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**Burden of disease from
environmental noise :
Practical guidance**

**Report on a working group
meeting**

14–15 October 2010



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Bonn, Germany

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Abstract

On the 14th and 15th October 2010, in Bonn, a group of international experts met to develop the assessment method of burden of disease from environmental noise and to promote capacity building of European countries in new EU countries, SEE and NIS countries regarding the health risk of environmental noise. Evidence on cardiovascular diseases and sleep disturbance was reviewed and exposure–effects relationships were presented. The state of implementation of European Noise Directive and the role of strategic noise map data in burden of diseases estimation was discussed, considering the uncertainties and confounding factors. Step-by-step guidance for DALYs calculation was proposed based on the pilot project in six EU countries. Methods for burden of diseases assessment of environmental noise in countries without strategic noise maps were discussed. The participants agreed that development of experts networks between European countries would contribute to knowledge transfer and capacity building for environmental noise risk assessment in the Region. For better communication and dissemination informing the policy-makers and the public, the idea for introducing a new indicator for noise effect based on DALYs was considered. The meeting concluded that WHO, EEA, DG Environment, DG JRC, professional networks such as ENNAH and ICBEN should collaborate with national experts for the development of guidelines for national and regional policies on environmental noise and health, and for the Pan-European estimation of burden of health impacts of environmental noise.

The WHO European Centre for Environment and Health, Bonn Office, WHO Regional Office for Europe coordinated the development of this WHO document.

Keywords

ENVIRONMENTAL NOISE
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CARDIOVASCULAR DISEASES
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Introduction

Environmental noise is a threat to public health, having negative effects on human health and well-being. In order to provide evidence-based support to the local and national policy-makers in the risk assessment and management of environmental noise, the WHO European Centre for Environment and Health (ECEH) Bonn Office developed “Night Noise Guidelines for Europe” in 2009. In addition, it is preparing “Practical guidance for health risk assessment of environmental noise in Europe”.

The Europe Union (EU) member states reported strategic noise maps and action plans to reduce noise exposure to the European Commission, according to the Environmental Noise Directive (END; 2002/49/EC). In the meantime, evidence has been accumulated indicating serious health effects of environmental noise than previously known. Cardiovascular effects such as myocardial infarction and elevated blood pressure are associated to exposure to transport noise.

In 2009, the WHO ECEH Bonn Office supported a project on estimating burden of disease for selected environmental stressors (EBoDE project) including environmental noise in six countries. It was noted that the burden of cardiovascular disease and sleep disturbance from environmental noise can be estimated in the countries where strategic noise maps are available. Unfortunately, data and information on the exposure level and health impacts of environmental noise are very limited in many member states in the European Region. There is a need for knowledge transfer and capacity building in these countries. The meeting was supported by the Bonn Office funds generously provided by the German Government through its Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

Scope and purpose

The WHO ECEH Bonn Office convened a meeting, Burden of Disease from Environmental Noise with the following purposes:

1. To develop guidance on the burden of disease assessment from environmental noise, focusing on cardiovascular disorders and sleep disturbance in many European countries as possible;
2. To promote knowledge transfer and assist capacity building of countries from the European region, in the area of health risk assessment of environmental noise.

According to specific terms of reference the invited experts from EU member states, SEE countries and NIS countries prepared background papers on the topics on implementation of END, risk assessment of environmental noise and burden of diseases assessment of environmental noise in the EU region.

Opening

Rokho Kim (WHO) opened the meeting with welcoming remarks and overall introduction to the objectives of the meeting. The participants were reminded that noise is a priority mentioned in the Parma Declaration adopted at the Fifth Ministerial Conference on Environment and Health in March 2010. Participants adopted the proposed agenda, and elected Danny Houthuijs (Netherlands) and Stephen Stansfeld (United Kingdom) as co-chairmen, and Gordana Ristovska (the Former Yugoslav Republic of Macedonia) as rapporteur of the meeting. This report summarizes the discussions and conclusions of the meeting. Key documents, programme and list of participants are attached as Annexes.

Summary of discussion

Need for knowledge transfer and capacity building

A summary presented by Gordana Ristovska (the Former Yugoslav Republic of Macedonia) on the situation and recommendations for capacity building (Annex 1). The country reports were presented by participants from Albania, Belarus, Czech Republic, Georgia, Serbia, Slovakia, Slovenia, and The Former Yugoslav Republic of Macedonia. These presentations provided an overview of current situation in the public awareness, policy development, and research on environmental noise in new EU member states, South East Europe (SEE) and Newly Independent States (NIS). In many countries, funding for studies on health impacts of noise is very limited. Most of the new EU countries prepared strategic noise maps, but have not yet prepared action plans according to END. SEE countries started to adopt END into the national legislation and policies. However, NIS countries didn't start the process of harmonization with END. SEE and NIS countries don't have strategic noise maps and action plans. Participants agreed that there is an urgent need for knowledge transfer and capacity building of human resources in the area of risk assessment of environmental noise.

Updated review of exposure-response relationship and exposure assessment

Methods of Environmental Burden of Diseases (EBD) estimation were presented by Sophie Bonjour (WHO). EBD methods utilize the exposure data, dose-response relationship, health statistics to estimate the burden of disease from specific environmental risk factor. The burden is expressed in terms of DALYs (Disability Adjusted Life Years) which allows comparison between burdens of different environmental pollutants. EBD methods depend on the availability of reliable data and information. Results of burden of diseases assessment are very useful as basis for economic evaluation, can inform national decision-makers in setting priorities for intervention areas, and can be fed into communication strategy.

Uncertainty in the EBD estimation was presented by Danny Houthuijs (Netherlands). The different categories of the location of uncertainty in burden of diseases of environmental noise were discussed. Contextual uncertainty refers to the boundaries of the assessment, the definitions used and the selected health endpoints and exposure metrics. The exclusion of hearing impairment, cognition and annoyance and the expansion from myocardial infarction to ischemic heart diseases are examples of contextual uncertainty. Being aware of innate uncertainties, a structured approach to the assessment, and the communication of uncertainties can lead to a more balanced interpretation of the results of EBD assessments. A typology of uncertainties can be used to systematically identify and describe key uncertainties.

Process, results and lessons of the EBoDE project in the calculation of burden of noise-related cardiovascular diseases and sleep disturbance were calculated in six countries were presented by Otto Hänninen (Finland), Thomas Classen (Germany), and Erkki Kuusisto (Finland). The EBoDE pilot project provided harmonized EBD assessments for selected environmental stressors in participating six countries (Belgium, Finland, France, Germany, Italy, Netherlands). According to the preliminary results, Particulate Matter (PM) is associated with the highest burden (6.000 to 10.000 DALYs per million people), followed by noise, second-hand smoke and radon (with overlapping estimate ranges from 600 to 1500 DALY per million). EBoDE project set an example of good practice of applying the EBD methods to comparative risk analysis at the country level, which can be followed by other countries. Because strategic noise map is produced only in the conglomerations with greater than 250,000 population, the estimated DALYs are conservative. In addition, the conversion of noise indicators can bring in uncertainties related to the assumptions attached to the procedure.

Evidence on impacts of traffic noise on cardiovascular diseases was extensively reviewed and the exposure–effects relationship to be used in EBD calculation was presented by Wolfgang Babisch (Germany). Results from epidemiological studies performed in past few years consistently indicate significant increases in the risk of myocardial infarction and elevated blood pressures among the population exposed to road or aircraft traffic noise. Confounding factors such as socioeconomic status were controlled in most of these studies. Because the risk estimates were significantly greater than one even with the innate misclassifications of exposure, the true risk might be greater than reported. A reliable exposure-response relationship can be established for myocardial infarction. The future studies should focus on potential synergistic effect of road traffic noise and air pollution on hypertension and myocardial infarction.

Updated evidence review on sleep disturbance induced by environmental noise was presented by Sabine A. Janssen (Netherlands). New curves derived in 2009 has shown higher sleep disturbance due to aircraft noise. We need more insight into trend in sleep disturbance by aircraft noise. The disability weight for highly sleep disturbed (HSD) was proposed to be 0.07 in the Night Noise Guidelines for Europe (2009). The exposure-effects relationship for moderate sleep disturbances was not proposed. This means that the DALYs for HSD will be a conservative estimate of overall burden of sleep disturbance.

The questions were raised whether other health effects, for example annoyance, cognitive impairment in children, and mental health should be considered. Annoyance is an adverse health impact according to the definition of health by WHO. However, annoyance was not a clinical condition or addressed in the estimation of global burden of disease by WHO. The participants agreed that the decision whether to include annoyance in the DALYs estimation should depend on the socio-cultural values and priorities in the country. To provide support to the national and local authorities in the European Region, annoyance was included in the document on health risk assessment along with cognitive impairment and tinnitus which will be launched by the WHO Regional Office for Europe in the coming months. As for elevated blood pressure, it is difficult to estimate the burden without a good understanding of clinical significance of elevated blood pressures. If the more studies show the association of traffic noise with clinically diagnosed hypertension, an exposure-response relationship can be formulated.

The state of implementation of END was presented by Balazs Gergely (Directorate General for the Environment of the European Commission). Based on the outcomes of review on the implementation, the EC will formulate the revision of END in the coming years. Coordination and joint actions between EC DG Environment, EEA, JRC and WHO are very important for the future direction of END. One of the options for the next development of END would be to include the EU-wide noise action limit values in the directive, following the examples of air quality directives. The Commission will report on the future of END in March 2011. Colin Nugent (EEA) presented the database of strategic noise mapping, the Noise Observation and Information System for Europe. This website provides data for number or percentage of exposed population to different noise level and from different noise sources according to END. Exposure data necessary for EBD calculation can be obtained from this website.

Based on Jurgita Lekaviciute's (Directorate General Joint Research Centre of the European Commission) presentation, the meeting discussed the usefulness of strategic noise maps, as source for exposure data for estimating burden of diseases. The participants agreed that strategic noise maps are useful starting point until more reliable data are available. When the second round of strategic noise maps is produced from 2012, the data will become much more reliable and harmonized. However, due to the minimum-size criteria for agglomerations, a large part of the European population will remain beyond strategic mapping. From the point of view of WHO European region, the exposure data are still sparse from EUR B and EUR C. Direct extrapolation of exposure data from EUR A to EUR B and C might be problematic. The limitations of strategic noise maps were discussed. Noise levels under 55 dB L_{den} and 50 dB L_{night} are not reported and

often even not estimated, but part of people still will be annoyed or sleep-disturbed. There is sufficient evidence that a threshold of sleep effects is around $L_{\text{night}} \approx 42 \text{ dB(A)}$.

Countries which don't have strategic noise maps should anyway make efforts to assess their burden of environmental noise, using alternative methods. Goran Belojevic (Serbia) proposed the use of public transport maps as proxies of exposure levels. Gordana Ristovska (the Former Yugoslav Republic of Macedonia) proposed survey based approach using number of people with high level of sleep disturbance or incidence of ischemic heart diseases, disability weights and corresponding duration.

Step-by-step guidance for DALYs calculation at the national and local levels

Based on the experience of EBoDE pilot project in six EU countries, step-by-step guidance for DALYs calculation was proposed by Thomas Classen (Germany), Otto Hänninen (Finland), and Erkki Kuusisto (Finland). The proposal discussed at the meeting is attached as Annex 2. In order to utilize the available data produced by END, formulas converting the END indicators into those of exposure-response functions should be used as needed. The END data has limitations such as high exposure cut-off, exclusion of small cities from strategic mapping, and non-reporting of exposure to many relevant noise sources, resulting in a very conservative estimation of the actual burden. In the meantime, it is important to have good exposure modelling on the general population, and careful interpretation of results. A preliminary set of supplementary methods has therefore been outlined for filling the gaps in END data and for countries without strategic noise maps (Annex 3). It was proposed that step-by-step guidance and other informative background documents presented at this meeting should be published as WHO document as output of the meeting, after further revision reflecting the discussions at the meeting.

Box1. Five steps for the calculation of DALYs

Step 1: Selecting health endpoints

Step 2: Aggregating exposure data from country-specific strategic noise maps and/or alternative data sources

Step 3: Selecting exposure-response functions (ERFs)

Step 4: Calculation of the health effects

Step 5: Conversion to disease-adjusted life years (DALYs)

Role of experts networks in the capacity building and risk communication

Capacity building in new EU states, SEE and NIS countries is essential in order to reduce gap in risk assessment between the countries in the European Region. The role of experts networks on noise and health, i.e., European Network on Noise and Health (ENNAH) and International Commission on Biological Effects of Noise (ICBEN), was discussed in relation to knowledge transfer and capacity building of human resources. Through collaborative researches, regular scientific meetings and exchange programmes, these networks enabled knowledge transfer from old EU countries to new EU member states and to SEE/NIS countries. The experiences of building research and policy capacities in Serbia, Slovakia, Slovenia, and the former Yugoslav Republic of Macedonia were shared. In spite of the limited resources in the country, significant activities were possible in those countries often adopting innovative approach to the studies of health impacts of noise. For instance, Serbia used the public transport maps as a proxy of noise exposure data in the studies of cardiovascular effects. Children in the kindergarten in noisy areas have higher blood pressure than those in quieter areas. The presenters all agreed that the role of international networks of scientists on noise and health is very important in capacity building and risk communication in the countries. WHO give support to each country through bilateral agreements between WHO and Ministry of health. The Parma Declaration of the Fifth Ministerial Conference

on Environment and Health includes one paragraph and gives priority for action on environmental noise. WHO is urged by the Member States to develop guidelines on noise. In order to support the works of WHO more formally, the leading institutes of experts networks could be designated as WHO collaborating centres, and contribute to the implementation of the Parma Declaration.

Social costs of environmental noise are being estimated in the project funded by the Danish government. Evaluation of social-economic impact is an important tool for raising awareness and communicating risks amongst politicians and general public, integrating noise reduction measures into traffic planning and local planning laws. The Danish study will provide a good example for other countries for economic valuation and cost-benefit studies.

Partnership between WHO and EC

Communication and dissemination informing the policy-makers and the public at European level was discussed by WHO and EU representatives. After reviewing the status of development in the Environment and Health Information System (ENHIS) coordinated by WHO ECEH Bonn Office, the participants proposed to add new indicators on exposure and effects of environmental noise to the ENHIS indicators. It was pointed out that the strategic noise maps already provide data for the exposure indicator which was initially included in the core set of indicators. Noise indicators in ENHIS are also important for the monitoring of the implementation of the Parma Declaration by the countries. EEA launched a website, Eye on Earth (<http://www.eyearth.eu>) showing the water and air quality from the 32 member countries of EEA, displaying the results on an interactive map. The user-generated ratings are displayed alongside official data gathered by the EEA. The participants proposed that EEA should consider to include noise component so that citizens can provide their own comments on the validity of END noise data.

Stylianos Kephelopoulos (DG JRC) presented about Common NOise aSSessment methOdS (CNOSSOS-EU) for road, railway, aircraft and industrial noise. The Institute for Health and Consumer Protection (IHCP) of the DG JRC is supporting DG ENV for the implementation of END to improve the reliability and the comparability of results across the EU Member States. The common noise assessment framework by CNOSSOS-EU will allow for a coherent, transparent, optimised and reliable use for strategic noise mapping (first level of application, mandatory) and action planning (second level of application, voluntary) in relation to the data requirements, their quality and availability and last but not least, in terms of flexibility to adapt the national databases of input values, thus ensuring a smooth transition from existing national methods to the common methods. CNOSSOS relevant tasks are preparation of Good Practice Guidelines (GPG) on the competent use of the common noise assessment methods for both levels of the 'fit-for-purpose' framework of CNOSSOS-EU updating and enforcing the use of the EEA's reporting mechanism and training of EU MS for the competent use of CNOSSOS-EU. The cooperation between CNOSSOS-EU and WHO ECEH on harmonized assessment of exposure and health risks of environmental noise was emphasized, especially in the context of upcoming revision of END. After presentation and discussion following activities were proposed:

1. Extend the CNOSSOS-EU GPG to provide guidance on planning and performing BoD from environmental noise calculations on the basis of:
 - The Step by step guidance for DALY calculation using strategic maps (EBoDE project)
 - In absence of data from strategic maps, extending for DALY calculation with proxies
 - Data availability and quality on exposure and dose-response assessment
2. Develop a web-based tool for performing on-line BoD from environmental noise calculations via a standardised framework capable/flexible of:
 - Coping with various health endpoints (as from WHO-JRC Risk Assessment Guidance)

- Accommodating existing (pre-built) and new (customised) exposure-response functions (ERFs) for various noise sources and across specific noise levels
- Choosing among a range of disability weights (DW) per health endpoint
- Providing guidance on aggregating exposure data from country-specific strategic noise maps
- Integrating to the BoD calculations report notions about quantitative/qualitative evaluation of associated uncertainties.
- Using the tool for training purposes

Conclusions and recommendations

The meeting made the following conclusions.

- Results for burden of diseases assessment are very useful as basis for economic evaluation, can assist national decision-makers in setting priorities for interventions areas, policy making and communication strategy.
- A structured approach to the assessment and a transparent communication of uncertainties can lead to a more balanced interpretation of the results of EBD assessments.
- Supplementary methods are available to fill the gaps in END data and for countries without strategic noise maps, enabling the pan-European risk assessment of environmental noise.
- There is an urgent need for capacity building in the risk assessment of environmental noise along with exposure assessments using strategic noise maps in many European countries.

The meeting made the following recommendations.

- Development of a common method will be useful for assessing the burden of disease of environmental noise in the European countries with strategic noise maps. Step-by step guidance for estimating burden of disease can be used by the national and local authorities. A typology of uncertainties can be used to systematically identify and describe key uncertainties.
- Indicators on exposure and effects of traffic noise can be added to the indicators for ENHIS utilizing currently available noise map data and BoD estimates.
- Professional networks such as ENNAH and ICBEN can serve as a channel of knowledge transfer and a platform for cooperation in the capacity building in the area of risk assessment of environmental noise. Centres of excellence in the area of environmental noise such as RIVM of the Netherlands, UBA of Germany, Barts and London School of Medicine and Dentistry of United Kingdom can consider being designated as WHO collaborating centres.
- Collaborations between WHO, DG ENV, EEA, and JRC should be strengthened through joint projects for the synergistic implementation of the Parma Declaration and EU directives to protect the public health from environmental noise.

Annex 1. Needs for knowledge transfer and capacity building in selected new EU members, SEE and NIS countries

Gordana Ristovska, Tomas Hellmuth, Lubica Sobotova, Sonja Jeram, Anna Preiss,
Goran Belojevic, Irina Zastenskaya, Nana Gabriadze

Preliminary results of the multinational Environmental Burden of Disease in Europe- Pilot project have shown that environmental noise is the third largest environmental burden of disease (after ambient air pollution and exposure to SHS in six European countries), as expressed in DALYs. Noise has not been traditionally high on the public health policy agenda. The involvement of the health sector in noise-related policies is seen particularly in EurG-B and EurG-D countries, where the health sector has wide responsibilities from policy formulation and implementation to control, evaluation and dissemination of information. In EurG-A countries this responsibility was shared, to a larger extent, with other sectors.

The EU directive on environmental noise was a relatively modern policy instrument, requiring the competent authorities in member states to produce strategic noise maps on the basis of harmonized indicators, to inform the public about exposure to noise and its effects, and to draw up action plans to address issues related to noise.

1. Current situation for noise policy, research and awareness

1.1. New EU countries

New EU countries like Czech Republic, Poland, Slovenia and Slovakia have fully adopted European legislation, developed strategic noise maps available to the public, some of them have already performed risk assessment in the field of noise and health, published reports and papers for noise and health (Table 1).

Ministry of Health in Czech Republic is responsible for public health safety related to environmental noise, considering environmental community area more as a public health problem, not only as an environmental problem. The statutory public health safety supervision and regulation is provided by Ministry of health and 14 regional Public Health Authorities and supported by regional Public Health Institutes. The Public Health Safety Act identified responsibilities in noise regulation, setting methods of noise assessment and noise limits in living and occupational environment. They introduced the general institute of the Health Risk Assessment as a legislative tool and started with noise mapping after the break of 70/80ties, based on field noise measurements. Since 1990 computational methods for noise mapping and predictions have been used. The Ministry of Health is also responsible for providing strategic noise maps according the END and they coordinate the action plans provided by Regional Authorities and the Ministry of Transport. Czech authorities developed the Guideline for certificated health risk assessment of environmental noise exposure (2004), based on the results of the Environmental Health Monitoring System, and introduced national D–R relations, but in 2006 they adopted the relations developed by Miedema et al. for the assessment of annoyance and sleep disturbance. These methods were used in the END-Action plans summary provided by Ministry of Health in 2008.

Table 1 Noise legislation in new EU, SEE and NIS countries – current status

country	Adoption of END and responsible authority	Implementation of END	Strategic noise maps and responsible authority	Action plan	HRA of noise
Czech Republic	Yes Ministry of Health	Yes	Yes Ministry of Health	Yes Ministry of health	Yes
Slovakia	Yes Ministry of Health	Not fully	Yes Ministry of health	No	Yes
Slovenia	Yes Ministry of Environment and Spatial Planning	Not fully	Yes Ministry of Environment and Spatial Planning	No	No
Poland	Yes Ministry of Environment	Not fully	Yes Ministry of Environment	No	Yes
Macedonia	Yes Ministry of Environment and Spatial Planning	Not fully	No Ministry of Environment and Spatial Planning	No	Yes
Serbia	Yes Ministry of Environment and Spatial Planning	Not fully	No Ministry of Environment and Spatial Planning	No	Yes
Albania	Yes Ministry of Environment	Not fully	No Ministry of Environment	No	No
Belarus	No	No	No	No	No
Georgia	No	No	No	No	No

In Slovakia Ministry of Health, Public Health Authority of the Slovak Republic and Regional Public Health Authorities are responsible for dealing with problems of noise pollution according to the Act No. 355/2007 Coll. on the protection, promotion and development of public health (including amendments to certain acts). The National Reference Centre for Noise and Vibration was set up by the Ministry of Health. The role of the Centre is to keep the professional contact with Ministry of Health, Public Health Authority of the Slovak Republic and Regional Public Health Authorities in the problems of environmental and occupational noise and vibration assessment as well as with the other non-governmental components, scientific and research institutions. National Reference Centre provides technical and methodological guidance to Regional Public Health Authorities responsible for noise and vibration assessment in the environment and occupational setting, prepares training materials for the chief hygienist, prepares proposals for measures to protect public health from noise and vibration, trains workers in the field of noise and vibration assessment, organizes local educational and scientific events for continuous professional growth, assists in resolving citizen complaints on noise and vibration, performs the tasks associated with the harmonization of existing European legislation, provides consultation for professionals, individuals and entities on noise and vibrations.

Systematic monitoring of public noise load in Slovakia has not been carried out systematically. Results from monitoring activities implemented at random sites, within investigation proceedings and following public complaints were available. In 2007, the first phase of strategic noise maps brought some data on Bratislava agglomeration and surrounding areas in major road crossing with more than 6 million vehicles per year.

Several research studies were published since 1970s in local journals about environmental noise exposure and annoyance in Bratislava and in the other Slovak towns. Epidemiological studies on environmental noise, annoyance and non-auditory health effects were published in peer-review journals recently, but most of them were cross-sectional studies. Slovakia has not participated in Pan-European collaborative research on noise and health yet.

In Slovenia the Ministry of Environment and Spatial Planning is responsible for adoption and implementation of the END. The Ministry works through the Environmental Agency and the Inspectorate of the Republic of Slovenia for Environment and Special Planning. Several accredited institutes and companies are involved in evaluation of noise exposure for the purpose of development of strategic noise maps and for environmental impact assessment in case of interventions in the environment. The main institution involved in environmental noise and health effects is the National Institute of Public Health working in collaboration with the University Medical Centre in Ljubljana. The initiative at the moment is conducting a survey among citizens to get information on annoyance and sleep disturbance in the city of Ljubljana. A working group involving representatives from Ministry of Environment and spatial planning, Ministry of Health, Ministry of Transport and Municipality is established to prepare the Action plan.

Poland as EU member state has implemented European legislation regarding strategic noise maps, percentage of exposed population to different noise levels, conduct several studies for assessment of annoyance and sleep disturbance. These results they achieved with collaboration between health sector, environmental authorities and research institutes. Researchers are unsatisfied with strategic noise maps, because they can not receive the necessary information in order to propose a successful action plan. If they find equal weighted noise indicators from different noise sources which one we should try to reduce at first? - is the main question of researchers and policy makers in Poland.

1.2. SEE countries: Albania, Serbia and The Former Yugoslav Republic of Macedonia

Development of policies addressing environmental noise, their implementation and enforcement is obviously less intensive, with a lower health system involvement in SEE countries than in the other parts of the Region (Table 1).

In The Former Yugoslav Republic of Macedonia, management of environmental noise is regulated with Law on Environmental Noise Protection (LENP), which is harmonized with European legislation END 2002/49. This Law identified noise exposure indicators, responsible authorities, strategic noise maps and action plans. Responsible authority for collecting data is Ministry of environment and physical planning. Authorized and accredited laboratories for noise exposure assessment will obtain data for noise exposure indicators in collaboration with responsible bodies, like MOEPP for major roads, major railways and major airports, local government for agglomeration and settlements. Laboratories are allocated in public health centers and consultant companies for environmental risk assessment. Strategic noise maps are not prepared yet, so there are no available data for noise exposed population and public is not informed about the current status for noise exposure. National limit values for prevention of noise adverse effects were established in compliance with WHO recommendations by Ministry of health. Ministry of health is responsible for assessment of noise induced health effects, in fact Institute of public health has developed methods for assessment of noise annoyance and sleep disturbance and performed cross sectional study for adverse health effects in capital Skopje. In 2002 the cross sectional study for noise exposure assessment of school children and psychosocial effects in exposed children. was performed. In 2006 the cross sectional study and prospective study 2006-2008 for assessment of annoyance, sleep disturbance and noise induced health effects in adult population was performed. Serbia has started the process for harmonisation with EU directive 2002/49/EC, by adopting the Law on Environmental Noise Protection, in May 2009. Adoption doesn't mean fully implementation, because strategic noise maps and action plans are not prepared yet. Noise monitoring is performed by public health authorities and they obtain data for daytime and night time noise equivalent level. Research activities in the field of noise and health have long tradition

in Serbia. The main research fields of Serbian BETBEN (Belgrade Team for Biological Effects of Noise) in the last 20 years have been: stress effects of noise, effects on mental performance, noise sensitivity, cardiovascular effects and noise annoyance, and they published papers for their research work in peer-review journals.

Albania has adopted END with Law on management and assessment of urban noise, in 2007, and national noise limits values were established according WHO recommendations. The Ministry of Environment, Forest, and Water Administration is the responsible authority for management of environmental noise, where a technical council under the ministry is suggested to lead the management of the noise. According the law the sector of noise in the Institute of Public (under the Ministry of Health), should be established and serve as reference base unit for measurements, monitoring and assessments. Ministry of Environment is responsible authority for noise mapping and national action plan for protection from environmental noise within 5 years. Unfortunately the Competent Authority is not yet in function-technical council under the Minister is not established yet. For the period 2002-2008 noise monitoring was regularly carried out by the Institute of Public Health and financed in the framework of National Monitoring Program by the Ministry of Environment Forest, and Water Administration. Intersectoral cooperation should developed between health sector, environmental authorities and other interested institutions to improve implementation of the law.

1.3. NIS countries Belarus, Georgia

The intensity of noise pollution is growing permanently in NIS countries mostly because of transport and economic (industrial noise) development. For example the equivalent noise level increased for 2-5 dBA in Minsk-city and 3-4dBA in regional towns for the last 10 years. Due to limited resources for protective measures for noise, the needs for risk assessment and provision of scientific evidence of social-economic losses have increased. The indirect confirmation of the increased losses is the number of claims caused by noise. Another reason is the very high level of cardiovascular diseases (CVD) in practically all NIS countries and noise exposure had input to this morbidity rate. In Belarus research of environmental noise health impact is developed, based on methodological documents developed at national level. The main aim of these studies was the development of national standards, identification of main noise sources and their input in a level of pollution and finally development of recommendations to decrease noise levels.

National legislation is not harmonized with European legislation, but they have intention to start the process of harmonization with European legislation. That means they don't use harmonized noise exposure indicators, they don't have developed strategic noise maps and action plans.

In 2007 Georgian Parliament adopted the Law of Public Health and stated responsibilities of each Ministry for provision environmental and public health. Ministry of Labor, Health and Social Affairs identify norms and technical regulations for environmental and public health, Ministry of Environment and Natural Resources ensures elaboration of integrated state policy for safe environment and its implementation in accordance with the sustainable development and management of natural resources and protection of environment from negative physical factors, that may give impact on public health. National Environmental Agency established under the supervision of Ministry of Environment Protection and Natural Resources of Georgia has Department of Environment Pollution Monitoring included in the above Agency. In this department they have Group for analysis of anthropogenic and physical factors that carried out noise monitoring in selected places in Tbilisi and other cities. Georgian authorities identified lack of financial resources, human resource for noise assessment, lack of laboratory equipment and facilities, lack of intersectoral cooperation between environment and health sector.

2. Needs for knowledge transfer and capacity building

Contributors for this summary identified common needs for knowledge transfer and capacity building in their countries and in the European region.

- knowledge transfer and capacity building related to harmonizing END in NIS countries, because they didn't start the process of harmonization
- capacity building for implementation of END, especially for preparing strategic noise maps and action plans is necessary in SEE countries and in some new EU countries.
- human resources development through education and training for health risk assessment and burden of diseases of environmental noise
- official common (pan-European) method and step-by step guidelines for HRA of environmental noise exposure, including recommendations for some scale of acceptable risks;
- common method for assessment burden of diseases of environmental noise for European region

3. Conclusions

Noise exposure and health effects are tackled predominantly from a research perspective, but the results of research work should be implemented in future policies and strategies for environment and health. Limited awareness among government institutions and civil society of the potential health effects of noise exposure require further efforts of public health services in this field. It is already confirmed in SEE and CIS countries, but it also remained as a problem in New EU countries.

SEE and NIS countries need great support in adoption and implementation of European Directive 2002/49 for assessment and management of environmental noise. Capacity building of technical and human resources will facilitate the process for accession to EU, but also will enable health authorities to arise the question for noise impact on public health. This summary has shown that knowledge transfer is necessary even between EU member states, especially in SEE and CIS countries for caring out risk assessment of environmental noise, burden of diseases assessment related to environmental noise, translation of research findings in policy making. The health costs, as a consequence of noise pollution is not sufficiently integrated into policymaking due to the lack of reliable data.

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Annex 2. Step by step guidance for DALY calculation using strategic maps

Thomas Classen and the EBoDE Working Group

Introduction & Objectives

In the EBoDE-project, strategic noise maps (processed in 2007 to meet the regulations of the European Environmental Noise Directive (2002/49/EC, “END”, [EU 2002]) were used as input data for exposure assessment to transport noise from road, rail and air traffic as a part of total environmental noise. These data from the first phase of END-reporting are to a high extent harmonized and representative especially for hot spots of noise hot spots of noise between different countries.

The availability of data from strategic noise mapping offers some great opportunities on the one hand but reveals some major limitations on the other hand particularly due to the low population coverage (displaying mostly hot spots). Therefore, a specific guidance how to assess and work with the data from strategic noise mapping is required displaying uncertainties, too.

Step by step guidance:

Step 1: Selecting health endpoints

In recent years, numerous health outcomes have been associated with the exposure to environmental and especially transport noise. Nevertheless, for many of these the evidence on causality is weak or insufficient and should to a great extent be improved. To assess the strength of evidence, excellent international reviews and guidelines have been drawn up such as the review of Berry and Flindell (2009), the WHO Night noise guidelines for Europe (WHO 2009a), and the WHO guidance on Health Risk Assessment of Environmental Noise (WHO 2010).

Most recently, exposure to occupational noise, neighborhood noise and other noise sources, e.g. resulting from leisure time activities, have been shown to have a high impact on hearing impairment and tinnitus. But information or inhomogeneous data availability e.g. in terms of exposure, groups at risk and morbidity of health outcomes inhibits EBD calculation.

Step 2: Aggregating exposure data from country-specific strategic noise maps

The exposure metrics used for the END strategic noise maps are the weighted day-evening-night level (L_{den}) and the nighttime average level (L_{night}), assessed separately for noises from road, aircraft and railway traffic. For exposure datasets utilizing other noise descriptors than L_{den} or L_{night} , conversion formulas are available.

From the first phase of END-reporting, carried out in 2007, noise exposure data per 5dB(A) categories are available for most of the EU-countries, modeled for large agglomerations (> 250,000 inhabitants), heavily trafficked roads (> 6,000,000 vehicles/passages per year) and railways outside agglomerations (> 60,000 trains/passages per year), and major airports (> 50,000 movements/flights per year).

These data are available on <http://circa.europa.eu> and have been aggregated recently by the Netherlands Ministry of Housing, Spatial Planning and the Environment. So far, the data only cover a relatively small percentage of the EU population. But since strategic noise mapping is modeled in a more or less standardized manner and population weighted, these data are representative for the investigated population. The coverage of the data depends substantially on the level of urbanization of countries (i.e. size distribution of agglomerations) and on the location of the country within Europe (central or in periphery) and resulting transit influences. Further limitations of the END data are the relatively high exposure cut-off and the non-reporting of

exposure to many relevant noise sources. Moreover, some European countries are still without complete (or any) strategic noise maps. For the above reasons, a preliminary set of supplementary methods has been outlined to fill the gaps in END data and for the use in countries without strategic noise maps.

Step 3: Selecting exposure-response functions (ERFs)

EBD can only be associated with health outcomes if valid ERFs are available. For high sleep disturbance (HSD) the ERFs of different sources of transport noise refer to an updated meta-analysis by Miedema & Vos 2007. For myocardial infarction (MI) as a proxy for IHD the ERF (OR) refers to a meta-analysis by Babisch 2006. Most of the ERFs nowadays refer to L_{den} or L_{night} (see formulas for sleep disturbance), some still to L_{day} or $L_{day,16h}$ (see polynome for daytime noise & MI).

Be careful: ERFs are normally only valid in a specific range of noise levels!

Step 4: Calculation of the health effects

For HSD no baseline health data is necessary, since the percentage of affected people is directly given by the ERF. For IHD, baseline data can be retrieved from the harmonized health statistics database as held by the World Health Organization (GBD-code W 107, assuming that 57% of deaths from IHD are of MI), providing country-specific data (deaths, YLLs, YLDs and DALYs) for the year 2004 (WHO 2009b). Health data can be obtained from national and local health authorities, too.

Step 5: Conversion to disease-adjusted life years (DALYs)

According to EBoDE Working Group (2010), calculation by noise level category is necessary for environmental noise due to the non-linear ERFs. Since noise levels are usually reported in 5 dB-categories, the category mid-values (e.g. 50-54.9 → 52.5) can be inserted in the non-linear polynomials to simplify the calculation of ORs and % of people with HSD. For infarcts, the population attributable fraction (PAF) can be obtained using the standard formula for PAF calculation .

For calculation of DALYs, choose disability weights (DW) as below:

- high sleep disturbance: DW (derived from primary insomnia, GBD code W 094) = 0.09 (confidence interval: 0.06 to 0.12).
- acute Myocardial Infarction as a proxy for IHD (GBD code W 107): DW = 0.23 (confidence interval: 0.1 to 0.4) or take DW=0.395 for EUR A (treated form).

Perform the calculations without lag and without discounting or weighting. For better comparability, as the unit for disease burden use DALYs per 1,000,000 inhabitant-years. There is no need of postulating time trends.

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Annex 3. Practical solutions for filling the gaps in (END) exposure data

Erkki Kuusisto and the WHO adviser group on noise burden of disease

Introduction and Aims

Strategic noise mapping provides valuable information on noise exposures in Europe, but the coverage and representativeness of the data are limited by its confinement to noise hot-spots. Therefore, the exposure data mandated by the Environmental Noise Directive (END) is not alone sufficient for nationwide health impact assessment (HIA). Further gaps stem from the non-coverage of low exposures and from the non-reporting of exposures to many relevant noise sources. Moreover, some European countries still lack resources for producing complete (or any) strategic noise maps. Thus, practical solutions are needed for overcoming the data shortages. Below, it is aimed to summarize the main gaps in current exposure data for nationwide HIA and to outline a preliminary set of practical solutions for filling the gaps, even in countries lacking strategic noise maps.

Gaps in current exposure data for nationwide HIA

Population beyond strategic noise mapping

The main shortage of END exposure data for nationwide HIA is the limitation of strategic noise mapping to hot-spots defined by the minimum-size criteria for major agglomerations and transport passageways (EU, 2002). However, a large fraction of the population lives in areas beyond strategic mapping. Thus, also a substantial fraction of all people exposed ($L_{den} \geq 55$ dB or $L_{night} \geq 50$ dB) will be missed. Biased towards relatively noisy areas, the exposure distributions obtained are not representative of the nationwide population.

Low exposure levels

The END does not require levels below 55 dB L_{den} or 50 dB L_{night} to be reported. However, when assessing annoyance and sleep disturbance, the presently most reliable ERFs predict that some are already affected at levels down to 45 dB L_{den} and 40 dB L_{night} (Miedema & Oudshoorn, 2001, Miedema et al, 2003). While the reliability of the ERFs in this regime is debatable, prevalence of exposure is high in the low-exposure categories. Ignoring them may thus result in a substantial underestimation of the numbers affected.

Other health-relevant noise sources

There is a growing list of noise sources that may have a substantial health impact and that belong to the scope of END, but for which exposure reporting to EC is not required. Among others, one may list construction work, real-estate maintenance, outdoor entertainment, noisy leisure driving, and wind farms. In addition, neighbor noise (including pets) and noise from military aviation are relevant for HIA, while beyond the scope of END. Many of the noises mentioned are commonly perceived as annoying (WHO, 2009).

Night time exposures and diversity of descriptors

It may be necessary to use non-END exposure datasets in place of and to supplement END data. However, a common shortage with non-END sources is the paucity of night time data. It is also usual with many older exposure datasets to have utilized noise-level descriptors other than those employed in common ERFs (e.g. L_{Aeq24h}).

Possible solutions for filling in the gaps

Please note that the solutions outlined below should not be regarded as ready-made tools but rather as a substrate for further refinement.

Population beyond strategic noise mapping

To fill the primary data gap of END, e.g. exposures in minor agglomerations, one may use a generalization approach based on surrogate data. The idea is to employ exposure distributions from a sample of cities/towns for which representative data can be obtained, e.g. from existing noise maps, or by ad hoc modelling. After collecting a set of representative cities/towns of different size classes, the average exposure distribution (e.g. % exposed per each dB category) in each size class are determined. The distributions are then generalized to all similar agglomerations in the country of focus.

Naturally, this approach can also be employed when no domestic END data is available, i.e. by using exposure data from acoustically similar agglomerations abroad. In these cases, however, the figures may need to be adjusted by expert judgement, to better reflect the acoustic conditions in the country of focus.

For minor roads, the same approach can be used, but instead of agglomerations one picks a sample of representative road districts. For example, one could use exposure distributions from already noise-assessed districts from other countries. Those distributions can be generalized to all acoustically similar districts in the country of focus. Exposures due to END major roads are then added from the NOISE database (EEA, 2010), taking appropriate measures to preclude double counting. For minor railways and minor airports, one can apply the principles used for minor roads and cities, respectively. For example, if no exposure data is available for a particular airport, one may retrieve from NOISE the average exposure distribution of airports of the same size class. Optionally, the exposure distributions can be adjusted based on relevant variables and/or by expert judgement.

Low exposure levels

Whenever feasible, the best remedy to obtain exposure data for L_{den} below 55 dB or L_{night} below 50 dB is to buy or request it from the agency or company that commissioned or carried out the strategic mapping. This naturally requires that the noise mapping also covered low-exposure areas.

As an alternative, fast and coarse method, a flat distribution can be assumed between 45 and 60 dB for L_{den} (and between 40 and 55 dB for L_{night}). That is, as a first approximation the exposure prevalence in the low-noise categories is assumed equal to those in the lowest reported categories. This crude method usually produces a conservative estimate, with a moderate error at least for street/road noise, based on the examination of the exposure distributions modelled for individual cities. It should be noted that ignoring the low-noise categories altogether likely results in a much larger error (in both numbers exposed and cases affected).

As a more accurate and more complex approach, one could use the principle of the generalization approach described above, but only applying it to the low-exposure regime.

Other health-relevant noise sources

To assess the impact of other relevant noise sources, an exposure-based approach is mostly unfeasible due to the paucity/absence of exposure data and reliable ERFs. For these sources, one may employ an outcome-based approach, if sufficient questionnaire-based prevalence data is available. The data should indicate the % affected (by a particular outcome to a defined degree) by noise from a given source. The data can originate from surveys addressing either the population of interest or other populations subject to acoustically similar conditions.

Night time exposures and diversity of descriptors

Night time exposure distributions can be deduced fairly accurately from daytime or 24-h average levels using conversion formulas, if the activity profile of the source is known. Conversion formulas can also be used to employ exposure datasets utilizing descriptors other than those in

common ERFs. However, the formulas should take into account all relevant variables: 1) averaging times, 2) time-of-day penalties, 3) assessment heights, and 4) meteorological average differences between day and night time (WG-AEN, 2006). Default formulas can be defined for situations in which representative input data is not available.

Summary of steps

To fill the gaps of END exposure data, the most viable procedure depends on the availability of complementary/surrogate data. The overall workflow may proceed as follows:

- 1) Retrieve domestic END data (if any) from NOISE and check for data consistency.
- 2) Search for complementary/surrogate exposure data (referring to step 3) from domestic and/or acoustically similar foreign contexts.
- 3) As needed, choose/tailor the most feasible methods...
 - for estimating daytime exposures if no END data is available,
 - for estimating exposures beyond major agglomerations and passageways,
 - for filling in low-exposure categories,
 - for predicting night exposures, and
 - for descriptor conversions to comply with ERFs.
- 4) Process the exposure data to obtain a nationwide dataset.
- 5) Calculate health effects using the ERFs.
- 6) To assess the numbers affected by other noise sources, use questionnaire data from the population of interest or from acoustically similar populations.
- 7) Proceed to calculate disease-adjusted life years (DALYs).

Conclusions

The main gaps of END exposure data for HIA are the non-coverage of population beyond noise hot-spots, low-exposure categories and health-relevant noise sources not required for EC reporting. To augment the exposure data, many practical solutions of varying complexity can be adopted, also when no domestic END data is available. In addition, questionnaire data can be used to directly assess the effects of many non-traffic noises.

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Annex 4. Programme of the meeting

WORLD HEALTH ORGANIZATION
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BURDEN OF DISEASE FROM ENVIRONMENTAL NOISE

Bonn, Germany
14-15 October 2010

Original: English

Provisional Programme

Thursday, 14 October 2010

- 08:30 – 09:00 Registration
- 09:00 – 09:30 **Introduction** of participants
Purpose and expected outcome of the meeting Rokho Kim
Election of chairs and rapporteurs
- 09:30 – 10:30 Need for knowledge transfer and **capacity building** in the New EU members, SEE and CIS countries
Gordana Ristovska, Nana Gabriadze, Irina Zastenskaya, Shkelqim Mema, Tomas Hellmuth, Lubica Sobotova
- 10:30 – 11:00 *Coffee break*

Updated review of evidence on exposure-response relationship and exposure assessment

Chaired by Danny Houthuijs

- Learning from the experience in EBoDE project
- Evidence review on cardiovascular diseases and sleep disturbance from noise
- Recommended exposure-effects relationships using END indicators
- Using the strategic noise map data to estimate burden of diseases
- How to deal with uncertainties and confounding

- 11:00 – 11:30 **Methods** of Environmental Burden of Diseases Sophie Bonjour
Uncertainties in the EBD estimation Danny Houthuijs
- 11:30 – 12:30 Process, results and lessons of the **EBoDE project**: How burden of noise-related cardiovascular diseases and sleep disturbance were calculated in six countries
Otto Hanninen, Thomas Classen, Erkki Kuusisto
- 12:30- 13:30 *Lunch*
- 13:30 – 15:30 Updating exposure-response relationship for **cardiovascular diseases** Wolfgang Babiscsh
Updating exposure-response relationship for **sleep disturbances** Sabine Janssen
- Q&A and discussion – Should we consider other health outcomes?
- 15:30 – 16:00 *Coffee break*
- 16:00 - 17:00 The state of implementation of European Noise Directive Balazs Gergely
The Noise Observation and Information System for Europe Colin Nugent
- 17:00 – 18:00 How useful are the strategic noise maps as exposure data for estimating burden of diseases? Jurgita Lekaviciute
How can EBoDE methods be applied to the countries not having the strategic noise maps? Goran Belojevic, Gordana Ristovska, Irina Zastenskaya
- 18:30 *Reception at the City Hall of Bonn (directions in the folder)*
- 19:00 *Social dinner (optional) at Brauhaus Bönnsch*

Friday, 15 October 2010

Towards pan-European estimation of burden of cardiovascular diseases and sleep disturbances

Chaired by Stephen Stansfeld

- Summary of guidance for DALYs calculation
- Capacity building in NIS/SEE countries
- Future collaborations between WHO and EU

09:00 – 10:00	Step-by-step hand-on guidance for DALYs calculation using strategic maps Thomas Classen, Otto Hanninen, Erkki Kuusisto, Sophie Bonjour
10:00 – 11:30	Role of experts networks (e.g., ENNAH, ICBEN) in the capacity building and risk communication in the member states Stephen Stansfeld, Sonja Jeram, Goran Belojevic, Gordana Ristovska
11:30 – 12:00	<i>Coffee break with fruits and sandwiches</i>
12:00 – 13:00	Communication and dissemination informing the policy-makers and the public <ul style="list-style-type: none">• European level - e.g., ENHIS indicator?, “Ear on Earth” website? Stelios Kephelopoulos, Colin Nugent, Rokho Kim, Andrey Egorov• Country level
13:00 – 13:30	Conclusions and recommendations
13:30 – 14:00	Follow-up actions for meeting report
14:00	<i>Closure of the meeting</i>

Annex 5. List of participants

WORLD HEALTH ORGANIZATION
REGIONAL OFFICE FOR
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ORGANISATION MONDIALE DE LA SANTÉ
BUREAU RÉGIONAL DE L'EUROPE

WELTGESUNDHEITSORGANISATION
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Burden of Disease from Environmental Noise Bonn, Germany, 14-15 October 2010

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