World Health Organization Regional Office for Europe

European Centre for Environment and Health
Bonn Office

WHO technical meeting on noise and health indicators
07 - 09 April 2003 - Brussels, Belgium
Meeting report

Abstract
This document summarizes the discussions and results of the meeting on noise and health indicators in the framework of the environmental health (EH) indicator project. The meeting was held in Brussels in April 2003. The meeting reviewed the existing indicators on noise and health and proposed a tentative core set of indicators to be integrated into the EH set. The experts agreed on the list of the indicators to be tested and on follow-up activities.

Table of contents

Background

Within the framework of the project funded by the European Commission (EC): "Development of environment and health indicators for EC countries" and of the WHO ECOEHIS project, the WHO European Centre for Environment and Health, Bonn office convened an international meeting of experts in the field of environmental noise and health indicators, at the European Commission in Brussels.

The ECOEHIS[1] project has as its main objectives, measuring the environmental health situation, facilitating the planning, monitoring and evaluation of the programmes and action and making international comparisons.

This project includes several environmental themes and its main results are expected to be an internationally agreed set of indicators that will provide information for monitoring public health and environmental policies (including the NEHAPs – National Environmental Health Action Plans). These indicators should

i) be evidence-based, using the valid exposure – effect relationships;
ii) ii) have a clear structure for communicating to policy-makers how each part of the information is related to the various processes (determinants, population health effects, actions);
iii) iii) provide meaningful (population relevant) comparability, be usable at different geographical scales;
iv) iv) always use the existing data and suggest priorities for data collection; and
v) v) take into consideration the existing international indicator sets, avoiding duplication of efforts.

Noise is one of the targeted environmental health areas for the ECOEHIS. It deserves special attention.

1) The impact of noise on health has been for too long limited to annoyance and sleep disturbance, and other health effects have been overlooked;
2) There are new legal developments within the European Union that should be taken into account when designing indicators;
3) Trends in transport and urban planning are likely to lead to major changes in exposure; a new assessment of the existing indicators is needed to ensure they work for the new environmental situation;
4) Noise pollution and its abatement are rising up the agenda of both politicians and the public.

Summary of the meeting

The WHO representative welcomed the participants and introduced the meeting objectives and the general agenda. Various speakers gave an overview of the ECOEHIS indicators process and the perspective of the DG Environment in the field of noise protection, followed by an introduction to the meeting objectives and work guidance.

Four invited speakers presented their papers, followed by discussions in plenary. More detailed analysis of these papers took place during working groups. On the last day the participants agreed on the conclusions and recommendations and on follow up actions for the testing of the indicators.

[1] For more information please consult "www.euro.who.int/eprise/main/WHO/Progs/EHI/Home"

Objectives of the meeting

The meeting was convened in order to:

- Agree on the indicators that will best reflect and monitor the health impact of noise;

- Devise and plan the next steps for testing and piloting the noise and health indicators.

18 experts and an observer from DG environment joined WHO staff at the meeting. They came from different European countries and Institutions working in public health issues, environmental epidemiology, environmental psychology, health impact of noise on humans and more technical issues related to noise exposure (see participants list in Annex 3).

The following issues were proposed for discussion:

a) Health effects - What were the effects of noise exposure that can be expressed with indicators? How could the key role of human perception be accurately taken into consideration?

b) Metrics - We should have appropriate metrics to make international comparisons and be able to translate the « localities » of noise pollution at national level;

c) How could indicators best answer and translate the importance of noise pollution? How could we make sure that indicators will provide guidance to policy makers and help identify strategies?

d) Children and other Risk groups: Which were the population groups considered most vulnerable to noise exposure? What were the best indicators to translate their susceptibility? The indicators should as much as possible take into account the behavioural and physical differences of children;

e) Data, feasible and realistic indicators: The countries may already have the necessary data, or the resources for gathering them.

Presentation of papers and discussion

The invited speakers presented their papers, which are annexed to this report.

- Driving forces, Pressure and state indicators (Prof Jacques Beaumont);
- Exposure and effect indicators of Environmental Noise (Prof Harmunt Ising);
- Noise Action indicators (Prof João Levy);
- Noise exposure and cognitive performance – children and the elderly as possible risk groups (Prof Staffan Hygge).

General discussion and working groups

After having heard the presentations of the background papers and the subsequent discussion the experts split into two working groups - Working group 1 - Brainstorming of new ideas to construct an aggregated indicator; and Working group 2 - Establishment of the core and secondary set based on the proposed indicators. The groups' mandate was to explore in more detail the indicators proposed and to agree on the noise and health indicators that would be tested. The groups were also asked to study in depth the construction of an aggregated index that could convey the noise situation in one single figure.

DRIVING FORCES, PRESSURE

The proposed indicators were related to definition and perception of a soundscape according to the following characteristics:

- Site characteristics: described main land use (urban area, rural environment,...),
- Source quantities: it translated the existence of noise sources (it could be represented by a noise index as L_{Aeq}(6h-22h) or L_{den} for example),
- Target: characterization of the environment where a noise exposure occurred (population, dwellings, urban area,...),
- Impact: took into account the effects of the noise emissions on the "target". This implied an impact function, which could be a dose-response function.

Four types of zoning were proposed:

- Rural areas: not exposed to important transport traffic noise or/and to industrial noise;
- Quiet areas;
- Urban areas: mainly exposed to traffic noise;
- Urban areas mainly exposed to human noise (pedestrian street, leisure places, streets with restaurants, auditorium, cinemas, theatres,…)

Six indicators were proposed, the use of the metrics Lden, Lmax and Lnight was accepted.

1) Traffic flow of transport infrastructures: $Q = Q_{LC} + Q_T$,
2) Leisure facilities of the quarter: $N_{leisure}$,
3) Working attraction of the quarter: N_{work},
4) Acoustical "cost" of different means of transport: SELP,
5) Sound emission class of a transport infrastructure (Noise level over 24 hours)
6) Emergences during sensitive periods: N_{emerg}.

Participants raised several questions about the representativeness of the indicators proposed and their feasibility (mainly because of data collection). The classification of the areas and the notion of emergences were considered interesting concepts. The "Acoustical energy of passenger mobility per person of the different means of transport" was endorsed by the group. The same concept was proposed for goods transport (of great importance during the night period). The site classification led to the proposal of an indicator "access to quiet areas". The indicators final list endorsed by the group were the following:

1. Acoustical energy of passenger mobility per person of the different means of transport

This indicator aimed to compare different means of transport from an acoustical point of view. It represented a way of assessing the "acoustical cost per passenger" of each transport mean.

Main questions raised:

The main questions behind this indicator related to its applicability. What did it really mean in terms of health?

Solutions proposed:

Some changes were proposed by the group in order to make this indicator more transparent. It had been suggested that, for the time being, data for public transport should be analyzed carefully in order to avoid misunderstanding of the results.

It was agreed that the best and most reliable way to address all the questions and doubts this indicator generates would be during testing and when comparing the results for different situations.

The complete name of the indicator should be mentioned when presenting results and not the acronym SELP (as it may lead to confusion with SEL).

2. Acoustical energy per unit of freight transport

This indicator was based on the same concept as the previous one but for transport of freight. It would assist comparison between freight transport modes and attribute to each of them an "acoustical cost".

3. Population exposed to various noise level ranges per source (air, road, rail, industrial others) (Lden and L night)

This indicator follows the European metrics and suggested methodologies of the Environmental Noise Directive. The population exposed to different noise ranges of values calculated in L_{den}, L_{night} are expressed as a total in number of people or as a percentage of the total population.

4. Population having access to quiet areas (within a 500 m distance)

This indicator was proposed at the meeting. One of the issues behind noise pollution was the ability of having access to quiet when desired.
Starting from a proposal of having zone classification, the group endorsed an indicator aiming at estimating the population accessibility to "quiet areas". The group proposed also to study the possibility of linking the number who have access to quiet places with the number of people exposed to various noise levels.

This indicator could be a tool at the disposal of local authorities who want to establish quiet zones.

The description of its computation is described in a more detailed way in the technical annex 1.

EXPOSURE AND EFFECTS

The proposed indicators for effects were traditionally based on two main health effects of environmental noise exposure - annoyance and sleep disturbance – that were accepted as representative effects of environmental noise exposure. Other effects were also of importance and the working group agreed that they should be taken into account by one or more additional

indicators. The major effects quoted were cardiovascular risk, interference with cognitive development, hearing impairment (inner ear damage) and tinnitus.

For annoyance and sleep disturbance the European Union and WHO had produced exposure-response curves that were suitable as a basis for these indicators calculation. For the other two effects WHO would convene sub-working groups to reach an agreement on the design for their computation.

The working groups endorsed the following indicators:

5. Percentage of the population highly annoyed by traffic noise

This indicator was one of the most consensual one but some questions about its "form" were raised.

Main questions raised:

Could we adopt the same indicator for both southern and northern countries, for rural and urban areas? Did cultural differences play a crucial role?

Solutions proposed:

The group generally agreed that there are differences and that they can be important. Nevertheless these differences were already taken into account in the exposure-response curves which had been developed so far, based on observation in different countries (including non-European).

6. Percentage of population suffering from sleep disturbance

The complexity of the phenomenon of "sleep disturbance" led to a specially detailed discussion for this indicator.

Main questions raised:

The question was raised of whether participants could think of any indicator that would convey increased risks of children's accidents caused by sleep deprivation and whether there were ways of quantifying the special vulnerability children have to noise. This idea was welcomed by the group, but for children at present, the evidence was still very scarce. Except for the impact on cognitive development, there was at present very little evidence that children are more vulnerable to noise, or differently affected, especially during night time. The group welcomed the idea that WHO, ECEH Bonn office would trigger the development of new research on this very important question.

The idea of having two indicators for sleep, one reflecting the sleep quantity and a different one to describe sleep quality was discussed by the working group. The first indicator would be based on the duration of the sleep and the second one on changes in sleep stages. This proposal of having two indicators would allow different effects of noise during night time to be taken into consideration, on one hand awakenings (very important for loud noise events) and on the other one arousals and changes in the sleep architecture (important for noise events with lower levels and continuous noise).

Solutions proposed:

Despite the very interesting points raised, the present state of knowledge did not allow proposals for new developments in the near future. Only the indicator of sleep disturbance based on the dose-effect curves resulting from the European Commission study "Night time transportation noise and sleep disturbance" could be used in a practical way. The current study established the relationships between noise-induced sleep disturbance and night-time noise exposure expressed in terms of L_{night} for aircraft, road traffic and railway noise[2]. This appeared to be the best possible solution for the time being.

7. Attributable fraction of risk of cardiovascular morbidity and/or mortality to noise exposure

The working group discussed the possibility of having ready for implementation an indicator describing cardiovascular morbidity and mortality that could be attributed to environmental noise exposure. The group endorsed the importance of this indicator and expressed special interest in having it as a part of the core set of indicators.

Main questions raised:

The main issue was to ensure that the existing knowledge and evidence on the attributable fraction of risk is sufficient at present to enable the indicator to be calculated.

Solutions proposed:

WHO offered to organize a sub meeting to establish agreement, if possible on the attributable fraction and then the indicator will be ready for testing. This meeting took place on 2 July 2003 in Rotherham, the Netherlands and the minutes will be available in the near future.

ACTIONS

The indicators proposed for the Action stage were divided into three groups.
1) accurate characterization of the noise situation,
2) action plans, and
3) implementation of measures.
These three groups of actions could be "aggregated" into: characterization of actions, planning actions and effective implementation of the measures. Following this division the following indicators were proposed:

First group - characterization of actions which are needed:

I.1 - Noise Maps;
I.2 - Characterization and monitoring of the noise emission along roadways and railways;
I.3 - Sound characterization near airports.

Second group - Action plans:

II.2 - Existing land use plans paying consideration to acoustical aspects.

[2] "Elements for a position paper on night time transportation noise and sleep disturbance"- H.M.E Miedema; W. Passchier- H. Vos, January 2003.

Third group – implementation:

III.1 - Monitoring of implementation / installation of noise barriers;
III.2 - Monitoring of implementation / installation of noise insulation;
III.3 - Effective control of the motor vehicle fleet.

After discussion and in order to be as pragmatic as possible the indicators recommended for testing were:

8. Ratio of the urban population living in areas covered with a noise map to the total urban population of the country.

The population covered by a noise map would be assessed with this indicator. This would indicate a first level of political willingness to take action and describe the level of implementation of the EU directive.

9. Population living in areas for which there is a plan taking into consideration the acoustical situation.

The population living in areas where noise protection measures had been identified during the urban planning phase were in principle more protected that the ones living in areas where there was no acoustical concern. This proportion of the population was considered to be better "protected".

10. Monitoring of implementation / installation of noise barriers

The most common abatement measures for traffic noise were barriers. This indicator could provide a measurement of the efforts to protect population highly exposed. It did not imply that noise barriers were the ideal solution, but it recognised that they were a possible means for improving some very difficult situations.

11. Effective control of the motor vehicle fleet

Another current noise abatement measure consisted in reducing noise emissions at the source. Annual inspections of vehicles of 5 years old and more was a common practice. This indicator would provide information on whether Member States were considering noise emissions during the fleet inspections or not.

12. Existing national legislation on maximum sound levels of leisure open air events and discotheques and its effectiveness

The entire group considered hearing impairment and tinnitus resulting from exposure during leisure activities as major health effects. Since indicators on hearing impairment as a environmental noise health effect still needed a considerable amount of developmental work (see the description of the indicator below) an indicator showing the concern of a country about the prevention of such diseases was proposed by the WG and endorsed by the plenary.

This indicator was based on the existence and enforcement of measures regulating sound emissions of sound equipment during public events.

13. National Action plans on noise

In 1994, at the second ministerial conference on Environment and Health, Ministers committed their governments to prepare NEHAPs. Some countries have prepared thorough plans that take noise into consideration. The task would be to identify the Action plans, such as NEHAPs, that incorporate a developed noise component with a clearly stated health protection objective.
The indicator would then translate the commitment at political level to action on environmental noise reduction.

AGGREGATED INDICATOR

14. Noise composed indicator (NCI)

This aggregated indicator was the result of the compilation of different indicators reflecting the various stages of the DPSEEA model, aggregated into a global one. It covered Pressure, Impact (Exposure and Effect) and Actions issues. The indicator was designed to reflect changes.

Concerns were raised about whether such an indicator would be easy to understand, or whether it would be necessary to disaggregate it quickly to explain the elements, for example to politicians.

Despite the risk of oversimplifying a complex issue it was been agreed to test this indicator and check if it was meaningful to non-experts.

Its calculation is described in detail in the technical table in the annex 1.

FOR FURTHER DEVELOPMENT

15. Noise Environmental Burden of disease

This indicator would be based on the results of the WHO study on “Global estimates of burden of disease caused by the environment”. This study would express the noise fraction in *Disability-Adjusted Life Year* (DALY), combining the burden due to death and disability in a single index. Using such an index would allow the comparison with other environmental risk factors or diseases.

This indicator would estimate the burden of disease caused by environmental noise. It would provide an important input into development and evaluation of policies by the health sector. Other sectors, which directly managed or influenced noise, would then have a chance to see how their decisions and actions impact on the global health status of the population.

16. Cognitive development

One way to develop an indicator for the sound cognitive development of children, was to gather archive data on the performance of individual children through nationwide tests on a few subjects in the curriculum, for example on the national language, a foreign language, and mathematics and perhaps one or two more subjects. By following the same individuals from e.g. the ages of 9 to 13 years, and by comparing children in living areas and school areas which have been mapped in the EC-manner for noise levels and noise sources, it would be feasible to

see whether noise was a strong determinant in children's cognitive development and whether different noise sources had selective impacts on different school subjects.

The participants noted that to some extent, this longitudinal approach of following the same children across several years, avoided the pitfalls of cross-sectional approaches, which were basically plagued by and confounded with socio-demographic background variables.

The RANCH study would also provide exposure effect relationships for chronic noise exposure and cognitive function and health, exposure effect relationships and children's psychological restoration and sleep. So the indicator was desirable but needed further development and work.

17. Hearing impairment and tinnitus on young people

Very loud sound/noise, such as at concerts, discotheques, car-races, computer-cafés and through headphones, was a health risk. Such loud noise could trigger the development of tinnitus and hearing impairment among young people. It was estimated that 20% of young people across Europe were overexposed to loud music and so at immediate risk of hearing loss of more than 25dB.

It was also important to gain recognition that loud noise is a public health issue affecting children and young people in order to create more political and community interest in all European Member States.

Main questions raised:

The definition of deafness and hearing impairment varies across Europe. An additional challenge was that the hearing loss caused by exposure to loud noise when young only starts to impair the quality of life many years after the exposure, during the ageing period when it comes on top of the normal biological degrading of hearing.

Solutions proposed:

The indicator was, by consensus, considered as very important. The current state of knowledge and the several difficulties behind the existing data mean that it is not ready for testing and further work on computation and data gathering should be developed. WHO was urged to develop work on this issue. One step than could be envisaged was checking the hearing and tinnitus on children entering and leaving school.

Follow up actions

A protocol for testing the feasibility and validity of the proposed set of indicators would be established. Italy, France, Germany, Portugal, Czech Republic and Poland agreed in principle to proceed with the testing of some of the indicators. In addition to this all Member States were most welcome to send their success stories and good practices that will be made available to other countries. The testing was open to all countries and was expected to last three months.

A second meeting would be held once the indicator testing had been completed, to endorse and adopt the Environment Health Indicators in the noise and health field for the WHO EURO Region. This meeting was planned to happen at the earlier in November 2003.

Meanwhile two parallel meetings would be organized to agree on the attributable fraction of cardiovascular morbidity and mortality of environmental noise exposure and possibly on the cognitive indicators.

Conclusions and Recommendations

The group endorsed the following conclusions and recommendations:

1. The DPSEEA model is a valid methodology for identifying the environmental noise – health indicators;

2. The effects on quality of life and the health end-points to be monitored with the core set indicators will cover:
   - Annoyance (as described in the EU environmental noise directive);
   - Sleep disturbance (as described in the EU environmental noise directive);
   - Cardio vascular morbidity and mortality (to be described by a WHO working group);
   - Effects on cognitive performance development (to be described by a WHO working Group).

3. The development of an indicator on hearing impairment and tinnitus was considered desirable but will require further developmental work;

4. When possible, the noise maps will be the preferred tool for providing data for the computation of exposure to various noise sources and levels;

5. When data exists in international regulations, standards or recommendations for the exposure-response for noise and health, it should preferably be used for the computation of the health impacts;

6. The group considered that further work was needed to reach a consensus on an indicator for cognitive development of children;

7. The meeting designed an aggregate noise index covering the different aspects of environmental noise and health, and agreed to proceed with testing it in order to assess its significance and its representativeness;

8. WHO should convene a group of experts to agree on the estimates for assessment of the relative risk for cardio-vascular diseases related to noise exposure, and to provide guidelines for computing the indicator;

9. WHO should coordinate the necessary work to review all the evidence substantiating the existence of health end points from sleep disturbance in view of the results of the latest studies;

10. If new evidence is found on sleep disturbance, WHO together with the Member States should undertake necessary work to validate the use of a “penalty” factor of 10 dB(A) to be added to night noise when computing Lden;

11. A protocol for testing the feasibility and validity of the proposed set of indicators will be established by the WHO. The secretariat was requested to send a letter to the Ministries of Health and Environment of the participants’ countries to get a formal agreement on this protocol;

12. The issue of indoor noise and insulation should be addressed by the housing-health indicators group;

13. Success stories and examples of good practice should be collected and made available to Member States as this was felt to be a powerful means to help them to improve the noise conditions to which the population is exposed;

14. A second meeting will be held once the indicator testing has been completed, to endorse and adopt the Environment Health Indicators in the noise and health field for the WHO EURO Region;

15. The participants agreed on a preliminary set of indicators according to the following 3 groups for future testing and monitoring:

1) Ready and recommended for implementation
2) Ready, but not feasible for immediate implementation
3) Desirable though requiring further developmental work

Title of the indicator	Work needed	Type	Category
Acoustical energy of passenger mobility per person of the different means of transport	Check significance and applicability when testing	2	Driving Forces Pressure
Acoustical energy per unit of freight transport	Check significance and applicability when testing	2	Driving forces, Pressure
Population exposed to various noise level ranges per source (air, road, rail, industrial others)		1	State, Exposure
Population having access to quiet areas	Agreement on the definition of quiet area	1	State, Exposure
Percentage of the population highly annoyed by traffic noise		1	Effects
Percentage of population suffering from sleep disturbance	Check the appliance of the EC dose-effect curves	1	Effects
Attributable fraction of risk of cardiovascular morbidity and/or mortality to noise exposure	Agree on the attributable risk / meeting in July	*2*	Effects
Ratio of the urban population living in areas covered with a noise map to the total urban population of the country.		1	Action
Population living in areas for which there is a plan taking into consideration the acoustical situation.		1	Action
Monitoring of implementation / installation of noise barriers		1	Action
Effective control of the motor vehicle fleet		1	Action
Existing national legislation on maximum sound levels of leisure open air events and discotheques and its effectiveness		1	Action
National Action plans on noise		1	Action
Noise composed indicator (NCI)	Check significance and applicability when testing	1	Compose index
Noise Environmental Burden of disease	*Further development*	*2*	Effects
Effectiveness of Implementation actions	*Assess the effectiveness of the noise reduction actions How to measure them?*	*3*	Action
Cognitive development	*Further development*	*3*	Effects
Hearing impairment / Tinnitus on young people	*Further development*	*3*	Effects

Table 1 - Preliminary list of environmental noise-health indicators for testing

Annex 1 – templates

Acoustical energy of passenger mobility per person of the different means of transport	D**P**SEEA
Issue	Noise
Definition of indicator	Acoustical level due to a passenger of a given transport mode
Underlying definitions and concepts	This indicator aims to facilitate comparison between different means of transport from an acoustical point of view. It assesses the "acoustical cost" of each transport mode. **Passenger**: person inside a mean of transport (car, truck, motorcycle, public transport, plane, train,…), **Transport mode**: any transport mode crossing important infrastructures, which are roadways (Average Annual Daily Traffic AADT exceeding 5000 vehicles per day), railways (AADT exceeding 50 vehicles per day) or airports (more than 20000 movement per year).
Specification of data needed	To assess a noise situation, one has to measure the SEL (Sound Exposure Level) of each vehicle passage. The emission values of each transport mode studied are needed, as well as the vehicle speed (to assess the length of the passage). An assessment of the total number of passengers using each transport mode is also required.
Data sources, availability and quality	To calculate the value of the actual indicator today, measurements will have to be performed. To forecast the changes on the noise situation, we will have to compute the SEL with the forecast data with a computation tool that will assess the propagation effects. To calculate the number of passengers present in a given transport mode, there are several possibilities: - roadways: with surveys and calculation of foreseen emissions made by local government or using physical count mode led during the study, - railways and aircraft: with data given by those in charge of the infrastructure (i.e.: SNCF for French railways).
Computation	$SEL = 10 \log\left(\int_{t1}^{t2} \frac{p_A^2}{p_0^2} \cdot dt\right)$, t_2-t_1 = duration of a passage The SEL is assessed at a based point (25m from the line, 4m above the ground for example) N = number of passengers, $SELP = 10 \log\left(\frac{1}{N}\int_{t1}^{t2} \frac{p_A^2}{p_0^2} \cdot dt\right)$
Units of measurement	dB(A) per passenger
Scale of application	Local as well as national or international to compare different transport modes
Interpretation	This indicator represents the acoustical contribution of a passenger for one vehicle passage. It may allow comparison between different alternatives of transport and provide a tool for transport management from the acoustical point of view. It may influence the choice of the transport mode which has "fewer costs" in terms of noise level per passenger. It could be a tool to support sustainable transport planning.
Linkage with the other indicators	*State, Exposure:* Population having access to quiet areas *Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet
Related data, indicators	French advocated proposals for sustainable development: http://www.environnement.gouv.fr/actua/com2003/developpement_durable/default.htm

Acoustical energy per unit of freight transport	DPSEEA
Issue	Noise
Definition of indicator	Acoustical level due to goods transport
Underlying definitions and concepts	This indicator is intended to facilitate comparisons between different means of goods transport from an acoustical point of view.
Specification of data needed	For each transport mode, the computation of this indicator will need noise emissions data and quantity of goods transported (in tons) per day. The SEL is computed using: - the number of vehicles per day, - the type of vehicle - the speed of the vehicles, - the type of lanes (for terrestrial transports). The noise levels at various points (4m above the ground for example), are calculated using an acoustical software.
Data sources, availability and quality	
Computation	$\mathrm{SEL} = 10 \log\left(\int_{t1}^{t2} \frac{p_A^2}{p_0^2} \cdot \mathrm{dt}\right)$, t_2-t_1 = duration of a passage The SEL is assessed at a specific point (25m from the line, 4m above the ground for example) T = number of tons, $SELT = 10 \log\left(\frac{1}{T}\int_{t1}^{t2} \frac{p_A^2}{p_0^2} \cdot dt\right)$.
Units of measurement	dB(A) per Ton
Scale of application	Local as well as national or international to compare different transport modes
Interpretation	It will allow comparison between different alternatives of freight transport providing a tool for transport management from the acoustical point of view. It could be a tool to support sustainable transport planning.
Linkage with the other indicators	*State, Exposure*: Population having access to quiet areas; Population exposed to various noise levels ranges per source *Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet
Related data, indicators	

Population exposed to various noise levels ranges per source	DPS**E**EA
Issue	Noise
Definition of indicator	Estimated population living in dwellings that are exposed to the noise ranges of values from different sources of environmental noise in urban areas and along major transport infrastructures
Underlying definitions and concepts	This indicator is a basic one for noise and health, it allows assessing exposure and has a direct connection to the other indicators. The ranges of values are the ones from the European Directive (2002/49/EC of 29 June 2002) as well as the noise sources (road traffic, Air traffic, Railway traffic and Industry).
Specification of data needed	Estimation on the number of people exposed to the following ranges of values of L_{den} in dB 4 m above the ground on the most exposed façade: 50-54, of L_{den} in dB 55-59, of L_{den} in dB 60-64, of L_{den} in dB 65-69, of L_{den} in dB 70-74, of L_{den} in dB > 75 of L_{den} in dB Separately for noise from road, rail and air traffic, and industrial sources.
Data sources, availability and quality	Noise mapping. Sound characterization near airports. Characterization and monitoring of the noise emission along roadways and railways. Surveys.
Computation	The indicator can be computed for each range of values. Absolute number and percentage of the city population can be provided: $100 * (N_a / N_t)$ Na – population living in dwellings that are exposed to each of the 6 bands of values Nt – total population of the city
Units of measurement	Number of people exposed, and percentage of a given population exposed
Scale of application	National as well as local – residential settings
Interpretation	This indicator is the basis for the calculation of the total health effects as it provides data on exposure. It is the rough “portrait” of the noise situation on a country.
Linkage with the other indicators	*State, Exposure:* Population having access to quiet areas *Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Monitoring of implementation / installation of noise barriers; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Noise composed indicator
Related data, indicators	European Directive 2002/49/EC of 29 June 2002

Population having access to quiet areas (in a 500 m distance)	DP**S**EEA
Issue	Noise
Definition of indicator	Percentage of the population with pedestrian access to a public "quiet area" within a range of 500 metres
Underlying definitions and concepts	Quiet areas – areas where no major transport infrastructure and no industrial noise sources exist. It has to be freely accessible to the general public. It is not necessarily an open area. A quiet area is not a silent zone, it is more to be seen as a relaxing "soundscape" area. It includes: - Public parks, gardens, … - Pedestrian areas - Museums - Riverside pedestrian paths - Cultural centres, public libraries - others,
Specification of data needed	Noise maps; Identification of quiet zones and their area; Surveys of population.
Data sources, availability and quality	The ideal way to calculate this indicator would be with a geographical support of the city. The quiet areas have to be identified and the population living within a 500m range has to be estimated trough the national census, questionnaires, data of the local authorities, …
Computation	$P_{qa} = \left[\left[\sum_{qa=1}^{n} P_{qai} \right] * 100 \right] / P_{agglom}$ P_{qa} – Population living in 500 m range from a quiet area qa – quiet area a P_{qa} – estimated population living in the defined quiet areas P_{agglom} – total population of the agglomeration (town or city)
Units of measurement	Percentage of urban population
Scale of application	Local. Can be translated at national level
Interpretation	One of the issues behind noise pollution is also related to the ability of having access to quietness when desired. The assessment of the population exposed should be crossed with existence of quiet and easily accessible public spaces when people can "rest" and relax" This indicator could also provide a tool for local authorities to establish quiet zones.
Linkage with other indicators in the set	*State, Exposure*: Population exposed to various noise levels ranges per source *Effects:* Percentage of population suffering from sleep disturbance Percentage of the population highly annoyed by traffic noise at day time *Actions:* Monitoring of implementation / installation of noise barriers; Population living in areas for which there is a plan taking into consideration of acoustical aspects; *Aggregated indicator:* Noise composed indicator
Related indicator sets	

Population annoyance by traffic noise	DPSE**E**A
Issue	Noise
Definition of indicator	Percentage of the population annoyed and highly annoyed by traffic noise
Underlying definitions and concepts	The indicator is based on the assumption that exposure to traffic noise (road, railway and air), induces annoyance in people who are awake. Using dose effect relationship (Miedema & Vos, 1998, 2002) the percentage of highly annoyed population can be calculated from exposure data.
Specification of data needed	*Road traffic*: Percentages of the population exposed to Lden = 50-54, 55-59, 60-64, 60-64, 65-69, 70-74, > 75 of Lden in dB *Air traffic:* Percentages of the population in areas with L_{den} = 45-49, 50-54, 55-59, 60-64, 60-64, 65-69, 70-74, > 75 of Lden in dB *Railway traffic:* Percentage of the population exposed to L_{den} = 55-59, 60-64, 65-69, 60-64, 60-64, 65-69, 70-74, > 75 of Lden in dB
Data sources, availability and quality	National models of traffic noise exposure. Noise maps of cities. Maps of flight noise areas around airports. Alternative: Representative annoyance surveys Population: total population
Computation	The indicator can be computed for each traffic noise source following the exposure-response formulas: Exposure-response curves formulas (Miedema, 2002): Aircraft: $\%A = 8.588*10\text{-}6\ (Lden\text{-}37)^3 + 1.777*10\text{-}2\ (Lden\text{-}37)^2 + 1.221\ (Lden\text{-}37)$; Road traffic: $\%A = 1.795*10\text{-}4\ (Lden\text{-}37)^3 + 2.110*10\text{-}2\ (Lden\text{-}37)^2 + 0.5353\ (Lden\text{-}37)$; Railways: $\%A = 4.538*10\text{-}4\ (Lden\text{-}37)^3 + 9.482*10\text{-}3\ (Lden\text{-}37)^2 + 0.2129\ (Lden\text{-}37)$; Aircraft: $\%HA = -9.199*10\text{-}5\ (Lden\text{-}42)^3 + 3.932*10\text{-}2\ (Lden\text{-}42)^2 + 0.2939\ (Lden\text{-}42)$; Road traffic: $\%HA = 9.868*10\text{-}4\ (Lden\text{-}42)^3 - 1.436*10\text{-}2\ (Lden\text{-}42)^2 + 0.5118\ (Lden\text{-}42)$; Railways $\%HA = 7.239*10\text{-}4\ (Lden\text{-}42)^3 - 7.851*10\text{-}3\ (Lden\text{-}42)^2 + 0.1695\ (Lden\text{-}42)$. Percentage of population annoyed = $\sum \%A * \%Ci$ Percentage of population highly annoyed = $\sum \%HA * \%Ci$ Ci – Noise band values (indicator “Population exposed to different noise level ranges)
Units of measurement	Percentage
Scale of application	National as well as local
Interpretation	The indicator provides a measure of the long-term substantial disturbances related to exposure to traffic noise.
Linkage with the other indicators	*Driving forces, Pressure*: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport *State, Exposure:* Population having access to quiet areas; Population exposed to various noise levels ranges per source; *Actions:* Monitoring of noise actions - Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet; National noise action plans; *Aggregated indicator:* Noise composed indicator

Sleep disturbance by night time environmental noise	DPSE**E**A
Issue	Noise
Definition of indicator	Percentage of the population with decreased quality of sleep
Underlying definitions and concepts	The indicator is based on the assumption that exposure to night time noise from different sources, e.g. traffic (road, railway and air), industry, entertainment facilities, neighbours induces sleep disturbance. Underlying definitions are: Sleep disturbance: arousal reactions and change of sleep phases, duration of deep sleep and REM sleep, irregularity of heart rate, stress hormone dysregulation, body movements; alternative: subjective quality of sleep and mood in the morning . Population: total population surveyed
Specification of data needed	Road traffic: Percentages of the population exposed to Lnight = 40-44, 45-49, 50-54... dB(A) Air traffic: Percentages of the population in areas with Lnight = 35-39, 40-44, 45-49,... dB(A) Railway traffic: Percentage of the population exposed to Lnight = 45-49, 50-54, 55-59... dB(A) Industry: factories and manufacturers; building activities; load/ unload facilities Entertainment: bars/ discos ; luna-parks etc ; noisy sports Total population of the sample surveyed
Data sources, availability and quality	National models of traffic noise exposure. Noise maps of cities. Maps of flight noise areas around airports. Alternative: Representative surveys of sleep disturbance
Computation	The indicator can be computed for each traffic source of noise as: ∑ (Rlevel * Nlevel / Nt) where Nlevel is the number of population exposed to a noise level category, R level is the regression coefficient of dose-effect-relationship (for arousals, awakenings and self-reported sleep disturbance) and Nt is the total number of population. aircraft $M_{night} = 0.000192 \times (L_{night} - Ldiff1-Ldiff2)^b$ road $\%HSD = 20.8 - 1.05L_{night} + 0.01486L_{night}^2$ $\%SD = 13.8 - 0.85L_{night} + 0.01670L_{night}^2$ $\%LSD = -8.4 + 0.16L_{night} + 0.01081L_{night}^2$. rail $\%HSD = 11.3 - 0.55L_{night} + 0.00759L_{night}^2$ $\%SD = 12.5 - 0.66L_{night} + 0.01121L_{night}^2$ $\%LSD = 4.7 - 0.31L_{night} + 0.01125L_{night}^2$. a outdoor at the most exposed façade b Ldiff1 : difference between L_{night} en L_{Aeq} most exposed façade. default = 0 dB(A) Alternative: The indicator can be computed for each source of noise as: 100 * (Nsd / Nt) where Nsd is the number of sleep disturbed people and Nt is the total number of surveyed population
Units of measurement	Percentage
Scale of application	National as well as local

Interpretation	The indicator provides a proxy of the long-term health effects related to exposure to different sources of environmental noise at night time
Linkage with the other indicators	*Driving forces, Pressure*: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport in tons. *State, Exposure:* Population exposed to various noise levels ranges per source; *Actions:* Monitoring of noise actions - Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet; National noise action plans; *Aggregated indicator:* Noise composed indicator
Related data, indicators	Dose-effect relations for transportation noise and sleep disturbance can be find in the study carried out by the European Commission. http://europa.eu.int/comm/environment/noise/home.htm . http://europa.eu.int/comm/environment/noise/noisesleepdisturbance.pdf

Population in cities with noise maps / urban population	DPSEE**A**
Issue	Noise
Definition of indicator	This indicator represents the percentage of population covered by noise assessment tools
Underlying definitions and concepts	Urban population – total population living in the areas that are covered by a noise map plus the ones that should be by law covered but are not yet.
Specification of data needed	Total population
Data sources, availability and quality	Local authorities Authorities responsible by the noise mapping Surveys of population;
Computation	Population living in an area covered with a noise map / total population living in areas that should be covered with a noise map according to the EC directive 2002/49/EC.
Units of measurement	Percentage
Scale of application	Local and national
Interpretation	This indicator will translate the level of implementation of noise mapping. It can be used for the calculation of the Noise Composed indicator
Linkage with other indicators in the set	*Driving forces, Pressure*: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport in tons. *State, Exposure:* Population having access to quiet areas; Population exposed to various noise levels ranges per source; *Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; *Aggregated indicator:* Noise composed indicator
Related indicator sets	

Population living in areas for which there is a plan taking into consideration of acoustical aspects	DPSEE**A**
Issue	Noise
Definition of indicator	Percentage of the population living in areas covered by urban plan or another tool that takes into consideration the acoustical aspects.
Underlying definitions and concepts	The existence of planning for urban areas for controlling and reducing the level of environmental noise in areas with different land use. The existence, the implementation and the strengthening of measurements and limits of noise levels for given types of sources. The restriction of noise levels during nigh-time hours.
Specification of data needed	Demographic and geographical data of municipalities.
Data sources, availability and quality	The analysis of the Different Municipal Master Plans and of Urban Development Plans. The analysis of strategic plans at the national level.
Computation	Population living in an area with acoustical planning / total population of the municipality or city in question
Units of measurement	Percentage
Scale of application	Local or national level.
Interpretation	This indicates the level of commitment for reducing the noise in sensitive or mixed areas at the planning stage. The result of this indicator will also be a component of the Noise Composed indicator
Linkage with the other indicators	Driving forces, Pressure: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport in tons. State, Exposure: Population having access to quiet areas; Population exposed to various noise levels ranges per source; Effects: Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time Actions: Monitoring of noise actions - Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet; National noise action plans Aggregated indicator: Noise composed indicator

Installation of noise barriers according to the legislation of each country	DPSEE**A**
Issue	Noise
Definition of indicator	Monitoring of implementation / installation of noise barriers according to the legislation of each country, with the aim of reducing the population exposed to high noise levels.
Underlying definitions and concepts	Exposure to high noise levels affects health. Acoustic barriers are applied for decreasing the level of noise to which the population is exposed.
Specification of data needed	Performed traffic surveys taking into account the following sources of noise: Road traffic, Air traffic, Railway traffic, Maritime traffic. Total population.
Data sources, availability and quality	Noise assessment nearby the above-mentioned sources of noise. Local authorities.
Computation	Area of installed acoustic barriers / population exposed to high sound levels.
Units of measurement	Km^2/inhab.
Scale of application	National or local.
Interpretation	This indicator may serve as a basis for the implementation of future noise decrease regulations.
Linkage with the other indicators	Driving forces, Pressure: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport in tons. State, Exposure: Population exposed to various noise levels ranges per source; Effects: Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time Actions: Monitoring of noise actions - Population in cities with noise maps/Urban Population; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet; National noise action plans;

Effective control of the motor vehicle fleet	DPSEE**A**
Issue	Noise
Definition of indicator	Effective control of the motor vehicle fleet.
Underlying definitions and concepts	Exposure of the population to high noise levels affects health. High levels of noise caused by motor vehicles affect the environment and consequently public health.
Specification of data needed	Survey of the number of motor vehicles undergoing annual inspection. National motor fleet.
Data sources, availability and quality	Number of vehicles undergoing annual inspection must be provided by a reliable source (e.g. Ministries of Transport). National competent entities on vehicle fleet.
Computation	100 * the number of motor vehicles inspected / the entire number of motor vehicles.
Units of measurement	Percentage
Scale of application	National or International.
Interpretation	This indicator may serve as a basis for the implementation of future regulations concerning the reduction of noise caused by motor vehicles.
Linkage with the other indicators	Driving forces, Pressure: Acoustical energy of passenger mobility in person of the different means of transport; Acoustical energy per unit of freight transport in tons. State, Exposure: Population having access to quiet areas; Population exposed to various noise levels ranges per source; Effects: Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time Actions: Monitoring of noise actions - Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; Aggregated indicator: Noise composed indicator

Existing national legislation regulations on maximum sound levels of leisure open-air events and discotheques.	DPSEE**A**
Issue	Noise
Definition of indicator	Composite index of ability to implement regulations, restrictions and noise abatement measures in leisure activities that involve high music levels
Underlying definitions and concepts	The existence, implementation and enforcement of regulatory instruments to control the exposure in leisure activities Has the Member State adopted sound emission levels at open-air concerts or/and discotheques? What level? Has the Member State adopted sound emission levels at discotheques? What level?
Specification of data needed	Evidence of existence and enforcement of regulations to regulate the music levels Evidence of the appliance (control) of this regulations
Data sources, availability and quality	Information on the existence and scope of the legislation and efficiency
Computation	The index is computed as a sum of the following 6 variables *SUM* (Ci) Where: i is the legislation and Ci is the score for component i For each component Ci the following scoring is accepted: 0 – Not existing, not clearly stated 1 – Clearly stated, partly (not) implemented or enforced; 2 – Clearly stated and obeyed, implemented and enforced The full list of components (Ci) is as follows: 1 Legislation for maximum sound levels in discothèques, bars and other similar settlements 2 Building regulations for acoustical insulation of discothèques, bars and other similar settlements 3 Legislation for open-air events, fairs markets and similar 4.Regulations for music concerts 5 Local authorities required to deal with noise complaints 6.Regulations for music appliances (walkmans, Discmans, ..) and computer games
Units of measurement	Ordinal score (0 – 12)
Scale of application	National to international
Interpretation	This indicator provides a general measure of the ability to implement policies for reducing the exposure to leisure noise: an increase in the score should be taken as a broad indication of increased ability, a reduction the reverse. Like all compound indicators, however, this one needs to be interpreted with care for the final score is the sum of many different components: areas with the same indicator score, therefore, do not necessarily have the same capability profile. It is equally important to examine the components of the indicator and handle appropriately the lack of data before drawing conclusions. .
Linkage with the other indicators	Effects: *hearing impairment and tinnitus*
Related data, indicators	

National action plans on noise	DPSEE**A**
Issue	Noise
Definition of indicator	Consideration of noise on the NEHAPs (National Environmental Health Action Plans) or existence of a specific noise action plan. Consideration of noise as a health determinant in any Plan related to public health.
Underlying definitions and concepts	The indicator expresses the commitment at political level to solve noise problems.
Specification of data needed	Existence of the noise and health action plans
Data sources, availability and quality	Information on the existence of the action plans and their implementation and fields of action.
Computation	This indicator is calculated by the description of the existing plan and if it is: 0 – Not existing, not clearly stated 1 – Clearly stated, partly (not) implemented or enforced; 2 – Clearly stated and obeyed, implemented and enforced
Units of measurement	National or regional noise action plans
Scale of application	Ordinal score (0-2)
Interpretation	Noise is analyzed in almost every country as an environmental problem, but its consideration as a health determinant is still not always visible. This indicator will express the commitment of the countries to abate noise. Other kinsd of national plans that take into consideration the relationships between noise and health should also be considered.
Linkage with other indicators in the set	*State, Exposure:* Population having access to quiet areas; Population exposed to various noise levels ranges per source; *Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers; Effective control of the motor vehicle fleet; Existing national legislation on maximum sound levels of leisure open air events and discotheques and its effectiveness;
Related data, indicators	

Noise Composed Indicator	DPS**EEA**
Issue	Noise
Definition of indicator	This indicator takes into consideration different aspects of noise characteristics and several aspects of noise pollution.
Underlying definitions and concepts	Urban population – population living around major transport infrastructures or agglomerations with noise maps Population exposed Population protected
Specification of data needed	For the calculation of this indicator we will need the calculation of the indicators for action that were presented previously.
Data sources, availability and quality	Noise maps, sound characterization around airports Demographic and geographical data of municipalities.
Computation	NCI=100*A1*A2*A3 A1=1- (Pexp above Lmax / Pexp) A2=1- (Pexp/ Urbain People A3=a_1*A31+a_2*A32+a_3*A33 A31=Population in cities with noise maps/ Urban Population A32=Population in zoning site/Urban Population A33=Population protected/Population exposed a_1=0.2 a_2=0.2 a_3=0.6
Units of measurement	0-100 (0 is the worse case, 100 the better)
Scale of application	National and international
Interpretation	This indicator reflects the actions in terms of which part of the population is protected. The higher the indicator value bigger part of the population is protected by noise abatement actions.
Linkage with other indicators in the set	*Effects:* Percentage of population suffering from sleep disturbance; Percentage of the population highly annoyed by traffic noise at day time *Actions:* Monitoring of noise actions - Population in cities with noise maps/Urban Population; Sound monitoring along major transport infrastructures in residential areas; Population living in areas for which there is a plan taking into consideration of acoustical aspects; Monitoring of implementation / installation of noise barriers
Related indicator sets	

For further development

Cardiovascular morbidity and mortality attributable to environmental noise exposure	DPSE**E**A
Issue	Noise
Definition of indicator	Number of cases of cardiovascular problems attributable to noise exposure Number of deaths attributable to noise exposure.
Underlying definitions and concepts	The indicator is based on the assumption that exposure to high levels of environmental noise (road and air), has the potential to increase the cardiovascular risk. Population: total population exposed to various noise levels Attributable fraction of risk for each noise levels interval Mortality and morbidity of noise cardiovascular effects
Specification of data needed	Total population Average number of strokes, dead from cardiovascular per 100 000
Data sources, availability and quality	National models of traffic noise exposure. Noise maps of cities. Maps of flight noise areas around airports. Disease mortality and morbidity Attributable risk to the different noise levels
Computation	
Units of measurement	Number of cases
Scale of application	National as well as local
Interpretation	The indicator provides a measure of the population percentage with increased cardiovascular risk due to traffic noise exposure.
Related data, indicators	
Work needed	Review the evidence to agree on the value of the risk – meeting in July 2003

Assessment of disease burden associated with exposure to environmental noise	DPSE**E**A
Issue	Noise
Definition of indicator	Assesses the burden of disease due to environmental noise at national or local level. Aggregated health impact indicator used by WHO for several environmental risks.
Underlying definitions and concepts	This indicator will estimate the burden of disease caused by the environment, providing an important input to the rational development and evaluation of policies by the health sector and activities of other sectors that directly manage or influence the determinants of health. Additional information required for the rational development of such policies and activities includes the effectiveness and cost-effectiveness of interventions, the availability of resources and the type of policy environment. Disease burden can be expressed in *Disability-Adjusted Life Year* (DALY), combining the burden due to death and disability in a single index. Using such an index permits the comparison of the burden due to various environmental risk factors with other risk factors or diseases. (WHO, 2003)
Specification of data needed	Definition of the risk factor (e.g. exclusion of occupational risk factors, loud music, noise from neighbours etc.) Requires also a discussion on applicability
Data sources, availability and quality	
Computation	
Units of measurement	DALYs
Scale of application	National and international
Interpretation	
Linkage with other indicators in the set	
Related indicator sets	
Work needed	Waiting for the WHO headquarters publication

Hearing impairment on young people/ people suffering from tinnitus	DPSE**E**A
Issue	Noise
Definition of indicator	Percentage of the population under 25 years old with hearing impairments
Underlying definitions and concepts	The indicator is based on the knowledge that the risk of noise induced permanent hearing impairment increases with increasing noise dose if certain acoustic limits are exceeded. Since it is difficult to determine the percentage of critically exposed population, it is suggested that hearing symptoms should be used, that are related to inner ear damage or behaviour, which are known to be related to dangerous noise exposure.
Specification of data needed	Probably data will only be available through specific surveys in countries where there is a systematic hearing check for military service or for example, when children enter and leave school.
Data sources, availability and quality	?
Computation	Number of people below 25 years old having hearing deficiency of more than 30 dB(A) in at least one ear in the range of 1 to 4000 Hz Number of people below 25 years old suffering of tinnitus
Units of measurement	Percentage and number of cases
Scale of application	
Interpretation	
Linkage with other indicators in the set	
Work needed	
Related indicator sets	

Annex 2 –Participants List

Dr Wolfgang Babisch
Federal Environmental Agency; Department of Environmental Hygiene; Division of Environment and Health
Germany

Prof Jacques Beaumont
Institut National de Recherche sur les Transports et leur Sécurité
LTE - Laboratoire Transports et Environnement
France

Ms Marie Louise Bistrup
National Institute of Public Health
Denmark

Dr Hans Bögli
BUWAL; Abteilung Lärmbekämpfung
Switzerland

Dr Augustinus de Hollander
RIVM
Netherlands

Prof Joao de Quinhones Levy
Instituto Superior Técnico; Departamento de Engenharia Civil
Portugal

Dr Staffan Hygge
Laboratory of Applied Psychology; Centre for Built Environment
Sweden

Prof Hartmut Ising
Berlin Center Public Health, Technical University Berlin
Germany

Dr Snezana Jovanovic
Landesgesundheitsamt Baden-Württemberg
Germany

Prof André Kahn
Hôpital univ. des enfants Reine Fabiola - Université Libre de Bruxelles
Belgium

Ms Fanny Levecq
ACNUSA – Autorité de Controle des Nuisances Sonores Aéroportuaires
France

Mr Gaetano Licitra
ARPAT Dipartimento provinciale di Pisa
Italy

Dr Erikas Maciunas
State Public Health Centre
Lithuania

Dr Christian Maschke
Müller-BBM
Germany

Mr H.M.E. Miedema
TNO - Inro
Netherlands

Mr Andras Muntag
Institut for Environmental Protection
Hungary

Prof Deepak Prasher
Institute of Laryngology and Otology; University College London
United Kingdom

Prof Stephen Stansfeld
Queen Mary University of London; Department of Psychiatry
United Kingdom

Observer

Mr Gilles Paque
Commission Européenne
Direction générale environnement
Bruit Environnemental
Belgium

World Health Organization

Regional Office for Europe

Mr Xavier Bonnefoy
Regional Adviser
ECEH Bonn; Germany

Dr Dafina Dalbokova
Environmental Health Information Officer
ECEH Bonn; Germany

Ms Célia Rodrigues
Technical Officer, Noise and Health
ECEH Bonn; Germany