposure and children's cognition and health in schools around airports in the Netherlands, Spain and the United Kingdom gave mixed results for effect modification. On one hand there was no effect modification by socioeconomic position concerning the association of aircraft noise exposure at school and impairment in reading comprehension (Stansfeld et al., 2005; Clark et al., 2006). On the other hand, van Kempen et al. (2009) reported higher annoyance due to aircraft and road traffic noise at school in children of mothers with higher educational status and the effect of road traffic noise on cognitive tests on episodic memory was stronger for children living in crowded homes (Stansfeld et al., 2005).

Air pollution

Exposure variation

WHO (Kinney & O'Neill, 2006: 135) has stated that:

> there is emerging evidence of inequities among the population in adverse health effects due to air pollution, as well as of links between the spatial distribution of pollution sources and the presence of certain population subgroups. … Data are still limited, but some evidence suggests that people who live, attend school and/or work near local sources such as traffic may … tend to be of lower socioeconomic position than the general population. Greater relative impacts of air pollution on mortality risk associated with long-term exposure have been seen for persons of lower socioeconomic

position, while evidence is mixed for such differences in acute effects on mortality and hospital admissions.

A report on children's environment and health strategy for the United Kingdom indicated that there are inequalities in the distribution of air pollution, with the most deprived areas in England, Scotland and Northern Ireland generally experiencing higher pollutant concentrations. It was supposed that this would be largely because most deprived communities are in urban areas, which typically experience higher levels of air pollution (Health Protection Agency, 2009).

For children, recent reviews of data in Europe summarized that children in lower socioeconomic position live more often in areas with decreased air quality and more often near streets with heavy traffic (Bolte & Kohlhuber, 2005, 2008).

Deguen & Zmirou-Navier (see Chapter 1 of this review document) stated in their review on ambient air quality that children may represent a particularly exposed group and that the exposure contrasts might even be greater among children than among adults. One reason is that outdoor air pollution tends to be more misclassified for the adult population than for children. Another reason is that schools are generally located where the children live and thus the air pollution level at school is close to the home level.

However, current evidence on social inequalities in children's exposure to air pollutants in Europe is still scarce.

Chaix et al. (2006) showed in a spatial scale study located in Malmö, Sweden, a gradient in the exposure of children to NO_2 at home and at school from the highest levels in children living in low income areas or residences to lowest levels in high income areas or residences.

A study in three districts in Moscow, the Russian Federation, demonstrated that children living in a highly polluted area were more disadvantaged (measured by household income and maternal education) than children in a district with low air pollution (Eroshina et al., 2004). The main sources of pollution in the highly polluted district were a large oil refinery, heavy traffic and indoor pollution due to ETS and cooking with gas. Also, children in the highly polluted area spent more time playing outside.

In Germany, social differences in terms of higher exposure mainly to traffic-related air pollution have been repeatedly shown for children (review: Bolte & Kohlhuber, 2008). Repeated cross-sectional studies in Bavaria, Germany, revealed that in both urban and rural settings children living in poverty were more likely to be exposed to traffic-related air pollution (Bolte & Fromme, 2008). In a study of an industrial hot spot area in North Rhine-Westphalia, Germany, Hoffmann et al. (2009) found a higher exposure to total suspended particulate matter (TSP) in children living in lower socioeconomic position characterized by foreign nationality or immigration background, low parental education and vocational training, unemployment and poverty.

Effect modification

In the meantime several studies in European countries have been published on the effect of socioeconomic position on the air pollution – health relationship in adults. Though studies on different air pollutants, exposure levels and locations suggest disproportionate health impacts for children (see Chapter 1), to our knowledge there is

up to now no study explicitly investigating effect modification of socioeconomic position on the relationship between air pollution and health among children in Europe.

One study in Strasbourg, France, included children and adults: Laurent et al. (2009) found no clear relationship between area based socioeconomic position and small area modelled air pollution (NO_2, O_3, PM_{10}). Children aged 0–19 years lived more often in deprived areas compared to adults aged 20–39. The sales of short-acting β-antagonist drugs as an indicator for asthma attacks were associated with higher concentrations of atmospheric pollutants but not with socioeconomic position in multivariate analyses. Also socioeconomic position did not modify the effect of air pollution on asthma.

Based on data of a study in Mexico on infant mortality (1 month – 1 year of age) and ambient PM_{10} levels on days before death Romieu et al. (2004) suggested that both micronutrient deficiencies and concurrent illnesses might decrease immune response and render children of low socioeconomic position more vulnerable to the adverse effects of air pollution.

Unintentional Injuries

Social inequalities in unintentional injuries in children (e.g. road traffic accidents, poisoning, drowning, injuries due to fire or falls) have been extensively reviewed in the recent WHO report by Laflamme et al. (2009) and especially summarized for children in the topical review paper prepared for this review document (see Chapter 3); the authors emphasized that childhood injuries are one of the major causes of premature death and disability in the WHO European Region.

Most of the studies on socioeconomic position and unintentional injuries in children identified by our systematic literature search have been already evaluated in these reviews. Therefore we do not repeatedly describe single studies but cite the main conclusions of the review on children in Chapter 3. The authors summarized the current state of knowledge regarding socioeconomic differences in unintentional injuries among children:

> Traffic-related injuries are by far the most studied injury cause, followed by falls and recreational injuries. The studies, though numerous, come from a few high income countries and the evidence at hand is therefore mainly representative of some types of governments, economies, and forms of social stratification. These studies very often show that children from low socioeconomic status and from less affluent areas tend to sustain – or die from – injury to a greater extent than others. This applies to most causes of injury and for several settings (e.g. home, work, transport). While little is known regarding the nature of the mechanisms lying behind those differences, a variety of individual and contextual ones might come into play. These may vary by cause of injury, sex and age group of the child and the setting in which the injury occurred.

Socioeconomic inequalities in injury occurrence and consequences may be due to (1) differing opportunities for safety, (2) differing opportunities to avoid risk, and (3) differing access to/use of medical care. Likewise Towner (2005) suggested several ways how socioeconomic factors may affect injury risks: Lack of money (e.g. parents may not be able to buy safety equipment), increased exposure to hazardous environments (e.g. lack of a garden or facilities for safe play), ability of parents/carers to supervise children (e.g. single parent families), children's attitudes and behaviour (risk-taking)

and access to information and services. Laflamme et al. (Chapter 3) formulated specific key messages on children.

1. There are disparities in several environments – traffic is studied more often. Although there is an abundant literature on socioeconomic differences in childhood injuries, the whole injury panorama is unevenly covered. Injuries sustained in the road traffic environment have been extensively covered – and the bulk of the evidence indicates that children from less affluent backgrounds are at greater risk as pedestrians, cyclists, and car riders at all ages. Disparities in those injuries occurring in and around the home (e.g. falls, burns, and poisonings), often sustained among younger children, are far less researched, but there is supportive evidence that they too may be over-represented among children from less affluent background.
2. Lower status – greater risks. Socioeconomic differences in childhood injuries appear to be common, both when all injuries are aggregated and when specific causes or circumstances are considered. Differences arise not only as regards injury mortality but also various severity measures (e.g. hospitalization, emergency department visits, long bone fractures, head injuries).
3. Greater severity – greater disparities. Studies indicate that the more severe the injury, the greater the socioeconomic differences. In other words, children from households with low socioeconomic status and from less affluent areas tend to die by injury or get severely injuries to a greater extent than others. This has been observed for most causes of injury (e.g. traffic, poisoning, burns) and also for several settings (e.g. home, work, transport).
4. Variation with age or with setting? Not only does the injury panorama vary with age of the child but this may also be the case with the magnitude of the socioeconomic disparities. … For instance, for some injury causes – and settings – socioeconomic disparities increased with increasing age (e.g. road traffic injuries as car riders and drivers in Sweden). For other causes and in other settings, disparities were relatively constant (e.g. in Trent; admission for fall-related injury and injury of high severity).
5. Few countries contribute evidence. The evidence is mainly representative of some types of countries (governments and economies) and does not encompass many forms of social stratification. Within Europe, the bulk of it stems from high-income countries and, most often, countries from the North.
6. One description does not fit all. Despite considerable socioeconomic disparities in injuries of various kinds, it ought to be underlined that not all children from lower socioeconomic status or deprived areas get injured. And not all injured children come from a deprived family or environment.
7. Gender-related socioeconomic disparities are under researched. The vast majority of the studies reviewed treated boys and girls in an aggregated manner. It is very likely that, as explained by some authors, although there are considerable gender differences in the risk for children and adolescent to sustain an injury, there are no obvious reasons why socioeconomic affiliation would have different impact of the risk distribution of boys than girls. It is possible that the age of the child matters in this respect but empirical evidence on this is lacking.

Exposure variation

One likely explanation for the safety divide is that the higher injury rates for children – and older people – from less affluent areas or families are merely reflection of rather systematic differences in living, commuting and working conditions (compositional differences). There are strong reasons to believe that – over and above family attributes – children from less affluent families and areas live and develop in environments that are intrinsically more hazardous.

In addition to differential environment conditions, the concept of differential exposure refers to being unequally exposed to various extraneous sources of danger that can be found in one's environment, such as living, playing, commuting and learning circumstances. When exposure is high, the likelihood of injuries occurring is increased due to one or several of the following mechanisms: more elements of the surroundings can be harmful, the consequences of making mistakes may be more immediately injurious, and injury avoidance is not a primary and conscious aim of all instances (in particular but not exclusively in the very young). Exposure is not only to be measured in the number of hazards but also in the duration of exposure (see Chapter 3).

Effect modification

The concept of differential susceptibility links the existence of safety differences between people to their social affiliation. Theoretically, related (dis)advantages may be regarded as either inherited (i.e. genetic predisposition) or under the influence of class attributes (e.g. educational, material, and influential assets).

In the public health sector, this mechanism is often attributed to differences in knowledge and practice and therefore efforts are deployed to provide "people at risk" with information likely to change their safety practice. Although some studies indicate this might be the case, there is an interesting body of knowledge on childhood injuries, mainly in the home, suggesting that the problems faced by people from deprived groups may not be exclusively – or above all – attributable to deficiencies in knowledge and practice.

Affordability, readability and power of influence have been documented as substantial barriers to the uptake of safe practice in economically and socially deprived groups (see Chapter 3).

Occupational setting/working conditions

The review papers by Brenner (Chapter 4) and Laflamme et al. (Chapter 3) were any data given on the relationship between socioeconomic position and occupational exposures in children or adolescents in Europe. No relevant studies were identified by the systematic literature search.

Excursion: critical windows of development: the relevance of prenatal exposure

As specified above, prenatal environmental conditions and exposures were not a topic of this review which was a priori confined to the group aged 0–18 years. Nevertheless the prenatal period is a critical window for exposure and an important factor for children's health. Therefore this excursion gives a few examples to illustrate the

interplay between socioeconomic position, prenatal environmental exposures and health.

As described before, smoking in general and especially during pregnancy is more common in mothers living in lower socioeconomic position. Also outdoor air pollution is in most cases higher in areas with lower socioeconomic position. Therefore prenatal exposure to ETS and air pollutants is likely to affect poorer children more often and more severely. In addition, children that are already exposed prenatally are probably more vulnerable to environmental exposures in the first months and years of life, so that multiple exposures cumulate over the lifetime.

In the PINCHE project a few studies were identified on socioeconomic factors, prenatal exposure to ambient air pollution, ETS, PCBs and dioxins, and their health effects in children like low birth weight and impaired cognitive and motor abilities (Bolte & Kohlhuber, 2005). Prenatal exposure to ETS and air pollution is associated with decreased birth weight especially among children of lower socioeconomic position. Also asthma and allergic sensitization were correlated with ETS exposure or prenatal smoking.

In contrast, studies found that children living in higher socioeconomic position were more exposed to PCBs and dioxins prenatally and during the first months of life (Bolte & Kohlhuber, 2005). The positive association with PCBs/dioxins in maternal blood or milk during pregnancy or shortly after birth of the child may be due to older age of academic mothers and decreasing PCBs concentrations in food and outdoor air in the last decades.

However, the consideration of the impact of socioeconomic factors as distal causes on environmental health and the related mechanisms exposure variation and effect modification is not widespread in this area. For example, the WHO report on the effects of air pollution on children's health and development (WHO Regional Office for Europe, 2005c) includes a chapter on intrauterine growth retardation, premature birth, low birth weight and birth defects. Socioeconomic characteristics are merely dealt with as potential confounding factors in the relationship between air pollution and birth outcomes instead as considering socioeconomic factors as distal causes. Thus, it is stated that though the socioeconomic characteristics of people living in more polluted areas can be less favourable than those of people living in less polluted areas it is unlikely that the social composition of the study populations confounded the relationship between air pollution and birth outcomes.

The study by Ponce et al. (2005) in Los Angeles is a counterexample by investigating preterm birth risk within a framework reflecting both the social and physical environments. Traffic-related air pollution exposure disproportionately affected low socioeconomic status neighbourhoods in winter. Furthermore, the effect of traffic-related air pollution on preterm birth risk was most pronounced in low socioeconomic status neighbourhoods. Thus, the susceptibility for preterm birth among vulnerable groups varied in relation to neighbourhood economic deprivation.

Discussion

Estimation of relative impact/magnitude of inequalities

At several levels of compiling and evaluating the evidence for this review, insufficient information and bias may have led to an impairment of its significance.

1. Not all recent publications with data on social inequalities in children's environment and health in Europe might have been identified by the systematic literature search. The result of a literature search depends on the assignment of keywords and MeSH terms. Further, we excluded articles with the mere statement in the abstract that analyses were adjusted for social factors. We might have lost some information on results which were described in the papers though not summarized in the abstract. In addition, the relative impact of socioeconomic factors cannot be assessed if only effect estimates adjusted for socioeconomic position are reported. In environmental epidemiologic studies socioeconomic indicators are mostly regarded as potential confounders and used for adjustment in statistical analyses instead of reporting associations with environmental exposures and health. This phenomenon has been described before (Bolte et al., 2005).
2. There is certainly a language bias because we concentrated on studies, reviews and reports published in English and German. We might have missed studies published in the national languages, especially from eastern Europe.
3. There may be also a publication bias if only studies showing inequalities were published and thus retrieved in the systematic search.
4. Bias might have already been introduced due to study design: Selection bias by socioeconomic position is quite common in epidemiologic studies. There may be an underestimation of the extent of social inequalities in environmental exposures if socially disadvantaged people tend to take part less often. Otherwise, information bias due to underreporting of adverse environmental conditions by socially disadvantaged people may occur. If people with a higher socioeconomic position report more often adverse environmental conditions or already feel annoyed at a lower exposure level compared to disadvantaged people, then there will be an underestimation of the extent of environmental inequalities, too.
5. The main obstacle for quantifying the magnitude of social inequalities in environmental conditions is the diversity of concepts and methods to define socioeconomic position on one hand and of estimating exposure on the other hand. Especially the differences between the European countries in the conceptualization of socioeconomic position and in educational systems were a constraint to quantify the results. Moreover, there is no widely approved method to define socioeconomic position of children and adolescents within and across countries. It has to be borne in mind that the 'choice of whether to use absolute or relative measures can affect the assessment of whether a health inequity exists and its magnitude.' (Kelly et al., 2007:76). Concerning exposure estimates, in studies on air pollution for example exposure is either assessed by direct measurement, by modelling using e.g. traffic counts or by questionnaire asking e.g. for the vicinity of the next main street with high traffic. Moreover, the exposure to air pollutants of different socioeconomic groups may vary considerably between areas.

Therefore choice of indicators of socioeconomic position, method of exposure assessment, and size and choice of a study area may affect the magnitude and even

direction of associations observed (Blakely et al., 2004; Stroh et al., 2005; Briggs et al., 2008; Jerrett, 2009).

In conclusion, due to the variety of methodological approaches and studies on one hand and lack of data for many topics and countries/European Regions on the other hand it was not possible to conclude an overall assessment and to quantify the magnitude of environmental inequalities among children and adolescents in Europe.

In accordance with our evaluation, only some of the working documents gave examples for the relative impact/magnitude of inequalities from single studies but no concluding results: For example, Swedish children were exposed at their residence to 13.5 $\mu g/m^3$ NO_2 (highest neighbourhood income class) versus 21.8 $\mu g/m^3$ NO_2 (lowest neighbourhood income class) (Chaix et al., 2006). Concerning pedestrian injuries children in deprived areas in United Kingdom had up to a four times higher risk than children in more affluent areas (Chapter 3).

This review summarizes the overall evidence (from rather fragmentary data) for common patterns of environmental inequalities among children and adolescents in Europe. However, it has to be kept in mind that the available evidence suggests that patterns of social inequalities are varied across populations and countries and that there is, therefore, a need for some caution in making claims of inequality and to be wary of overgeneralization.

For the interpretation of evidence it has to be considered that not all observed socioeconomic differences in environmental conditions and exposures may have a health impact on its own but may be only effective in situations of multiple exposures. Further, the aspect of salutogenic impacts of the environment on children's health and how environmental resources may counterbalance environmental threats has not been comprehensively studied in the context of social inequalities.

Settings relevant for children

For children, especially three settings are important: the home with its immediate surrounding area, the school or kindergarten environment and the wider community setting. Most studies were conducted in the home environment of children. There are only few publications dealing with the school setting such as the Heathrow Airport study (Haines et al., 2001, 2002; see chapter on noise) or ambient air pollution at schools in Malmö, Sweden (Chaix et al., 2006; see chapter on air pollution). An example for a community setting is a study in three cities with high exposure to lead in the Ukraine (Friedman et al., 2005). Another example for a hot spot setting is the study in three highly industrialized districts in the Ruhr Area, Germany (Hoffmann et al., 2009).

The settings are characterized by multiple (several distinct exposures) and cumulative (single exposure repeated many times) environmental impacts on children.

Policy implications

As previously discussed, the available information is not sufficient, with the notable exception of injuries, to provide quantitative estimates of the dimensions of

environmental inequalities among children and adolescents in the European Region. Nevertheless, this review provides compelling evidence of the importance of socioeconomic factors in determining differential health outcomes in children as a result of environmental exposure. The need for action to address environmental inequity[10] particularly among children has been recognized by the 53 WHO Member States in the European Region in the Fourth Ministerial Conference on Environment and Health, held in Budapest in 2004.

This section builds on the body of evidence provided by the present review as well as on existing literature on equity in health and offers to policy-makers and public health experts a policy framework to address environmental inequity among children and adolescents.

Addressing the main causal pathways of environmental inequity among children and adolescents

Action to address environmental inequity among children may be included into four main policy approaches, according to their primary aim. These comprise policies to reduce the socially determined differences in:

1. environmental conditions in settings where children live;
2. individual children's exposure to hazardous environments;
3. children's susceptibility to specific environmental pollutants and risk factors;
4. the access to high-quality diagnostic, treatment and rehabilitation services for children who suffer the health consequences of being exposed to hazardous environments.

Settings where children live

The first policy approach addresses the environmental conditions that often characterize deprived communities such as the presence of highly pollutant industries, the lack of water and sanitation infrastructure, dangerous traffic conditions, lack of safe playgrounds, vicinity to hazardous waste sites, etc. Actions are aimed at controlling the sources of pollution and environmental risk, which vary across countries and geographical areas: e.g. in the industrial areas of the most developed countries they usually include heavy road traffic, or soil contamination by POPs such as PCBs and dioxins; in rural areas they may include soil and water contamination by pesticides; in the least developed countries in the European Region they are most likely to include the use of unsafe heating systems and inadequate water and sanitation infrastructure (Valent et al., 2005).

Controlling the sources of environmental hazard typically requires action at legislative and administrative level, including the development and enforcement of legislation, adequate budgetary allocations, cross-sectoral collaboration and dialogue with those responsible for the pollution or the unsafe environmental conditions (Bartlett, 1999). An important advocacy role can be played by health professionals and NGOs. Due to the amount of the financial investments usually required to modify environmental conditions and the likely existence of conflicting interests within the same communities

[10] The term 'inequities' is used in the section on policy implications to refer to those inequalities that are avoidable or can be redressed and are assumed to be unjust (WHO, 2009).

– such as those of the industrial or agricultural workers – actions of this kind encounter several obstacles. Yet, once change is achieved in the environment, it produces sustainable effects for the whole community. National and local authorities in many countries of Europe have achieved experience in addressing environmental issues relevant for children over the last decade (WHO Regional Office for Europe, 2004c). The step forward will be to adopt an equity lens by giving priority to the communities at highest environmental risk, which, as it has been previously shown, often coincide with the most socially deprived ones.

Exposure to hazardous environments

The second policy approach addresses specific exposure patterns, several of which are typical, if not exclusive, of developing organisms, including during their prenatal period. It aims at improving the information and building awareness within communities and households so that children's exposure to environmental toxicants and risks is reduced. This is achieved by modifying practices and behaviours of both parents and their children with respect to injury prevention, dietary habits, physical activity, exposure to toxicants, etc. Since behaviours and practices are strongly influenced by social determinants such as household income, access to information, educational level, cultural and religious background (Bartlett, 1999; Donohoe, 2003), reducing the social divide requires action through the educational sector, the media, and, most important, work within and with the involved communities. Action in this field may be quite effective, even in the short-term, but needs continuous efforts to maintain its effect. Therefore it should be combined with action to modify and control the sources of environmental risk.

Susceptibility to specific environmental pollutants and risk factors.

The third policy approach is aimed at reducing children's susceptibility to the action of hazardous substances and settings to which they may be exposed. This can be achieved, for example, by improving infant and child nutrition, starting from pregnancy, as well as by improving early childhood development through appropriate stimulation and play. Since parents and other caregivers are the fundamental mediators of child nutrition and development (WHO Regional Office for Europe, 2005b; Engle, 2007) action will essentially be aimed at improving parental knowledge, practice and skills regarding child nutrition and early development and to provide material and social support when necessary. Examples of action to reduce the consequences of hazardous exposure are ensuring an adequate intake of calcium to decrease lead absorption, avoiding prenatal and postnatal exposure to environmental tobacco smoke to reduce susceptibility to acute and chronic respiratory conditions in settings characterized by high air pollution, and promotion of reading aloud to children to counteract the effects of social neglect and exposure to neurotoxicants (Walkowiak, 2001). These actions are clearly remedial and should not imply that little or no action is taken to address effectively the source of risk or to decrease exposure. They are acceptable within a strategy that aims at removing the environmental conditions that create the hazard to child health and development.

Access to high-quality services

The fourth policy approach aims at improving the capacity of the health system to ensure adequate diagnosis and treatment of the medical conditions that may arise as a consequence of hazardous environmental exposures, such as injuries, gastrointestinal and respiratory disorders, developmental delays, acute and chronic intoxications, cancer

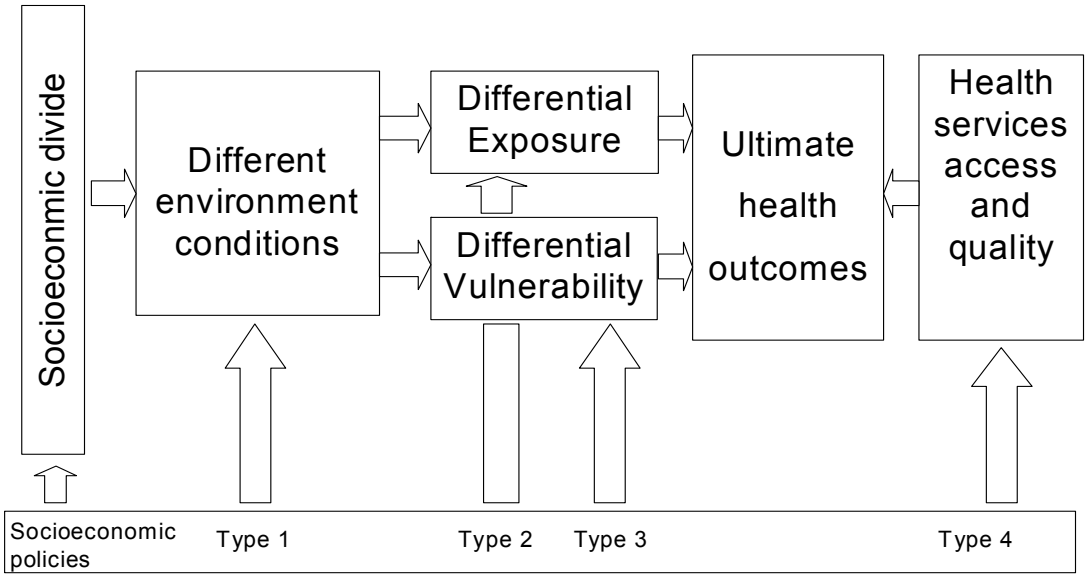
and other health problems (EEA & WHO Regional Office for Europe, 2002). Since risk can be reduced but rarely eliminated, it is important that at risk children can promptly access quality health services without any kind of financial or normative obstacle, including for migrant children, non-accompanied children and refugees. Professionals, both in the educational and health sector should be adequately trained in prompt recognition of early signs as well as in diagnostic and treatment protocols.

Action down whole pathway

Action is needed along the whole causal pathway of the social divide in environmental hazards with priority to action aimed at removing socially determined differences in environmental conditions.

These four policy approaches should be seen as a continuum along the causal pathways of environmental inequity, from the distal socioeconomic causes, to the increased susceptibility and exposure that characterize socially deprived human beings and children in particular, to the proximal factors related to access and quality of care (Fig. 1).

Fig. 1. Policy approaches to address the main causal pathways of environmental inequity



Source: adapted from Commission on Social Determinants of Health (2008).

Type 1 actions, by acting upstream in the causal pathway of environmental risk, generally achieve a stable and sustainable risk reduction and therefore have the greatest long term preventive potential. Type 2 and type 3 actions have a more limited scope and should not be seen as stand alone measures. Yet, the potential of nutrition and early child development policies to reduce the susceptibility and effects of exposure to unsafe and unhealthy environments cannot be neglected. Type 4 actions are clearly remedial rather than preventive, although they may still be quite important to save lives and prevent disabilities in the case of injuries and severe intoxications. Examples of type 1–4 actions addressing the four priority goals of the CEHAPE are provided in Table 1. The table also provides a generic (the responsible authorities may not be the same across the 53 countries in the WHO European Region) indication of what kind of authorities could be responsible for developing and implementing the relevant policies and interventions.

Table 1. Addressing environmental inequity among children and adolescents in the CEHAPE priority areas: Examples of four policy approaches and responsible authorities

Policy approach (CEHAPE priority areas)	Action (examples)	Responsible authorities
Indoor air pollution		
Reducing sources of pollution in deprived communities and households	• Plan urban development to minimize exposure to pollutant industries and heavy road traffic • Provision of financial incentives for improved heating systems and safer fuels at household level	• Local administrative authorities • National and local legislating bodies
Reducing exposure at individual level	• Information, Education and Communication at community and household level on ways to reduce exposure in children with special emphasis on poor communities (e.g. keep children and pregnant mothers away from smoke)	• National and local health and environment authorities • Health professionals
Reducing susceptibility to pollutants' effects	• Avoidance of prenatal exposure to ETS, fine particulate matter and PAH	• National and local legislating bodies • National and local health and environment authorities • Health professionals
Reducing health consequences	• Quality health services for respiratory diseases	• National and local health authorities • Health professionals
Water and sanitation (WS)		
Reducing sources of pollution in deprived communities and households	• Improved WS facilities in poor communities (houses, schools and daycare centres) • Financial incentives to WS improved facilities in private houses	• National and local administrative authorities • National and local legislators
Reducing exposure at individual level	• Information, education and communication on ways to reduce exposure in children (e.g. washing hands, etc.) with special emphasis on poor communities	• National and local health and environment authorities • Health professionals
Reducing susceptibility to pollutants' effects	• Improve infant and young child nutrition	• National and local health authorities • Health professionals
Reducing health consequences	• Quality health services for diarrheal diseases	• National and local health authorities

Policy approach (CEHAPE priority areas)	Action (examples)	Responsible authorities
Chemicals		
Reducing sources of pollution	• Ban lead from gasoline, implement ban on PCBs and other POPs	• International agreements • National legislators
Reducing exposure at individual level	• Information, Education and Communication on ways to reduce exposure in children (e.g. monitor PCBs content of soil and food and advise accordingly) with special emphasis on poor communities	• National and local health and environment authorities
Reducing susceptibility to pollutants' effects	• Improve early child development by appropriate parental practices to reduce susceptibility to adverse neurodevelopmental effects caused by postnatal exposure to neurotoxicants	• National and local health and education authorities • Health professionals
Reducing health consequences	• Train health professionals in early recognition of signs and symptoms of lead intoxication • Implement biomonitoring in at risk populations	• National and local health and environment authorities
Physical activity		
Reducing adverse environmental conditions	• Improve availability of playgrounds and safe walking or cycling paths to school	• Local administrative authorities
Reducing exposure at individual level	• Promote physical activity and reduce time of exposure to TV and computer screens	• National and local health authorities • Health professionals
Reducing susceptibility to risk factors	• Improve infant and young child nutrition	• National and local health authorities • Health professionals
Reducing health consequences	• Train health professionals and school personnel in promotion of physical activity and infant and young child nutrition • Improve therapy of obesity and its health consequences	• National and local health and education authorities • Health professionals

Upstream progressive policies

Upstream progressive policies are needed to reduce the social divide, starting from the earliest years.

In addition to actions specifically aimed at reducing the social divide in environmental risk, policy-makers should always consider the need for progressive, redistributive social and economic policies (left column in Fig. 1), to improve household income, parental education and welfare systems. Acting in this direction will reduce the social

divide both in its magnitude and its consequences (Yazbeck, 2009). When designing these broad policies, government authorities should remember that children deserve a special attention not only because they are at increased risk, but also because the fight against poverty and social inequity should start from investments early in life (World Bank, 2005; Commission on Social Determinants of Health, 2008). Children living in areas at high environmental risk and belonging to deprived communities should therefore be given priority by national governments as well as local administrative authorities. International agencies have a specific mission in providing technical and financial support to governments that show commitment in this direction, with particular emphasis on those countries whose children are at higher environment and health risk (WHO Regional Office for Europe, 2005b).

Lens focused on child equity

A lens focused on child equity is needed in environment information systems and IEC (information, education, communication) activities There are two further areas that health policy-makers should pay great attention to if an equity approach to children's environmental health is to be adopted.

The first and most important is to set up an environment information system with a focus on equity and with child specific sources of data and indicators. Such a system should allow to identify and to monitor differential exposure across the population groups, through monitoring of the emissions, concentration of pollutants in various media and by direct biomonitoring of the exposed population, including children and pregnant women (Technical Working Group on Integrated Monitoring, 2003; Commission of the European Communities, 2004). This information is key to effective action, first to identify the communities and areas at highest risk, and second to evaluate the effects of interventions. In addition, social inequalities in health must be monitored and measured on a national and global scale and public health research must be focused on the socioeconomic determinants of health. This also includes training of policy-makers and health practitioners (Commission on Social Determinants of Health, 2008).

The second is an IEC strategy and ad hoc equity-minded initiatives. The information asymmetry and the educational divide play an important role on determining environmental inequity. Information campaigns may be effective and yet increase the differences along the social gradient if they are not designed in their contents, methods and language to effectively reach the most deprived communities (Victora, 2000).

Addressing selectively diseases that affect disproportionately the poor is a strategy that has been suggested to reduce inequities in health (World Bank, 2005; Tamburlini, 2005). To be applicable to the environmental issues, though, this strategy requires a reasonably precise estimate of the differential burden across population and age groups. As previously discussed in this paper, for many important issues we are not yet able to produce this kind of information. The only available information are the estimates produced by the Environmental Burden of Disease Study among children and adolescents (Valent et al., 2005). The study provides clear evidence of the fact that there is an important differential across European countries with respect to the burden of diarrhoeal disease, respiratory diseases, and mild mental retardation due to lead. This reinforces the need for the international agencies to give priority to countries with the

highest environment related burden of disease and for the governments of these countries to improve data collection to focus their action according to risk.

These two areas represent also a challenge for public health experts and researchers, since there is the need to improve information systems as well as the way available information is used, including risk communication to involved communities. Effective communication efforts should take into account the specific difficulties in reaching out for the most deprived communities, and research is needed to develop and evaluate innovative ways to do it. Also, risk communication to communities should be able to offer a balanced view of the risks and benefits of action and inaction on the various issues, so that actions are prioritized according to cost effectiveness and cost opportunity criteria, and to the precautionary approach when appropriate (EEA & WHO Regional Office for Europe, 2002). Further research and careful evaluation of experiences is needed in this area.

Conclusion

This review is a concise summary of evidence on environmental inequalities among children and adolescents in Europe. Though scientific evidence on this topic increased during the past years and concurrently attention to the issue environmental injustice accumulated there are still numerous research and knowledge gaps leading to fragmentary evidence. With the data at hand, quantification of the magnitude of environmental inequalities among children and adolescents in Europe was not possible. Main reasons for this were the variety of methodological approaches for defining socioeconomic position and for measuring exposure on one hand and lack of data for many topics and countries on the other hand.

Based on the available fragmentary evidence the main finding is that there is a common pattern that children living in adverse social circumstances suffer from multiple and cumulative exposures, are more susceptible to a variety of environmental toxicants and often lack environmental resources/goods and other resources such as access to quality health care to counterbalance environmental threats and reduce their health consequences.

This challenge requires a broad and active engagement, not only of the public health and health care systems, but of many other policy areas as well.

As stated above, environmental inequalities have several dimensions: inequalities among population groups within a country or urban area, inequalities across countries, and inequalities between generations (EEA & WHO Regional Office for Europe, 2002). Addressing the first dimension of inequalities is essentially, although not exclusively, a responsibility of national and local governments and authorities. Addressing the second dimension needs also the engagement of the international community and of its regional institutions, such as the European Commission and the European Parliament. Addressing the third dimension should be everybody's responsibility, at all levels of society, with a particular emphasis on international agencies such as WHO, and mechanisms – such as the G8, or the Ministerial Conferences on Environment and Health – called to set standards and make commitments. Today's children and the future generations should not pay the price of our neglect for the environment.

Key messages

Policy implications

- The need for action to address environmental inequity particularly among children most at risk as a consequence of the social divide, both within and across countries, has been widely recognized.
- Four types of policy approaches need to be considered, each addressing a specific causal pathway of the social divide in environmental hazards:
  - reducing the socially determined environmental divide in settings where children live,
  - reducing the socially determined differences in children's exposure to hazardous environments;
  - reducing the socially determined differences in children's susceptibility to specific environmental pollutants and risk factors;
  - reducing the socially determined differences in the health consequences of children's exposure to hazardous environments.
- These more specific actions should be combined with upstream progressive policies to reduce the social divide, starting from the earliest years.
- It is important to incorporate a child focused equity lens in environment information systems and in IEC activities.

Research implications

- The need to fill the knowledge gaps on social inequalities in children's environment and health throughout Europe has been widely acknowledged.
- Several research approaches need to be considered:
  - using a variety of measures of socioeconomic position to be able to compare data across countries;
  - using similar methodological approaches and study designs to be able to quantify the magnitude of environmental inequities among children and adolescents in Europe;
  - assessing the interaction between socioeconomic position, multiple and cumulative environmental hazards, and community stressors;
  - applying a multilevel approach to improve understanding of the complex, multifactoral causation of environmental health disparities;
  - applying a community-based participatory research strategy to identify environmental justice issues.
- Research on social inequalities in exposure and susceptibility to hazardous environments should be complemented with research on social inequalities in environmental salutogenic resources.

It is important to integrate socioeconomic indicators in environmental health monitoring systems and to develop indicators of environmental inequities.

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WHO Regional Office for Europe (2005a). *The European health report 2005. Public health action for healthier children and populations.* Copenhagen, WHO Regional Office for Europe. (http://www.euro.who.int/document/e87325.pdf, accessed 13 July 2009).

WHO Regional Office for Europe (2005b). *Children's health and environment. Developing action plans.* Copenhagen, WHO Regional Office for Europe. (http://www.euro.who.int/document/e86888.pdf, accessed 13 July 2009).

WHO Regional Office for Europe (2005c). *Effects of air pollution on children's health and development. A review of the evidence.* Copenhagen, WHO Regional Office for Europe (http://www.euro.who.int/document/E86575.pdf, accessed 29 July 2009)

WHO Regional Office for Europe (2006). *Physical activity and health in Europe: evidence for action.* Copenhagen, WHO Regional Office for Europe. (http://www.euro.who.int/document/e89490.pdf, accessed 13 July 2009).

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Appendix 1. Search strategy and number of publications identified by the initial systematic literature search

Database Search term	Results: number of papers initial	published since 2000	without duplicates, only Europe (after first scan of title and abstracts)	after application of further exclusion criteria
Medline (MeSH term)				
socioeconomic factors AND environmental pollution AND child OR child, preschool OR infant OR adolescent	1687	877	364	54
socioeconomic factors AND accidents AND child OR child, preschool OR infant OR adolescent	1290	636	293	54
social justice AND environmental exposure AND child OR child, preschool OR infant OR adolescent	19	17	1	1
social justice AND environment AND child OR child, preschool OR infant OR adolescent	18	15	2	2
environmental justice (all fields) AND child OR child, preschool OR infant OR adolescent	214	150		8
PsychINFO:				
environment AND socioeconomic WHERE age group IS NOT adulthood	15			1
environmental justice WHERE age group IS NOT adulthood	17			0
SocINDEX				
child AND environmental pollution	6			1
child AND environmental exposure	40			0
child AND environmental justice	23			0
Current contents connect CCC, **Social science citation index + science citation index + arts & humanities**				
child AND environment AND social	861			
=> search within categories: paediatrics OR public, environmental & occupational health OR environmental sciences & ecology OR geography	127			13
Summary				**134**

Appendix 2. Reports published since 2000 considered in this review

Report	Authors/institution and year published	URL
Special reports on socioeconomic inequalities in children's environment and health		
PINCHE project: Final report WP5 Socioeconomic Factors.	Bolte & Kohlhuber, 2005, Public Health Services Gelderland Midden	http://www.pinche.hvdgm.nl/resource/pdf/documents/final/PINCHE_WP5_final_181105.pdf
Socioeconomic factors and environmental exposures in Germany – current state of knowledge and analysis of selected environmental pollutants. Project part A: Systematic compilation of the current state of knowledge in Germany.	Bolte & Kohlhuber, 2008, Federal Environmental Agency	http://www.umweltdaten.de/publikationen/fpdf-l/3663.pdf
Reports on children's environment and health		
A Children's Environment and Health Strategy for the United Kingdom.	Health Protection Agency, 2009	http://www.hpa.org.uk/cehape
Children's health and environment. Developing action plans.	WHO Regional Office for Europe, 2005	http://www.euro.who.int/document/e86888.pdf
Inheriting the World: The Atlas of Children's Health and the Environment.	WHO, 2004	http://www.who.int/ceh/publications/en/atlas.pdf
Burden of disease attributable to selected environmental factors and injuries among Europe's children and adolescents. Environmental Burden of Disease Series, No. 8	WHO, 2004	http://www.who.int/quantifying_ehimpacts/publications/en/ebd8web.pdf
Children's health and environment: A review of evidence. Environmental issue report No 29	European Environment Agency & WHO Regional Office for Europe, 2002	http://www.euro.who.int/document/e75518.pdf
Children's health and the environment in Europe: A baseline assessment.	WHO Regional Office for Europe, 2007	http://www.euro.who.int/document/e90767.pdf
Health and Environment Primer.	HEAL, 2007	http://www.env-health.org/IMG/pdf/Health_and_Environment_Primer_2007_FINAL_MARCH_4_2008.pdf
Reports on children's health in Europe		
The European health report 2005. Public health action for healthier children and populations.	WHO Regional Office for Europe, 2005	http://www.euro.who.int/document/e87325.pdf

Report	Authors/institution and year published	URL
Reports on health inequalities in Europe		
Health Inequalities. Third Report of Session 2008–09.	The Stationery Office, 2009	http://www.publications.parliament.uk/pa/cm200809/cmselect/cmhealth/286/286.pdf
Closing the gap in a generation. Health equity through action on the social determinants of health.	WHO, 2008	http://whqlibdoc.who.int/publications/2008/9789241563703_eng.pdf
The social determinants of health: Developing an evidence base for political action.	Measurement and Evidence Knowledge Network, 2007	http://www.who.int/social_determinants/resources/mekn_final_report_102007.pdf
Reports on built environment, urban setting & health (e.g. physical activity, obesity)		
Our cities, our health, our future: Acting on social determinants for health equity in urban settings.	Knowledge Network on Urban Settings, 2007	http://www.ucl.ac.uk/gheg/whocsdh/knsreports/knsus
Promoting physical activity and active living in urban environments. The role of local governments.	WHO Regional Office for Europe, 2006	http://www.euro.who.int/document/e89498.pdf
Tackling Obesity by Creating Healthy Residential Environments.	WHO Regional Office for Europe, 2007	http://www.euro.who.int/Document/E90593.pdf
Physical activity and health in Europe: evidence for action.	WHO Regional Office for Europe, 2006	http://www.euro.who.int/document/e89490.pdf
Children and physical activity: a systematic review of barriers and facilitators.	EPPI-Centre, 2003	http://eppi.ioe.ac.uk/cms/LinkClick.aspx?fileticket=mvkDhy1VBKc%3d&tabid=245&mid=1081&language=en-US
Reports on transport and health effects (including air pollution, noise)		
Transport-related Health Effects with a Particular Focus on Children [THE PEP].	BMLFUW, 2004	http://www.euro.who.int/Document/trt/PEPSynthesis.pdf
Health effects and risks of transport systems: the HEARTS project.	WHO Regional Office for Europe, 2006	http://www.euro.who.int/document/E88772.pdf
Reports on air pollution		
Effects of air pollution on children's health and development.	WHO Regional Office for Europe, 2005	http://www.euro.who.int/document/E86575.pdf
Reports on injuries		
European report on child injury prevention.	WHO Regional Office for Europe, 2008	http://www.euro.who.int/Document/E92049.pdf

Report	Authors/institution and year published	URL
Socioeconomic differences in injury risks. A review of findings and a discussion of potential countermeasures.	WHO Regional Office for Europe, 2009	http://www.euro.who.int/Document/E91823.pdf
Addressing the socioeconomic safety divide: a policy briefing.	WHO Regional Office for Europe, 2009	http://www.euro.who.int/Document/E92197.pdf
Reports on chemicals		
Blood lead levels in children.	WHO Regional Office for Europe, 2007	http://www.euro.who.int/Document/EHI/ENHIS_Fact sheet_4_5.pdf
Reports on water		
Water and health in Europe.	EEA & WHO Regional Office for Europe, 2002	http://www.euro.who.int/document/E76521.pdf
Additional material		
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8. Summary report on interventions and actions to tackle inequities in physical activity in children

Authors
David L Pattison
National Health Service
Scotland, United Kingdom

Leda Nemer
WHO Regional Office for Europe, Rome office
Italy

Background

On 19–20 October 2009, the third WHO/Health Behaviour in School-aged Children (HBSC) Forum took place in Siena, Italy. About 80 participants from 10 countries attended, representing a combination of academic institutions, HBSC principal investigators and national public health institutions.

The theme of the 2009 Forum was "socio-environmentally determined health inequities among children and adolescents" with a focus on CEHAPE Regional Priority Goal (RPG) II, because current available HBSC data is on the topics of physical activity, unintentional injuries, and in some cases, school/neighbourhood physical environments. As environment and health inequities and their socioeconomic determinants are also a cross-cutting theme of the Fifth Ministerial Conference on Environment and Health, to be held in Italy in 2010, this summary aims to provide a picture of WHO/HBSC contributions.

Across the WHO European Region there is a growing recognition that decreasing levels of physical activity, coupled with increasing levels of unhealthy weight in children and young people and within a context of challenging physical and social environments, contributes to increased risks of obesity, diabetes and unintentional injuries. With this context in mind, the 2009 Forum brought an environmental inequities lens to examine the physical and social facilitators and barriers to reducing injuries and increasing physical activity among children and adolescents. It also revealed a wide range of evidence and intelligence relating to the field of environment, physical activity, and unintentional injuries – all linked to children and young people.

While Forum background papers and case studies confirmed a high disease burden in some Member States from unintentional injuries and lack of physical activity, experiences and evidence also showed that most of the burden can be prevented. From the inequities angle, the Forum also provided ample evidence of high risk taking behaviour in lower socioeconomic (SE) groups. It also showed that, while children from more affluent groups or high-income parts of countries engaged more in physical activity and tended to be injured in organized sports, those in low SE groups not only had lower levels of physical activity but when they engaged in it, sustained more severe injuries.

During the Forum, two background papers were presented: a review on environmental inequities in children (Chapter 7 of this report) and a paper on HBSC findings on injury

and physical activity. In addition, 10 country case studies were presented; their abstracts comprise Chapter 9 of this report. Table 1 lists the issues covered.

Table 1. Case studies produced for 2009 WHO/HBSC Forum

Country	Topic
Armenia	Linking adolescent health behaviour and physical activity with socioeconomic, environmental and education factors
Germany	Injury and physical activity in association with well-being in children and adolescents
Hungary	A strategic approach to child injury prevention
Ireland	Socioenvironmental context of child well-being and the involvement of children in the development of a national set of well-being indicators
Italy	Tuscany Region: the ideas of the young for their health and the regional project "Di testa mia"
Kazakhstan	Prevention of road injuries among schoolchildren
Lithuania	Mediating effects of alcohol and traffic safety control and policies
Norway	Reducing inequality gaps in physical activity through school based interventions
Poland	Progress in child and adolescent physical activity promotion and injury prevention
United Kingdom (England)	The Play Strategy and social inequalities

Common themes identified

All case studies show the complex nature of addressing inequity within their own countries and were extremely honest in terms of recognizing the specific problems they were facing irrespective of the area being investigated, such as physical activity/injuries being linked to environments. Considering the overall findings from the case studies the following themes emerged.

Data-related issues

All case studies identified important gaps in data and issues around the sharing and interpretation of existing data sources.

Gaps in both existing health data and access to and understanding of a much wider range of intelligence or data sources by all partners should be addressed.

The issues of translating evidence into concrete actions with appropriate systems to measure impact were highlighted by several case studies.

The majority of case studies used both international and national HBSC data.

All drew on an interesting range of data sources such as police traffic accident reports, hospital admissions, European Commission and WHO sources, and evidence directly from young people.

HBSC and other data sources confirmed key issues the case study authors identified in terms of the scale of the problems relating to uptake of physical activity, increases in non accidental injuries and barriers to providing and increasing uptake of programmes

and services aimed at tackling these issues and the attitudes of adults (both parent/non parent).

Approaches taken

All highlight the importance of an intersectoral approach and understanding the priorities of partners. A clear indication is given in some of the case studies of the importance of working with young people from the beginning and not just at the end of the development process with varying degrees of 'active' participation of young people being highlighted throughout the process.

The role of modern media approaches cannot be underestimated. Several case studies used a range of media formats to engage with young people.

All case studies make reference to the importance of having government policies which support both targeted action such as improving physical conditions of facilities and more generic action such as the introduction of national action plans.

Challenges faced

The issue of devolved government was identified as a potential barrier with examples provided by both the German and Italian case studies.

The effects of positive and negative environments, both natural and built, are illustrated throughout the case studies.

A wide range of actions taken, as a result of governments recognizing the problems, were highlighted, with some actions at more advanced stages than others.

The challenge of effective monitoring and evaluation of actual outcomes and impacts was highlighted in several case studies.

Several case studies identified the negative impact the current global economic situation is having on work to address environment and health inequity issues in their countries.

Key lessons arising from Forum discussions and case studies

The 2009 WHO/HBSC Forum looked at several mechanisms for reducing environment and health inequities among children and adolescents, including: youth involvement, translating research to policy, use of a settings approach and intersectoral collaboration/action. While there are a scarce number of documentable experiences showing reduction of inequities, possibly indicating low levels of awareness of the problem, a lot of knowledge exists as to approaches that can be taken at country level.

The following section highlights the key lessons that arose from discussions on how to reduce environment and health inequities among children and adolescents using these four approaches.

Youth involvement

Youth should be involved early on in any process looking to reduce environment and health inequities as they are key players in confronting environment and health changes. As future citizens who will be able to influence policy-makers, it is important to raise their awareness about the context in which they live. To do this successfully, a clear, strategic approach for proactive youth involvement is needed and a national strategic approach for youth involvement can set the precedent for their involvement in addressing the impact of the environments on their health. Involving youth from the outset inevitably leads to a feeling of ownership and results in greater support and compliance from their side, a win-win situation for all concerned.

Youth involvement should go beyond reaching the mainstream. It should be age and culturally appropriate taking into consideration the specific needs of each phase of childhood and adolescence. To ensure reductions in inequities, strategies to engage younger children or children that fall out of the mainstream should be plentiful as one size does not fit all. Increasing participation of youth, while empowering them, may help to reach those that do not frequent mainstream settings to take or demand action for their health.

Settings approaches

Use of a settings approach can also contribute to reductions in inequities since such an approach considers where children and adolescents can be best reached and where are they most at risk. Nonetheless, care needs to be taken to ensure that inequities are not widened by use of a settings approach. The WHO/HBSC Forum and its case studies found that, among the settings where effective action to improve environments, reduce injury and increase physical activity can take place, schools, the built and natural environment in communities and the health system (both physical facilities that comprise health system and the corporate role) were key.

Advantages of using a settings approach to reduce environmental inequities include more control over the environment itself, the possibility to concentrate investment more directly since parameters can be set, and easier targeting and limiting resource of intensity. It should be kept in mind that a settings approach alone for reducing environmental inequities is not enough and should be complemented with other approaches since the unintended consequence can be exclusion of individuals that do not go to school or those whose involvement in schools is limited (i.e. schools can reduce inequities only if children attend them).

Translating research to policy

The importance of frequent and open dialogue with policy-makers and their engagement was highlighted by several case studies collected for the 2009 Forum. Most agreed that researchers have the responsibility to engage policy-makers to ensure their work benefits society while at the same time, engaging all relevant stakeholders from early on to formulate relevant policy questions to be answered by that research. Issues related to communicating research findings and implications to policy-makers as well as assessing the most appropriate timing of getting policy-makers involved should be considered in this context.

Chapter 7 shows that, to be able to adequately portray the environmental inequities picture in a country, research resources should target the groups most at risk and most in need. Further, it showed that there are not only gaps in health, environment and other data but challenges in accessing those that exist.

To deal with data gaps in Europe, government ministries need to assess whether they have sufficient data to deal with the complexity of environment and health issues and consider investing in appropriate intelligence systems. An understanding of a much wider range of intelligence systems and sources by all partners would be of enormous benefit to resolve research data gaps as many potentially useful sources are currently not being used. Knowledge of kinds of intelligence systems one has access to and the information they provide can aid decision-making and enable better targeting of interventions to reduce inequities.

Intersectoral collaboration

The findings from the 2009 WHO/HBSC Forum relating to intersectoral work highlight the generic benefits of taking this approach, as well as identifying some key issues related to the capacity building that is required to adopt such an approach effectively. From an inequities perspective, especially in the current economic climate, there can be no doubt that working across government ministries, across regional and local government departments and in partnership with other agencies (including those from civil society) provides the opportunity to maximize scarce economic and physical resources. It also allows – at the national, subnational and local levels – a greater ability to identify the communities and individuals most in need or vulnerable and to develop more coherent policies, strategies and action plans to reduce inequities. From a public engagement perspective, including working with young people, adopting an intersectoral approach allows a range of partners to engage more constructively and inclusively in addressing inequities within their communities; it also improves the opportunities to put in place performance management systems to measure impact and effectiveness.

The discussions on intersectoral collaboration that took place during the 2009 Forum also highlighted the benefits of engaging in intersectoral action to reduce inequities, as well as the use of an ecological public health model that takes a comprehensive approach to health and well-being and embraces a wider spectrum of interacting determinants. Case studies and discussions stressed the need to build up capacity to work intersectorally and the importance of uniting behind a common goal to work to reduce inequities. The integration of relevant stakeholders early on to enable understanding of each partner's corporate objectives and capacities was highlighted. Further, before entering into discussion with other ministries, it would be critical to become aware of their policies and how these can contribute to or alleviate inequalities; showing the health benefits of each stakeholder's work and demonstrating how the health ministry can support them to reach their own aims would be a valuable step towards engaging partners in intersectoral work. Subsequently, governments can take the lead in supporting and promoting the benefits of intersectoral collaboration by integrating it into undergraduate and post-graduate training for relevant professionals.

The 2009 Forum concluded that no level of inequity is acceptable and it is better to take small steps towards solving the problem than to take no steps at all. Ultimately, all

Member States have a responsibility to ensure the highest standard of health for their citizens, especially those that cannot take action for themselves. Member States would benefit from questioning whether the existing policies in their countries might increase inequities and make systematic reviews of policies to ensure that this does not happen.

The suggestions outlined above are not exhaustive or unique to environment and health, but they represent a growing recognition across the WHO European Region of the importance of all government departments working in partnership to reduce inequity and improve the health and well-being of their citizens.

9. Abstracts of country case studies on interventions and actions to tackle inequities in physical activity in children

Armenia: linking adolescent health behaviour and physical activity with socioeconomic, environmental and education factors

Sergey Sargsyan, Ara Babloyan, Marina Melkumova, Eva Movsesyan
Arabkir Joint Medical Centre Institute of Child and Adolescent Health

Nune Bakunts
State Hygiene and Anti-epidemic Inspectorate, Ministry of Health

Naira Gharakhanyan
Children of Armenia Foundation

Nune Pashayan
Ministry of Health

Anahit Muradyan,
Ministry of Education and Science

Anahit Alexandryan.
Ministry of Environmental Protection

Abstract

Analysis of the general health statistics of Armenia shows an obvious correlation between low physical activity, sedentary behaviours and unhealthy eating habits in childhood and adolescence with high morbidity and mortality from noncommunicable diseases in adulthood.

Lack of opportunities for physical activity, sedentary behaviours and inadequate facilities to support physical activity in communities and education institutions are among the health risk factors faced by Armenian children and adolescents. Data from a pilot HBSC survey show that the physical activity levels of most adolescents in Armenia are inadequate; indeed, they are among the poorest in Europe. Many schools do not have adequate facilities to support physical activity for students. Most Armenian adolescents watch at least three hours of television every day, and while most rural inhabitants do not use computers routinely, many adolescents living in the capital city of Yerevan play computer games and search the Internet daily; as a consequence, students' vision problems increase by up to five times during the school years.

A crowded curriculum and heavy study commitments for students preparing to enter university also contribute to decreasing levels of physical activity. At least one in three children living in Yerevan spends 4–5 additional hours in academic preparation daily, which, when combined with the commitments of the conventional school day, means 10 hours are being spent each day on learning activity. All these factors have led to low physical activity becoming the norm for many adolescents.

Armenian youth also face environmental challenges. The pilot HBSC survey reports inadequate sanitary and hygiene conditions in schools, and some schools do not provide adequate heating in winter (a circumstance reported by half of the interviewed pupils).

Comparison of data from different groups shows a growing polarization within society, although children from all socioeconomic groups face dangers and specific health risks. Some 12% of interviewed children noted that they sometimes went hungry due to lack of food at home; at the same time, many children living in the capital city of Yerevan reported consuming relatively expensive fast foods daily. Many children living in villages were involved in

physically vigorous farm work, while children in urban settings did not engage in physical activity due to the development of habitual sedentary behaviours.

Pilot HBSC survey data and those from other relevant surveys provide a rationale for interventions in child and adolescent health and development. The Ministry of Health has set out relevant actions through the newly developed child and adolescent health strategy and other policies. The Ministry of Education and Science has introduced healthy lifestyle lessons into the secondary school curriculum. The government and donor organizations have launched programmes on improving school conditions, with the result that many schools have now been fully renovated and sports facilities have been revitalized to provide opportunities for thousands of children. These, however, are only the first steps. Many policies aimed at improving the environments and lifestyles of Armenian children still have to be implemented, and the current financial crisis and expected budget deficits may delay the implementation of many plans.

Overall, the Armenian experience reinforces the importance of recognizing the close correlations between children's and adolescents' health and health-behaviour indicators and socioeconomic, environmental and education factors. The case study stresses a need for strong intersectoral collaboration.

Germany: injury and physical activity in association with well-being in children and adolescents

Veronika Ottova, Nora Wille, Michael Erhart, Ulrike Ravens-Sieberer
University Medical Centre Hamburg-Eppendorf, Hamburg

Ute Winkler
Federal Ministry of Health, Berlin

Martina Abel
Safe Kids Germany, Bonn

Bärbel-Maria Kurth
Robert Koch Institute, Berlin

Abstract

The primary objective of this case study is to highlight the process of translating evidence into action by describing how research results from surveys have influenced strategy development and policy-making.

The two surveys that are central to the case study are the HBSC survey and the German Health Interview and Examination Survey for Children and Adolescents (KiGGS). KiGGS is a large survey of 17 641 children and young people aged 0–17 years which provides for the first time comprehensive information on health and health behaviour and detailed insights into environmental conditions and well-being of children and adolescents in Germany.

The results of these two surveys confirm that deaths due to unintentional injuries in Germany are generally decreasing in children under 15 years. Survey results also show that boys are significantly more likely to report an injury in the past 12 months. The majority of children are physically active, but differences are found between high- and low-affluence groups. The highest proportion of 3–10-year-old children who are physically active less than once a week is found among those from low socioeconomic status (SES) backgrounds. This negative trend is most pronounced among children with a migratory background and/or those living in eastern Germany. In terms of well-being, survey results confirm those of previous studies, which found that children with low SES generally report a lower health-related quality of life (HRQoL) than their peers with higher SES.

As a consequence of the surveys and their findings, the Federal Ministry of Health has developed a strategy paper for the advancement of children's health which will be highlighted here along with national policies and interventions aimed at tackling these health problems and reducing health inequalities. The strategy paper defines concrete measures and interventions in various areas of child health and describes how the health of socially disadvantaged children and those with migrant background can be improved. Activities and national recommendations put forward by Safe Kids Germany, an association taking the lead in injury prevention in children, are presented and discussed.

There are many promising activities in Germany, reflecting the subject's importance. Improvements can nevertheless be made in terms of coordination and cooperation at federal, state and regional levels and between stakeholders from political sectors and nongovernmental organizations (NGOs). Coordination of activities is especially important in Germany due to its federal structure, so networking and greater exchange among participants is both desirable and necessary.

Hungary: a strategic approach to child injury prevention

Páll Gabriella, Andrea Valek, Dóra Várnai, Ágnes Németh
National Institute of Child Health, Budapest

Anna Páldy, Tibor Málnási
National Institute of Environmental Health, Budapest

Ildikó Almási
CEHAPE International Youth Representative, Hungary

Morag MacKay
European Child Safety Alliance, Amsterdam, the Netherlands

Abstract

As is the case with most European countries, the majority of fatalities among children and young people after the first year of life in Hungary arise as a result of injuries. There are over 300 deaths due to unintentional injury in the age group 0–24 years every year and around 24 000 injury-related hospitalizations. Injuries often result in long-term health care and rehabilitation needs and also lead to permanent impairment, a decrease in the overall quality of life and reduced work capability. The consequences not only affect the life of the individual concerned, but also influence the future of the family and present serious burdens to society.

Children and young people are exposed to accident risk to different extents. Toddlers (1–4 years of age), adolescents, boys, young people with higher risk-taking attitudes and those living in poverty are at greater risk of injury.

According to research results and international experience, it is possible to reduce significantly the number of serious injuries suffered by children and young people and to mitigate their consequences. WHO, the European Union and the Conference of European Environmental and Health Ministers have urged European countries to prepare national action plans with a view to preventing injuries among children and young people, on the basis of an assessment of the present situation in their countries.

In Hungary, the national programme for infant and child health has provided an adequate framework for strategic planning. The national action plan on child and youth safety has arisen as a result of cooperation among Hungarian experts working in various related areas. The document aims to promote the prevention of unintentional injuries among those under 24 years of age. It describes objectives for the next 10 years (2010–19), defines actions for the first three years (2010–12) and identifies methods through which results can be monitored and evaluated.

The programme's mission is to establish: "a national partnership for the greater safety of children and youth". It seeks to more effectively prevent the incidence of unintentional injuries with the most serious outcomes without obstructing the healthy physical, mental, social and psychological development of children and youth. The goal is to reduce mortality due to injuries among people under 24 years by 30% in 10 years; if achieved, this target would result in a mortality rate from this cause in Hungary that is similar to that found in the European countries with the best results.

The action plan focuses on road traffic safety, safety at home and at child care institutions, safety during play, leisure and sports activities and on the coordination, monitoring and evaluation of domestic efforts aimed at injury prevention.

The goals can only be achieved through joint efforts in the areas concerned with the support of decision-makers and through cooperation among experts, involvement of children and young people and utilization of the resources and capabilities of non-profit-making organizations.

In this case study, we share our experience of the development and evaluation process of the national child and youth safety action plan.

Ireland: the socioenvironmental context of child well-being and the involvement of children in the development of a national set of well-being indicators

Anne-Marie Brooks, Sinead Hanafin
Office of the Minister for Children and Youth Affairs, Department of Health and Children, Government of Ireland

Noreen Kearns
Child and Family Research Centre, National University of Ireland, Galway

Michal Molcho, Saoirse Nic Gabhainn, Lisa Pursell
Health Promotion Research Centre, National University of Ireland, Galway

Abstract

This case study from Ireland includes an exploration of the relationships between engaging in physical activity and perceptions of local area among children, highlighting the importance of local facilities, and the perceptions of children of such facilities in promoting physical activity. It sets this exploration in the context of recent policy and strategy development for children in Ireland, particularly that which focuses on the provision of appropriate play and leisure opportunities.

The focus of the case study is the involvement of children in developing indicators of well-being for children. During the process of indicator development, children provided clear indications that having "good places to go" was important to their well-being. Subsequently, this was adopted as an indicator of child well-being and will be reported on every two years, employing data taken from the HBSC surveys in Ireland.

Given the relationships between having good places to go and physical activity, future initiatives designed to improve access to recreational environments may also have a positive impact on physical activity levels. Social inequalities in physical activity and having good places to go will continue to be monitored and tackled as part of these initiatives.

Italy: Tuscany Region: the ideas of the young for their health and the regional project "Di testa mia"

Mariano Giacchi, Michele Martiello
CREPS Department of Physiopathology, Experimental Medicine and Public Health, University of Siena

Serena Consigli, Katalin Majer, Benedetta Rotesi, Alberto Zanobini
General Direction of Right to Health, Tuscany Region

Giuliana Gasparrin,
Department for Environmental Research and Development, Ministry for the Environment, Land and Sea focal point, Rome

Emma Teresa Quaresima
Directorate General for Prevention, Ministry of Health focal point, Rome

Students who participated in the regional project "Di testa mia" (http://www.facebook.com/group.php?gid=78265962931&ref=ts)

Abstract

The regional project "Di testa mia" ("My head") offered an opportunity for young people to set out proposals to enhance their own health and well-being through adopting a peer-to-peer approach. Based on HBSC and Eurisko research data, five thematic areas were defined, which subsequently were used as items in an open competition for young people in 2008: love and sexuality; body and self-image; risks and entertainment; individuality and conformity; and networks and relationships.

The winning projects, which commenced in 2009, include one related to the theme of road injury prevention ("Have fun in a safe way") and one related to the physical environment and risk reduction ("Koinè"). "Have fun in a safe way" is related to the broad thematic area of "risks and entertainment," while "Koinè" is related to both "risks and entertainment" and "networks and relationships."

The project "Have fun in a safe way" was selected as a winner because of its practical nature and its adoption of a peer-education approach. "Koinè" has as its main objective the redevelopment of an urban area in Grosseto as a youth cultural centre. The aims are to move young people away from boredom and risky activities towards an education in arts and culture and create an open dialogue with health care institutions.

The 2008 competition was open to young people aged 17–20 years living in Tuscany. They were invited to submit ideas for promoting protective health factors and tackling specific problems in relation to the five thematic areas. They had to produce not only ideas on how to communicate about healthy lifestyles, but also present proposals for improving existing prevention services for young people in the Tuscan health service.

It was recognized that there was a need to organize a health campus during the summer to support young people to develop their ideas and create projects with concrete actions under the supervision of experts and tutors. The campus week was the most significant aspect of the project "Di testa mia." It brought together 40 young people, chosen by a commission, who introduced 18 fresh ideas about health. The young people, who demonstrated great involvement and responsibility, were divided into five groups based on the five thematic areas, each of which were supported by an expert and two tutors.

The five best projects, one for each thematic area, have now been developed through the Tuscany Regional Board. In accordance with the Regional Board deliberation, the experience of the pilot regional project "Di testa mia" will be rolled out through the regional territory during 2009 and 2010 in collaboration with local health agencies.

Kazakhstan: prevention of road injuries among schoolchildren

Akhmet Khairushev
Centre for Injury Prevention and Safety Promotion

Lyudmila Shumilina, Alma Zhylkaidarova
National Centre on Healthy Lifestyles

Gainel Ussatayeva
Kazakhstan School of Public Health

Abstract

This case study focuses on the educational intervention (school curriculum) developed for schoolchildren aged 6–14 years to help them learn the rules of the road and first-aid skills for injured people. The intervention was introduced in September 2008.

Data on children's mortality and morbidity due to road traffic injuries (RTIs) were derived from traffic police reports and studies conducted by the authors of the case study. We attempted to analyse data in respect of gender, socioeconomic and rural–urban differences, but only indirect information was obtainable due to lack of data and studies in this area.

The analysis showed age differences, with the majority of children killed being of school age. We also discovered information about regional differences in mortality levels due to RTIs and the number of transport units in different regions (oblasts). High numbers of RTIs with child fatalities occurred in regions with high-density populations, a high proportion of people under 15 years and a large quantity of transport units.

The case study describes the social and policy context in Kazakhstan, which is characterized in economic terms as a country in transition; the same could reasonably be said about its policy situation regarding road safety. Despite this, Kazakhstan has started to move in the direction of promoting road safety.

We then provide information about the intervention, its aim and objectives, implementation mechanisms, tools of control, settings and actions. We also discuss relationships between the intervention and European policy frameworks. The implementation of the intervention, which is designed to cover all groups of schoolchildren who live and study in Kazakhstan, does not involve the use of external monitoring and evaluation tools, apart from routine rating of schoolchildren's knowledge and skills.

The lessons learnt emphasize the importance of sustainability of the intervention in the future and the development of monitoring and evaluation (M&E) tools to derive evidence-based information to track positive changes in the health status of children at country level. The main lessons learnt point to the need for:

- a rigorous M&E system, with the introduction of effectiveness indicators and the development of pre- and post-test questionnaires;
- regular training for teachers;
- seminars and workshops on road safety for specialists from different sectors, including mass-media specialists;
- involvement of parents in road safety activities, as parents are the most important stakeholders in promoting the health and safety of their children; and
- public health leadership to drive the sustainable promotion of children's environmental health.

Lithuania: mediating effects of alcohol and traffic safety control and policies

Apolinaras Zaborskis, Aurelijus Veryga, Nida Zemaitiene
Institute for Biomedical Research, Kaunas University of Medicine

Romualdas Zuoza
Ministry of Education and Science, Vilnius

Aldona Gaizauskiene
Lithuanian Health Information Centre, Ministry of Health, Vilnius

Robertas Petkevicius,
WHO Country Office, Lithuania

Aida Laukaitiene
State Environmental Health Centre, Ministry of Health, Vilnius

Abstract

Lithuania has been among the countries with the highest injuries rate in the European Union (EU), a rate that is becoming more and more associated with the youngest inhabitants of the country. According to statistical data from Lithuania, injuries remain responsible for nearly 46% of all child and adolescent deaths. Road traffic injuries in childhood and adolescence continue to constitute the greatest proportion (44%) of all external causes of death and are among the highest in the EU.

Many deaths and injuries on roads are caused by drink–driving. Data from HBSC surveys carried out in Lithuania in 1994, 1998, 2002 and 2006 demonstrated the growing prevalence of unintentional injuries; by year of survey, 22.9%, 31.0%, 50.3% and 53.5% of students reported at least one medically attended injury in the last 12 months, respectively. A significant relationship between adolescents' injuries and repeated alcohol use was revealed.

The facts call for immediate and effective preventive actions. The government and many professionals recognize the importance of the issue, and all policies on child health adopted by the Ministry of Health in recent years have considered children's injury an important area. New traffic safety measures, road safety education programmes in schools and social advertisement campaigns have been implemented in Lithuania during the past few years.

Alcohol consumption is also recognized as one of the greatest social problems Lithuania faces, with substantial effects on the injury rate. The year 2008 was announced as the "year of sobriety". All the efforts made in 2008 produced clear results. This was the first year since the adoption of the Lithuanian health programme in which consumption of alcohol decreased significantly, from 14.3 litres of pure alcohol per person in 2007 to 13.2 litres in 2008. The percentage of alcohol-related fatal road accidents also declined, from 18.4% in 2000 to 12.2% in 2008.

The positive changes that have taken place clearly demonstrate that implementation of evidence-based alcohol control and other measures have a significant influence on road traffic safety overall and help to preserve children's health and save lives. There is, however, a lack of scientific data reflecting the role of new policy aimed at reducing injury rates among the youngest inhabitants of our country.

Our case study highlights the burden of child and adolescent injury in the context of alcohol and traffic safety control policy in Lithuania over the last decade. The analysis is based on the data of four HBSC surveys and other relevant data retrieved from national and international databases. It concludes that the prevention of child injuries can be strongly improved in Lithuania; indeed, the country has recently developed policies to reduce and prevent road traffic accidents and alcohol-related injuries.

Norway: reducing inequality gaps in physical activity through school-based interventions

Ellen Haug, Oddrun Samdal
Research Centre for Health Promotion, Faculty of Psychology, University of Bergen

Grete Haug
Directorate of Education

Sissel Jacobsen, Vigdis Roenning
Ministry of Health

Torill Larsen,
Betanien Deaconal University College

Nina Strand Oelnes, Henriette Oien
Directorate of Health

Abstract

The national policy focus on physical activity in Norway started in 1999 with the establishment of the National Board of Nutrition and Physical Activity. A key priority for the new board was to explore existing national population data on physical activity and the relationships between physical activity and health as a basis for policy and action development. Norwegian data from the HBSC survey have been key sources for population data on children's and adolescents' levels of physical activity and sedentary behaviour. The priority given to promoting physical activity by Norwegian national authorities has been demonstrated further through White Papers from the ministries of health and education. In addition, an extensive collaboration involving eight ministries was initiated as part of the development of the *Action plan on physical activity 2005–2009: working together for physical activity*, which was launched in 2005.

The ministries of education and health launched a joint intervention programme, "Physical activity and healthy meals in school", in 2004. This aimed to identify models that facilitate 60 minutes of daily physical activity in the course of the school day and ensure implementation of national guidelines for healthy meals in school. In total, 400 schools have been involved. The evaluation results indicated that primary schools were better able to develop models in which physical activity and healthy eating were integrated by teachers in their daily teaching, while secondary schools seemed more successful when physical activity was integrated into the teaching schedule and was included as part of learning objectives in other subjects. In this way, all students were involved through compulsory teaching. Teachers participating in the project asked for training and the provision of a searchable database with descriptions of concrete activities to help them in their efforts to facilitate daily physical activity at school. In response to this, the Minister of Education established a web-based tool to enable teachers to increase students' daily physical activity.

Three main lessons have been learnt from the processes of development described above. First is the importance and usefulness of employing research to guide the development of national policies and actions. Second, close collaboration involving several ministries in the development of action plans and policy documents has proven to be highly successful. And third, the ministries have emphasized the importance of evaluating the effects of their actions to learn how they can best improve population-level physical activity, particularly among children and adolescents.

Poland: progress in child and adolescent physical activity promotion and injury prevention

Joanna Mazur, Anna Dzielska
Department of Child and Adolescent Health, Institute of Mother and Child, Warsaw

Barbara Woynarowska
Faculty of Pedagogy, University of Warsaw

Wojciech Hanke
Department of Environmental Epidemiology, Institute of Occupational Health, Lodz

Tomasz Półgrabski
Ministry of Sport and Tourism

Marta Malinowska-Cieślik
Institute of Public Health, Jagiellonian University Medical College, Cracow

Hanna Kołoło
Faculty of Humanistic Sciences, Academy of Physical Education, Warsaw

Abstract

Awareness of the importance of socioenvironmental determinants of health inequalities and of partnership approaches to activities aimed at promoting physical activity and preventing injury is increasing in Poland.

Recent reports from the EU Survey on Income and Living Conditions (EU-SILC) and HBSC have highlighted the problem of child poverty in Poland. While the socioeconomic situation has generally improved following accession to the EU, up to one third of young people (particularly those in households with three or more children) are at risk of poverty and related health problems.

The child safety action plan (CSAP) project highlighted injury risks to young people from situations other than road accidents, including those occurring during sport and recreational activities. The national programme for the prevention of injuries among children and young people has not yet been implemented, but several deficiencies and barriers to progress in the area of child injury prevention have been identified.

The main objectives of this case study are to describe the extent of health inequalities affecting children and to provide examples of national actions, with special emphasis on environmental interventions. An attempt has been made to combine individual data reported by students during the HBSC survey in relation to family and neighbourhood characteristics with school-level data. The data show that:

- the risk of low physical activity increases notably among poorer families and young people who have a negative perception of the school environment;
- the risk of injuries increases in more socially disadvantaged areas;
- basic school resources are appropriate to meet needs only in a small number of schools;
- students in well equipped schools perceive the school psychosocial environment more favourably, and there are fewer injuries and less antisocial behaviour; and
- the social gradient is less pronounced in relation to students meeting the minimal recommended physical activity levels.

The “My sports field – Orlik 2012” programme provides an outstanding example of good practice in the area of social inclusion. It was developed to provide accessible sports fields to populations in each community. Improvement across two important child health indicators was

anticipated as a result: an increase in the level of physical activity, and a reduction in the prevalence of injuries and related health consequences. The programme may also contribute to the reduction of regional health inequalities through its contribution to creating sustainable development within regions.

The initiatives described in the case study show that it is possible to achieve cooperation among stakeholders. Cooperative agreements between ministries and local communities have been put in place and many institutions have started to engage in joint projects, with cooperation between institutions and merging of programmes with common goals being observed.

United Kingdom (England): the Play Strategy and social inequalities

Richard Vaughan, Ciarán Hayes, Robert Clogher
Department for Children, Schools and Families, United Kingdom Government

Abstract

The Government's central objective is to make England the best country in the world for children in which to grow up. In December 2007, it published the *Children's plan: building brighter futures.* This is a 10-year strategy outlining the government's approach to improving the lives of children and young people.

The children's plan builds on the "Every child matters" reform programme to improve outcomes for all children and young people to ensure they:

- stay healthy and safe;
- secure an excellent education and the highest possible standards of achievement;
- enjoy their childhood;
- make a positive contribution to society and the economy;
- have lives full of opportunity, free from the effects of poverty.

The Play Strategy is a Government policy, led by the Department for Children, Schools and Families (DCSF) and the Department of Culture, Media and Sport. It aims to develop new and improved play areas and child-friendly public space across England, providing all children with increased opportunities for play and informal recreation. This case study describes the details of the policy, the motivation and evidence base for action and the social and policy context in which the policy was made.

10. Gender inequities in environment and health

Authors
Lourdes Cantarero
Ministry of Health and Social Policy
Spain

Isabel Yordi Aguirre
WHO Regional Office for Europe

Abstract

Background

Emerging evidence from all over the world suggests that because of social (gender) and biological (sex) differences, boys and girls, women and men are affected by environmental factors in different ways, and their levels of sensitivity differ. Furthermore, gender interacts with race, ethnicity and other social stratifications, resulting in unequal benefits among various social groups and between women and men.

Review methods/data

The process of reviewing the evidence was carried out in two stages: (1) a search for relevant articles, studies and reports was run on international databases and web sites related to the study topic; (2) the most relevant literature was selected. Relevance of the articles was assessed in relation to the four regional priority goals (RPGs) of the Children's Environment and Health Action Plan for Europe (CEHAPE), adopted in 2004 at the Fourth Ministerial Conference on Environment and Health (WHO Regional Office for Europe, 2009):

- RPG I: ensure safe water and adequate sanitation;
- RPG II: ensure protection from injuries and adequate physical activity;
- RPG III: ensure clean outdoor and indoor air;
- RPG IV: aim at chemical-free environments.

By addressing environmental risk factors, the CEHAPE covers two of the seven priorities within the comprehensive WHO European strategy on child and adolescent health and development.

Results

Gender inequities in environment and health have been identified for the four regional priorities (safe water and adequate sanitation; secure human settlements; environment with clear air; hazardous working environments). Major parts of the rural population of eastern Europe, the Caucasus and central Asia have no access to safe drinking-water. This implies that every day millions of women and girls collect water for their families reinforcing gender inequities in employment, health and education. When gender interacts with other social determinants (ethnicity or migration background) the exposure to risk is reinforced. The Roma community of Serbia for example, suffers

disproportionately poor access to water and sewerage compared to the general population. Evidence from all over Europe shows that from the age of 1–2 onwards, reported injury rates are higher for boys than girls. Evidence also shows that boys are more active than girls and it has been suggested that the male excess in injury rates is, at least in part, attributable to this. There are also significant questions linked to exposure to biomass or coal smoke, nutrition, and pregnancy that remain to be researched. Depending on the type of housing, ventilation, and cooking patterns, exposure to the particulates and gases found in biomass and coal smoke can be very high. Most concern is about prenatal exposure to endocrine disruptors. During pregnancy, certain synthetic chemicals stored in a woman's body fat have the ability to cross the placenta where they have the potential to cause birth defects or other more subtle damage to development of the fetus.

Conclusions

The empirical evidences presented in this literature review demonstrates the need for more visibility, better understanding and sensitivity when it comes to identifying, and tackling gender inequities in environment and health.

Introduction

Emerging evidence from all over the world suggests that because of social (gender) and biological (sex) differences, boys and girls, women and men are affected by environmental factors in different ways, and their level of sensitivity differ (Ostlin et al., 2006). Gender norms and values drive women and men into behaviours that affect differently their exposure to environmental risk. Societies assign men roles and division of labour that promote risk-taking behaviour and cause them to neglect their health. Still in many societies, women have less access to health information, care, services and resources to protect their health. Furthermore, gender interacts with race, ethnicity and other social stratifications, resulting in unequal benefits among various social groups and between women and men. Indeed, when these differences are unfair, unjust or avoidable we are talking about gender inequities in environment and health.

It is well documented that health promotion programmes sensitive towards gender differences where a gender analysis has been conducted are more effective and reach their goals in a more cost effective way than gender blind programmes (Ostlin et al., 2006). Despite of the evidence, many health promotion programmes are still gender blind and based on research where the sex of the study participants is not made explicit (Ekenvall et al., 1993). As a result, collection, analysis and presentation of data are often not disaggregated by sex and no gender analysis is undertaken.

The European Environment and Health Committee recommended addressing gender as a cross-cutting issue, and as such, it was presented in the first high-level preparatory meeting held in March 2008. This is in line with the WHO strategy to integrate gender analysis and actions into the work of WHO, approved by the World Health Assembly in 2007, together with World Health Assembly resolution WHA 60.25. The strategy and the resolution encourage Member States to address gender-based inequities across health policies and programmes.

The United Nations Environment Programme's (UNEP's) Governing Council in 2005 adopted Decision 23/11 on gender equality in the field of environment. It called upon governments and UNEP itself to mainstream gender in their environmental policies and programmes, to assess the effects on women of environmental policies, and to integrate further gender equality and environmental considerations into their work. Given the stated international responsibility to achieve health equality between the genders, development of a better understanding of gender inequities is fundamental to the improvement of young's people health and is necessary to better guide appropriate policy and practice responses.

This evidence-based literature review seeks to identify gender inequities in environment and health in relation to the four regional priorities. Concretely, the aims are to identify:

1. which environmental risks relevant to RPGs I–IV present most unequal distribution in relation to gender inequities; and
2. those environmental risks where gender interacts with other social determinants reinforcing the exposure to the risk.

It is expected that this review will shine a light on the situation on the WHO European Region and emphasize the need for more programmes addressing gender inequities in environment and health.

Review methods

The process of reviewing the literature available in the field of gender inequities in environment and health was carried out in three stages.

1. A search for relevant articles, studies and reports was run on international databases and web sites related to the study topic.
2. The most relevant literature was selected. Relevance of the articles was assessed in relation to the four RPGs (safe and affordable water and adequate sanitation for all children; promote safe, secure and supportive human settlements for all children; ensure that children can live in an environment with clear air; reduce hazardous working environments during pregnancy, childhood and adolescence).
3. The selected international material was reviewed.

Search strategy to identify studies for this literature review

A first search for relevant articles was run in the PUBMED database. The MESH terms used for the search were: "environmental pollution" and the free text "gender differences." The MESH term "environmental pollution" was exploded, including MESH terms found below this MESH tree. A total of 106 peer review articles where identified. A second search was run in MESH combining the MESH terms "Europe" AND "Environmental pollution" AND the free text "gender." When exploding the MESH term "EUROPE" all the European countries including the Transcaucasia countries were included in the search. A total of 353 where initially identified. A third search was carried out with the MESH term "central Asia" AND "Environmental pollution" AND the free text "gender." Two articles were identified. Taking into consideration that gender differences in environment and health is still a minor topic when it comes to peer review published articles and to have a better understanding of

the situation in the region, search using the Internet engine Google Scholar was run using the same research criteria mentioned above. The web sites of WHO, the United Nations Development Programme (UNDP), UNEP, the Women's Environmental Network (WEN) and Women in Europe for a Common Future (WECF) web sites were also consulted. Last, a review was conducted based on the references provided in the selected studies.

Inclusion criteria for the studies

The set of inclusion criteria referred mainly to year of publication, country and relevance in relation to the four regional priorities. All the WHO European Region countries were included and special attention was given so that every country of the region would show some light in those subsectors more relevant to their context. As expected the number of peer review articles in the field of gender inequities in environment and health in South-eastern European countries were very limited and even more so in the newly independent states. The reason why emphasis was given to the WHO European Region Member States voluntary excluding the United States of America and Canada[11] is twofold: to have a better understanding of the specific situation in the region and to highlight the need for more research in the field of gender inequities in environmental health in Europe. As for the time frame, reports published during the past 20 years (1989 to date) were included in the revision.

Methodological challenges

It is important to highlight the "gender insensitivity" in the PUBMED Information retrieval system. As defined by Ruiz-Cantero et al. (2007), an androcentric bias is the lack of a term to specifically index gender studies within the 17 000 MeSH index linked words. Neither is gender bias included among the 186 epidemiological method descriptors.

Empirical evidence

The following section is structured in four main subheadings. Under these subheadings the description of the evidence is summarized according to the four regional priorities.

Gender differences in water supply and sanitation (focus on central Asia and ethnic minorities)

Everyday millions of women and girls collect water for their families reinforcing gender inequities in employment, health and education. In almost all countries the gender division of labour assigns women responsibilities that men do not share. The intrahousehold division of labour means that women and young girls shoulder a greater burden of disadvantage than do men because they are responsible for fetching drinking-water from far away sources. Beyond the household, income inequality interacts with wider inequalities (rural–urban divides, region divides, group divides) reinforcing deep gender inequities (UNDP, 2006).

[11] When a search was run with the terms "USA" OR "Canada" AND "Environmental pollution" AND "gender" a total of 246 articles were identified. This is almost the double as when running a search with the term "Europe".

Major parts of the rural population of eastern Europe, the Caucasus and central Asia have no access to safe drinking-water. Bad hygiene and the lack of proper sanitation are main causes for this problem. Leaking pit latrines in the gardens pollute the ground water and waste water infects the drinking-water (WECF, 2009).

Gender inequities help to explain the low demand for sanitation in many communities. Evidence from many countries suggests that women place a higher value on access to private sanitation facilities than do men: an outcome that reflects the greater disadvantage women face through insecurity, loss of dignity and adverse health outcomes associated with lack of access. Indeed, the absence of toilets poses particularly severe public health and security problems for women and young girls (WECF, 2009).

Young girls, particularly after puberty, are also less likely to attend classes if the school does not have suitable hygiene facilities. Disparities in education linked to water and sanitation have lifelong impacts transmitted across generations. Education can empower women to participate in decision-making in their communities. As adults, educated girls are more likely to have smaller, healthier families, and their children are less likely to die and more likely to receive an education than the children of less educated mothers. These gains are cumulative, as are the losses associated with gender inequalities linked to water and sanitation. Because of the links between maternal education and child health, gender discrimination also holds back progress in child mortality reduction (UNDP, 2006).

Roma population represents the largest ethnic minority in most of eastern European countries. To show their commitment, eight countries in the region have declared 2005–2015 “The Decade of Roma Inclusion”, and have developed an agenda to improve access to housing, employment, education, and health care. Yet despite the good intentions, little is known about the health status of Roma (Sepkowitz, 2006). Even less when it comes to environment and health.

When gender interacts with other social stratifies, the exposure to environmental risks reinforces. The Roma community of Serbia (and Montenegro), for example, suffers disproportionately poor access to water and sewerage compared to the general population. The percentage of non-Roma and Roma households without access to facilities in Serbia (and Montenegro) is striking. Population without water supply in the general population is 63% versus 91.5% among Roma population. The same trend goes for toilet within the dwelling (30% compared to 82%) and sewerage (33% compared to 63%). In light of the facts in relation to women and sanitation, we can conclude that the female Roma population is one of the most vulnerable groups in Europe.

Unsafe settlements and gender differences in children

Evidence from all over Europe shows that from the age of 1–2 onwards, reported injury rates are higher for boys than girls, being boys consistently more likely to report having had a medically attended injury (Currie et al., 2008; WHO & UNICEF, 2008; McQuillan & Campbell, 2006). These differences are consistent over time and continue through adulthood and into old age (Currie et al., 1997, 2000, 2004; Rivara & Aitken,1998). Evidence also shows that boys are more active than girls (Currie C et al., 2008) and it has been suggested that the male excess in injury rates is, at least in part, attributable to this (Currie et al., 2008; Hillier & Morrongiello, 1998c). There is also

clear evidence that adolescence is a period of heightened vulnerability to injury (WHO & UNICEF, 2008; Agran et al., 2001b; Pickett et al., 2002a, 2002c; Williams et al. 1997), and that the gap between boys' and girls' injury risk widens during this period of life (Lyons et al., 1999).

McQuillan & Campbell (2006) found significant gender inequalities in adolescent injury risk, which were largely attributable to boys' sports injuries. These findings are also interesting because of what they suggest about teenage girls' lack of participation in sport and habitual physical activity.

Hillier & Morrongiello (1998b) argue that boys are at greater risk of injury because they perceive risk differently and are more likely to engage in risk-taking behaviour than girls (Currie et al. 2008). There is evidence for a biological basis for male risk-taking behaviour from both human and primate studies (Morrongiello et al., 2000). There is also evidence that boys and girls are differently socialized (Morrongiello & Dawber, 2000a; Soori & Bhopal, 2002), which could result in gender differences in risk perception and behaviour (Morrongiello et al., 2000). It may be that socialization processes shape gender differences in injury–risk perception and behaviour and this taking place on a foundation of biological differences (Morrongiello & Dawber, 2000b).

Olsson, Fahlen, & Janson (2008) argue that changes in behaviour, psychosomatic complaints and attitudes started at the age of 10 among both girls and boys. At the age of 11, an increasing number of girls had ceased to use bicycle helmets, started to drop out of sports associations, reported problems with headache and backache and used painkillers. At the age of 19, the girls in this semi-rural district of Sweden had far more problems with headache, body image and dieting than the boys of the same age. The decline of well-being among girls is a finding consistent with that of other studies (Bakoula et al., 2006; Hetland et al., 2002; Ostberg et al., 2006).

Jones et al. (2007) show that the increase in use of cannabis for recreational purposes in Sweden has created a problem for road-traffic safety. The proportion of men far exceeded that of women (94% versus 6%, $P < 0.001$) and the women tended to be a few years older than the men. Similarly, Khiabani et al. (2006) show a predominance of male offenders (96%) in Norway, compared with 97% in Sweden.

The HBSC 2005/2006 survey included questions on health-related behaviours considered to place the child or adolescent at risk of a range of negative outcomes. These risk behaviours include substance use, early sexual behaviour, bullying and fighting. The most substantial and consistent gender differences are found for these behaviours, and in almost all countries and age groups boys are more likely than girls to report that they engage in risk behaviours on an experimental or regular basis. In the majority of countries, this is the case for alcohol and cannabis consumption and for early sexual behaviour, bullying and fighting. In addition, boys are more likely to report that they initiated substance use at or before the age of 13 (Currie et al., 2008).

Boys from different foreign backgrounds in western Europe are more at risk of injuries than boys with European background. A study of Turkish migrants in Germany found that 50% of all children aged 7–14 cared for themselves and that more than 20% of pre-school age children were being cared for by siblings who were in many cases little older than the pre-schoolers (Carballo et al., 1998). Immigrants may also be more vulnerable to other types of accidents and data from Germany indicate that non-German children in

the 5–9 year old age bracket are more vulnerable to traffic and other injuries than German children of the same age (Korporal, 1990). In the Netherlands children of Moroccan and Turkish origin also appear to be more at risk of domestic accidents including poisonings and burns, as well as traffic accidents (de Jong & Wesenbeek, 1997). The poor housing migrants often end up in is often a major risk factor for accidental injuries and in France is associated with relatively high incidences of lead poisoning among young children who spend a lot of time in apartments and tend to pick and nibble paint splinters (Carballo & Mboup, 2005). Hence migration is characterized by relatively massive human wastage in terms of avoidable illness, injury, neglect and mortality.

Air pollution as a challenge for gender inequalities

The Swedish National Environmental Health Survey 2007 (2009) shows that women report ailments in the form of allergies and respiratory or skin hypersensitivity to a higher extent than men do. In Bordeaux, France, the effects of air pollution were greater for women than for men among the elderly (Filleul et al. 2003), and (Sunyer et al. 2000) showed that in Barcelona, Spain older women were at greater risk of dying associated with black smoke.

On the other side of the WHO European Region, Armenian women report that, due to prolonged fuel scarcity, many urban dwellers took to burning municipal waste for cooking and house heating. Burning of plastic, bleached paper, preserved wood and many other modern types of household waste exposed them to heavy loads of dioxin-like substances, polycyclic aromatic hydrocarbons (PAH) and heavy metals (Holmen et al., 2002). There are significant questions linked to exposure to biomass or coal smoke, nutrition, and pregnancy that remain to be researched. Depending on the type of housing, fuel, stove, ventilation, and cooking patterns, exposure to the particulates and gases found in biomass and coal smoke can be very high. The issue can be further compounded through exposure to environmental tobacco smoke (WECF, 2000).

Data show an increase of women with lung cancer and that chronic obstructive pulmonary disease death rate for women rose much faster between 1980 and 2000 than it did for men. Women are at higher risk of lung cancer due to their exposure to smoke from coal fires in their homes and, as previously highlighted, due to more biological vulnerability. This increase likely reflects also the increase in the number of female smokers particularly among young women. The HBSC 2005/2006 survey showed that, although there is a clear pattern among the youngest age group indicating that boys are more likely to be weekly smokers, this pattern is not seen among older age groups. In some countries, older girls report higher rates of smoking than boys (Currie et al., 2008). The effects of environmental tobacco smoke have serious implications on girls. As Holmen et al. shows, girls were more vulnerable than boys to the impact of smoking on respiratory symptoms and lung function (Holmen et al., 2002).

Sex and gender differences of asthma in adulthood are still relatively new areas of research and there is still no clear explanation of the differences that come with puberty. A gender-specific difference in asthma development in young children has recently been suggested in several publications (Anderson et al. 1992; Schonberger et al. 2005). Van Merode et al. (2007) show that boys suffered more from asthma-like complaints than girls, as diagnosed by the general practitioner (32% versus 18%, respectively).

Jedrychowski et al. (2009b) explored the gender differences in fetal growth of newborns exposed prenatally to airborne fine particulate and provided evidence that observed deficits in birth outcomes are rather attributable to prenatal $PM_{2.5}$ exposure and that male fetuses are more sensitive to prenatal $PM_{2.5}$ exposure.

Through an observational, prospective blind follow-up study performed in a primary care centre in Alicante, Spain (Ruiz-Cantero et al., 2007) showed that although men and women had similar respiratory complaints, after adjustment by age, marital status, employment, education, co-morbidity and severity, men were more likely to be asked about smoking habits: RRa:[12] 2.41 (95% CI: 1.57 to 3.70), auscultated: RRa: 1.30 (0.90 to 1.75), provided with a defined diagnosis: RRa: 1.77 (0.98 to 3.32) and considered unfit to work: RRa: 5.43 (1.64 to 9.96). Women were more likely to receive a pharyngotonsillar exploration: RRa: 0.63 (0.41 to 0.97). In view of this, they concluded that despite having the same respiratory symptoms, women were less likely to undergo diagnostic procedures and doctors tended to classify women in the category of undefined diagnosis more often. It should be considered that gender bias in the diagnosis could contribute to an erroneous estimation of respiratory disease prevalence, which could lead to unequal management of one sex related to the other.

Hazardous working environments during pregnancy, childhood and adolescence

In relative terms, little is still known about biological differences in environmental health between men and women in areas not linked to reproductive health. As shown by Stijkel & van Dijk (1995), even though physiological stress, such as pregnancy and lactation, can affect women's capacity to deal with environmental exposure, toxicological research predominantly uses male subjects to avoid variation caused by the female hormonal cycle.

Apart from differences in hormonal status, sex-related differences in sensitivity to toxic substances might be due to differences in detoxifying activity. Animal research indicates a five times higher detoxifying capacity in males. There may also be variations in the ability to absorb chemicals (children absorb lead twice as fast as adults); and in the susceptibility to damage (greater vulnerability of the fetus to many toxic and mutagenic compounds) (Sims & Butter, 2000).

Endocrine-disrupting compounds

The role of biology in environmental health risk can be more specifically demonstrated through the current widespread attention to endocrine disruptors. A gender finding of interest in connection with environmental estrogens is that women are more susceptible than men to autoimmune conditions. Women's heightened immune response to both foreign and self-antigens appears to account for their greater preponderance of autoimmune disease (Ahmed et al., 1999). An important difference is that usually women have a higher body fat percentage than men (Botella et al., 2004), and this has been associated with a larger storage of lipophilic chemicals.

Studies have shown we all carry a burden of synthetic chemicals in our bodies; up to 300 synthetic chemicals have been found in body fat and breast milk and many have

[12] Relative risk adjusted.

been shown to be cancerous, toxic to the brain and nervous system or to have the potential to cause birth defects or abnormal development in animal tests (del Rio Gomez & Campaigns, 2007).

Most concern is about prenatal exposure to endocrine disruptors. During pregnancy, certain synthetic chemicals stored in a woman's body fat have the ability to cross the placenta where they have the potential to cause birth defects or other more subtle damage to development of the fetus (Guillette et al., 1995; Harris et al., 1978; Hurst et al., 2002; Longnecker et al., 1999). It is estimated that background concentrations of dioxins and PCBs in industrialized areas in western Europe account for subtle congenital disorders such as hyperactivity and lowered IQ in 10% of the newborn (Koppe, 1995; Patandin et al., 1999b).

Reproductive organ malformations and defects in their offspring have enormous emotional and practical implications, not only for those affected directly but also for their families, for the implications for their caregivers, mostly women. Effects are diverse and multiple, including different bodily systems, and can appear at different stages during the lifespan of a woman, from spontaneous abortions (Arbuckle et al., 1999; Doyle et al., 1997; Gerhard et al., 1998b), congenital malformations and prematurity (Correa et al., 1996; Gerhard et al., 1998a; Taylor et al., 1993), low birth weight and low IQ to breast, ovarian, endometrial cancers, neurodegenerative disease like Alzheimer disease, diseases of the reproductive system due to disruption of the ovarian function, endometriosis (diZerega et al., 1980) and female endocrine system dysfunction within infertility (Massaad et al., 2002; Sharpe & Franks, 2002). Biologically, multiple differences in basic cellular biochemistry can affect health.

DDT and related compounds

DDT and PCBs in breast milk is reported to be associated with decreased lactation periods and lesser ability to breastfeed (Gladen & Rogan, 1995; Patandin et al., 1999a). DDT was phased out in most countries, but stocks of old pesticides form a hazard in all regions. In general DDT breast milk levels from countries applying DDT are higher than the WHO-standard but it is not too clear from what source, as DDT contamination can occur through the food-chain rather than from direct exposure. Similarly, high levels of persistent organic pollutants (POPs) have been found in the Arctic food chain. Although they have never been used there, these compounds have settled in the Arctic due to atmospheric transport. Inuit women report increased incidence of cancers by eating fish and game from the region (Sims & Butter, 2000).

Environmental disasters

Fears about breastfeeding and the safety of the food-chain greatly added to the trauma of affected populations in eastern Europe following the Chernobyl nuclear disaster of 1986. It has been estimated that the psychosocial dimensions of the disaster far outweighed the physical disease manifestations for many years afterwards (WHO Regional Office for Europe, 1990).

An extensive environmental catastrophe has been taking place for over 20 years around the Aral Sea. Significant destruction of livelihoods occurred, followed by massive impoverishment and outmigration and the weakening of family and social networks (Sims & Butter, 2000). Breast-milk monitoring in southern Kazakhstan revealed levels of dioxin-like compounds 10 times higher than those found in the United States. The

levels of concentrations of TCDD (tetrachlorodibenzo-p-dioxin) in Kazakh women's breast-milk resembled those found in populations exposed to industrial accidents (Hooper et al., 1999). The data suggest that exposure to these compounds is chronic, environmental and long-term. Cotton defoliants are a likely origin of exposure, with the most likely pathway being contaminated foodstuffs. Similar findings have been reported from Karakalpakstan and Uzbekistan (WECF, 2000).

The 2003 heat-wave created one of the hottest summers on record in Europe, especially in France. It led to health crises in several countries and combined with drought to create a crop shortfall in southern Europe. More than 37 451 people in the European Region died as a result of the heat-wave. In France, 14 802 people (mostly elderly) died from heat, according to the French National Institute of Health. From 35 years of age, the excess mortality was marked and increased with age. It was 15% higher in women than in men of comparable age as of age 45 years (Fouillet et al., 2006). Heat-waves must be considered as a threat to European populations living in climates that are currently temperate.

At a more general level, when dealing with environmental hardships men have some definite advantages over women. In the case of natural disasters and seasonal hardships, disaster statistics habitually record more female victims than males. For various reasons, women were at much greater risk of death in the Tsunami than other people. The ratio of female to male deaths was 3:1 and in some communities only women are reported to have been killed (Carballo et al., 2005). Apart from differences in physical strength, social norms restrict women's freedom and independence of movement, which affect their willingness to leave homes and possessions in times of risk (Sims & Butter, 2000).

Gender roles and differential exposures to chemical hazards

Gendered roles mean women and men are exposed differently to environmental factors. In most societies, women's lives have been lived mostly in the domestic/ private sphere, men's in the public sphere. So women are exposed more at home, in caring for others and through personal care, men have greater exposure at work and less in those other roles. As traditional roles change, so exposures are likely to change. Social factors such as access to education, involvement in scientific research, political representation and access to power have all limited women's participation in decision-making, leading by omission to gendered decisions (del Rio Gomez & Campaigns, 2007).

Women are entering a different workforce era, sharing jobs which had previously been occupied only by men, like working in pesticide factories (Smith et al., 1997). However, women who may be exposed to the same substances in the same working environments as men may develop different responses. For example, while men exposed to pesticides like DDT have been reported to have an increase in testicular cancer (Ekbom et al., 1996), reduction in sperm concentration and infertility (Rozati et al., 2000), testicular dysfunction (Burlington & Lindeman, 1950), cryptorchidism and hypospadias (Weidner et al., 1998) high levels of serum LH and FSH and reduced sperm count (Sharpe & Skakkebaek, 1993), epidemiological studies have also shown that women's exposure to pesticides is associated with an increase in menstrual cycle disturbances(Shy, 1993), reduced fertility (Smith et al., 1997), prolonged time to pregnancy (Juul et al., 1986) spontaneous abortion (Correa et al., 1996; Kolstad et al., 1999) stillbirths and developmental effects (Bretveld et al. 2006). Studies have also shown adverse reproductive health outcomes among women exposed to pesticides, solvents and

organic pollutants (Restrepo et al., 1990; Stockbauer et al., 1988). A special concern for women and their offspring is contamination of breast-milk through exposure to chemical compounds being manufactured and used for industrial, agricultural and domestic purposes. In fact, breast-milk analysis is an increasingly common method to monitor body burdens of persistent contaminants (Dewailly et al., 1996; Gladen et al., 1999; Hooper et al., 1997; McKone, 1989). For example, DDT in breast milk is reported to be associated with short lactation periods (Gladen et al., 1999; Smith, 1999). Brody et al. (2007) and Brody & Rudel (2003) through their literature review on environmental pollutants and breast cancer came to the conclusion that, although few epidemiological studies have been conducted for chemical exposures, occupational studies show associations between breast cancer and exposure to organic solvents and polycyclic aromatic hydrocarbons (PAHs).

Key messages on inequities on boys and girls: gender inequities from conception until adolescence

Research has shown that some contaminants can alter gene behaviour at extremely low doses, so adult diseases and sensitivities to subsequent exposures can be programmed during development in the womb. Jedrychowski et al. (2009a) provide evidence that 3-year-old boys are more susceptible than girls to prenatal very low lead exposure, documenting cognitive deficit.

Evidence also shows that there may also be variations in the ability to absorb chemicals – children absorb lead twice as fast as adults – and in the susceptibility to damage – greater vulnerability of the fetus to many toxic and mutagenic compounds (Sims & Butter, 2000). Furthermore, girls exposed to certain chemicals may have their menarche earlier, as well as an earlier onset of puberty (Howdeshell et al., 1999; Krstevska-Konstantinova et al., 2001; Partsch & Sippell, 2001).

As mentioned, evidence from all over Europe shows that from the age of 1–2 onwards, reported injury rates are higher for boys than girls, being boys consistently more likely to report having had a medically attended injury (Currie et al., 2008; WHO & UNICEF, 2008; McQuillan & Campbell, 2006). These differences are consistent over time and continue through adulthood and into old age (Currie et al., 1997, 2000, 2004; Rivara & Aitken, 1998). According to WHO data, in children under 15 years, there are on average 24% more injury deaths among boys than girls. Data from developed countries indicate that, from birth onwards, males have higher rates of injury than females, for all types of injury. However, the pattern is less uniform in low- and middle-income countries, but the overall gender differential is clear, with injury death rates around one third higher for males under 20 years of age than females (WHO & UNICEF, 2008).

In is also important to highlight the great impact of gender inequities in relation to household tasks systematically assigned to girls. As mentioned, for school-age girls the time spent travelling – sometimes hours – to the nearest source of water is time lost from education, denying them the opportunity to get work and to improve the health and living standards of their families and themselves. Collecting water and carrying it over long distances keep millions of girls out of school, consigning them to a future of illiteracy and restricted choice. Also girls, particularly during and after puberty, miss school or even drop out due to the lack of sanitary facilities, and/or the absence of separate girls' and boys' toilets. In these situations girls also stay away from school

when they are menstruating. An assessment in 20 schools in rural Tajikistan revealed that all girls choose not to attend when they are menstruating, as there are no facilities available. Lack of adequate toilets and hygiene in schools is a key critical barrier to girls' school attendance and education (WECF, 2009).

Sex differences were not completely explained by differences in exposure to risk and differences in injury rates begin to appear at the same age as differences in behaviour. Various theories have been proposed for the difference in injury rates between boys and girls. These include the idea that boys take more risks than girls, are more active (Currie et al., 2008; Hillier & Morrongiello, 1998a) and behave more impulsively. Also included are the suggestions that boys are socialized in a different way from girls and are less likely to have their exploration restrained by parents, although more likely to be allowed to roam further and to be allowed to play alone (WHO & UNICEF, 2008). There is also clear evidence that adolescence is a period of heightened vulnerability to injury (WHO & UNICEF, 2008; Agran et al., 2001a; Pickett et al., 2002b, 2002c; Williams et al., 1997), and that the gap between boys' and girls' injury risk widens during this period (Lyons et al., 1999).

The magnitude of inequity: a methodological discussion

Analysing the strength of gender inequities in environment and health, encounter the problem of gender bias in research, impeding to assess the real the magnitude of the inequity. Ruiz-Cantero et al. (2007) argue that most gender bias is to be found in the context of discovery. The biased production of new knowledge is indirectly evidenced by the lack of research and scientific literature concerning some of the significant issues related to women's health, such as occupational health. Not indicating the susceptibility of women to certain diseases that are common in both sexes is another gender bias of knowledge, such as the false belief that more men suffer chronic obstructive pulmonary disease than women.

Another impediment highlighted by Ruiz-Cantero et al. (2007) comes when incorrectly assuming equality between women and men. This in fact may be considered a selection bias in social epidemiology. A clear example could be underrepresentation of women in research on chemical risks: protecting the health of workers is the aim of occupational chemical risk evaluations. However, a selection bias because of gender insensitivity may influence the threshold limit values (TLVs) of these risk evaluations, since no specific information is available regarding chemical substances and women. The TLVs do not consider sex differences despite the obvious metabolic differences between the sexes that may affect their reactions to exposure. Consequently, the values given are the same for both sexes in most countries as well as for the ACIGH (American Conference of Governmental Industrial Hygienists). This is the case of the non-sex specific chemical risk evaluation in an occupation that is typical to women, hairdressing. In addition, the reference values are not applicable as they focus on inhalation risks, and do not consider the risk of cutaneously absorbed chemicals used in this occupation. Moreover, these values have been set for specific chemicals used in an eight-hour working day, but not for chemical compounds that a hairdresser would usually use for working days that last longer than 8 hours and often involve work concentrated at the weekends and in shifts. Also, the different responses from pregnant women workers have not been taken into account in the setting of these limits.

Another bias related to gender-blind approach comes when analysing results. The following case involves a study on the effects of exposure to pesticides on reproduction and illustrates how gender stereotypes may influence a biased perception of risk, making it necessary to re-analyse the information to identify the risks existing in women population groups that had not initially been classified as risk groups (Murphy et al., 1984). When working women were compared to housewives to evaluate the effects on reproduction, worse results were observed in the housewives: low birth weight relative risk (RR) = 1.2 (1.1 to 1.3) and preterm delivery RR = 1.2 (1.1 to 1.4). The possible reasons for these results are a healthy worker selection bias, differences in access to medical care during pregnancy and differences in other risk factors that could aggravate the situation. However, another explanation could be misclassification bias. Housewives could sometimes be classified as unexposed to a risk when in fact they were exposed. For instance, the great risk of fetal mortality in children of agricultural workers exposed to pesticides was RR = 1.62 (1.01 to 2.60). However, when this RR was stratified by the occupational status of the wives of agricultural workers exposed to pesticides (housewives versus employed women), it was higher for housewives, RR = 1.68 (1.03 to 2.73), and lower for employed women, RR = 1.24 (0.38 to 4.02) (Ronda et al., 2005). These results may be due to indirect exposure (washing laundry, longer time spent at home, etc) or to the fact that the housewives may have helped their partners apply the pesticides (Ruiz-Cantero et al., 2007).

Suggested pathways and mechanisms

The discussion of causal factors follows the arrows introduced by the framework model in the introduction chapter.

Arrow 1 – Differential environment conditions

Bartley et al. (2004) argue that studying gender differences in health inequality highlights some of the problems in health inequality research more broadly. These have been based on consideration of gender differences in access to more secure and privileged positions in the labour force combined with imbalances of power over household roles. Closer attention is needed to the different processes behind material power and emotional power within the household when investigating gender differences in health and risk factors.

The most immediate social context for the great majority of individuals is the household within which they live. Household influences on health and risk factors are only just beginning to receive attention in the literature on social determinants of health (Chandola et al., 2003). The still persistent intrahousehold division of labour both in developed and in major scale developing countries subjugate women and girls to a greater burden of disadvantage than do men. One of the most observable divides between women and men especially in developing countries (and to some extent also applicable to countries in transition) is in sanitation and hygiene (WECF, 2009). There is therefore an urgent need to integrate perspective into the efforts to promote safe and sustainable sanitation.

Arrow 2 – Differential exposure

The work women do exposes them in a particular way to double tripe and sometimes quadruple jeopardy. For example women may be exposed to pesticides at work, at home, in the garden and in the wider environment. Meanwhile, men tend to work in more risky workplaces which lead to more accidents (Lynn, 2009). When gender interacts with other social stratifications the exposure to environmental risks reinforces. Evidence shows that boys from different foreign backgrounds in western Europe are more at risk of injuries than boys with European background (Carballo et al., 1998).

A methodological aspect that has to be taken into account when analysing differential exposure is the complexity of the interactions between gender, sex and different social stratifies. Rohlfs et al. (2007) argue that disaggregation by sex, while constituting one of the first steps in any analysis of gender health inequalities, is not sufficient to understand the full underlying complexity of the situation. The interaction between sex, which unlike gender is a measurable variable, and other variables, social constructs, and biological characteristics can also have an impact on health. These interactions may be additive or multiplicative, and in the multivariate analyses certain factors may counteract the effect of sex. It should also be noted that the direction of certain associations between variables may be different when the analysis is stratified by sex. Data must be analysed with care to emphasize the social relationships between the sexes and clearly delineate underlying inequalities in them (Rohlfs et al., 2007).

Arrow 3 – Differential susceptibility

Gender inequities in general and more concretely, gender inequities in environmental and occupational health are still an underrepresented area of research (Ruiz-Cantero et al., 2007). Furthermore, when gender inequities are explored, often they are subject to several bias (Ruiz-Cantero et al., 2007). Hence, differential susceptibility is underestimated in the discovery field. Having said this, differential susceptibility has been demonstrated by several authors. As an example given in the previous chapter, Filleul et al. (2003) and Sunyer et al. (2000) showed that elderly women, especially socioeconomically deprived, show a higher degree of susceptibility to cardiovascular risk factors when exposed to black smoke.

Possible solutions

The empirical evidences presented in this literature review demonstrates the need for more visibility, better understanding and sensitivity when it comes to identifying, and tackling gender inequities. This section lays out 5 areas where research and policy-making can move forward.

Collecting and analysing sex disaggregated data systematically

Collection, analysis and reporting of data disaggregated by sex, age, socioeconomic status, education, ethnicity and geographical location should be performed systematically by individual research projects or through larger data systems. Attention needs to be paid to the possibility that data may reflect systematic gender biases due to inadequate methodologies that fail to capture women’s and men’s different realities (Ostlin et al., 2004).

Incorporating gender analysis on national health surveys

In refining the design of population health surveys, it is essential that policy-makers, social health investigators, epidemiologists and interest groups should contrast their perspectives and pool their knowledge to establish national guidelines that overcome shortcomings in the identification of gender and other social inequalities, which result in the failure to address unseen needs (Rohlfs et al., 2007). Some proposals include:

- for data analysis, comparing findings of women and men, and supplying context in the framework of social inequalities in health, for which it is not sufficient to simply fit models by sex as a confounding variable (instead separate analyses should be conducted for each sex);
- considering interactions of sex with other contextual variables such as social class;
- studying the diversity of groups of women and compare their health, for example, in terms of their domestic and paid workloads, presence of social support, or their having experienced situations of violence or discrimination.

The way results are expressed is also very important, since the aspects that are emphasized can condition the interpretation that is made.

Identifying and addressing gender inequalities in health policies and programmes

WHO is implementing the WHO strategy to integrate gender analysis and actions into its work. Member States from the WHO European Region were among those in the World Health Assembly that adopted resolution WHA 60.25, which accompanies the Strategy, and calls on ministries of health to identify and address gender inequalities in health policies and programmes.

Developing gender-sensitive indicators

Member States should ensure that their policies in this area identify and address gender inequities, and that gender sensitive indicators are developed to monitor progress.

Promoting the use of gender tools developed by the WHO Regional Office for Europe

The European strategy for child and adolescent health and development (WHO Regional Office for Europe, 2005), adopted by the WHO Regional Committee for Europe, identified physical environment as one of the seven priorities to be addressed by countries. To support the development of the strategy at the country level, the WHO Regional Office for Europe produced several tools, such as the gender tool.[13]

[13] Gender tool for the European strategy for child and adolescent health and development (http://www.euro.who.int/document/gem/eurostrat_gender_tool.pdf).

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11. Social inequality and environmental health in the Russian Federation

Author
Boris Revich
Russian Academy of Sciences
Russian Federation

Abstract

Social inequality is more evident in the Russian Federation than in any other country in the WHO European Region, except the republics of central Asia. The Gini coefficient, which measures the relative degree of disparity between the richest and the poorest, is much higher in the Russian Federation than in Finland and Sweden, which have extensive social security programs. The effects of social inequality on health of Russian citizens have been described in several publications (Kiselev et al., 2006; Prochorov et al., 2007). The effects of social inequality on diseases related to the environment have been rarely studied. This overview does not attempt to quantify the relationships between social inequality and the environment-related diseases. Nevertheless, matching the social conditions in the Russian Federation against certain health indicators can provide the basis for such risk assessments in the future. We also review some results of the most reliable epidemiological surveys. In the first part of this overview we consider average background mortality as well as selected social and economic factors. Morbidity rates are less informative in this context, since the standard methods of assessment of the burden of environment-related diseases (such as bronchial asthma and congenial abnormalities) have been used only in a few regions of the Russian Federation.

Mortality in the Russian Federation and social inequality

The Russian Federation lags behind the top ten developed countries in life expectancy by 15–19 years for men and 7–12 years for women. Compared to other countries with a similar per capita gross domestic product (GDP), the life expectancy gap is still 3–11 years for men and 1–5 years for women. Mortality in the Russian Federation is consistently higher across all age groups than in the industrially developed countries. If one compares the Russian Federation to the countries with similar level of economic development, two important observation can be made: the death rates among older people are roughly the same (Kiselev et al., 2006), and the death rates among people of working age in the Russian Federation are higher by 3–5 times for men and by 2–3 times for women (Prochorov et al., 2007).

The Russian health care system faces two sets of acute problems. First, the structure of mortality by cause among children and young people of working age is typical for the early industrial society (e.g. many accidents and poisonings). Second, cause-specific structure of mortality of the elderly population is typical for an industrial or even post-industrial society; where the dominant causes are cardiovascular diseases and cancer. The negative trends in premature mortality among young people of working age are driven primarily by the social consequences of the economic transition, including the increase in poverty and inequality of living standards, as well as unequal access to

education, health care and other social services. The severity of health challenges for the elderly is caused by demographic shifts and can be therefore mitigated by appropriate demographic policies. The common trends in life expectancy observed among the socialist countries before the dissolution of the USSR suggest that public health policy in socialist countries played a key role in mitigation of mortality risks (UNDP, 2009a). After 1990, life expectancy in several eastern European countries increased gradually, but this trend was not observed in the Russian Federation, which experienced great difficulties on its way out of the economic and social crises occurred in the preceding decades (Fig. 1).

Fig. 1a. Trends in life expectancy in eastern Europe and the Russian Federation, 1970–2004

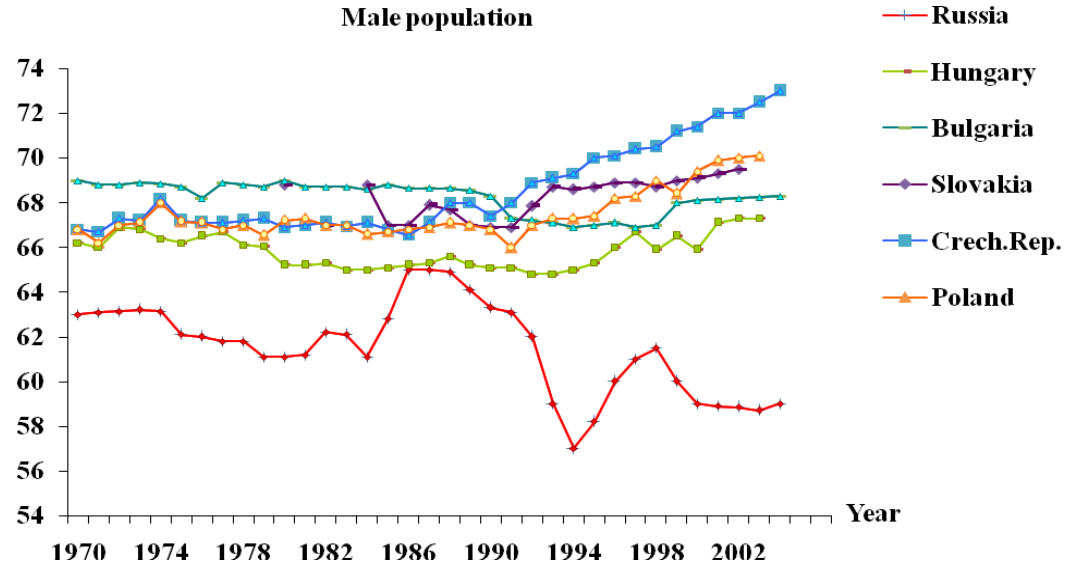
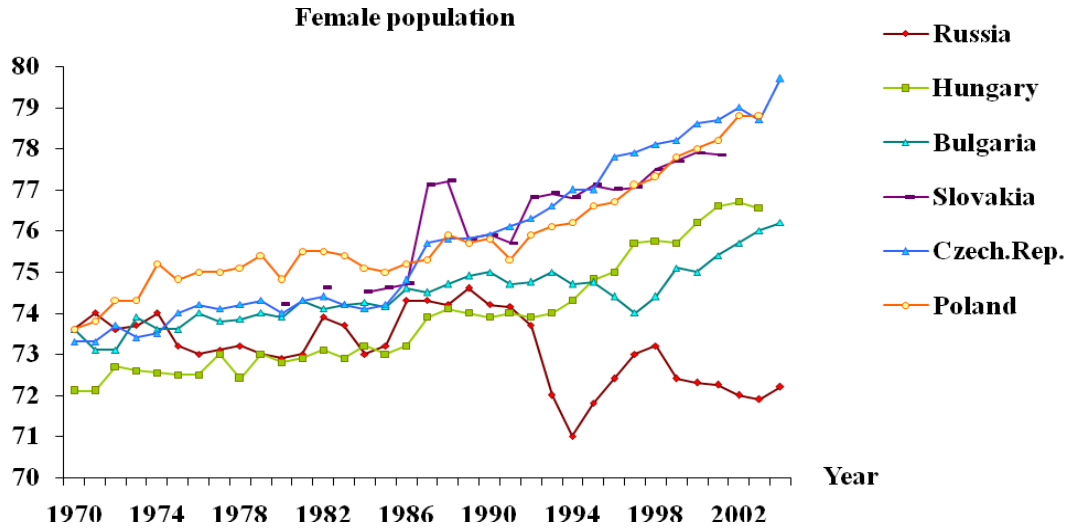


Fig. 1b. Trends in life expectancy in eastern Europe and the Russian Federation, 1970–2004



Source: UNDP, 2009a

An inverse relationship has been identified between life expectancy and poverty level, particularly among urban women of retirement age (Table 1).

Table 1. Pearson correlation coefficient (r) between the percentage of total population and the percentage of retired people, whose income during this year was below the subsistence level, and life expectancy in the same year, for 1995–2004

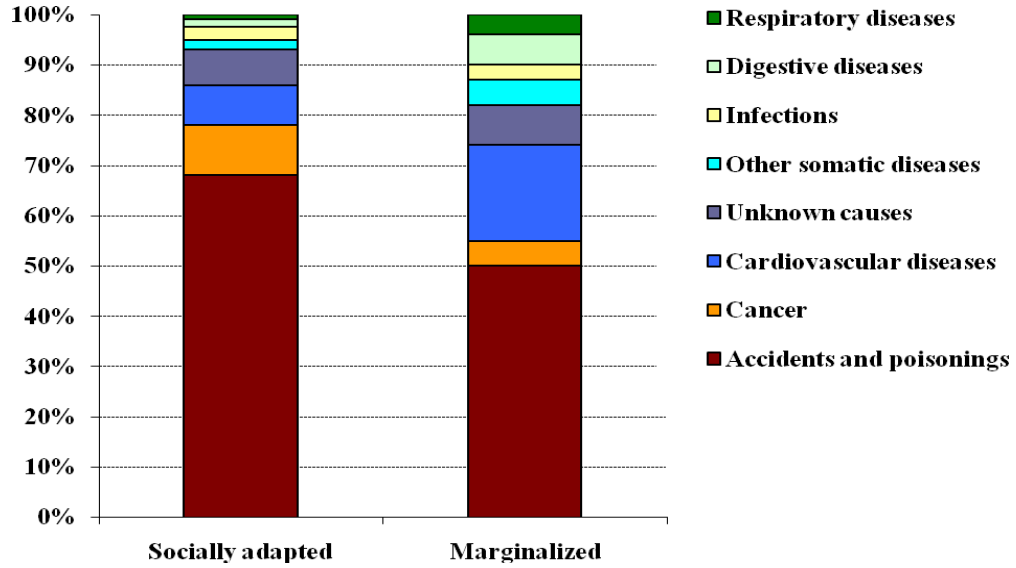
Population	Total population		Urban population	
	Males	Females	Males	Females
Total population	–0.330	–0.509	–0.421	–0.539
Retired people	–0.361	–0.542	–0.457	–0.573

Source: Adapted from Prochorov et al., 2007.

The transition from socialism resulted in a diverse and growing proportion of the population that was marginalized and did not participate robustly in public life. The term "marginal" denotes certain vulnerable groups or subgroups not positively involved in the social, political and economic life of the community. In addition to the traditionally marginal groups, such as homeless people or prisoners, the unemployed and illegal labour migrants grew in numbers (Ivanova, 2009).

High death rates among the young people of working age (20–39 years) are mainly attributed to the marginal groups. For example, the unemployed people contribute up to 55–70% of total deaths in this age group, while the remaining 20–30% is the share of low-qualification labourers. Thus, the share of socially adapted people in total mortality among this age group is quite small: no more than 5–10%. The shares of deaths from traumas, accidents, poisonings and malignant tumours in total age-specific mortality are lower for marginal groups than for socially adapted people. Conversely, the shares of deaths from circulatory diseases, respiratory and infectious diseases in total age-specific mortality are higher for marginal groups than for socially adapted people. The structure of mortality from external causes also differs between socially adapted and marginalized groups. Socially adapted population in the Russian Federation, just like in other economically developed states, dies mostly from traffic accidents and suicide, while marginal groups die mostly from accidental alcohol poisonings and homicide, see Fig. 2 (Ivanova, 2009).

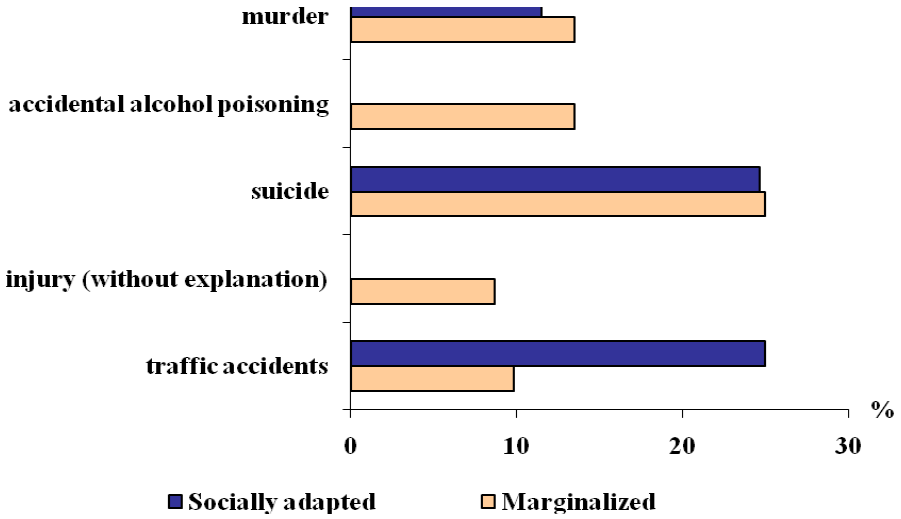
Fig. 2. Causes of death among people in socially adapted and marginalized groups aged 20–39 years[a]



[a] Average data for all three areas (Kirov, Smolensk and selected districts in Moscow)
Source: Ivanova, 2009.

Mortality from external causes also exhibits significant differences. As in most developed countries, the cause of death among socially adapted groups tends to be mainly traffic-related accidents and suicides, as opposed to intoxications and injuries among marginalized groups (Ivanova, 2009). Unfortunately, this work does not specify the number of deaths due to accidental alcohol poisoning among socially adapted groups (Fig. 3).

Fig. 3. External causes of death in socially adapted and marginalized groups in the Kirov area, 2004



Source: Ivanova, 2009.

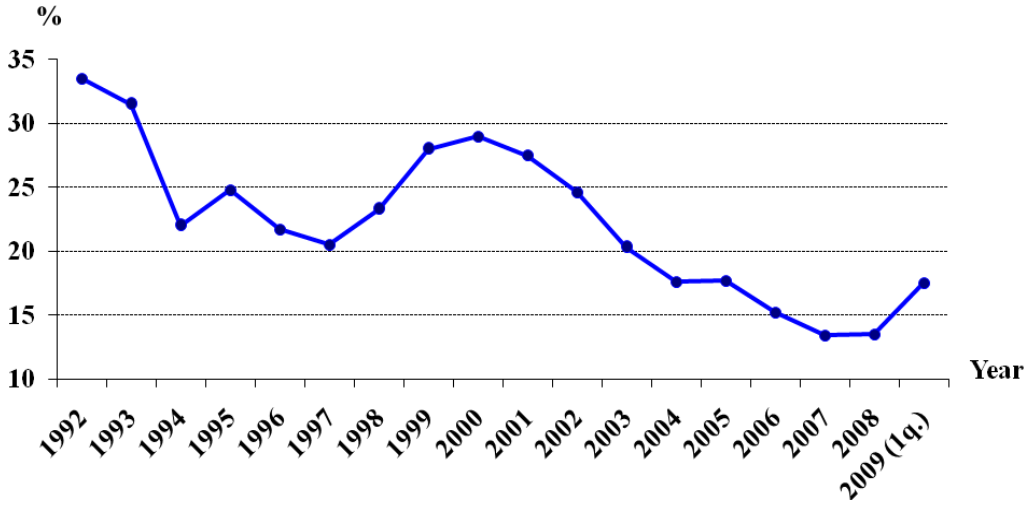
Indicators of social inequality

Income inequality and poverty

Although poverty was never measured in the USSR, an estimated 30–40% of the population lived below the poverty line. According to Rosstat (2009), 17.4% of the population had an income below the subsistence level in the first quarter of 2009, which equals to 24.5 million people (Fig. 4). Institute of Sociology of Russian Academy of Sciences reported that the per capita disposable income decreased by 30% in 57 administrative regions of the Russian Federation during the first nine months of 2009 (www.rg.ru/2009/12/11). This accounts for approximately two thirds of Russian regions (currently there are 83 regions in the country).

The residents of Moscow have the highest per capita income in the country. While only 7.1% of the country's population lives in Moscow, their share in national disposable income is 20%. The proportion of poor people in small cities with population under 100 000, where the most polluting enterprises operate, is almost twofold greater than that in the cities with over 1 million inhabitants: 21% and 12%, respectively. About 23% of children under 16, 13% of the retired people and 40% of the unemployed people live below the poverty line (Denisenko, 2008). The degree of poverty varies greatly by region. In the poorest regions (republics of Kalmykia, Ingushetia, Tuva, Mari-El and Ivanovskaya oblast), the level of poverty is 40–45%, and the Gini coefficient approaches 10. There is also income inequality between the sexes. Average salaryof a female is only 63% of a male's average salary (Zubazrevitch, 2005). This differential is greater in oil and gas production regions where average salaries are relatively high. The ratio of male-to-female employees is greater in the well paid sectors like finance, management and IT. Women typically find employment in public education, public health and social security sectors (Zubazrevitch, 2005). The proportion of males having a second job is greater than that for females (Rostchin, 2003). Average retirement benefits for males are also higher than those for females of the same age (Denisenko, 2008).

Fig. 4. Percentage of population with income below the subsistence level in 1992–2008



Source: Rosstat, 2009.

GDP – comparative assessment

Per capita gross regional product (a regional analogy of GDP) is used for comparative assessment of living standards. It is initially calculated in Russian Rubles and then converted to US dollars, using purchasing power parity (PPP) coefficient. Among the regions of the Russian Federation, Moscow has the highest per capita gross regional product (US$ 28 400 in 2006), which is higher than the GDP of several countries of eastern Europe. Per capita gross regional product exceeds US$ 10 000 in 40% of Russian regions. For comparison, Bulgaria and Romania have GDP less than US$ 10 000. The poorest regions of the Russian Federation had per capita gross regional product less than US$ 5000 in 2006. These regions include Ingushetia, Chechnya, Adigeya, Kabardino-Balkaria and Dagestan in the Caucasus; republics Tuva and Altai in southern Siberia, Kalmyk republic and Ivanovsksya oblast (UNDP, 2009b). While this indicator is not available for individual cities, where most environmental problems are concentrated, some authors estimated gross regional product for several subregions within a region. For example, this indicator varied from US$ 4400 to US$ 16000 (UNDP, 2009c) in Republic Bashkortostan, which has a rather stable regional economy, based on its oil refineries and chemical plants.

Unemployment

In recent years, unemployment has dramatically increased and reached 10% of the able-bodied population. It may reach 12% by the end of 2009 (Fig. 5).

Fig. 5. Unemployment in the Russian Federation (% of able-bodied population)

Source: Rosstat, 2009.

Unemployment in the Russian Federation is higher than in France, Germany and several other European countries. Unemployment rates are extremely high in Caucasian regions of the Russian Federation and in some of Russian monocities. Since the concept of monocities is discussed in some detail in the next section of this paper, they are defined as small or medium-sized towns where most of the population relies directly or indirectly on the success of one industrial company. They are widespread in the Russian Federation and represent about 12% of the country's population. Monocities were built

in the USSR around large metallurgical or chemical plants during the period of industrialization. These towns have acquired the nicknames of “metallurgical,” “lead,” or “chemical” towns, because the corresponding plants provide employment for nearly everyone there, and even communal enterprises (water supply and sanitation, residential houses, kindergartens, etc.) belong to the companies that manage the plants.

Social and environmental problems in monocities

Environmental surveillance and monitoring authorities in Russian monocities frequently lack analytical equipment to monitor environmental levels of the most toxic pollutants there. The levels of environmental pollution in monocities are extremely high. Approximately 40% of all cities in the Russian Federation (460) belong to this type (Stolyarov, 2009*)*. Their water supply, sanitation and communal heating systems had been previously managed by the industrial companies but were eventually handed over to the municipalities. Local administrations frequently cannot maintain such infrastructure because of lack of municipal budgets. In such cities, most houses are connected to centralized heating networks. Still, a small proportion of households may have individual heating systems. Monocities suffer the most in economic crises, when unemployment rises dramatically after the plant closures or reduction of industrial output. The Russian Government has offered financial support to 20 monocities, which is 5% of the total.

The impacts of environment pollution on public health are particularly evident in the monocities. Fifteen years ago, Russian Government came up with the legislative concept of “environmental disaster territories” to identify the most disastrous cities. Only 12 Russian cities have officially obtained this status, most of which were monocities built around a metallurgical or chemical plant. Unfortunately, this concept was abandoned after three years of its legislative application. An expert evaluation of environmental situation and public health showed that about 100 cities with total population of nearly 5 million could potentially qualify for this status (Revich, 2007).

In economic crisis, the companies that manage monocities may try to fire the employees of the environment protection departments in the first place. The companies try to save on operational and maintenance costs of emission control and wastewater treatment facilities. Some large enterprises have closed their corporate health care centres, which served the employees and their families. These problems are particularly severe for coal-mining monocities. In several European countries, including the Czech Republic, Germany and the United Kingdom, where coal mines were phased out, extensive social adaptation programmes were implemented to help coal miners to find new jobs. Many coal mines were closed in the Russian Federation in the 1990s, and coal production dropped. Since 2000, however, coal production has started to increase again, and the volume of discharges of untreated water from coal mines into surface reservoirs increased by 83%, while the volume of untreated air emissions in coal-mining sector increased by 62% (Kcharitonovsky and Tolchenkin, 2008). Coal mines typically operate in the regions that already have high levels of environment pollution. Several coal mining regions, such as Kuzbass, also have large metallurgical and chemical plants, which aggravates environmental situation.

Air quality, social inequality and environmental health

Coal mining regions provide an example of a combination of combined influence of negative environmental and social factors on public health. Coal mining and strip mining are the sources of air and water pollution, while closures of economically unprofitable mines create numerous social problems. Environmental problems of coal mining regions have been most extensively studied in Kemerovskaya oblast in western Siberia. There are eight coal mining towns in this region, which are characterized by high levels of total suspended particulates (TSP) in the air and polluted drinking-water. Locally produced foods contain high levels of lead, cadmium, mercury and arsenic. Public health of coal miners greatly depends upon the labour conditions and environmental factors. Relative excess mortality due to air pollution has been estimated at 4–19% (Zenkov, 2000). Between 1993 and 2006, morbidity rates among general population of Kemerovskaya oblast increased by 19.4%, and total mortality rate increased by 19.7% (Kemerovo, 2006a). A coal-mining town of Prokopyevsk (population 213 000), which previously had 17 mines and 5 coking plants, still has high concentrations of air pollutants; annual average levels of NO_2, TSP and benzopyrene are respectively 120 μg/m^3, 300 μg/m^3 and 3.8 ng/m^3 (Kemerovo, 2006b).

Unemployment and social problems create additional stress on the residents of coal-mining towns. Closures of coal mines cause pollution of drinking-water sources. Many of the mines, which are not closed, were equipped with water disposal and waste disposal facilities. Ten coal mines reported failures of these systems during year 2008, which was a rather trouble-free year for Russian economy. These failures posed real risks of massive pollution of the water-bearing strata and surface reservoirs. Wear and tear on technical equipment and relaxed maintenance standards caused leaks of methane from coal mines. At the same time, the level of underground water kept rising *(*Zenkov and Lodza, 2001*)*. Closures of coal mines in Perm *oblast* in the Urals was reportedly associated with increased levels of TSP in the air, which caused an increase in bronchial asthma rates among children, and corresponding increase in medical treatment costs *(*Farnosova, 2008*)*.

High levels of air pollution are typical for the regions where coal is extensively used for fuel. Siberia and the far east are characterized by combination of high levels of air pollution and persistent poverty. More than 70% of local district heating plants burn coal; these boilers contribute 50–60% to the total air emissions from stationary sources in these regions. These regions have a strongly continental climate with frequent temperature inversions. During temperature inversions, harmful substances can accumulate in the air at high concentrations. Average annual TSP concentration in the cities of Asian part of the Russian Federation is 30% higher than in the cities of European part of the Russian Federation: 143 and 110 μg/m^3 correspondingly. This is equivalent to 79 and 61 μg/m^3 of PM_{10} (a fraction of suspended particulates with aerodynamic diameter less than 10 μm) (Atmospheric Air Protection Scientific Research Institute, 2008). Coal-fired power plants in Siberia and far east are characterized by obsolete and outdated emission control technologies. This contributes to air pollution and aggravates social inequalities among regions. Average gross regional product in the regions with the greatest proportion of coal-fired power plants was only US$ 9600 in 2006, while national average value for this indicator was US$ 11 700. Among the 10 regions of the Russian Federation with the lowest per capita gross regional product (US$ 6200), six used coal as the dominant fuel for communal heating. Average life expectancy in these six regions (republics of Altai, Buryatia, Tuva,

Amurskaya *oblast*, Evreiskaya autonomous area and Zabaikalsky *krai*) is 60.9 years, 4.4 years less than the national average.

Eastern Siberian and far eastern cities (Ulan-Ude, Tchita, Khabarovsk, Kuizuil and Komsomolsk-on-Amur) typically have very high annual average TSP levels of 200–300 μg/m^3 (Atmospheric Air Protection Scientific Research Institute, 2008) Relative increment in total mortality caused by exposure to these TSP levels may reach 17% in Ulan-Ude (Boloshinov and Makarova, 2002) while the national average TSP-related mortality is 2%, or 40 000 annual deaths (Revich, 2007). Similar findings have been reported in the Russian Federation's country profile by WHO: 37 000 excess deaths attributed to the exposure to particulates in the air (WHO, 2009).

Water quality, social inequality and acute intestinal infections

In 2002–2008, 41.2% of surface sources of drinking-water and 17.3% of underground sources in the Russian Federation did not comply with national standards of drinking-water quality (Table 2).

Table 2. Percentage of drinking-water sources non-compliant with national sanitary standards in 2002–2008, minimum–maximum (mean) and estimated number of people who drink water that does not meet chemical or biological standards

Water quality	Surface water	Underground water	Number of people (millions)
Overall	38.8–45.8 (41.2)	16.7–18.2 (17.3)	-
Chemical contamination	24.1–32.2 (27.9)	27.4–28.3 (27.9)	10
Microbiological contamination	17.5–21.1	4.4–6.2	19

Source: Federal Hygiene and Epidemiology Centre, 2009.

A significant proportion of Russian population drinks water that does not meet microbiological contamination standards. This proportion is usually greater in the poor regions. These regions include Kalmykia, where73% of the population drink unsafe water, Karachayevo-Cherkessia and Ingushetia in the south of the country, as well as Nenetsky *okrug* (31%), Yamalo-Nenetsky *okrug* (27%) and Yakutia (66%) in Russian Arctic, where, correspondingly, 31%, 27%, 66% of regional population drink unsafe water (Federal Hygiene and Epidemiology Centre, 2009).

The main causes of low drinking-water quality are:

- water pollution at drinking-water intake does not meet hygienic standards;
- insufficient capacity of drinking-water treatment facilities;
- obsolete technologies of drinking-water treatment (coagulation, filtration, sedimentation and chlorination) do not completely remove hazardous toxicants and biological compounds resistant to chlorine;
- violation of technological procedures at drinking-water treatment facilities;

- excessive use of highly toxic organohalogen compounds during water chlorination;
- absence or inadequate administration of sanitary protection zones around drinking-water sources;
- secondary pollution of drinking-water because of depreciation of water supply and distribution networks;
- lack of qualified water engineers and personnel at sanitary surveillance departments;
- absence of scheduled capital repair and maintenance works;
- insufficient oversight and enforcement in drinking-water supply sector;
- unstable drinking-water supplies.

Non-compliance with the standards of microbiological quality has caused a few outbreaks of waterborne acute enteric infections in all regions of the country. Better quality of drinking-water may be expected in the regions where water supply facilities have recently been reconstructed or retrofitted, and the advanced water treatment technologies have been implemented. Some regions suffer from deficit of drinking-water. The poorest regions in the south suffer the most from low quality of drinking-water. These regions include Kalmykia, Dagestan, Chechnya and Astrakhanskaya *oblast*. For reference, per capita gross regional products in these regions are US$ 4208, US$ 4556, US$ 2372 and US$ 8016, respectively, and the national average is US$13 522.

About 42% of Kalmykia faces a shortage of drinking-water every day. Because of high content of calcium in underground water, the incidence of urolithiasis among children in Kalmykia is fourfold greater than the national average value (www.fotoelista.com/2008/kalmykia-water). A transregional water diversion system had to be built to solve this problem, but this project could not be implemented in the current economic conditions. Many communities in the Arctic also experience shortages of drinking-water, and local people import water for drinking. About 70% of population of Sakha Republic (Yakutia) receive the imported water without any preliminary purification or disinfection (Federal Hygiene and Epidemiology Centre, 2009).

The links between social conditions and the incidence of acute intestinal infections are obvious. Table 3 reports the incidences of waterborne infections including dysentery. The mean value for the two poorest regions is compared to the mean value for the 12 richest regions. Average per capita gross regional product in the richest regions is four times that in the poorest regions. The incidence of dysentery in the poorest regions is 5.2 times greater, and the incidence of acute intestinal infections is twofold greater than the mean values of these indicators for the richest regions.

Table 3. Incidence of waterborne diseases in regions with different GDP, 2005–2007

Area	Per capita gross regional product US$ in 2006	Incidence (per 100 000 population)	
		Dysentery	Acute intestinal infections, including dysentery
The poorest regions (Tuiva, Altay)	4 494	134.8	272.3
The richest regions (Moscow, St Petersburg and 10 others)	18 492	25.3	141.7

Poverty makes people consume locally produced food in the areas with high levels of environmental pollution

The diet of Russian population is characterized by low intake of meat products, fish, milk and dairy products, fruit and vegetables, which leads to deficit of animal protein, polyunsaturated fatty acids, vitamins, some trace nutrients and dietary fibre. The consumption of fruit and vegetables was only half of the recommended rates in some regions in 2008 (Federal Hygiene and Epidemiology Centre, 2009).

The Institute of Nutrition of the Russian Academy of Medical Sciences studies relationships between nutrition and health in poor families. For the purposes of this study, nutritional and health information and anthropometric data were collected for 11 000 people living in the five regions in the European part of the Russian Federation for the period 1997–1998 (Baturin et al., 2002).

Infants and small children

Children from the poorest families consumed less meat and vegetables. The consumption of most food items approached the recommended norm only in the fourth and fifth income quintiles. Daily intakes of calcium and iron were insufficient. Average body length of girls from low-income families was much less than the regional average. The children in urban families had higher incidences of many chronic diseases.

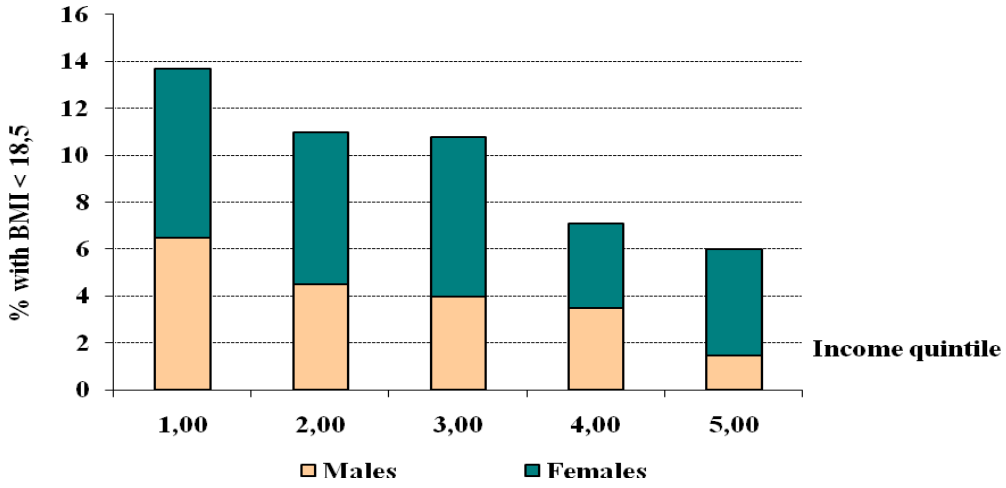
Children aged 3–15 years

In this age group, 3–5% of children had subnormal body weight, which indicated insufficient nourishment. There was a clear link between chronic undernourishment and family income. The diet of families with the lowest incomes was poor in fat. No correlations were found between diet and morbidity patterns.

Adults

All families were grouped in the five quintiles by their family income. Average body mass index (BMI) for the first three income quintiles (an indicator of low income) was significantly lower than the grand average (Fig. 6). The lowest protein consumption was observed in the twelve northern regions, including Komi Republic. The consumption of most vitamins, calcium and iron in the first and second income quintiles was lower than recommended by WHO guidelines. Insufficient intake of proteins and calories led to reduced body weight among children and teenagers in the poor families.

Fig. 6. Percentage of subnormal BMI in adults in five income quintiles



Source: Baturin et al., 2002.

Insufficient nourishment of adults also results in reduced body weight and lower level of physical activity (Baturin et al., 2002). In this research, morbidity rates were taken from official medical reports. However, poor families less frequently undergo a full medical examination. Medical care gets more expensive, and personal health expenditures increased more than threefold between 1994 and 2004. The share of health expenditures in personal income rose from 11% to 35% during this period (Shishkin, 2009). Further and more comprehensive research is needed to fully assess the health status of poor families.

In many highly polluted cities, people with low incomes are forced to consume polluted food. According to official data by Rospotrebnadzor, the proportion of people consuming chemically polluted foods was only 2.5% in 2008 (Federal Hygiene and Epidemiology Centre, 2009). However, the results of epidemiological research conducted in the most polluted cities revealed that this proportion could be greater, and continuous consumption of polluted foods could have serious impacts on public health.

In Chapaevsk, a city with high levels of persistent organic pollutants (POPs) in the environment, consumption of local food products was found to be associated with increased rates of breast cancer. The women who consumed locally grown foods had a higher incidence of breast cancer. Odds ratio (OR) of developing breast cancer was 5.7 for those who regularly consumed local pork or used cooking lard made from local pork and 2.3 for those who ate local fish (Table 4). These findings are important for planning preventive measures to reduce the incidence of breast cancer (Revich et al., 2001).

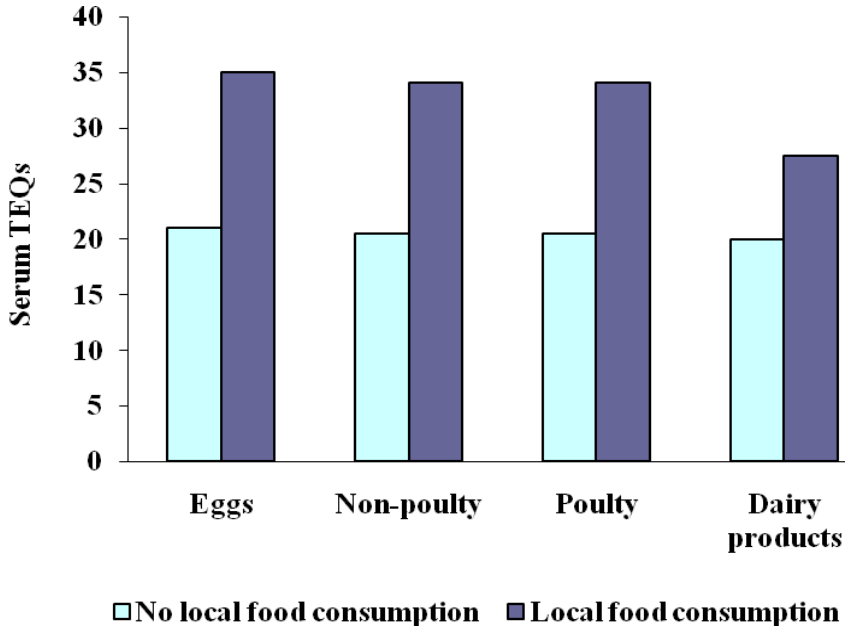
Table 4. Probability of developing breast cancer by risk factor in Chapaevsk

Risk factor	Odds ratio (95% CI)	*P* value
Nulliparity	3.8 (1.1–13.5)	0.038
Oral contraception	2.4 (1.03–5.5)	0.042
History of breast cancer in relatives	9.0 (1.85–43.6)	0.006
More than 50% of consumed pork was grown in local farms	5.7 (1.3–25.5)	0.021
More than 50% of consumed fish was caught in local lakes or rivers	2.3 (1.13–4.80)	0.022
Parents worked at the chemical plant	1.8 (0.80–4.00)	0.16
Employed at the chemical plant	2.1 (0.95–4.68)	0.07
Age at menarche > 13 years	0.82 (0.34–1.97)	0.64

Source: Revich et. al., 2001.

Higher concentrations of dioxin-like compounds in the blood serum of boys of Chapaevsk were significantly associated with age and dietary habits, i.e. consumption of fish and local meat products, except poultry (Hauser et al., 2005; ,Hauser et al., 2009) (Fig. 7).

Fig. 7. Mean serum toxicity equivalents (TEQs) and consumption of locally grown foods among boys in Chapaevsk[a]



[a] Adjusted for age, BMI, history of breastfeeding, residence in Chapaevsk, mother's employment at Khimprom chemical plant, vegetable gardening by the boy's mother, etc.
Source: Hauser et. al., 2009.

High levels of toxic metals in the environment are quite common in the cities with metal works in the Urals, northern Caucasus and far east. The town of Karabash in the Urals (population 15 000) provides an example of highly polluted town. The main source of pollution in Karabash is the copper smelter founded in 1910. The levels of toxic metals in the environment round the smelter are very high. The concentrations of cadmium in well water reach 10 μg/l, exceeding the national standard by an order of magnitude. The concentrations of lead, zinc and arsenic in soil reach 1500–2000 mg/kg, 700–1000 mg/kg and 150–300 mg/kg, respectively (Kozhevnikov, 1995). The vegetables grown by local people on the polluted lands contain high concentrations of lead (1.5–2.5 mg/kg), arsenic (1.1–2.3 mg/kg) and zinc (8.5–21.0 mg/kg). For reference, Russian maximum allowable concentrations (MAC) of these metals in vegetables are 0.5 mg/kg for lead, 0.2 mg/kg for arsenic and 10.0 mg/kg for zinc. Unfortunately, there are no published data on lead levels in blood of children from Karabash, but lead levels in children's hair were found to be very high. The rates of complications of pregnancy and birth, premature birth and neonatal morbidity in Karabash were significantly higher than in other cities in the region (Uralshin, 1993). However, the cited research had a descriptive character and did not consider confounding factors.

Rudnaya Pristan in the far east presents another example of a community plagued by lead pollution. Lead smelting there began in 1930, and the local plant has produced lead storage batteries since 1999. The concentrations of lead in the soil of vegetable gardens in Rudnaya Pristan reached 95 000 mg/kg, while Russian maximum allowable concentration of lead in the soil of settlements is 130 mg/kg (Braun et al., 2002). The US Environmental Protection Agency (EPA) recommends immediate decontamination of soil if the lead content exceeds 400 mg/kg. The lead content in locally grown potatoes in Rudnaya Pristan reached 1–3 mg/kg while the Russian hygienic standard is 0.5 mg/kg. The lead levels in children's blood in Rudnaya Pristan were 1.6–56.7 μg/dl; in 84 children these levels exceeded 10 μg/dl (Sharov, 2005).

The most detailed assessment of health impacts of mercury are currently being conducted near Bratsk reservoir and Angara river (Table 5).

Table 5. Mercury content in fish from Bratsk reservoir

Type of fish	**Number of sample**	**Mercury content, mg/kg range (mean ± m)**	**Measurements below MAC (0.3 mg/kg) (%)**
Bream	85	0.07–2.0 (0.46 ± 0.12)	18
Common carp	45	0.03–1.2 (0.50 ± 0.18)	3.9
Roach	53	0.08–0.12 (0.54 ± 0.11)	12.0
Perch	60	0.06–3.1 (0.75 ± 0.32)	30.0
Total/average	243	0.03–3.1 (0.54 ± 0.19)	12.8

Source: Yefimova and Lisetskaya, 2007.

The fish from the reservoir makes up 25–30% of the diet of local people. The mean level of mercury in the hair of the residents of Balagansky village near Bratsk reservoir was 2.1 μg/g, while WHO estimates the background level of this indicator as 0.5–1.0 μg/g. The residents of Balagansky village had higher rates of psycho-emotional disorders than the control group living far from Bratsk reservoir. The disorders observed among local residents included higher levels of situational and personal anxiety,

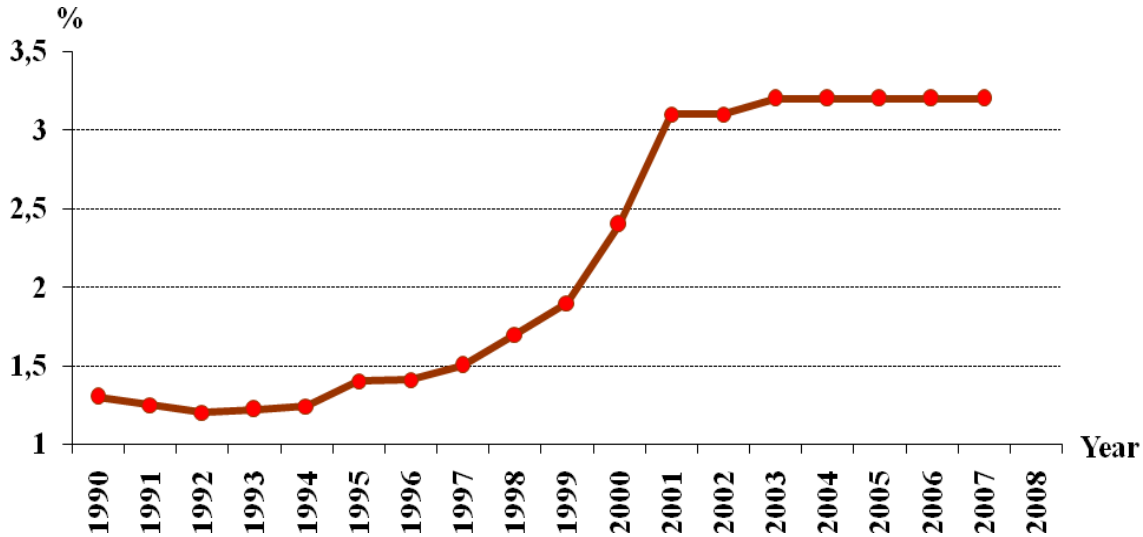
reduced capacity for logical thinking and abstraction, weaker memory and reduced levels of attention to detail (Yefimova and Lisetskaya, 2007). The cited report did not mention social status of surveyed subjects. Locally grown foods usually constitute a significant part of diet of villagers, because they do not have enough money to buy similar foods in supermarkets.

Social inequalities and housing facilities

Most people in the Russian Federation live in houses built between 1971 and 1995, although about 12% of Russian population still live in old wooden houses in small towns. Most houses have centralized water supply (88%), sewage disposal (86%), heating (91%) and private bathrooms (81%). The growth in housing construction during the last decade slowed down compared to the previous decades. Since commissioning of new residential housing did not keep pace with the economic growth in the country over the past 10 years, the proportion of dilapidated and unserviceable housing has significantly increased. The rate of construction of new houses is currently lower than the depreciation rate (Fig. 8).

As Fig. 8 shows, national average proportion of dilapidated and unserviceable housing is 3.2%, which is not very significant. However, some experts have insisted that the official statistics considerably underestimates the real state of affairs in residential housing *(*Belkina et al*., 2008)*. At the same time, small towns typically have greater proportions of dilapidated and unserviceable housing, than national average, and personal incomes there are lower than in big cities. The percentage of population living in dilapidated and unserviceable houses negatively correlates with life expectancy. Absolute values of Pearson correlation coefficients are greater for males than for females, see Table 6 *(*Prochorov et al., 2007*)*.

Fig. 8. Percentage of the housing stock in dilapidated or unserviceable condition, 1990–2007



Source: Rosstat, 2009.

Table 6. Pearson correlation coefficients (r) between housing conditions and life expectancy, 1999–2004

Housing conditions	Total population		Urban population	
	Males	Females	Males	Females
Living space (m^2/person)	0.075	0.269	0.092	0.218
Percentage living in dilapidated or unserviceable dwellings	–0.468	–0.110	–0.410	–0.471
Percentage with a water supply	0.447	0.403	0.397	0.337
Percentage with a sewage disposal system	0.373	0.325	0.331	0.259
Percentage with a heating system	0.502	0.477	0.465	0.414
Percentage with a bath	0.350	0.278	0.311	0.215
Percentage with a gas supply	0.301	0.498	0.338	0.518

Source: Adapted from Prochorov et al., 2007.

A steady increase in the proportion of unserviceable houses implies that the impact of housing conditions on public health will increase over time. Rapid depreciation of communal infrastructure and power supply networks resulted in increase in the number of accidents in communal heating sector during the winter season during several resent years. This can lead to tragic consequences during very cold Russian winters. The failures of residential and public school heating systems have occurred in Yakutia at outdoor temperatures of –45 °C, in Primorsky krai at –30 °C, in Karelia at –47 °C and elsewhere.

There are no direct estimates of health impacts of such accidents and failures in the Russian Federation. However, an estimated 340 people died from frostbite in the Russian Federation in 2002, and most of these deaths occurred among homeless or those intoxicated by alcohol. No deaths from frostbite have been recorded in the Nordic countries of Europe during recent years (Revich, 2008). After the recent accident at Sayano-Shushenskaya power station, problems with the electricity supply have been reported in Siberia. Even though one may expect significant health impacts of this accident during the forthcoming winter, these impacts can hardly be quantified.

The failure of communal heating during the season when outdoor temperatures are below 10 °C (3–5 months per year) leads to the drop of indoor temperatures below the normative threshold of 15 °C. Such failures have occurred frequently in the Russian Federation. For example, 20 Russian cities reported such failures during the winter of 2002/2003. More than 1 million people were affected and exposed to uncomfortably low temperatures, a third of them for a prolonged period.

Northern indigenous peoples: social and environmental factors

Social and economic situation in the Russian Arctic varies greatly by region, because some regions are very rich in hydrocarbons and other natural resources, while others are not. Social indicators are quite sensitive to the level of economic development in the region. Surveys of household budgets showed that per capita disposable income of northern indigenous peoples could be only 25% of the regional average value of this indicator. For example, per capita monthly disposable income of northern indigenous peoples in Taymyr okrug in 2006 was 3400 Rubles, while the regional average was Rub

13 800. The corresponding estimates for Evenk okrug were Rub 3800 versus Rub 12 900, and for Republic of Sakha (Yakutia) were Rub 5200 versus Rub 13 600. In the economically prosperous Khanty-Mansiysk okrug this income differential was the greatest: Rub 4900 versus Rub 22 400 (Russian Statistical Service, 2007). The indigenous peoples usually have worse housing conditions with inadequate water supply and sewage systems. Most of residential houses in Komi Republic and the Evenk okrug have no access to centralized water supply and sanitation. Only 26% of houses are connected to centralized sewage disposal systems in Republic Sakha (Yakutia).

Regional per capita expenditures on public health also vary greatly among the regions of the Russian Arctic. There was a significant decrease in the headcounts of doctors and medical personnel, in the numbers of hospitals, ambulatories and obstetrical and maternity homes. The traditional areas of dwelling of the indigenous peoples usually experience shortages of medical services for females and children. Many hospitals need urgent repairs; local hospitals do not have adequate supplies of essential drugs and modern medical equipment. Many remote areas remain inaccessible for qualified medical personnel. The medical accessibility indicator measures average number of hours per week when transportation is available. This indicator is equal to 7 hours per week in Taymyr *okrug*, 62 hours per week in Evenk *okrug*, 28 hours per week in Chukotsky *okrug*, 25 hours per week in Republic Sakha (Yakutia) and 18 hours per week in Yamalo-Nenetsky okrug (Bugromenko, 2008).

Climate change causes melting of permafrost, and northward shifts of permafrost boundaries. Permafrost melting corrupts building foundations and communal infrastructure in northern settlements, increasing the risks of infectious diseases. Climate scientists have predicted that the total area of permafrost might shrink by 10–12%, and permafrost boundaries might shift by 150–200 km to the north-east during the next 20–25 years (Anisimov et al., 2004). Permafrost degradation along the coast of the Kara Sea may intensify coastal erosion, and shift the coastline inland by 2–4 m per year (Anisimov and Lavrov, 2004). Coastline retreat poses considerable risks for coastal population in Yamal, Taymyr and other littoral lowland areas. Climate change may lead to massive disruption of residential housing and bring about the problem of climate refugees. Such climate refugees have already appeared in some Arctic territories of Canada (Tuktoyaktuk) and the United States (Shishmaref).

Approximately 160 000 indigenous people reside in the Russian Arctic and subarctic territories (Table 7). There are several major industrial centres in the Russian Arctic. The examples include Norilsk metallurgical plant, which is one of the largest sources of sulfur dioxide emissions in Europe; and metallurgical plants on Kola peninsula. These industrial centres and oil and gas exploration sites are the principal sources of environmental pollution in the northern territories. Although some indigenous peoples still lead nomadic life in relatively clean or even pristine areas near the seacoast, far from the sources of industrial pollution, they shall also experience health impacts of contamination of soil, pastures, and aquifers in the long run.

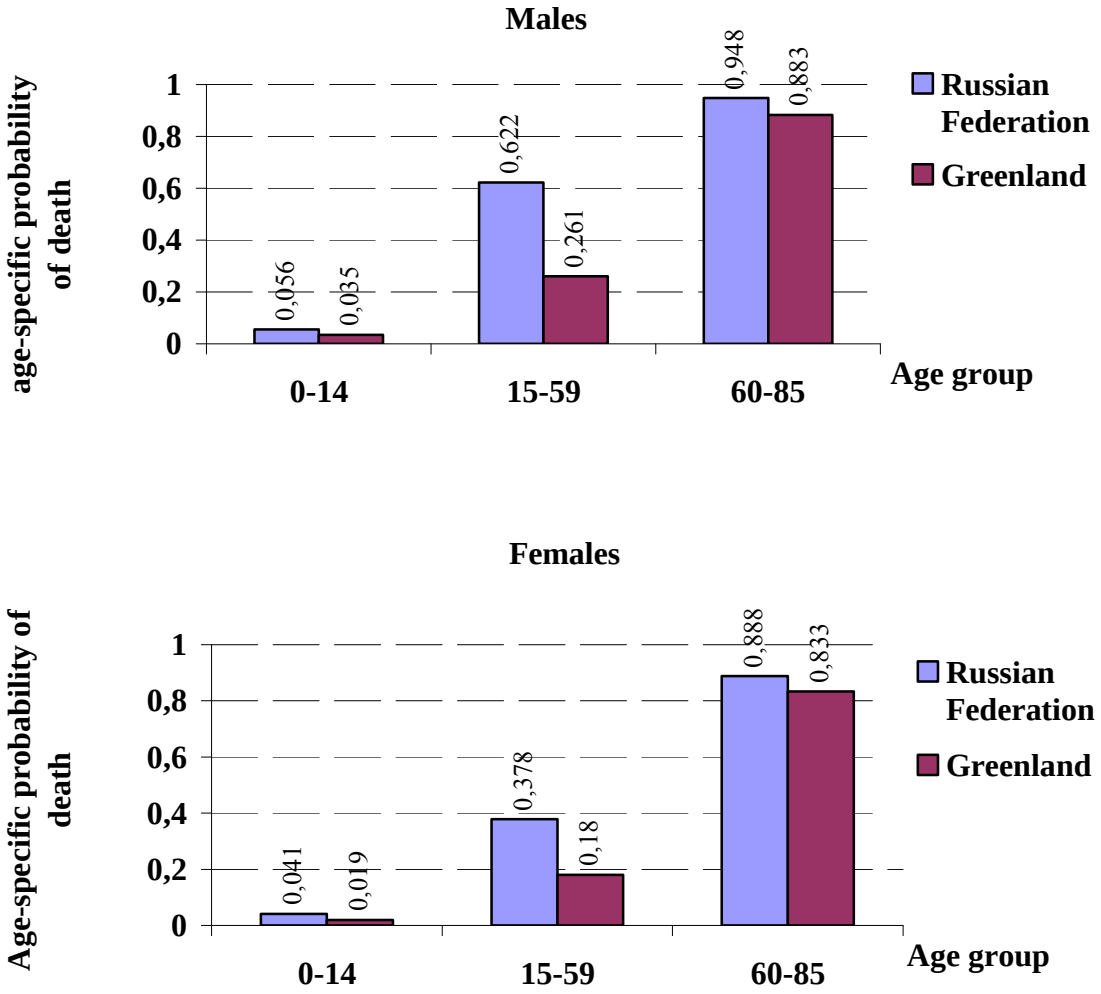
Table 7. Northern Indigenous populations (2002 census) and sources of pollution

Region	Indigenous population	Sources of pollution
Murmansk area	1 995	Metallurgical plants on the Kola Peninsula
Arkhangelsk area and Nenets	8 410	Pulp and paper mills; diamond mines; Plesetsk spaceport
Komi Republic	1 381	Coal mines, oil wells, pulp and paper mills
Yamalo-Nenetsky and Khanty-Mansiysk	65 783	Oil and gas wells
Norilsk and three neighbouring districts	1 254	The world's largest industrial metallurgical complex
Taymyr	9 879	Coal mines
Sakha Republic	33 133	Diamond mines
Magadan and Chukotka	21 860	Gold mines
Evenkia and Koryak	14 317	Small industry

The current demographic trends are caused by extremely high mortality rates among indigenous adults. The northern indigenous peoples have higher mortality rates and lower life expectancy than national average values of these indicators. In 1998–2002, average life expectancy among the indigenous peoples of the north was lower than national average by 10.5 years for males and by 11.4 years for females (Bogoyavlensky, 2008). While more than three-fourths of Inuit males and over 80% of Inuit females (indigenous people of Greenland) live up to age 60, the corresponding proportions among the small indigenous peoples of Russian north are only 1/3 for males and 2/3 for females. Fig 9 compares age-specific probabilities of death among indigenous peoples of Greenland and the northern territories of the Russian Federation.

The numbers reported in Fig. 9 should be interpreted as follows. For example, let us consider 1000 indigenous males of Russian North of age 15. Before they turn 60, 622 of this group will die and 378 will survive. Then, 0.622 is conditional probability to die and 0.378 is conditional probability to survive until the age 60 for a 15-year-old male in the Russian Federation. This graph proves that standardized age-specific death rates of indigenous peoples are higher in the Russian Federation than in Greenland, for all age groups and for both sexes. The difference is the greatest for group aged 15–60. This conclusion applies only to the indigenous peoples of the North and not to the population in general.

Fig. 9. Age-specific probability of death among indigenous peoples of Russian North and Greenland



Source: Bogoyavlensky, 2008.

The input of external causes in total mortality of the northern indigenous minorities in the Russian Federation is 36%, which is more than two times greater than the national average (15%). Accident-related mortality rates in the Russian Federation more than double the international average. Accident-related mortality among the indigenous peoples of the Russian Arctic is twice as much as the national average. Between 1998 and 2002, suicide rate among the northern indigenous minorities in the Russian Federation was more than 100 per 100 000 people, while the national average was 38 per 100 000. Homicide rates were correspondingly 70 per 100 000 and 27 per 100 000. Mortality rates from infectious diseases (mainly tuberculosis) were 60 per 100 000 and 23 per 100 000, respectively. Such rates are considered extremely high for an economically developed country in the 21st century, and indicate a demographic crisis *(*Bogoyavlensky*, 2008)*.

Nutrition patterns significantly influence public health of northern indigenous peoples. Such traditional foods as wild animal meat (game) and fish may contain excessive

content of persistent organic pollutants, lead or mercury. Approximately 85% of persistent toxic substances, which end up in human tissues, originate from local sources of pollution. These local sources include 15 million barrels of industrial waste that have accumulated during the intensive development of the Russian Arctic. Medical examinations of the indigenous peoples in the Russian Arctic have revealed high levels of polychlorinated biphenyls (PCB), lead and hexachlorobenzene in the umbilical cords of newborn children, adult males and females. The concentrations of these pollutants in human tissues of Russian indigenous peoples were among the highest of those reported in northern countries (Chashchin, 2008).

Climate change as a risk factor for socially vulnerable population groups

Climate change, air pollution and mortality

Many European researchers have reported that the elderly suffer the most during heat waves (Matthies et al., 2008). The same finding has been reported in Moscow, the capital of the Russian Federation, where the researchers analysed daily mortality during cold spells and heat-waves using time-series method (Tables 8 and 9) (Revich and Shaposhnikov, 2008).

Table 8. Excess mortality during the two cold spells of 2006 in Moscow in age group ≥ 75 years

Cause of death	**First cold spell**			**Second cold spell**		
	Excess mortality (%)	**95% CI**	**Total excess deaths**	Excess mortality (%)	**95% CI**	**Total excess deaths**
All non-accidental causes	9.9	(8.0–11.8)	195	8.9	(6.7–11.0)	176
Ischaemic heart disease	9.6	(4.8–14.3)	92	4.7	(2.1–7.4)	43
Cardiovascular diseases	6.5	(2.2–10.8)	36	10.2	(7.7–13.3)	70

Source: Revich and Shaposhnikov, 2008.

Table 9. Cumulative excess mortality during the heat-wave of July 2001

Cause of death	**Age group (years)**	**Excess mortality (%)**	**95% CI**	**Total excess deaths, 15–26 July**
All non-accidental causes	All	33	(20–46)	1200
	≥ 75	45	(25–65)	690
Ischaemic heart disease	All	32	(16–48)	430
	≥ 75	43	(23–64)	290
Cardiovascular diseases	All	51	(29–73)	370
	≥ 75	58	(31–74)	250
Respiratory diseases	All	80	(57–101)	30
	≥ 75	59	(0.3–118)	10

Source: Revich and Shaposhnikov, 2008.

Unfortunately, the available death certificates do not indicate education, income level, housing type, etc. Therefore, further epidemiological research is needed to estimate the impact of such confounders on climate-related mortality.

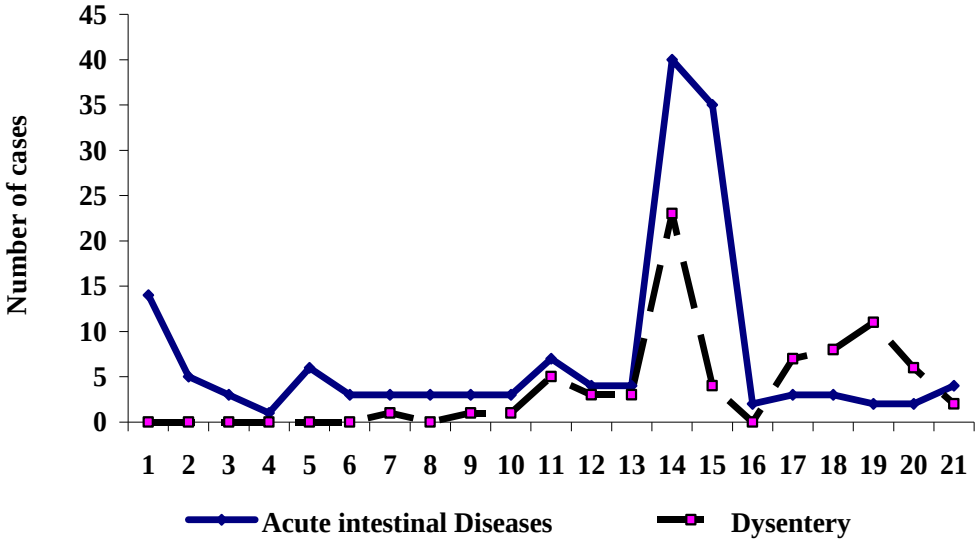
Climate change, drinking-water pollution and acute intestinal infections

Southern and Arctic regions in the Russian Federation suffer the most from these problems. Many regions in the south of the Russian Federation experience shortages in water supplies. A combination of these shortages and frequent heat waves greatly increases the risks of acute intestinal infections. The impact of floods on human health is so great that the WHO Regional Office for Europe issued a special report *Floods: climate change and adaptation strategies for human health* (http://www.euro.who.int/document/E77096.pdf). The social impacts of floods include damage to housing, infrastructure, industrial facilities and energy networks. Floods can also lead to pollution of drinking-water with hazardous chemicals which are stored in storage facilities.

In recent years, Yakutia had floods more than any other region. One of the worst floods occurred in the city of Lensk in 2001, when an extremely cold winter caused an unprecedented spring thaw. A warm spring and heavy rains caused rapid melting of the glaciers in the upper reaches of Lena river. This flood cut off the delivery of vital sanitation and health services for more than 38 000 residents of Yakutia in the spring and the summer of 2001. Urban infrastructure was ruined, industrial and communal water supply was discontinued, and drinking-water sources were seriously contaminated. About 9000 tons of petroleum products spilled in Lena river after the destruction of petroleum tanks. More than 80% of all houses in Lensk were destroyed and 95% of the city territory was flooded, including the sewage pumping stations and urban wastewater treatment facilities were flooded. To prevent outbreaks of intestinal infections, local authorities prohibited intake of drinking-water from all sources but one, which they equipped with hyperchlorination system. Despite these urgent measures, pollution of drinking-water led to increase in the incidence of dysentery and acute intestinal infections (Fig. 10).

It is quite likely that climate change will bring about more floods and other natural disasters, which will pose even more serious threats to public health in Yakutia. Only 40% of Yakutia's population drink tap water from centralized water supply sources, and 140 water supply pipes in Yakutia do not meet sanitary standards.

Fig. 10. Incidence of dysentery and acute intestinal infections of unidentified etiology in Lensk in 2001 (average for 5 days)



Source: Protodyakonov, 2007.

Conclusion

The main findings of this review may be summarized as follows. A significant proportion of population of the Russian Federation (18%) lives below the poverty line. Unemployment rate has risen dramatically. Income inequality is huge. Air quality and drinking-water quality do not meet applicable standards. Social problems are especially pronounced in so-called monocities, built around large industrial plants. Many local residents in these cities grow crops and vegetables on highly polluted lands, because they cannot afford to buy food in supermarkets. Some locally produced foods have very high levels of toxic pollutants, especially in small settlements near metallurgical and chemical plants. The meat of sea mammals and fish, which are traditional foods of northern indigenous peoples, may also contain high levels of toxic substances. The impacts of climate change on public health are most evident among the elderly people. There is a need to develop a comprehensive programme for protection of socially vulnerable population groups living in highly polluted areas. Our current understanding of combined impacts of social and environment factors on public health is very limited. Further studies of combined impacts of environmental pollution and social inequality on public health have to be undertaken in the Russian Federation and other newly independent states. Information on unemployment, income, poverty and gross regional product is currently available on the regional level. Although such information now complies with international reporting requirements, it is still difficult to obtain in many regions.

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World Health Organization
Regional Office for Europe
Scherfigsvej 8, DK-2100 Copenhagen Ø, Denmark
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