

# Transport-related Health Effects with a Particular Focus on Children

**Towards an Integrated Assessment of their Costs and Benefits.  
State of the Art Knowledge, Methodological  
Aspects and Policy Directions**



Transnational Project and Workshop Series of Austria, France, Malta, the Netherlands, Sweden and Switzerland



Federal Ministry of Agriculture  
Forestry, Environment and Water  
Management (BMLFUW)



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Agency for Environment  
and Energy Management



Ministry of Health, Elderly &  
Community Care



National Institute of Public  
Health and Environment



Swedish Institute  
for Transport and  
Communications Analysis



Federal Office of Public Health





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Swedish Institute  
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Federal Office of Public Health



Swiss Federal Office  
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# EDITORIAL

The project “Transport Related Health Effects with a Particular Focus on Children - Towards an Integrated Assessment of their Costs and Benefits. State of the Art Knowledge, Methodological Aspects and Policy Directions” is a contribution to the UNECE - WHO Transport, Health and Environment Pan-European Programme - THE PEP and to the Children’s Environment and Health Action Plan for Europe - CEHAPE.

Specific topics have been elaborated under the responsibility of one leading country:

- Air Pollution - by France
- Noise - by the Netherlands
- Physical Activity - by Switzerland
- Psychological and Social Effects - by Austria
- Economic Valuation - by Sweden

Within this project the topics Climate Change and Road Safety were covered by contributions from WHO Europe.

This project was developed through a series of reviews and workshops:

Workshop I: “Transport Related Health Impacts - Review of Exposures, Epidemiological Status”, Vienna 24-25 April 2003

Workshop II: “Economic Valuation of Health Effects due to Transport”, Stockholm 12-13 June 2003

Workshop III: “Health Impacts of Transport on Children”, The Hague 16-17 October 2003

Workshop IV: “Synthesis and Policy Recommendations”, Malta 19-20 February 2004

This project was commissioned and financed by:

Austria: Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW), Federal Ministry of Transport, Innovation and Technology (BMVIT), Federal Ministry of Health and Women (BMGF)

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Malta: Ministry of Health, Elderly & Community Care

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Sweden: Swedish Institute for Transport and Communications Analysis (SIKA), Swedish National Institute of Public Health (FHI)

Switzerland: Federal Office of Sports, Federal Office of Public Health

This Synthesis Report covers the main outcome and conclusions of the project. Additionally, detailed results and outcomes of the various topics are published in specific topic reports on:

**Topic Report 1: Air Pollution**, Agency for Environment and Energy Management (ADEME), France

**Topic Report 2: Noise**, National Institute of Public Health and Environment (RIVM), the Netherlands

**Topic Report 3: Physical Activity**, Institute of Sport Sciences, Federal Office of Sports, Magglingen, Switzerland

**Topic Report 4: Psychological and Social Effects**, Institute of Environmental Health, Medical University Vienna, Austria

**Topic Report 5: Economic Valuation**, Swedish Institute for Transport and Communications Analysis (SIKA)

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# FOREWORD

Efficient transport systems are essential for the growth of our economies and the mobility of our people. However, the current trends in transport development challenge sustainable development, resulting in large detrimental health and environmental impacts that to a disproportionate extent affect the most vulnerable and particularly children.

Our capacity to develop technological solutions is to a large extent offset by the relentless growth in the number and length of trips as well as in the motorization rates in the eastern part of the region. In addition, reduced public investments into efficient and attractive public transport as well as growing urban sprawl further encourage private motorized transport. Even if the totality of our fleets were converted to “zero emission” vehicles, we would still face the toll posed by road traffic injuries, which in the European region claimed some 127,000 lives in 2002, of which about 6,500 were 0-to-14 year old children. Furthermore, the present urban and transport settings contribute to physical inactivity, a leading risk factor for health, which has recently been associated to some 5 to 10 % of total mortality in the region. This would add to the economic costs and the lower quality of life that result from increasingly widespread congestion and the loss of natural habitats due to the growing need for roads and infrastructure for car transport.

By integrating environmental and health aspects into decisions concerning transport and land use planning new synergies may become apparent and transport may lead to positive health and environmental effects, such as when safe cycling and walking and public transport become a realistic travel option.

The Transport, Health and Environment Pan European Programme (THE PEP) was established to support the achievement of healthier and more environmentally friendly mobility in the region through the implementation of concrete actions. The completion of the project “Transport-related health impacts and their costs and benefits, with a particular focus on children” is one of the first results of the implementation of THE PEP. Not only this project is successful in improving our understanding of the type, magnitude and costs of the effects of transport on health, in particular on children. It also contributes to the development of the Children’s Health and Environment Pan-European Programme (CEHAPE), by highlighting policy directions that member States will need to consider in their efforts to “promote safe, secure and supportive human settlements for all children”.

Another important result of this project has been its capacity to bring together six different countries and many other stakeholders. We wish to commend Austria, France, Malta, the Netherlands, Sweden and Switzerland for their commitment to THE PEP implementation, for their leadership in steering this project and for making available the expertise of highly competent scientists. What has been achieved through this project makes us looking forward with confidence to the next steps in the implementation of THE PEP and to the possibility that our joint efforts will eventually succeed in achieving transport, which is sustainable for health and the environment.

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# FOREWORD

Today's transport and mobility is not yet sustainable. Its environmental and health impacts and its predicted trends can be seen as a major challenge in order to improve the quality of life. Children are vulnerable. Therefore considering their needs as a point of reference in policies aiming at achieving sustainability can be a benefit for all.

Reconciling transport and mobility with the need for a healthy environment for our children and enough space for their physical and mental development is one of the major challenges for our environment, health and transport policies. Taking children as a point of reference into our policies will avoid high losses and provide us with substantial gains in the future.

In recognizing this challenge Austria, France, Malta, the Netherlands, Sweden and Switzerland undertook this joint project and workshops series "Transport Related Health Effects in Particular on Children – Towards an Integrated Assessment of their Cost and Benefits.", thus contributing to the "Transport, Health, Environment Pan-European Programme (THE PEP)" of UNECE and WHO as well as to the development of the Children-Environment-Health-Action-Plan for Europe.

Our work was based on an intersectoral and interdisciplinary approach, shared responsibilities and resources and a fruitful and constructive spirit of discussion and collaboration. All the country experts and external contributors particularly WHO are to be highly acknowledged for their efforts and achievements as they explored much scientific ground and faced a considerable variety of uncertainties in data and knowledge.

This synthesis report compiles the major outcomes: the state of the art knowledge on the major transport related health effects on children i.e. air pollution, climate change, noise, physical activity, psychological aspects and road injuries, the lessons learned and methodological indications for health impact assessments and for evaluating the economic costs and benefits and last but not least the concluding key messages and policy directions.

We hope that this joint project and its results will contribute to further progress on an integration of children's concerns into policies, on achieving a more children friendly transport system and on a full acknowledgement of the transport related health impacts, their costs and benefits in decision making.

We are looking forward to following up our joint work and to further cooperation in the implementation of THE PEP and the CEHAPE in order to achieve a more sustainable and healthy mobility pattern.



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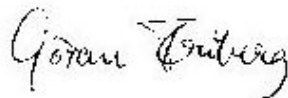
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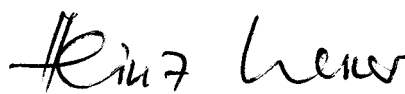
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# EXECUTIVE SUMMARY

## Background and Objectives

Motorized road transport has increased rapidly in the European Region in the last decades. Forecasts for 2020 in the EU show a further rise in passenger and freight transport and similar trends are also expected in the eastern part of the European Region. There is an increasing awareness of the environmental and health effects of transport. The health risks posed suggest an increased urgency for action to reduce these effects and related risks. The integration of environmental and health dimensions into transport policies is necessary for achieving sustainability and reducing the disease burden. This is a challenging task but necessary for providing a viable future for our children.

To this end, Austria, France, Malta, the Netherlands, Sweden and Switzerland launched a joint project and series of workshops on "Transport-related Health Effects with a Particular Focus on Children" in 2003. With this joint initiative the participating countries intend to make an active contribution to the UNECE - WHO Transport Health and Environment Pan-European Programme - THE PEP as well as to the development of the CEHAPE - Children's Environment and Health Action Plan for Europe.

The aim of this project, which focused particularly on road transport, was to make progress towards an integrated assessment of major transport related health effects by:

- 1) Focusing on children
- 2) Bringing together state of the art of knowledge about these health effects
- 3) Highlighting their costs and benefits
- 4) Focusing on methodological aspects
- 5) Identifying policy directions to address transport-related health effects on children

One of the outcomes of this joint project is a set of "Key Messages". These 'messages' were developed after reviewing the evidence and a comprehensive list of policies addressing different aspects of transport-related effects on environment and health. This was undertaken by experts and was developed further at the Workshop on "Synthesis and Policy Recommendations" (Malta, 19-20 February 2004) by an panel of decision makers and external experts.

Experts from the six participating countries shared tasks, experiences and resources. Austria focussed on the psychological issues, France on air pollution, Malta on road safety, the Netherlands on noise, Sweden on economic valuation and Switzerland on physical activity. The project was supported by expert input from the WHO on road safety and climate change. A series of reviewing workshops in Vienna, Stockholm, The Hague and Malta complemented these studies involving also external experts and stakeholders. The results and conclusions of this joint project are summarized and published in a synthesis report complemented by five topic reports.

It has to be stressed that due to limited time and resources, some effects of transport, such as the contamination of water and soil, as well as more comprehensive economic calculations could not be sufficiently undertaken. Follow-up activities would be advisable.

## Air Pollution related Health Effects



Many epidemiological studies have assessed and shown the association between ambient air pollution and health effects on adults using different indicators such as particulate matter (PM expressed as PM<sub>10</sub>, PM<sub>2.5</sub>, Total Suspended Particles - TSP, Black Smoke - BS) or gaseous pollutants (nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>) and ozone (O<sub>3</sub>)).

Although fewer studies have focused on the effects of air pollution on European children, their results suggest that there is a relationship between air pollution in Europe and numerous adverse health outcomes in children, in particular, respiratory disease.

Children, in particular those under two years of age and adolescents, are considered to be more susceptible than adults to the effects of air pollution, partly because of their immature metabolism and their physiology.

Even at relatively low levels, ambient air pollution has been shown to affect children with asthma and other respiratory conditions. Living along busy streets in urban areas, particularly with heavy motor traffic, has been associated to several respiratory diseases (exacerbation of asthma, chronic respiratory symptoms, allergic symptoms, increased prevalence of atopic sensitization, reduction in lung function).

Results from different study consistently indicate that neonatal or early post-neonatal exposure to air pollution results in mortality; these effects seem to be stronger in the post-neonatal (1-12 months) period and due to respiratory causes. Studies from Brazil suggest that there is a positive relationship between exposure to air pollution and respiratory mortality in young children (< 5 years). There are no European studies using this health outcome.

Technical and legal measures implemented since 1990 (e.g. ban of lead in petrol, decrease in sulphur content of fuels, emission standards for vehicles) have led to a reduction of some vehicles exhaust emissions. In contrast, the effects of road transport-related particulate emissions and their continued increase in many countries are at the fore of today's health concerns. Models which forecast traffic growth and factor in both, the implementation of regulations and improved technical measures, suggest that any improvements archived by the latter measures, will be offset by the increased emissions due to traffic growth. As a result, if emission ceilings and air quality objectives are to be met, technical measures will have to be complemented by economic and structural actions, which act to restrict emissions from road transport and other mobile sources.

Several studies have produced estimates of the health benefits that could be attained by decreasing ambient air pollution levels in European cities, using particulate matter with a diameter smaller than 10 µm (PM<sub>10</sub>) as an indicator. Other important indicators for transport related air pollution are PM<sub>2.5</sub>, NO<sub>2</sub> and black smoke. To put this in perspective, it has been estimated by the Air Pollution and Health: A European Information System (APHEIS) study that a decrease of 5 µg/m<sup>3</sup> in ambient PM<sub>10</sub> levels (other factors unchanged) in nine French cities would prevent 1,561 anticipated deaths. The same scenario if applied to 19 European cities estimates that 5,547 deaths would be prevented. If the PM<sub>10</sub> air quality guide value of 20 µg/m<sup>3</sup>, which must be implemented in 2010 in Europe, had to be implemented in the 19 European cities, this would prevent 11,855 deaths.

## Climate Change and Health

The transport sector is the second largest energy consumer in Europe. Over the period 1990 to 2000, transport greenhouse gas emissions in the EU-15 increased by 19 %, whereas emissions from Central and Eastern Europe had a smaller increase of 4 %. Projected trends forecast that CO<sub>2</sub> emissions will further increase in the future due to the growth in passenger and freight transport.

The health impacts of climate change have a unique set of features, (a) they are global, (b) they affect future generations even more than current ones, (c) they are unevenly distributed, and (d) they can be worsened through coexistent environmental changes. The effects will undoubtedly have a greater impact on societies or individuals with scarce

resources, where technologies are lacking, and where infrastructure and institutions are least able to adapt. The Burden of Disease assessment of the WHO estimated, that, in the year 2000 there were an excess of 160,000 deaths due to climate change worldwide. The African and Asian continents face the biggest risk with children being the most vulnerable. In Europe, there is increasing evidence to show that extreme weather and climate events are becoming more frequent and intense and are associated with increases in hospital admissions in children during hot periods. The elderly, disabled, children, women, ethnic minorities and rescue workers may be at greater risk of exposure to the effects of flooding than others.

The analysis of the time series of climate patterns and laboratory confirmed cases of indigenous salmonella infections from ten European countries found that increases in temperature contributed to an estimated 30 % of cases of salmonellosis in most countries investigated. In relation to climate and ecosystem changes preliminary results show that Lyme borreliosis (LB) has spread into both higher latitudes and altitudes, and in some areas is associated with an extended and more intense LB transmission season. Among children, *Borrelia burgdorferi* is now the most common bacterial cause of encephalitis and facial palsy.

The health impacts of climate change are difficult to quantify and surrounded by a high degree of uncertainty with regard to the long time-scale involved, the extent of the impacts, and the pattern of future world development. However what has become clearer is that international efforts are needed to achieve a world-wide reduction in greenhouse gases emissions, if climate change is to be slowed.

## Noise Exposure and Health Effects

In Europe, transport (road, rail and air traffic) is the most important source of community noise. Approximately 30 % of the European Union's population (EU-15) is exposed to levels of road traffic noise of more than 55 dB(A). Exposure to high noise levels has decreased in some countries since 1980 due to technological measures, noise barriers and spatial planning. Due to the expected growth in traffic, extra measures will be needed. At current noise levels many people are annoyed and disturbed in their sleep. A small effect on cardiovascular risk is highly plausible.



The limited number of epidemiological studies in children indicates that noise exposure affects children's learning (cognition), motivation and annoyance. In addition, there is some evidence that noise is associated with impacts on the cardiovascular and endocrine system of children. A few intervention studies show the benefits that could be attained by decreasing noise levels: reduction of railway and aircraft noise improved the long-term memory and reading ability of school children. To avoid such effects, protection of children against noise exposure during the night and during learning activities is recommended. Recent estimations of the noise-related health impacts in the Netherlands suggest that current noise levels may be associated with annoyance in 1.5 - 2 million people (out of a population of 16 million) disturbed sleep in 550,000 - 1 million and about 220,000 cases of hypertension. In total, 1-2 % of the total disease burden could be attributed to traffic noise. Impacts in children cannot be estimated yet. The results of noise and HIA studies in different countries are difficult to compare due to methodological differences. The new EU directive on environmental noise provides a basis for further harmonisation.

The benefits of implementing several source-measures for noise abatement on cars and trains will exceed the costs of these measures, as cost-benefit analyses clearly indicate. For example, it has been estimated in the Netherlands that the implementation of several source-measures on cars and trains will cost about 2 billion Euros. The benefits in terms of reduced annoyance are estimated with about 4-6 billion Euros. Estimations are that in the EU-15 the overall external (abatement) costs of road and rail traffic noise amount 0.4 % of the total GDP, some 36 billion Euros.

## Transport-related Physical Activity and Health



The importance of regular physical activity for health is well established. Positive health effects have been demonstrated for life expectancy, cardiovascular disease, stroke, type II diabetes, obesity, some forms of cancer, osteoporosis, depression and independence at old age.

International minimum recommendations for health-enhancing physical activity refer to 30 minutes of moderately-intense activities. Moderate intensity is characterised by getting somewhat out of breath but not necessarily sweating, typical examples being walking and cycling. Further activities will convey further health benefits and in many countries the minimum recommendations for children are set at one hour per day.

However, levels of physical inactivity are alarmingly high not only in industrialized countries, and this poses a major public health problem. Studies indicate high levels of inactivity among young people and a tendency towards declining activity levels from childhood to adolescence, which starts at puberty and continues through to young adulthood. Transport-related physical activity can make an

important contribution to overall physical activity in children. A wealth of data exists on overweight and obesity which are strongly influenced by physical activity behaviour. Direct health impacts of physical activity in children have been shown for major diseases. Short-term effects of physical activity are most easily demonstrated and impressive in size for weight control, while the associations with type II diabetes and cardiovascular disease could become very important if current trends of inactivity continue. There is a greater likelihood that physically active young people, compared with those inactive, will be more active in later life as well, so it is perceivable that all health effects of physical activity in adults may be influenced by increasing and maintaining active behaviour in young people.

There is a clear need to develop more interventions to increase physical activity and more specifically transport-related physical activity and to assess their effectiveness. In particular, traffic interventions should be identified, such as awareness programmes relating to taking children to school, that are most likely to increase health-enhancing physical activity and to reach physically inactive population groups.

In Switzerland, a country with 7 million inhabitants, current estimates suggest that between 1.4 and 1.9 million cases of disease, between 2,000 and 2,700 deaths and direct treatment costs of 1.1 to 1.5 billion Euros are caused by physical inactivity.

## Psychological and Social Impacts

Psychological and social impacts of transport are often ignored or underestimated despite the fact that they can influence mobility behaviour. For instance fear from traffic dangers has led to an increase number of parents who drive their children to school.

Furthermore health effects of noise and air pollutants also have a psychosocial component and therefore cannot be properly studied nor understood if psychology is neglected. Psychological and social mechanisms triggered by the perceived impact of transport alone can lead to disease. Every disease can also have consequences on the mental and social status of a person or an affected group of people. In addition, mental and social conditions can directly modify the impact of environmental stressors on humans.

In the long run high traffic density in human settlements may also lead to social effects by hindering the development of independence and social interaction in children.

Psychological and social effects of transport should be seen as an integral part of transport-related health impacts. One example is that walking to school instead of being taken by car has a direct positive effect on psychological and physical well-being in children, in terms of lower scores of depression, anxiety, aggression and hostility, fewer psychosomatic symptoms, and improved motor skills. Conversely, fear of road traffic injuries acts as a barrier which prevents children from more walking and cycling.

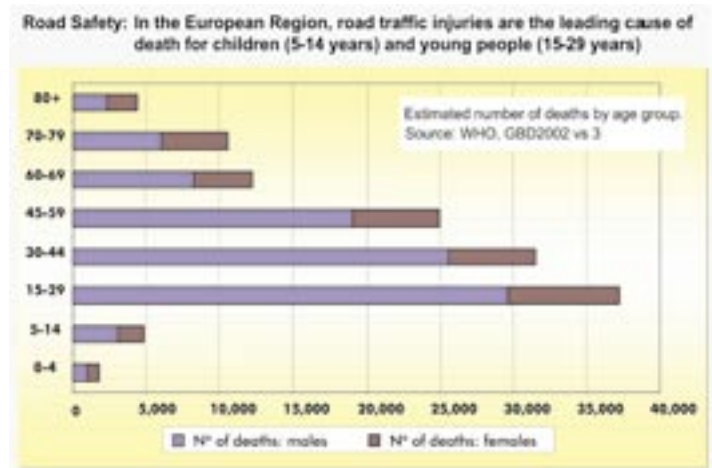
Addressing our true needs, including those of children, requires us to address physiological, safety, security, social, intellectual and aesthetic dimensions. Moreover, children have very definite ideas as to what they need and what they want. These ideas are surprisingly consistent and coherent and even younger school children are able to express their wishes if they get the proper opportunity. Children's needs and aspirations should be taken as an important reference point in the planning of human settlements and mobility management. This would improve planning processes, children's self esteem and their social competence.

## Road Traffic Injuries

Ten percent of the 1.2 million deaths estimated worldwide from road traffic injuries (RTIs) in 2002 occurred in the European Region. Road traffic injuries are the leading cause of death of children and young people (age of 5-29 years). 6,500 deaths/year are reported among children aged 0-14 years. Nearly 67 % of crashes occurred in built-up areas. Cyclists and pedestrians pay a disproportionate price, representing one third of the deaths from road traffic injuries. For the EU, the cost of RTIs are estimated to be 180 billion Euro per year. Children are particularly vulnerable because their ability to cope with traffic is limited until 10 years of age. They are more at risk in conditions with heavy or fast traffic, limited visibility, or when drivers' attention is focused elsewhere rather than on pedestrians or cyclists. A study reported that 33 % of children involved in road traffic crashes had post-traumatic stress disorder.

Real and perceived safety concerns are quoted as the most important barrier preventing many people from choosing walking and cycling as means of transport. Reducing road danger requires control of this threat and reducing casualties. Of particular concern is the issue of speed at the moment of collision, which is a key determinant for the severity of road traffic injuries. In pursuit of reducing road danger, studies using a Willingness to Pay approach suggest that

the public may be willing to have more rigorous road safety controls and greater accountability by governments, as in the rail and air sectors. These studies serve as a pragmatic basis for assessing the value and appeal of safety programmes. More generally, road safety, including danger reduction, should become a governing parameter of road transport, and not a tradable variable. This requires strong political commitment and leadership. The adoption of a comprehensive approach to road safety, should address all components of the transport system, namely road users, vehicles and infrastructure, and should take into account the human body's vulnerability to excess kinetic energy and that imperfect road user behaviour is likely.



## Lessons Learned: Assessment of Health Impacts and Economic Valuation

Assessments of transport related health impacts should be important tools to guide policy decisions in transport and land use policies. Health Impact Assessment (HIA) studies can also provide relevant information for policy makers on the effects of interventions on public health. Cost-benefit analyses can be derived from these estimates. There are challenges to the estimation of transport related health impacts in children their costs and their benefits in particular:

- How to select pertinent health effects in children and how to estimate the quantitative relationships between exposure and health effect (exposure response function)
- How to accurately estimate the fraction of exposure coming from transport
- How to measure and express in monetary terms effects of physical, mental and social health and well-being and how to achieve comparability

There are different concepts to evaluate mortality or the risk of mortality and it is important to consider the context in which they are to be used.

For transport related air pollution and the related external costs two main methodologies have been used. These have been designed to answer different questions. The Tri-national European project of Austria, France and Switzerland for the London Conference of WHO 1999 and the APHEIS study have led to a more global understanding of the overall impact of air pollution and is more appropriate for general transport policy planning at a national level. The ExternE study, which follows an impact-pathway approach, offers a better methodology to understand and assess the effects of specific interventions, such as minimum standards on fuel quality and engine or exhaust technology.

For noise assessments the mapping of noise exposure of the population and therein of children is crucial. Annoyance and sleep disturbance are recommendable end-points for health impact assessments. For these indicators generalized exposure response functions are available which can be used for impact assessment of transport noise.

Road safety impact assessments should focus in particular on vulnerable road users (e.g. children, bicyclists and pedestrians) and the decisive role of speed. They should be included into impact assessments of transport and land use programs and strategies.

Areas that require further investigation are the quantification and monetary valuation of psychological and social effects and the benefits of physical activity. A number of selected Swiss projects have begun to assess the effectiveness of interventions to promote physical activity. Studies to incorporate the health benefits of cycling into the cost benefit analysis of infrastructure development are also underway in Norway and Sweden. The result of a recent cost-benefit-analysis of cycling infrastructure in three Norwegian cities show that when the positive health aspects of physical activity are considered, the benefits for society of investing in cycle networks, significantly outweigh the cost.

Economic analyses and tools like cost-benefit analysis are often used in decision making regarding transport investments. These economic valuations have not to date taken sufficiently into account the transport related environmental health effects. Another major challenge when undertaking economic valuations is the issue of monetarization. Although not all health effects can be monetized as yet, there is a need to find ways of taking these fully into account when undertaking assessments and evaluations.

The Willingness To Pay (WTP) methodology of monetarization satisfies the condition of economic welfare theory by evaluating people's preferences. So far there have been no economic valuations that have applied this approach to children, but only to their parents as relevant studies of the US Environmental Protection Agency have shown. Economic valuations of transport-related health effects in children should apply at least the same costs as for adults, until child-specific values become available.

Often incomparability is a major obstacle. Different studies may give different results. The reasons for the differences should be made transparent. Harmonization of the methodology is strongly desirable.

Further research and work on traffic-related health effects on children and their economic evaluation is recommended.

# BACKGROUND AND OBJECTIVES

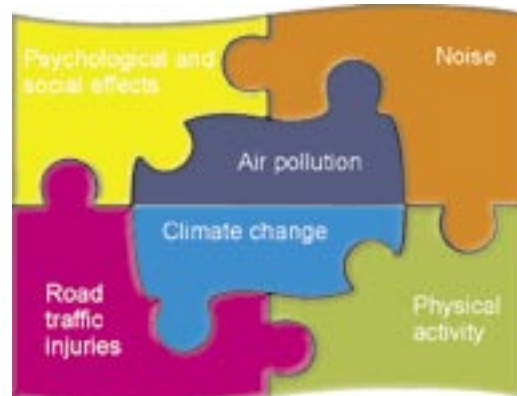
Motorized road transport has increased rapidly in the European Region in the last decades. Forecasts for 2020 in the EU show a further rise in passenger and freight transport and similar trends are also expected in the eastern part of the European Region. There is an increasing awareness of the environmental and health effects of transport. The health risks posed suggest an increased urgency for action to reduce these effects and related risks. The integration of environmental and health dimensions into transport policies is necessary for achieving sustainability and reducing the disease burden. This is a challenging task but necessary for providing a viable future for our children.

To this end, Austria, France, Malta, the Netherlands, Sweden and Switzerland launched a joint project and series of workshops on “Transport-related Health Effects with a Particular Focus on Children” in 2003. With this joint initiative the participating countries intend to make an active contribution to the UNECE - WHO Transport Health and Environment Pan-European Programme - THE PEP as well as to the development of the CEHAPE - Children’s Environment and Health Action Plan for Europe.

The aim of this project, which focused particularly on road transport, was to make progress towards an integrated assessment of major transport related health effects by:

- 1) Focusing on children
- 2) Bringing together state of the art of knowledge about these health effects
- 3) Highlighting their costs and benefits
- 4) Focusing on methodological aspects
- 5) Identifying policy directions to address transport-related health effects on children

Transport related health effects



Source: Reproduced with permission from the WHO publication “Preventing road traffic injury: a public health perspective for Europe”



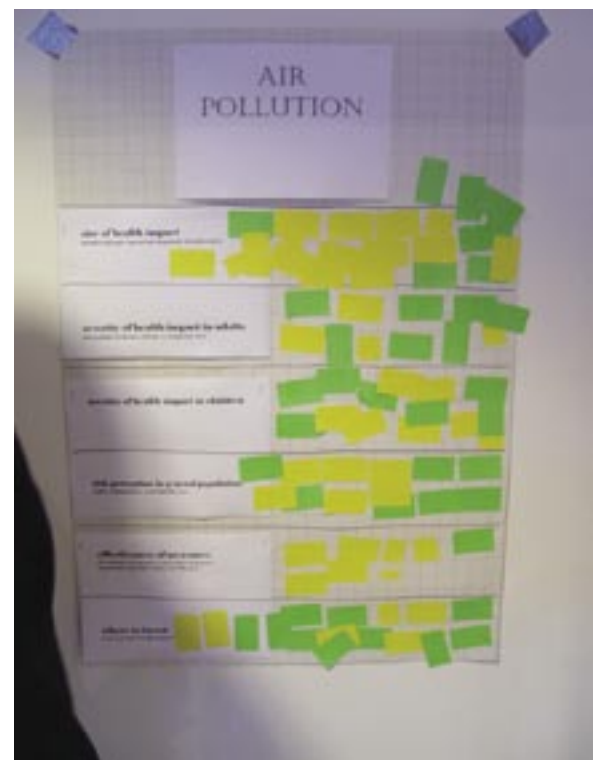


One of the outcomes of this joint project is a set of “Key Messages”. These ‘messages’ were developed after reviewing the evidence and a comprehensive list of policies addressing different aspects of transport-related effects on environment and health. This was undertaken by experts and was developed further at the Workshop on “Synthesis and Policy Recommendations” (Malta, 19-20 February 2004) by an panel of decision makers and external experts.

Experts from the six participating countries shared tasks, experiences and resources. Austria focussed on the psychological issues, France on air pollution, Malta on road safety, the Netherlands on noise, Sweden on economic valuation and Switzerland on physical activity. The project was supported by expert input from the WHO on road safety and climate change. A series of reviewing workshops in Vienna, Stockholm, The Hague and Malta complemented these studies involving also external experts and stakeholders. The results and conclusions of this joint project are summarized and published in a synthesis report complemented by five topic reports.



It has to be stressed that due to limited time and resources, some effects of transport, such as the contamination of water and soil, as well as more comprehensive economic calculations could not be sufficiently undertaken. Follow-up activities would be advisable.



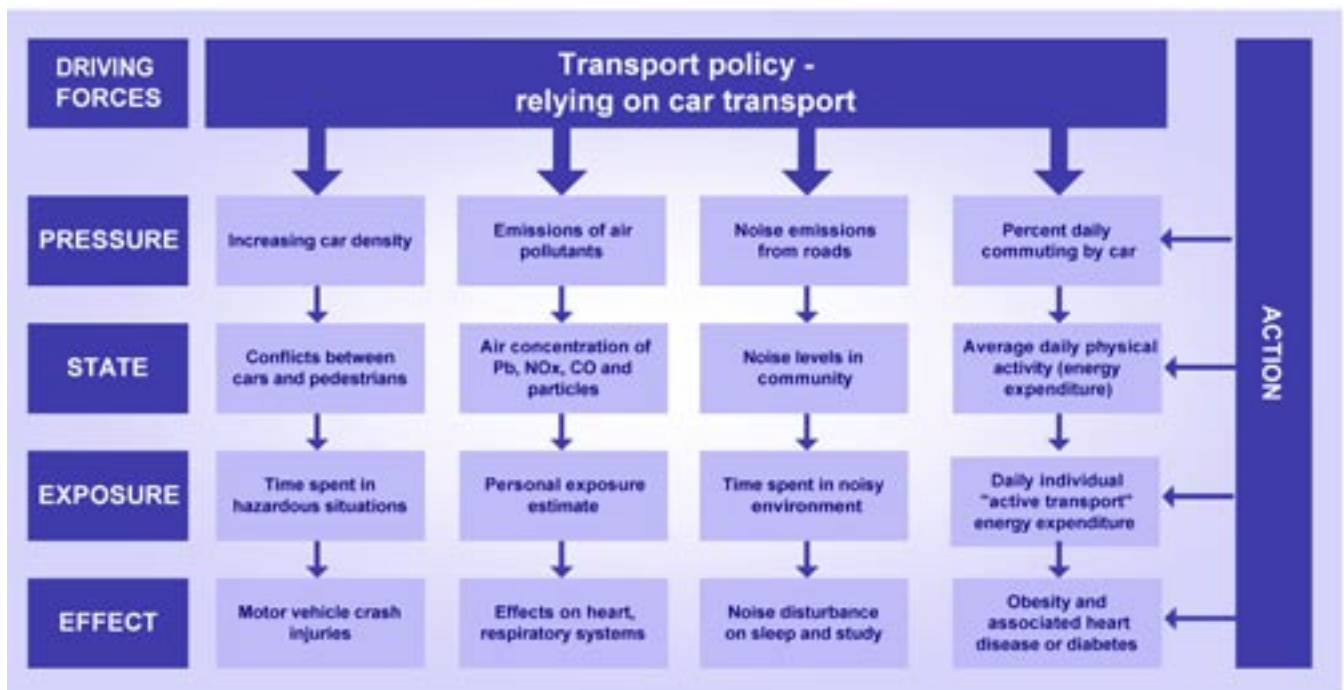
## Background Information

**DPSEEA: A framework to support an integrated vision of the effects of transport on health and the environment**

WHO has developed a specific framework on Driving forces, Pressures, State, Exposures, health Effects and Actions - DPSEEA). This framework can be applied to transport policy as shown in the figure below. The framework presents linkages between health, environment and development. It is an adaptation of the pressure-state-response (P-S-R) framework that was developed by OECD. The DPSEEA is a descriptive representation of the way in which various driving forces generate pressures that affect the state of the environment and ultimately human health through the various exposure pathways by which people come into contact with the environment. The framework allows identifying different levels to be addressed by specific corrective measures.



The application of the DPSEEA framework to Transport



Various studies indicate that transport will not meet the requirements of a system sustainable for health and the environment if current trends will continue. Benefits of technological progress in vehicle technology and fuels would be offset by the large increase of the number of vehicles and the volume of road traffic.

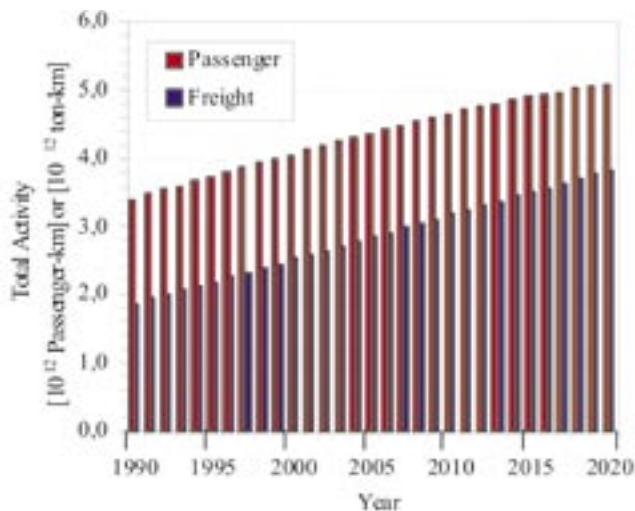
On the other hand OECD has already stated quite clearly that a sustainable transport system would be possible if a package of measures according to the recommendations of the OECD Guidelines for Environmentally Sustainable Transport (EST) were implemented.

Components of the package are the promotion of clean technology and fuels, mobility and infrastructure management, the promotion of rail and public transport use, cycling and walking; the implementation of economic instruments as well as the reorganisation of land use policy and the raise of public awareness.

Certainly EST would also meet the needs of our children and the requirements for a children friendly mobility.

## Passenger and freight road transport are growing rapidly

Development of passenger and freight road transport from 1990 to 2020 in EU-15



Source: TRENDS 2002, EC, 2003

## Trends in Transport

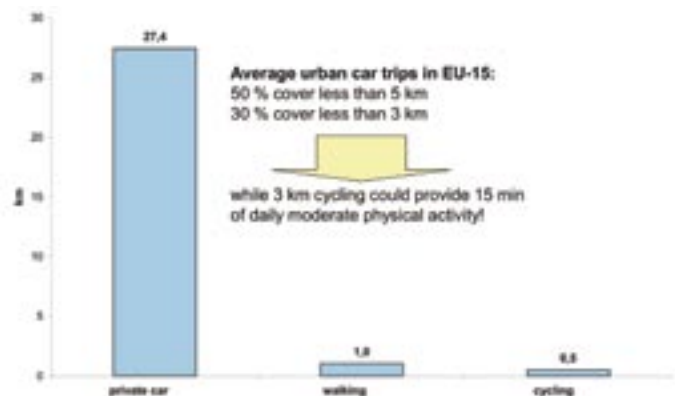
Overall, motorized transport has increased rapidly in the European Region in the last two decades. Freight transport is growing faster than passenger transport. In the EU-15 from 1990 to 2000 passenger transport increased by 18 %; freight transport increased by 40 %, while on the opposite freight transport by train decreased in Europe by 0.6 percent per year (EEA, 2000).

In the forecast in TRENDS 2002 (EC, 2003) this development is predicted to continue until 2020 according business as usual. In the countries of Central and Eastern Europe, following a decrease in transport activities in the early 1990s freight volume and passenger transport have been rising again since the mid-1990s, following economic recovery; similar trends are also likely to occur in Commonwealth of Independent States countries, although data to confirm this are limited.

The number of vehicles has risen drastically for all modes of transportation. The OECD predicts an increase in motor vehicle kilometres of 40 % in the next 20 years (OECD, 2001). The largest increase in passengers kilometers is expected in aviation.

For Europe as a whole, the European Environmental Agency expects an ongoing shift towards road and air transport. In the new EU countries a shift from public transport towards private road transport is observed, as took place before in the "old" EU countries.

Daily mobility pattern per person in urban areas in EU-15



Total distance 35,6 km per person and day (including 6,5 km public transport with bus and coach, railway, powered two-wheelers and metro)

Source: Energy & transport in figures, EC, 2003

Graphic: HERRY Consult

## AIR POLLUTION

The transport-related health effects of *Air Pollution* have been elaborated under the auspices of France by a French expert team involving other experts of the other participating countries and WHO. A special focus is therefore given to the French situation with French specific data and examples. The detailed results and conclusions on the topic of air pollution as well as detailed references are compiled in the project specific topic report: on *Air Pollution* complementary to this synthesis report.

### Air Pollution Exposure

Technical and legal measures implemented since 1990 (e.g. ban of lead in petrol, decrease of sulphur content of fuels, emission standards for vehicles) have led to a reduction of some vehicle related exhaust emissions. Nevertheless, trends show that transport-related emissions of Total Suspended Particles (TSP) emissions have increased by 12 % between 1990 and 2001. This increase is mainly linked to the rapidly growing vehicle fleet and their use leading to higher overall emissions. Road, tyre and break abrasion contributing for 80 % to the TSP road transport emissions. Road transport's share of particle emission increases with the decrease of particles' size considered. Nationwide, road transport contributes for 13 % in PM10 emissions (industries 31 %, agriculture 31 %, residential/tertiary 20 %). In the main French cities, 68 to 79 % of NO<sub>x</sub> air emissions come from road traffic.

Since 1990, annual average air concentration have decreased for PM and for NO<sub>x</sub> in France. Comparable annual average air concentration levels in urban and rural areas of some high density population regions indicate that the major part of PM10 air concentrations are coming from transboundary pollution transportation and secondarily formed particles. PM10 levels are elevated close to main roads and during the winter period. Despite the smooth concentration decrease observed for NO<sub>2</sub>, urban areas remain subject to episodic pollution events that exceed air quality criteria and most of the urban sites still exceed the thresholds that should be effective in Europe in 2010.

### Increasing the Efficiency of Existing Measures to reduce Emissions

- European directives aim at reducing atmospheric emissions from different sources (industries, electricity production, transports,...). The attributed National Emission Ceilings (NEC) represent the national emission quantity that a country must not exceed for selected pollutants (SO<sub>2</sub>, NO<sub>x</sub>, VOC, NH<sub>3</sub>) in 2010. Results from a national evaluation (called OPTINEC) show that the only ceiling that France will be able to respect is VOC. If forecasts for traffic growth and regulation implementation are accounted for, this indicates that technical measures will have to be complemented by economic and structural action mainly in restricting road transport emissions and other mobile sources. Transport will be responsible for 65 % of NO<sub>x</sub> emissions in 2010. Technical measures are indispensable to decrease motor vehicles emissions and for improving air quality in urban areas but their effects are absorbed by increased traffic and vehicles life expectancy attenuating the effect of the new coming limitation on pollutant emitted per engine.
- French data indicate that road traffic ought to be decreased by 15 % to meet the European air quality standard in 2010 for NO<sub>x</sub>.

Comparison between NEC and forecasted emissions (1.000 t) in France 2010

	SO <sub>2</sub>	NO <sub>x</sub>	VOC	NH <sub>3</sub>
Total French emissions (2010, OPTINEC)	461	988	954	857
European directive, French (2010, NEC)	375	810	1050	780
Differences between OPTINEC and NEC	+ 86	+ 178	- 96	+ 77

### Health effects of air pollution on children

Children, in particular those under two years of age, have been considered more susceptible than adults to the effects of air pollution, partly because of their immature metabolism and their physiology.

A synthesis of European epidemiological studies focusing on children has been carried out making a distinction between studies that investigated the association between ambient air pollution exposure (selecting PM and NO<sub>2</sub> as indicators for traffic-related exposure) and health outcomes, and studies that have looked specifically to traffic-related exposure.

Although children have been recognised as a group particularly vulnerable to air pollution there is less available epidemiological data focused on children than on adults. Around 60 studies based on ambient air pollution are available (45 on respiratory symptoms or hospitalisations in asthmatic and healthy children, 6 for non respiratory symptoms, 6 for mortality or pregnancy outcomes) whereas only about 20 studies investigated specifically traffic-related exposure of children (16 using a traffic index, 6 with models).

Both epidemiological approaches have found consistent conclusions: they suggest or indicate a relation between ambient air pollution or traffic-related air pollution in Europe and numerous health outcomes on children, in particularly for respiratory diseases.

### Epidemiological Studies

Many epidemiological studies have assessed and shown the association between ambient air pollution and health effects on adults, using different indicators such as particulate matter (PM, expressed as PM<sub>10</sub>, PM<sub>2.5</sub>, Total Suspended Particles-TSP, Black Smoke-BS, ...) or gaseous pollutants (nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>) and ozone (O<sub>3</sub>)). Health effects have been found in short-term studies relating to day-to-day variations in air pollution and health, and long-term studies which have followed cohorts of exposed individuals over time. Effects have been seen at very low levels of exposure, and it is unclear whether a threshold concentration exists for PM below which no effects on health are likely to occur.

Despite the widely recognised contribution of motorized traffic to air pollution, relatively few European studies have looked at specific traffic emissions-related effects because it remains difficult to distinguish traffic exposure from overall exposure to air pollution. Some studies have used a traffic index (expressed as distance between residence and main road, traffic density, ...) to compare different groups of people's exposure at a local scale (street, city, ...) but very few published studies estimate for the effect of an increment in a specific traffic-related air pollutant (using models with computerised forecasted emissions and exposures from traffic).



## Health Impacts on Children

### Mortality

Consistent results indicate neonatal or early post-neonatal air pollution exposure effects on mortality; these effects seem to be stronger in the post-neonatal (1-12 months) period and specific to respiratory causes. Brazilian studies suggest a relationship between air pollution exposure and respiratory mortality of young children (< 5 years) but there is no European data concerning this health outcome. Results from the association between air pollution exposure during pregnancy and intra-uterine mortality and stillbirths are not homogeneous and do not exhibit a clear exposure-response relationship.

### Respiratory morbidity

Even at relatively low levels, ambient air pollution has been shown to affect children with asthma or chronic respiratory symptoms (exacerbation or increase in respiratory symptoms, medication) and non-asthmatic children (increased prevalence or incidence of respiratory symptoms, increased risk of developing respiratory infections). Hospital admissions and number of childhood consultations in emergency wards or medical visits for asthma or other respiratory diseases are also associated with exposure to ambient PM or NO<sub>2</sub>, in particular during winter months. Children with prevalent asthmatic symptoms seem to be more susceptible to the effects of particulate air pollution than children without symptoms. Use of medication for asthma does not prevent the adverse effects of particles on children with symptoms. Children with hyper-reactive airways and very young children (< 1 year of age) are particularly susceptible.

Living along busy streets in urban areas, particularly with heavy motor traffic may have several adverse effects on respiratory health (chronic respiratory or asthma symptoms, allergic symptoms, increase prevalence of atopic sensitisation, reduction in lung function). Some data suggest that children admitted with an asthma diagnosis were more likely to live in an area with high traffic flow.

### Non respiratory morbidity

Some data suggest that school absenteeism, immune response, eye irritation, or child's growth rate could be associated with current levels of air pollution in Europe. Moreover, there are some indications for an association between traffic exhaust and childhood cancer (leukemia, central nervous system tumors, Hodgkin's disease) in children living near busy roads and exposed during pregnancy.

### Adverse pregnancy outcomes

A possible association between exposure to ambient air pollution during the first or the last trimester of pregnancy, birth-weight reduction or low birth weight (LBW) has been described. Maternal exposure in the first months of pregnancy may also contribute to the occurrence of pre-term birth (< 37 weeks). Conclusions from studies on the relationship between intra-uterine growth retardation and air pollution exposure differ and is still difficult to establish a dose-response relationship.

### Traffic related Health Impact Assessment Studies

Health Impact Assessment (HIA) studies can also provide relevant information for policy makers in forecasting the potential impact of their decisions on public health. Different methodologies have been performed on the one hand in the Tri-national European study (Austria, France, Switzerland) and in the ExternE study. Health impact assessments of traffic related air pollution are based on three phases: 1) to estimate exposures related to transport emissions, 2) to estimate health impacts due to exposures with Exposure-Response-Function (ERFs), and 3) to estimate costs of the health impacts by using unit costs for each of the health outcomes.

The first approach is based on ERF from epidemiological studies and a single indicator of air pollution. The second one is based on dose response functions coming from both animal and/or epidemiological studies and includes a range of individual pollutants.

The approaches also differ in air pollution exposure assessment: the first one is based on Air Quality Monitoring Network data, whereas the second one is based on emission factors and models (impact pathway).

The first approach will give a more global appreciation of the overall impact of air pollution. It may be more appropriate for general transportation policy planning at a national or European level. The second one offers more opportunities to understand or assess the effects of specific actions like minimum standards on fuel quality and engine or exhaust technology.

In conclusion, the Tri-national European study approach seems preferable for HIAs of traffic related air pollution on children at a national scale.

### Exposure assumption comparison between Tri-national and ExternE studies

Steps in exposure assessment	Tri-national study	ExternE study
Pollutant selected	PM10 as indicator of the total air mixture	PM2.5, SO <sub>2</sub> , NO <sub>2</sub> , CO, O <sub>3</sub> , benzene, 1,3-butadiene, formaldehyde, PAH
Quantitative estimation	Based on air quality monitoring network data and spatial distribution between measurement point estimated by model in 4 km <sup>2</sup> grid where land use weigh each sources contribution specific rate	Based on emission factors (expressed as g/km) and annual kilometres covered by each type of vehicles in the location studied, then models used for estimating local scale dispersion and trans-boundary imported pollution
Road transport exposure	Transport contribution rate in the total air concentration are based on Switzerland inventory of particles emission	Not relevant
Secondarily formed pollutant	Integrated into the air quality measurement data	Calculated by a chemical equation in the model use
Expressed results	Annual average of PM10 air concentration due to road transport emission expressed in µg/m <sup>3</sup>	Concentrations due to road transport expressed in µg/m <sup>3</sup>
Area studied	Whole metropolitan national territory	Only urban area in the country
Scenario	Increased background air PM10 concentration due to transport	Marginal (after one year air concentration revert to is initial level) increase in local area

### Health Impact Assessment study of ambient air pollution

The APHEIS study (Air Pollution and Health: a European Information System, <http://www.apheis.net>) has estimated health benefits from a decrease in ambient PM<sub>10</sub> levels in 26 European cities. All other things being equal, in the 9 French cities a decrease of 5 µg/m<sup>3</sup> would prevent 1,561 anticipated deaths. The same scenario applied to 19 European cities gives an estimation of 5,547 (3,368 to 7,744). If PM<sub>10</sub> limit value of 20 µg/m<sup>3</sup> (which has to be implemented in 2010 in Europe) was already implemented in the 19 European cities, 11,855 anticipated deaths could be prevented, all other things being equal.

Those results demonstrate that a small decrease in PM<sub>10</sub> levels generates important public health benefits even in cities which have moderate PM<sub>10</sub> annual air concentrations.

### Key Questions on Impact Assessment

Estimating health impacts of air pollutants related to transport emissions on children at the national scale would face two main challenges:

- How to select pertinent health effects of air pollution on children and how to estimate the quantitative relationships between air pollutant exposure and health effect (ERF)?
- How to accurately estimate the part of exposure to air pollution coming from road traffic emissions?



### Intervention Studies

Some intervention studies indicated health benefits coming from reductions in air pollutant emissions. Studies which have given concordant results (when air pollution levels decrease public health impacts decrease as well) should be repeated in many other situations or locations to strengthen the existing evidence base.



### Non transport related

- **Dublin, Ireland:** the diminution of average Black Smoke concentrations (70 %) after the ban on coal sales was associated with reductions in respiratory and cardiovascular daily death (116 respiratory deaths per year and 243 cardiovascular deaths per year have been avoided after the ban).
- **East-West comparison studies in Europe:** higher prevalence of infectious airway diseases and lower prevalence of allergies in Eastern areas were observed; the decrease of TSP (in term of mass) and SO<sub>2</sub> concentration in Eastern Germany after reunification had a favorable effect on children's health; it is related to the decreasing prevalence of non-allergic respiratory disorders of children (bronchitis, sinusitis...). It indicates the reversibility of adverse health effects on children. For allergies and related symptoms no differences in time trends could be detected or no association with SO<sub>2</sub> or TSP could be seen in Eastern Germany.
- **Utah Valley, USA 1980s:** with the opening of steelworks industry PM<sub>10</sub> levels were nearly doubled and were strongly correlated with hospital admissions for asthma and respiratory disease, particularly of children. Public health benefits were observed for a closure period of the mill (decreases in incidence of respiratory symptoms, school absenteeism, respiratory and cardiovascular mortality).

### Transport related

- **Atlanta, USA 1996:** during the Summer Olympic Games, the alternative transportation strategy reduced downtown traffic congestion. This action was associated with a prolonged reduction in ozone pollution and a significant lower rate of childhood asthma events.
- **Hong Kong, China 1990:** A restriction on sulphur content in fuel for power plants and road vehicles led to an immediate fall in ambient air SO<sub>2</sub> content associated with a substantial reduction in death rate (average gain in life expectancy per year of exposure was 20 to 41 days) and with reduction in bronchial hyper responsiveness of non-asthmatic and non-wheezing children; reducing sulphur content in fuel led to improved breathing function of healthy children.
- **Linz, Austria 2002:** A birth cohort study on school children documented an improvement of forced expiratory flow in small airways in those districts where not only SO<sub>2</sub> and coarse particles (from industry sources), but also NO<sub>2</sub> (from road transport) was reduced significantly.
- **Oslo, Norway:** Two tunnels were built to protect the urban environment from traffic emission. Air concentration (NO<sub>2</sub>) after opening the tunnels decreased from an annual average of 51 to 40 µg/m<sup>3</sup>. Life quality indicator (declared tiredness) decreased by 5 to 10 % in the population. When noise exposure increased more people experienced annoyance due to air pollution.
- **USA, 1998:** Evaluation of the influence of national vehicle emissions policies and practices on CO. If rates of unintentional CO-related deaths had remained at pre-1975 levels, an estimated additional 11,700 motor vehicle-related CO poisoning deaths might have occurred by 1998.
- **South Africa, 1990:** A stepwise reduction in petrol lead additives from 0.8 to 0.4 g/l (1984-1990) was associated with a significant decrease in the blood lead levels of city dwellers. Similar trends were found in many other countries that have reduced petrol lead additives or entirely eliminated them.

### Examples of transport related intervention studies

Localisation	Action	Air pollution impact	Health impact
Atlanta (1996)	alternative transportation strategy	↘ O <sub>3</sub>	↘ asthma in children
Oslo (1996)	building of tunnels	↘ NO <sub>2</sub>	improve life quality, ↘ annoyance
Hong-Kong (1990)	↘ sulphur content in fuel	↘ SO <sub>2</sub>	↘ death rate ↘ BHR (bronchial hyper-responsiveness) in children improve breathing function in children
South Africa (1990)	↘ petrol lead additives	↘ lead	↘ blood lead levels

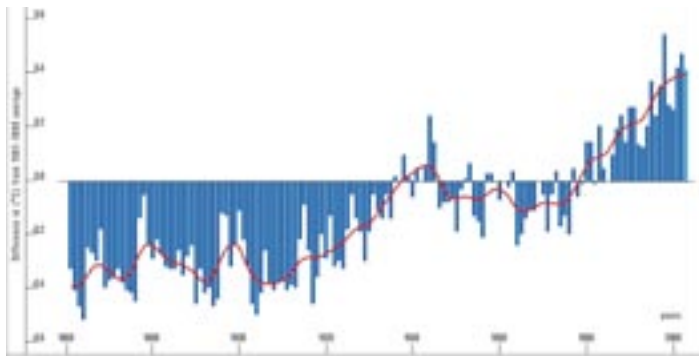
## CLIMATE CHANGE

### Trends in Indices of daily temperature and precipitation Extremes in Europe, 1946–1999

The warming observed in Europe can be split into two sub-periods:

- 1946-1975 sub-period, with slight cooling and an annual number of warm extremes decreasing, but the annual number of cold extremes not increasing;
- 1976-1999 sub-period, being an episode of pronounced warming, the annual number of warm extremes increases two times faster than expected from the corresponding decrease in the number of cold extremes. Throughout the year, the frequency of days that are much colder than normal has decreased and the frequency of days that are much warmer than normal has increased.
- A decreasing number of frost days and to a lower extent an increasing number of summer days accompanied the observed warming trend.

Global mean temperature is rising (in the period of 1850 to 2003).



### Climate Change in Europe

Over the past decade, the fact that the world's climate is changing has become visible. The global average surface temperature has increased since 1861. This unprecedented warming has taken place in a time span far shorter than the spans paleoclimatic studies have shown for geological periods with similar changes. The global average sea level has risen, the heat content of the oceans has increased and the extent of snow cover and ice has decreased.

For millennia, the greenhouse effect has facilitated a balance between incoming solar radiation and outgoing terrestrial radiation; a change in either incoming or outgoing radiation modifies the surface temperature of the Earth. Numerous human activities that transfer gases into the atmosphere enhance the natural greenhouse effect.

Over the period from 1990 to 2000, transport greenhouse gas emissions in the EU-15 increased by 19 %, whereas emissions from Central and Eastern Europe (CEE) had a smaller increase of 4 %. Although technological improvements will bring increased efficiencies, CO<sub>2</sub> emissions will increase in the future due to the growth in passenger and freight transport.

Transport in Europe is the second largest energy consumer with a share which in 1999 reached 30 % in Western Europe and 22 % in CEE (EEA, 2003). An annual growth of about 2 % and 3 % in WE and CEE respectively was recorded for transport energy consumption in the decade from 1990 to 1999. The low energy consumption of the transport sector in Eastern Europe, Caucasus and Central Asia (EECCA) indicates that the contribution of transport emissions in this region is much smaller than in the other regions of Europe. Transport growth is strongly driven by economic growth and transport emissions are expected to grow substantially in CEE and EECCA as economies recover and the demand for transport increases.

### The Health Effects of Climate Change in Europe

The health effects of climate change are complex and far reaching. Worldwide it has been estimated that 160,000 deaths were attributable to climate change in 2000 (WHO, 2003). The African and Asian continents face the biggest risk.

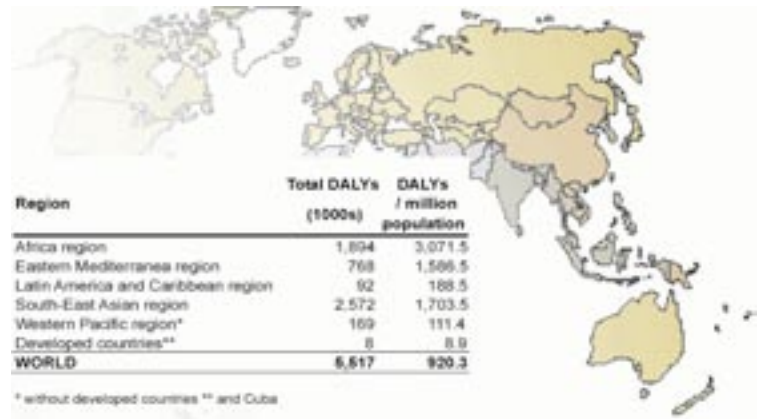
Evidence is increasing that extreme weather and climate events are becoming more frequent and intense in Europe. The heat-wave in 2003 caused approximately 25,000 excess deaths in the aging population. Evidence is mounting of increased child hospital admissions during hot periods. Floods in recent decades have caused some rare disease outbreaks or increased incidences of respiratory or diarrheal diseases and an increase of symptoms of posttraumatic stress disorders. The elderly, disabled, children, women, ethnic minorities and rescue workers may be at greater risk of exposure to the effects of flooding than others.

The analysis of the time series of climate patterns and laboratory confirmed cases of indigenous salmonella infections from ten European countries found that temperature increases contributed to an estimated 30 % of cases of salmonellosis in the majority of countries investigated.

Preliminary results show that in relation to climate and ecosystem changes Lyme borreliosis has spread into both higher latitudes and altitudes, and in some areas contributes to an extended and more intense LB transmission season. Among children, *Borrelia burgdorferi* s.l. is now the most common bacterial cause of encephalitis and facial palsy/paralyses.

The health impacts of climate change are difficult to quantify and surrounded by a high degree of uncertainty on the long time-scale involved, the extent of the impacts, and the pattern of future world development.

Estimated impacts of climate change in 2000 by region



Climate change and health: pathway from driving forces through exposure to potential health effects



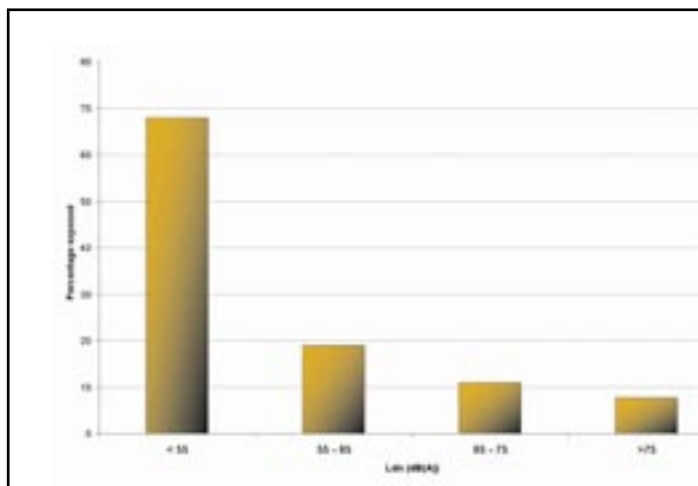
Source: Kovats et al, 2003

## NOISE

The transport-related health effects of *Noise* have been elaborated under the auspices of the Netherlands by a Dutch expert team involving other experts of the other participating countries and WHO. A special focus is therefore given to the situation in the Netherlands with Dutch specific data and examples. The detailed results and conclusions on the topic of noise as well as detailed references are compiled in the project specific topic report on *Noise* complementary to this synthesis report.

Approximately 30 % of the European Union's population (EU-15) or close to 120 million people are exposed to levels of road traffic noise of more than 55 dB(A). In general many people are annoyed and disturbed in their sleep at these levels.

The exposure of European Union's population to traffic noise (façade dwelling) expressed in Ldn (noise pressure during day, and night)



Source: (Roovers, 2001)

### Noise Levels in the EU

Community noise is a widespread environmental problem. In Europe, transport (road, rail and air traffic) is the most important source of community noise. Exposure to high noise levels has decreased substantially in some countries since 1980 due to technological and spatial measures. Nevertheless, noise levels are expected to rise again due to the growth in traffic, unless extra measures are taken.

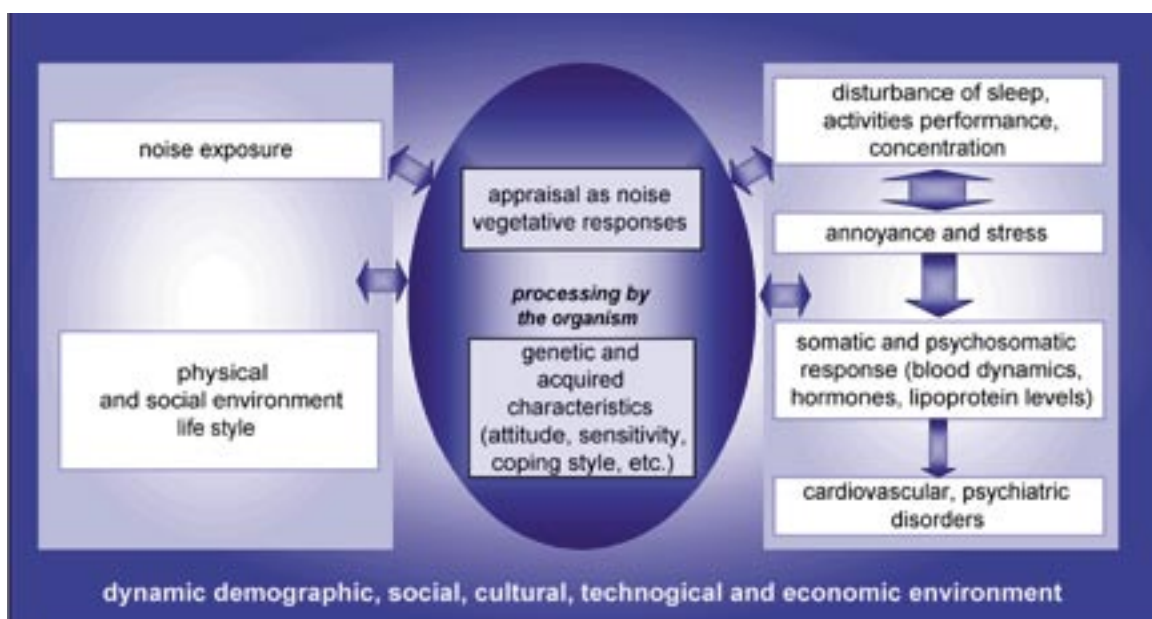
### Health Impacts on Adults

A review of epidemiological studies shows that noise exposure at community levels causes annoyance and sleep disturbance on adults. There is limited evidence that noise exposure contributes to the development of cardiovascular disease. However, a small effect on blood pressure levels is deemed highly plausible.

Reported annoyance and sleep disturbance levels vary across European countries, but are difficult to compare due to differences in methodology.

Noise exposure explains about 25-30 % of the observed variance in annoyance. Individual and socio-economic factors are important too (e.g. anxiety, appraisal of a noise source, trust in responsible authorities, perceived economical advantages).

Conceptual model representing the relationship between noise exposure, health and quality of life



### Health Impacts of Noise on Children

The limited number of available epidemiological field studies on children shows that noise exposure affects children's learning (cognition), motivation and annoyance. Noise exposure may also have impacts on the cardiovascular and endocrine system. There is no convincing evidence that noise exposure leads to congenital abnormalities, decreased birth weight or disorders related to the immune system. Current levels of environmental noise exposure in Europe do not have an effect on hearing threshold levels of children. Nevertheless, combined effects should not be excluded: recreational noise (walkmans, discotheques) may make children and adolescents more vulnerable for the effects of traffic or occupational noise.

### Effects on Learning

The RANCH study, a recent multi-centre study, found that aircraft noise exposure was associated with reading comprehension. A 5 dB(A) increase in noise was associated with a 1-2 month impairment in reading age. The findings with regard to road traffic noise are inconsistent. While some studies indicate that the effects on reading may be reversible if the noise ceases, the long-term developmental consequences of exposure that persists throughout the child's education remain yet to be determined. However, intervention measures (outdoor and indoor) such as reducing the noise levels in classrooms have been shown to result in improvement long-term memory and reading ability of children.

### Do Children need extra Protection?

Children are more vulnerable than adults with regard to effects on learning. Although children appear to be less disturbed during their sleep than adults, there is some evidence for 'hidden effects' occurring during sleep that, in the long term, might add to the risk of cardiovascular disease. To avoid these effects, protection of children against noise exposure during the night and at school is recommended.

HEALTH OUTCOME FOR CHILDREN	STRENGTH OF EVIDENCE
Annoyance	Sufficient
Hearing loss	Sufficient
Cognitive performance - reading	Sufficient
Cognitive performance - memory	Sufficient
Cognitive performance - auditory discrimination	Sufficient
Cognitive performance - speech perception	Sufficient
Cognitive performance - academic performance	Sufficient
Cognitive performance - attention	Inconclusive
Motivation	Sufficient / limited
Wellbeing/perceived stress	Sufficient / limited
Catecholamine secretion	Limited / inconclusive
Hypertension	Limited (weak associations)
Psychiatric disorder	Inconclusive / no effect
Sleep disturbance	Inconclusive / no effect
Birth weight	Inadequate
Immune effects	Inadequate

### Transport-related Intervention Studies on Children show Benefits of reducing Community Noise Levels:

- New York City: railway noise intervention measures reduced classroom noise levels by 6-8 dB(A) - improved reading ability of the children
- Los Angeles Airport Study: reduction of noise levels by 7 dB(A) in noise-abated classrooms - small improvements on cognitive performance
- Closure of old Munich Airport: reduction of noise levels with 14 dB(A) - improvement in long-term memory recall and reading while the reverse effect occurred in children living near the new airport (Hygge, Bistrup)



### Reference Limits for Exposure to Noise

It is proposed to use national standards (where existing) or WHO guidelines as these specify noise levels for different settings, activities and times. In general, noise levels in residential setting should not exceed 55 dB(A). Current guidelines for school noise levels (35 dB(A) LAeq, in school) can be used for setting objectives but may be difficult to reach. Current WHO guidelines for night-time noise (45 dB(A) LAeq) do not allow acting towards reductions of peak levels.

### Promote Exchange of New Evidence

Regular supranational scientific reviews on evidence and consensus building on 'safe' noise threshold levels (updating WHO guidelines) should be promoted. Results of ongoing studies on the relationship between noise exposure and health impacts should be fed directly in the WHO process and made available to other countries.

Results of best practices and intervention studies should be fed directly in e.g. THE PEP process.

### Health Impact Assessment of Noise in the Netherlands

In the Netherlands 1-2 % of the total disease burden can be attributed to health impacts of road traffic noise exposure.

Effect	Number of adults affected <sup>d</sup>
Annoyance <sup>a)</sup>	1.5 to 2.2 million
Severe annoyance <sup>a)</sup>	500,000 - 850,000
Sleep disturbance <sup>b)</sup>	550,000 - 1 million
Severe sleep disturbance <sup>b)</sup>	200,000 - 450,000
Attributable cases of hypertension	Max. 200,000
Deaths attributable to hypertension attributable to noise	Max. 1,100 per year



- a) Estimated by means of the exposure-response relation as derived by Miedema & Oudshoorn and only valid for Ldn 45-65 dB(A).
- b) Estimates on the basis of the exposure-response relation from Miedema et al, 2003 and only valid for Lnight 45-65 dB(A).
- c) Estimated by means of a RR of 1,26 per 5 dB(A)) from a meta-analysis on noise and cardiovascular disease (Van Kempen et al, 2002) under the assumption that there is a causal relationship (worst case estimation).
- d) Deaths attributable to hypertension estimated by means of the Chronic Disease model (Hoogenveen et al, 1998).

### Valuation of Noise Reduction - Cost and Benefits

Noise abatements are expensive but if abatement fails, noise may have adverse effects on health and well-being. These adverse effects can be expressed in monetary terms.

It has been estimated that for EU-15, the overall external costs (abatement costs) of road and rail traffic noise amount to 0.4 % of the total GDP, some 36 billion Euro.

The benefits of implementing several source-measures on cars and trains will exceed the costs of these measures, as cost-benefit analyses clearly indicate. The implementation of several source-measures on cars and trains in e.g. the Netherlands will cost about 2 billion Euros (net present value). However, the benefits in terms of reduced annoyance are estimated with an amount of about 4-6 billion Euros. Thus, the benefits of source measures for the Dutch society as a whole would exceed the costs.

Households in the EU are willing to pay 25 Euros for a noise reduction of one decibel per year (Navrud 2003). No data are known about the value children put to noise reduction.

Noise related health effects such as sleep disturbance and ischaemic heart disease have rarely been given a monetary value. As one of the first the EU-funded project, UNITE derived monetary values for these health impacts. Amenity losses were also estimated. However, it has to be kept in mind that considerable uncertainty is attached to the economic estimates of myocardial infarction, hypertension and sleep disturbance.

Using the values from the UNITE project the total external costs from noise exposure for Zurich airport were estimated at 17.7 million Euro per year (1998 prices). External costs for Orly airport (France) only including annoyance from aircraft noise were estimated at about 5 millions Euro per year.

### Equity (or environmental inequity) should also be included in cost-benefit analysis.

In the Netherlands low-income groups are more often exposed to high noise levels (> 65 dB(A)) and live less than average in quiet areas (<50 dB(A)).

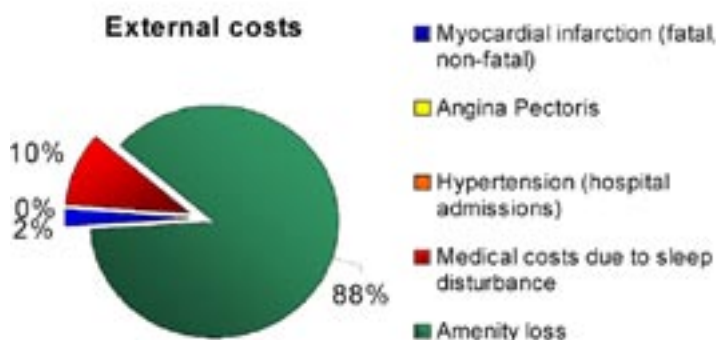
Socio-economic distribution of environmental pressures ('bads') and 'goods'(green areas) in the Netherlands per income category (neighbourhood level). Index 1 is the average of the total population, a value smaller than 1 is favourable

Distribution of environmental pressure per income categories



Source: Bouwman, 2001

Disutility costs (annoyance) of noise dominate over eventual medical costs (example for Zurich Airport)



Source: Bickel, 2004

### Cost-benefit Analysis

The Valuation of health effects attributable to noise exposure is the last part of a three-stage process, consisting of:

1. calculation of exposure
2. calculation of population impacts using exposure-response relationships
3. valuation of health impacts in monetary terms:
  - a) cost of the separate impacts
  - b) mean aggregate monetary values of all health effects due to noise exposure

Estimated costs (Euros) for impacts due to noise (average costs per case), which can be used for cost-benefit analysis of noise

Impact	Avg Europe <sup>x)</sup>	Netherlands <sup>x)</sup>
<b>Myocardial infarction (fatal, 7 YOLL)</b>		
Total per case	522,900	592,000
<b>Myocardial infarction (non-fatal, 6 days in hospital, 24 days at home)</b>		
Medical costs	4,720	5,680
Absentee costs	2,820	3,140
WTP	15,070	17,630
Total per case	22,610	26,450
<b>Angina Pectoris (severe, non-fatal, 5 days in hospital, 15 days at home)</b>		
Medical costs	2,960	3,560
Absentee costs	1,760	1,960
WTP	9,440	11,040
Total per case	14,160	16,560
<b>Hypertension (hospital treatment, 6 days in hospital, 12 days at home)</b>		
Medical costs	1,630	2,210
Absentee costs	1,580	1,760
WTP	550	620
Total per case	3,960	4,590
Medical costs due to sleep disturbance (per year)	197	223
Average (net) rent per person per year (basis of calculation of WTP for avoiding amenity losses)	not yet available	1,285

x) Derived from table 33 from Certan et al. Unification of accounts and marginal costs for transport efficiency. The pilot accounts for the Netherlands, June 2003.

Source: UNITE, 2004

The purpose of the valuation is usually to express the severity of the noise problem in terms of changes in welfare. Welfare consists of three components: (i) resource costs i.e. medical costs paid by the individual, health service or insurance, (ii) opportunity costs i.e. the costs in terms of lost productivity and the opportunity cost of leisure (leisure time loss), (iii) disutility i.e. other social and economic costs including any restrictions on or reduced enjoyment of desired leisure activities, discomfort or inconvenience (pain or suffering). In the health valuation literature the first two components are summed into the „Cost-Of-Illness“ (COI) measure of welfare. All three components are thought to be non-overlapping. Yet, there is a clear danger of overlap, since any individual tends to include in their assessment of loss of welfare both financial and non-financial concerns. In the case of noise, disutility clearly dominates over eventual medical costs.

Therefore, and to avoid double-counting, valuation techniques for noise concentrate on calculating a price on the utility loss such as the Willingness To Pay methodology (WTP). In the field of noise the revealed preferences and stated preference-methods are most commonly used. Methods based on revealed preferences consider noise (or better: silence) as a free-market good that can be bought. By comparing real estate prices in neighbourhoods with different noise loads, the price of silence (or the price of avoiding negative health effects) is revealed. With the stated preference methods people say how much they value a certain good, for example a silent environment. Both methods are aimed at adults (SIKA 2003, Dusseldorp et al, 2001, Nijland et al, 2003)

# PHYSICAL ACTIVITY

The transport-related health effects of *Physical Activity* have been elaborated under the auspices of Switzerland by a Swiss expert team involving other experts of the other participating countries and WHO. A special focus is therefore given to the Swiss situation with Swiss specific data and examples. The detailed results and conclusions on the topic of physical activity as well as detailed references are compiled in the project specific topic report on *Physical Activity* complementary to this synthesis report.

## Transport-related Physical Activity and Health

The importance of regular physical activity for health is well established. Positive health effects have been demonstrated for life expectancy, cardiovascular disease, stroke, diabetes II, obesity, some forms of cancer, osteoporosis, depression and independence at old age among others.

However, levels of inactivity are alarmingly high - not only in industrialized countries, and physical inactivity is a major public health problem. In the World Health Report 2002, the global estimate for prevalence of insufficient physical activity is 41 %. The global estimations of WHO also indicate that physical inactivity causes about 10-16 % of cases each of breast cancer, colon and rectal cancers and diabetes mellitus, and about 22 % of ischaemic heart disease, resulting in 1.9 million deaths and 19 million DALYs (disability-adjusted life years).

There is a growing number of interventions to increase physical activity among the inactive, and in particular in otherwise physically inactive individuals transport-related physical activity has a great potential in the promotion of overall physical activity. Current research questions are:

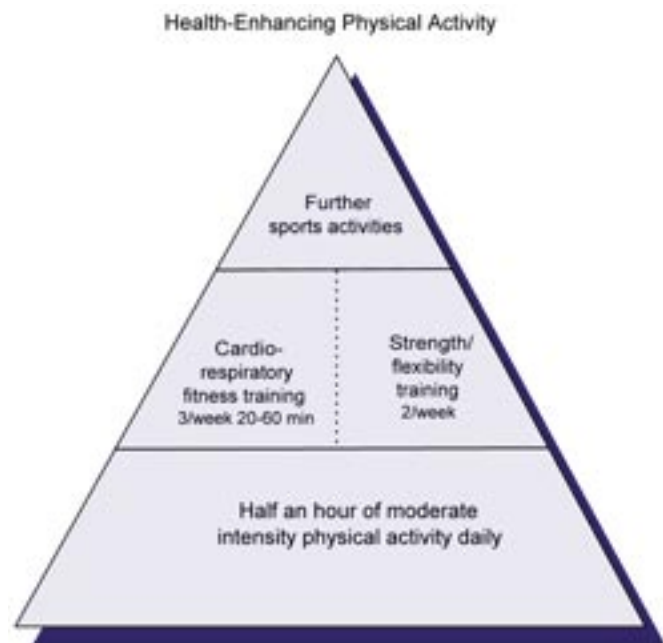
- the quantification of changes in behavioural patterns
- health outcomes that can be expected to be influenced in traffic interventions.

International minimum recommendations for health-enhancing physical activity refer to 30 minutes of moderate-intensity activities. Moderate intensity is characterised by getting somewhat out of breath but not necessarily sweating, typical examples being walking and cycling. Further activities will convey further health benefits and in many countries the minimum recommendations for children are set at one hour per day.

### Recommendations for Health-enhancing Physical Activity

**There is international consensus about the minimum recommendations for physical activity.**

**In the "Global strategy on diet, physical activity and health" discussed in the World Health Assembly 2004, it is stated that "at least 30 minutes of regular, moderate-intensity physical activity on most days reduces the risk of cardiovascular disease and diabetes, colon cancer and breast cancer".**



At least half an hour a day of moderate intensity physical activity is recommended to women and men at any age.

People who already attain this level can further increase their well-being, health and efficiency by adding some training for cardio-respiratory fitness, strength and flexibility.

For people who already train regularly, further sports activities bring about additional benefits for health. Yet, the additional effect diminishes gradually.

The recommendations for health-enhancing activity currently in use in Switzerland are an attempt to integrate the additional health benefits of higher levels of physical activity.

### Health Effects at the Population Level

First estimations of the health effects of physical inactivity at the population level have been made for Switzerland, but remain to be refined once greater standardization in measurement methods is achieved. Depending on the assumptions made about the actual level of inactivity in the population, current estimations vary between 1.4 and 1.9 million cases of disease, 2,000 and 2,700 deaths and direct treatment costs of 1.6 and 2.2 billion Swiss francs (1.1 to 1.5 billion Euro) caused by physical inactivity in Switzerland, a country of 7 million inhabitants.



### Health Impacts of Overall Physical Activity and Transport-related Physical Activity

The health effects of physical activity have been thoroughly studied over the last decades and a wealth of different endpoints has been identified. A dose-response-relationship can be demonstrated for most of these endpoints, most clearly for overall mortality and cardiovascular morbidity. This dose-response-relationship shows that higher levels or physical activity are associated with greater health benefits and that increases in physical activity are most beneficial in groups and individuals least active.

There is international consensus that health effects can already be expected from activities of “moderate intensity” and that not only exercise of longer duration, but that also shorter bouts of activity are relevant for health.

Most research has studied the associations between health and overall physical activity, but some projects have also been able to study and demonstrate the independent effects of transport-related physical activity on health.

In general, transport-related physical activity is most likely to be relevant for health if it represents an important contribution to the overall physical activity of individuals or population groups. Therefore it is of great importance in otherwise physically inactive people and in individuals who find it difficult to fit other and more time-consuming forms of exercise or physical activity into their tight timetables.

Overview of health effects of physical activity

- ↑ Life expectancy
- ↓ Cardiovascular disease
- ↓ Diabetes II
- ↓ Obesity
- ↓ Colon cancer
- ↓ Breast cancer
- ↓ (Prostate cancer)
- ↓ (Pancreatic cancer)
- ↓ Osteoporosis
- ↓ Symptomatic gallstone disease
- ↓ Depression
- ↑ Stress tolerance
- ↑ Independence in old age



### Health Effects of Physical Activity in Children

Health impacts of physical activity in children exist on different levels:

- Direct health impacts of physical activity in children have been shown for obesity, diabetes type II, osteoporosis, psychological effects and predictors of cardiovascular disease. Short-term effects are most easily demonstrated and impressive in size for weight control, the associations with diabetes II and cardiovascular disease could become very important if current trends in activity patterns continue. The long term implications for the prevention of osteoporosis are fundamental as there is very strong evidence that physical activity during the most active period of maturity (with respect to longitudinal growth of the body) plays a vital role in optimising peak bone mass and that benefits – but also deficits – will extend into and through the adulthood lifecourse.
- There is a greater likelihood that physically active young people, compared with those inactive, will be more active in later life as well (low to moderate tracking of physical activity), so it is perceivable that all health effects of physical activity in adults can be influenced by increasing and maintaining active behaviour in young people.

- Developmental and other quality of life effects of physical activity in children may be of great importance, but due to their nature and to methodological deficits they have only partially been quantified so far.

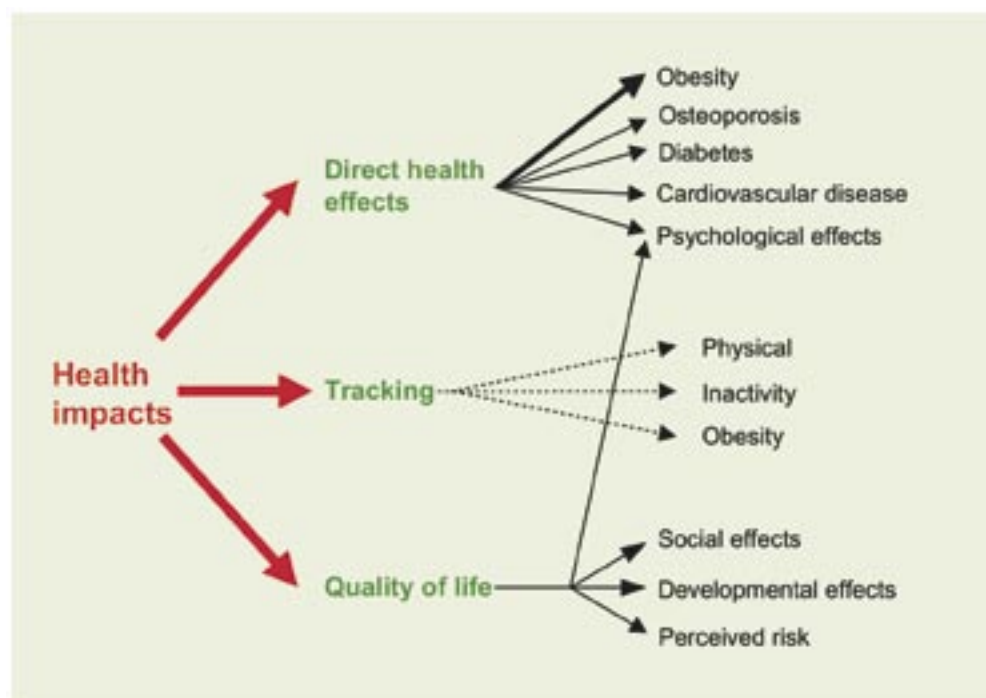
Some estimations of the health effects of physical activity on the population level including all age groups have been carried out; the development of specific economic models for children is a challenge for further development.

### Research Challenges

The importance of physical activity for health has been clearly demonstrated. Nevertheless, a number of questions about the effectiveness of specific strategies remain unanswered.

In parallel to the development and implementation of interventions to promote walking and cycling, the standardization of measurement methods and the establishment of monitoring and evaluation systems are of great importance.

Model for the health effects of physical activity in children on three levels



### Physical Activity Patterns at the Population Level

The World Health Report 2002 reports summary statistics for physical activity states that “the global estimate for prevalence of physical inactivity among adults is 17 %, ranging from 11 % to 24 % across sub-regions. Estimates for prevalence of some but insufficient activity (< 2.5 hours per week of moderate activity) ranged from 31 % to 51 %, with a global average of 41 % across the 14 sub-regions.”

A Pan-EU survey on consumer attitudes to physical activity, body-weight and health carried out in 15 member states of the EU was published in 1999. It contained items on physical activities of moderate intensity. The proportion of individuals reporting no more than 3 hours per week of such activities was 57 % in the EU average, with the lowest values being 32 % and 33 % in Sweden and Finland.

Though methodological issues still restrict the possibilities to quantify this problem in absolute terms and to carry out intercultural and international comparisons, subgroups with particularly low activity levels and changes over time can be documented.

A systematic integration of data from the health and transport sectors has not yet taken place.

The availability of epidemiological data is an important element in the political process leading to a better recognition of the importance of health-enhancing physical activity on the national and international level and the current attempts for standardized measurement procedures will play an important role in this process.

### Physical Activity Patterns in Children

**No international monitoring systems for physical activity in children exist yet, but a number of studies in different countries have addressed the issue. In general, they indicate high levels of inactivity in populations of young age and a tendency towards declining activity levels over age and time. All recent studies which examined the pattern of overall physical activity from childhood to adolescence, confirmed a decline in active behaviour, which starts at puberty and continues through to young adulthood. Transport-related physical activity can make an important contribution to overall physical activity in children. A wealth of data exists on overweight and obesity which are strongly influenced by physical activity behaviour. The prevalence of both conditions is high and rising in most of today's societies.**

There are clear indications for regional differences and for decreasing trends in transport-related physical activity in children

Travel to school by car			
	1986	1998	2000
GB 5-10 y <sup>1</sup>	-	38 %	-
GB 11-16 y <sup>1</sup>	16 %	30 %	-
CH 6-9 y <sup>2</sup>	-	-	9 %
CH 10-14 y <sup>2</sup>	-	-	4 %

<sup>1</sup> Department for Transport (2002). transport Statistics Bulletin. national Travel Survey. london: DfT for 1986 the data period was 1985/1986, for 1998 it was 1996/1998 and for 2000 the data period was 1999/2001.

<sup>2</sup> Mikrozensus 2000 (2001). Scientific survey of the population's travel behaviour in Switzerland Swiss Federal Office of Spatial Development, Swiss Federal Statistical Office, Bern and Neuenburg (percentage of trips).

## PSYCHOLOGICAL AND SOCIAL EFFECTS

The transport-related health impacts due to *Psychological and Social Effects* have been elaborated under the auspices of Austria by an Austrian expert team involving other experts of the other participating countries and WHO. A special focus is therefore given to the Austrian situation with Austrian specific data and examples. The detailed results and conclusions on the topic of psychological and social effects as well as detailed references are compiled in the project specific topic report on *Psychological and Social Effects* complementary to this synthesis report.

### Psychological and Social Interactions

#### Humans React to the Environment

The impact of the built environment (with the transport systems being a prominent part of it) on human health is not just one-way:

- Psychological and social reactions can themselves modify the systems and thus are both able to accelerate changes in the form of a vicious circle or else to absorb the impact of technical changes or pressures.
- Depending on the desirability of a development both acceleration and delay due to psychological and social mechanisms can be deemed good or bad.
- Irrespective of that these phenomena must be considered in all programs and policies concerning transport and health. Technical or economic solutions of single problems that do not consider human reactions are often prone to fail.

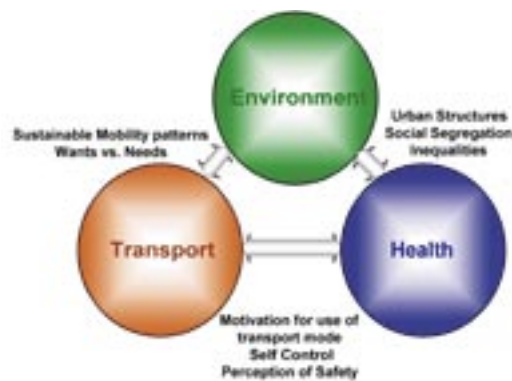
Do not focus on problems alone but also on Human Needs:

- Our current transport systems and activity patterns are determined by political decisions and past and present social and cultural factors which imperfectly meet our needs.
- Addressing our true needs, which encompass (in a hierarchical order) physiological, safety, security, social, intellectual and aesthetic needs (see table), would improve our understanding as to what we want transport for and where we should improve our systems.
- Children's views as to their transport needs are rarely sought and, for example, there is significant suppressed demand for walking and cycling-modes most readily available to them.

Layer of needs

Layer	Suggested areas which are included
Aesthetic Needs	Interests, hobbies, goals, wishes, ...
Intellectual Needs	Cognitive performance, learning, creativity, ...
Social Needs	Significant primary relationship, autonomy, social roles and opportunities to participate, ...
Safety, Security Needs	Housing, economic security, non-hazardous environment, safety of transport, appropriate health care, security in childhood, basic education, ...
Physiological Needs	Nutritional food, clean water, recreation, no sleep disturbance, ...

A conceptual triangle: Psychology and social sciences provide insight into the interconnections within the triangle of transport, environment, and health.



### The Influence of psychological Aspects on Transport Perceptions and Behaviours

Most persons judge car use emotionally:

- For most persons the car is more than a vehicle. It provokes and promotes underlying dreams of speed, power and easy access to distant locations, feelings of comfort privacy and time saving.
- Psychoanalytic studies indicate that the car is perceived as an enlargement of the own body and as a means to overcome our physical limitations. Sitting in a car evokes emotions of security and of all-pervading power.
- The privacy of one's own car combined with the anonymity towards other road users are suboptimal conditions for sociable and responsible behaviour.

# Health Impacts - Evidence and Main Facts

## Psychological and Social Effects

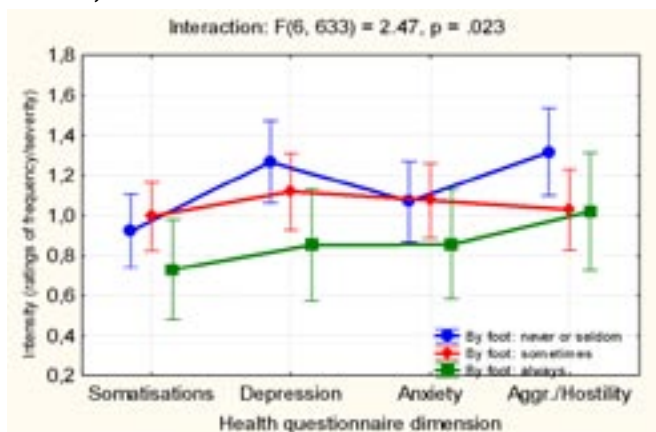
Examples for psychological and social effects mediated through specific risk factors

Risk Factor	Examples for psychological or social effects
Climate Change	Migration, changes in life styles and food production techniques
Physical Activity	Effects on depressiveness, anxiety, motor skills
Air Pollution	Annoyance by the smell of fumes, sleep disturbance due to nocturnal cough
Noise	Noise annoyance, reduced social contacts, aggressiveness, speech intelligibility
Accidents	Post-traumatic stress, anxiety, behavioural changes, fear to engage in cycling and walking

### The Relationship to Disease:

- Psychological and social mechanisms triggered by the perceived impact of transport by themselves can lead to disease
- Every disease can also have consequences on the mental and social status of a person or an affected group of people. In addition to this, mental and social conditions can directly modify the impact of environmental stressors on human health.

Means (and 95 % confidence interval) of health related scores for the 3 modes of going to school(walking never/seldom, sometimes and always)



## Psychological and social Well-being

### Relating Psychology to Transport-related Health Impacts

- Primarily psychology reminds us of the comprehensive definition of “health” given in the WHO Constitution, according to which that “health is more than just the absence of disease” but also includes mental and social well-being.
- Many health effects of noise and some of air pollutants cannot be studied nor understood if psychology and sociology are neglected.
- The impact of the built environment on our activity patterns is mediated by psychological and social processes.
- Psychological and social effects of transport should be seen as an integral part of transport-related health impacts.



### Positive and Negative Effects

Walking to school instead of being brought by car has a direct positive effect on psychological and physical well-being in children:

- lower score in depression
- lower score in aggression/hostility
- less psychosomatic symptoms
- lower score in anxiety
- improved motor skills
- better ventilation of basal lung segments

In the long run high traffic density in human settlements also leads to social effects in the way of hindering the development of independence as well as social contacts of children.

### Let Children Voice their Needs

Children have very definite ideas as to what they need and what they want. These ideas are surprisingly consistent and coherent and even younger schoolchildren are able to express their wishes if they get the proper opportunity.

So far there have been no economic valuations applying the WTP approach to children. Such an approach would have to overcome severe obstacles. Nevertheless, children's values should be considered when discussing economic valuation. A Vienna Medical University pilot study on the values of traffic related effects was performed in 2003. Different environmental images (photos and sound-scapes) were presented to the children (age 11 to 14) and they were asked to rate the "value" of the environments by means of "pieces of chocolates", "pocket money", and "holidays". The responses were quite consistent and coherent and thus proved the applicability of this approach.

### Results on WTP in Children

The distribution of ratings suggest a much more systematic "dose-response-relation" for the "limited" amount of chocolates. Effects of class (age) can mainly be seen in the "free format" of pocket money and in particular for the higher levels. However, for both answer formats the trade off is quite comparable.

### Let Children Voice Ideas for Change

Encourage children to discuss their route to school and propose improvements like providing better and safer environments for walking or improving the timetables of public transport facilities. This would improve planning processes, children's self esteem and their social competence.

### Children's "Willingness to Pay (WTP)"

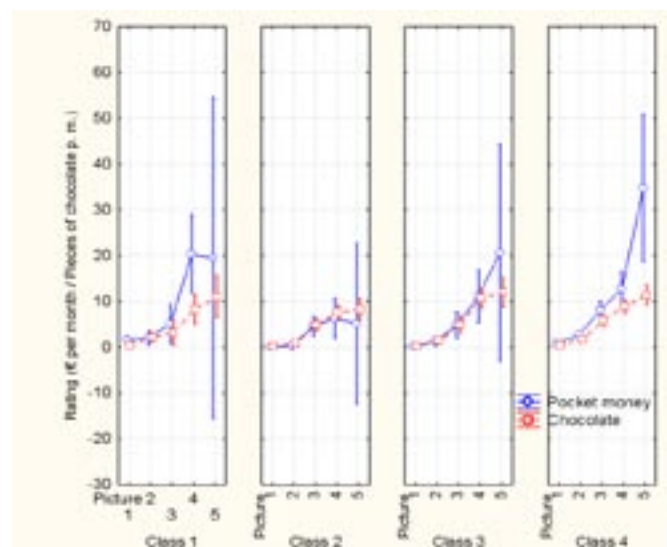
Two scenarios:

- (1) density of cars on a road
- (2) car-related background noise combined with natural sounds at varying intensities.

Three answer formats

- (1) pocket money
- (2) pieces of chocolate
- (3) holidays

Means (and 95 % confidence interval) of ratings of the amount of WTP for different levels of background noise (noise 1 = loud, noise 5 = no background noise) by listening to singing birds in the "free field" in the two answer formats by school class



Children were asked how much they would be willing to pay (in terms of chocolate or of pocket money) to achieve the different sound-scapes. The less noisy sound-scapes were generally considered worth more pieces of chocolate or more pocket money. While the absolute values are difficult to interpret and especially the money value obviously depends on age and sum of pocket money usually received from parents, the acceptability and ranking of different scenarios relative to each other does not depend on answer format or age.

# ROAD TRAFFIC INJURIES

## Road Traffic Injuries are Important in the European Region because:

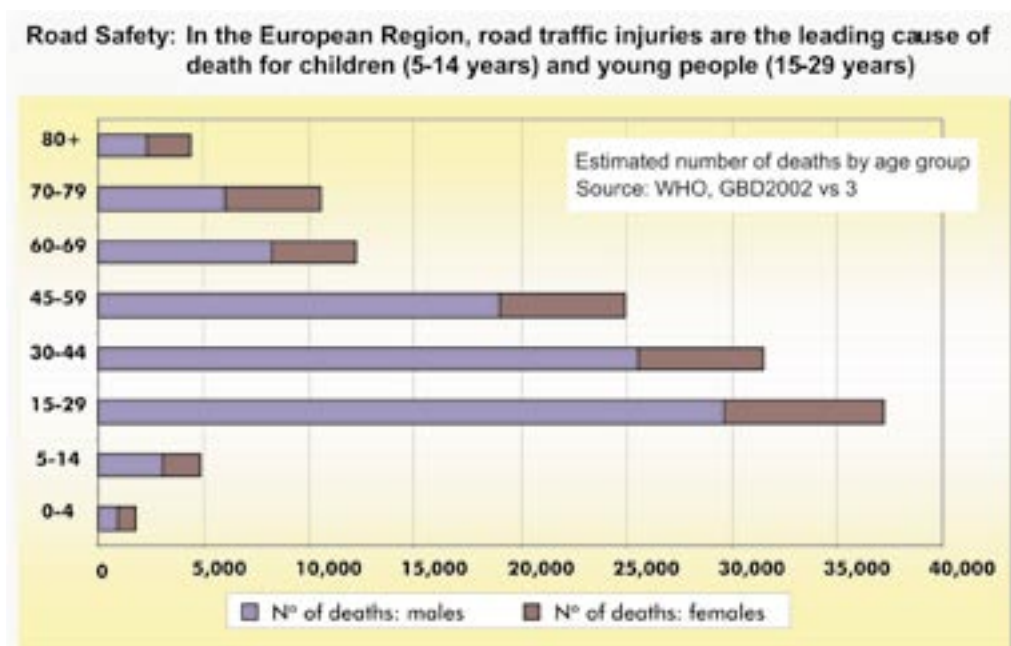
- 2.4 million people are injured per year
- 127,000 die per year
- Of these, 6,500 deaths are in children aged 0-14 years
- 37,000 deaths occur in young people aged 15-29
- Road traffic injuries are the leading cause of death for children aged 5-14 and young people aged 15-29
- They cause post traumatic stress disorder in up to 33 % of children
- They cost the EU (15 countries) about 180 billion Euros per year or 2.0 % of the GDP
- 200,000 families in the EU are affected each year by death or disability of at least one family member
- Low and middle income countries have amongst the highest casualty rates

## Road Traffic Injuries in the European Region

Ten percent of the worldwide estimated 1.2 million deaths from road traffic injuries (RTIs) in 2002 occurred in the European Region. RTIs ranked 6th in terms of disability-adjusted life-years lost and 13th for mortality. Nearly 67 % of crashes occurred in built-up areas. Cyclists and pedestrian pay a disproportionate price, representing one third of deaths from road traffic injuries. This highlights the need to implement road safety measures in urban areas, where the density and variety of road users, including vulnerable users and children, is higher.

## Impact on Children and Young Adults

Children under 15 years represent 5 % of the total deaths from RTIs and those aged 15-29 years account for 33 %. Children's ability to cope with traffic is limited until 10 years of age. They are more at risk in conditions with heavy or fast traffic, limited visibility, or where drivers' attention is focused elsewhere rather than at pedestrians or cyclists. The head to body ratio in children makes them more vulnerable to head injuries. Younger people are more likely to be engaged in risk taking behaviour, as they are easily distracted and interested in new focuses.



### Psychological Distress

Between 20-25 % of road crash victims develop an acute stress reaction or have mental problems within the first year. Long-term mental disorders consist mainly of mood disorder, phobic travel anxiety and post-traumatic stress disorder. A study reported that 33 % of children involved in road traffic crashes had post-traumatic stress disorder at 22 and 79 days post-crash. This was related more to the child's perception of the crash as life threatening rather than to the type of crash, the nature, or severity of the injury. Mostly, the psychological needs of injured children remain unrecognized, and few receive professional help.

### Inequalities by Geography

Inequality in mortality from RTIs in the Region can be recognized. There is an East-West divide with the average for the Newly Independent States 1.5 times higher than that for the EU-15 (see Figure). Similarly, rates in the Northern European countries of Scandinavia and Great Britain are lower than those for the Southern European countries of Greece, Italy and Portugal. The countries with the lowest and highest rates of injuries differ by several fold. Latvia, Lithuania, the Russian Federation and Greece (in decreasing order) report the highest mortality rates, Great Britain and the Nordic countries have the lowest rates (see Figures). There is incomplete data from some countries in South-Eastern Europe and central Asia. Increased economic prosperity, such as with the enlargement of the EU, may lead to increased inequalities in RTIs, especially if increased motor traffic volumes are not matched by implementation of appropriate traffic safety policies. The substantial differences between parts of the Region can partly be explained economically, with a higher burden in the low and middle income countries, which also have proportionately more vulnerable road users (pedestrians, cyclists and motorbikes). In addition, legislation, enforcement and institutional capacity have not kept up with the relatively recent growth in private transport in Southern and Eastern Europe, representing an obstacle to developing effective road safety strategies.

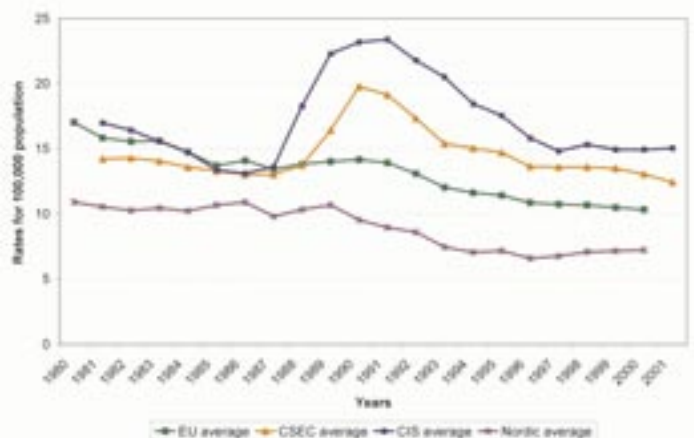
### Inequalities in Childhood Experience

- RTI rates are higher in the East and in the South of the European Region
- Children from lower social class have a higher mortality from pedestrian injuries than those from higher social class
- Children belonging to ethnic minorities have an increased risk of pedestrian injuries
- Boys are more likely to suffer RTIs than girls

### Inequalities by Gender

75 % of people involved in crashes are male. This gender imbalance is especially pronounced among people 15-29 years old where males constitute 80 % of the total. The gender difference can be explained by differences in exposure and risk-taking. Males have greater access to motor vehicles, including those with the highest fatality rates (motorbikes and mopeds). Further, they are more likely to engage in risky behaviour, such as speeding and driving under the influence of alcohol, which increases crash likelihood and severity.

Mortality from Road Traffic Injuries by European sub-regions, 1980-2001

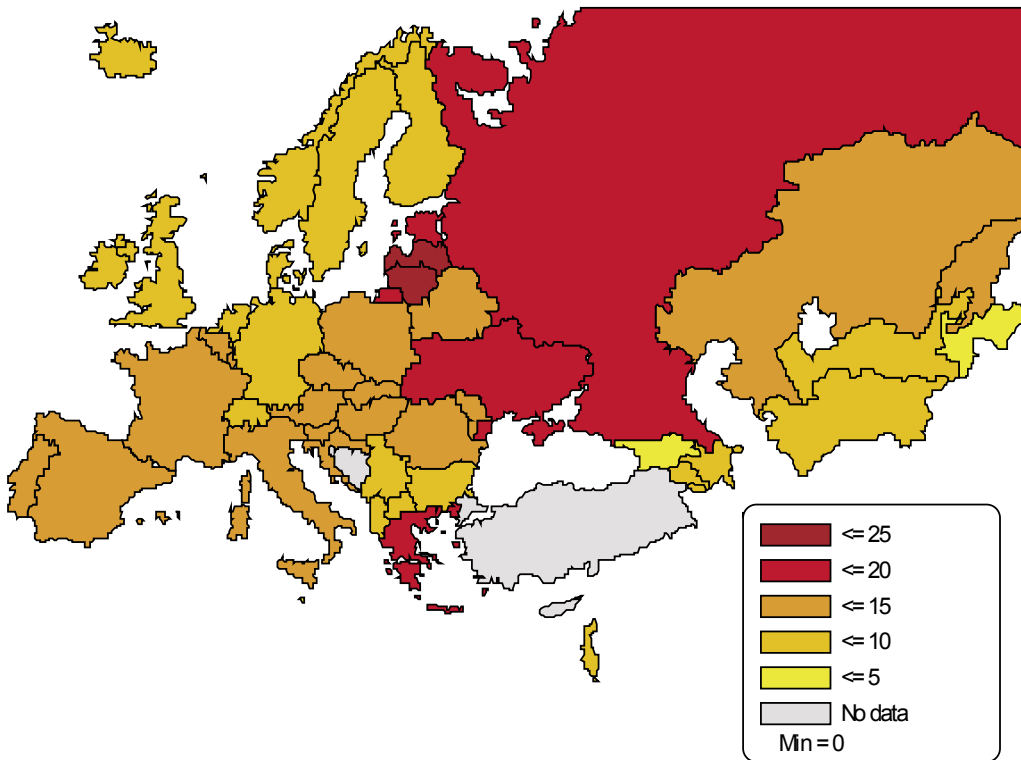


Source: Mortality indicators by cause of death, age and sex (off-line version). Supplement to the WHO European health for all database. EU average: the 15 European Union countries. CSEC average: 15 countries in Central and South-Eastern Europe, including Estonia, Latvia and Lithuania. CIS average: 12 countries of the Commonwealth of Independent States. Nordic average: Denmark, Finland, Iceland, Norway and Sweden.

# Health Impacts - Evidence and Main Facts

## Road Traffic Injuries

Standardized mortality rates from RTIs per 100,000 population in the WHO European Region, 2002 or last available year (average for the Region = 12.43)



Source: Mortality indicators by cause of death, age and sex (off-line version). Supplement to the WHO European health for all database. NOTE: The designations employed and the presentation of this material do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organisation concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

### Trends

Despite the differences between countries, mortality rates from RTIs have declined overall (see Figure). Where estimates of the volume of road traffic are available, the declining mortality in the mid-1990s in several countries in the eastern part of the Region seems to be associated with a decline in road transport activity, rather than from road safety strategies. In the western part of the Region, although RTI mortality has continued to decline, progress has slowed in the past few years, indicating the need for new transport policies and preventive strategies.

### Road Safety through Danger Reduction

Road safety is a term that is commonly used to mean the 'unsafety' of the road transport system (Silcock et al 1991). Real and perceived safety concerns are quoted as the most important barriers preventing many people from choosing walking and cycling as means of transport. Reducing road danger requires controlling this threat and reduce casualties. Health can then be promoted through increased opportunities for access to social support networks and health promoting activities, such as walking and cycling.

### Economic Costs of Road Traffic Injuries

For the EU, the cost of RTIs are estimated to be € 180 billion per year, or 2 % of GDP and twice the annual budget for all its activities. In the countries of Central and Eastern Europe, the cost of crashes is estimated at 1.5 % of GDP. The large costs are explained partly by the large proportion of young victims, which amplifies the economic loss in terms of lost productivity, and earnings, including those of carers.

There are differences between countries which are partly explained by methodological issues. The valuation of the costs of lives lost, injuries and disabilities differs between countries, with a wide range. The estimated European average of the value of a life saved is about 1 million Euros, though values used in different countries can be significantly different (e.g. in the Netherlands a figure of 4 million Euros is applied). Estimates will also be influenced by the completeness of data on deaths and injuries; data recording may differ between the police, hospitals and insurance companies.

### What the Economic Studies Imply

These studies are based on the Willingness to Pay (WTP) approach, which estimates the value that individuals attach to human life by means of surveys aimed at determining the amount of money they would be willing to pay to reduce the risk of loss of life or injury. An important aspect of these several studies, which assessed the WTP for reducing the risk of road traffic injuries, is that values are convergent from one country to another and across modes of transport. They show that the public values crash prevention; and in the rail and aviation sectors this is reflected in investment in rigorous safety standards. This is because public authorities are accountable and liable for crashes in these sectors. In contrast to this, road sector policies place the responsibility more on the individual rather than with the public authorities. The important implication of this finding is that the public may be willing to have more rigorous road safety controls by governments, like as in the rail and air sectors. They serve as a pragmatic basis for assessing the value and appeal of safety programmes.

### Policy Recommendations

Strong political commitment and leadership are required for the adoption of a comprehensive approach to road safety. The underlying social values of road safety need to be explicitly considered. Avoidable death and disability in childhood can be reduced from RTIs by implementing existing cost-effective strategies using a multi-sectoral approach. Cost-effective strategies need to be implemented by:

- Integrating injury prevention with sustainable transport policies
- Acknowledging that road safety is a shared responsibility and requires a multi-sectoral approach
- Adopting a systems approach, which addresses all main components, related to road safety, i.e. road users, vehicles and road infrastructure. Understanding that speed is the core problem.
- Ensuring that road transport systems are programmed to take human mistakes into account.
- Making road safety part of the core business of the health sector
- Improving implementation mechanisms that promote road safety.

### Recommendations for Further Research

Cost-effectiveness analyses and cost-benefit analyses are promising as tools to develop road safety policies, but the evidence base of injury and crash prevention interventions and programmes needs to be developed further. Additional research is required as follows:

- Improving the knowledge about implementation processes and the development of measures and tools in order to improve the implementation of safety strategies.
- Improving the quality and availability of injury-related indicators that provide information about the effects of RTIs.
- Improving the assessment of the severity of injuries.
- Improving the evidence base for practices in crash notification, pre-hospital care, trauma care, and rehabilitation, including that for children.
- Elucidating the effects of medicinal and recreational drugs as risk factors.
- Better understanding the roles of ageing, disease and fatigue as risk factors.
- Clarifying the cost-effectiveness of practices in health examinations for granting and renewing driving licences.
- Developing risk analysis and simulation models to allow the effects of human behaviour leading to a crash to be predicted for all possible kinds of crash situations.
- Optimizing the balance between changes in speed, acceleration and the capacity of a vehicle to absorb the energy of a crash.
- Improving knowledge of injury mechanisms and tolerance.
- Further developing models simulating the exposure and effects of crashes involving pedestrians and cyclists.
- Identifying and improving methods of assessing the effectiveness of safety approaches, e.g. by using economic instruments.
- Further developing methods for cost-benefit analysis.
- Further improving methods, tools and models for integrated impact assessment.
- Further exploring the possible role of mobile phones or smoking in cars as risk factors for crashes.



## LESSONS LEARNED

### Air Pollution

#### Lessons for HIA of traffic-related air pollution in children

Since ERF from epidemiological studies refer to increased risk per unit of air pollutant concentration, HIA studies will have to assess exposure in terms of air concentration.

In urban areas many sources of air pollutants co-exist. Different methods for exposure evaluation are available but none is able to quantify the respective contribution of different sources with certainty. Methods based on ambient air concentrations measurements include all source contributions and chemical and physical phenomena. Difficulties lie in attribution of the quantitative true contribution of traffic source but an advantage is that results are close to the true exposure. In methods based on air concentration estimations by model calculations, the attributable source concentration are more accurate but chemical and physical phenomena are difficult to include in the calculation. The difficulty in a modelling approach is to accurately predict the true air concentration exposure. Sophisticated models currently are able to calculate the chemical and physical phenomena and other sources contribution.

#### Recommended approach

- assess exposure with a classical traffic indicator for which today epidemiological ERF are established in children and in adults (such as PM or NO<sub>2</sub>)
- select health outcomes in children which provide sufficient evidence (linked or simply associated to air pollution) (see the Table below)
- select health outcomes avoiding multiple counting of the same impact
- select health outcomes allowing monetary valuation
- select health outcomes for which baseline frequency data are available
- select and use ERF derived from at least two European studies, if available, and expressed for an increase in air pollutant concentrations.

#### Exposure-Response Function for children

- ✓ neo-natal and post neonatal mortality,
- ✓ asthma attacks,
- ✓ respiratory symptoms in healthy children (including bronchitis),
- ✓ hospitalization for respiratory disease,
- ✓ hospitalization for asthma,
- ✓ emergency or medical visits for respiratory disease,
- ✓ childhood cancer,
- ✓ pre-term birth

Selection of children health outcomes from epidemiological studies to inclusion in Health Impact Assessment Study

Health outcome	Epidemiological studies*		At least 2 ERF available**	Baseline frequency	External cost valuation	Between studies results constancy	Evidence on causality	Inclusion in HIA	
	Europe	Others							
<b>Mortality</b>									
	Intra uterine	1	1	no	no	unknown	contradictory	no	no
Neo & post-neonatal (1-12m)		2	3	yes	yes	possible	constancy	weak	yes
	Infants (< 5 y)	0	2	only 1	yes	possible	erratic	weak	no
<b>Respiratory Morbidity</b>									
	Asthma attacks	10	10	yes	yes	possible	constancy	good	yes
Symptoms in healthy children including bronchitis		13	13	yes	yes	possible	constancy	good	yes
	Respiratory hospitalisation	7	3	yes	yes	possible	constancy	good	yes
	Asthma hospitalisation	6	6	yes	yes	possible	constancy	good	yes
	Emergency visit	6	6	yes	yes	possible	constancy	good	yes
<b>Non Respiratory Morbidity</b>									
	Childhood cancer***	2	-	yes	yes	possible	erratic	good	yes
	School absenteeism	1	5	only 1	no	possible	erratic	no	no
	Immune response	2	-	only 1	no	unknown	erratic	no	no
	eye irritation	2	-	yes	no	unknown	constancy	mild	no
	Growth rate	1	-	no	yes	unknown	-	no	no
<b>Adverse pregnancy outcomes</b>									
	IUGR	3	-	only 1	no	not direct	contradictory	weak	no
	LBW	3	4	only 1 PM10	?	not direct	constancy	weak	no
	Pre-term birth	2	3	yes	yes	possible	constancy	weak	yes

\* Only studies assessing exposure by increment of air concentration of the indicators (i.e.: based on model or air quality monitoring network), in other word excluding studies based on traffic volume

\*\* Only for PM

\*\*\* For childhood cancer, exposure is assessed with N<sub>2</sub>O or benzene air concentration

## Lessons on uncertainties and limitations

- Recent data on traffic related air pollution exposure have shown that PM<sub>10</sub> expressed in mass are less correlated with traffic proximity than other indicators as absorbency of the PM<sub>10</sub> or PM<sub>2.5</sub> filter (elemental carbon), benzo[a]pyrene, total PAH, benzene or total VOC, but we need to know specific ERF to use those new indicators in HIA. Currently, there is no other epidemiological study giving ERF for those new indicators.
- Results from European studies on childhood cancer due to air pollution do not reflect the full range of impacts and therefore are not sufficiently comprehensive. Benzene, an important traffic exhaust compound, is a carcinogenic agent that causes leukaemia. Two European studies and other countries data based on distance between road and residence or living near high traffic density roads show consistent results for an association between childhood leukaemia and traffic exposure. Although only one study result can be used for the ERF between leukaemia and air pollution indicator, childhood cancer has been selected.
- Numerous epidemiological studies have shown a relationship between air pollution exposure and alterations of the pulmonary function in children. Nevertheless, this outcome is excluded from economic valuations because: 1) it is currently not feasible to estimate costs of such health outcomes, and 2) an increase in respiratory symptoms or pulmonary disease can reflect lung function modifications (avoids double counting).
- Lung function reduction is correlated with reduction in life expectancy. Including this relationship would be a way for taking lung function impairment into account. This approach is still uncertain because there are two successive links to quantify: 1) ERF for PM and pulmonary function decrease (well established for children), 2) ERF for pulmonary decrease and years of life lost (not so well known). This correlation is very difficult to establish because the final outcome (death) will be generally observed in the elderly whereas the initial exposure occurred during childhood.

## Further research to improve HIA's quality of traffic-related air pollution in children

Develop metrological and epidemiological studies in Europe:

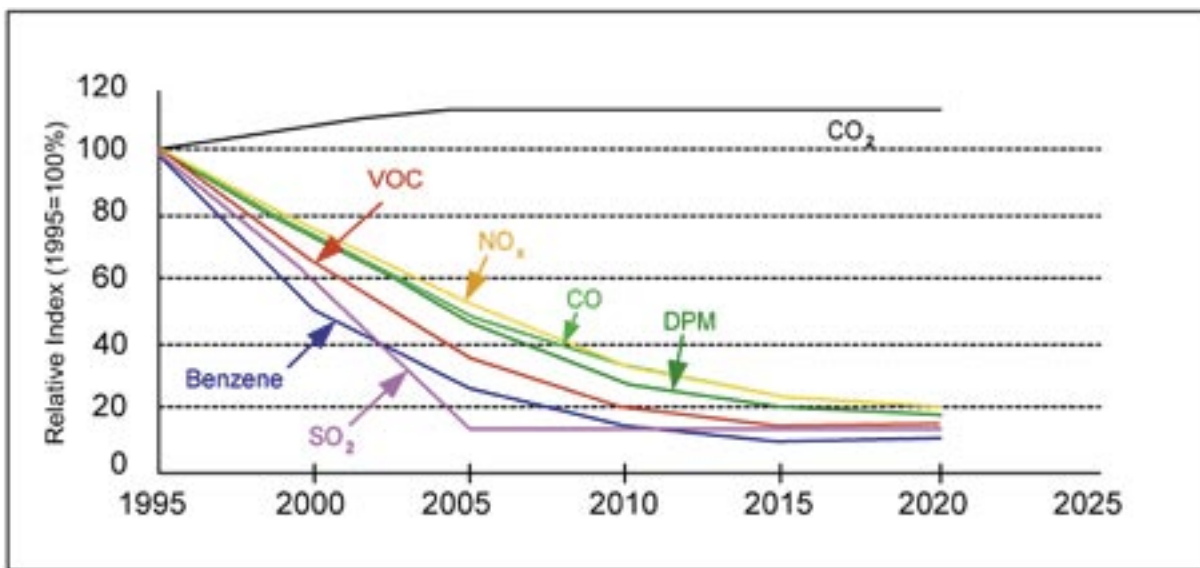
- to determine the best (accurate and reliable) indicator of traffic related air pollution (PM<sub>2.5</sub> elemental carbon, PAH and VOC) and to encourage monitoring in European cities,
- on traffic exhaust effects in children giving a RR for an increase in individual air-pollutant concentration,
- on the causality of air pollution in children mortality (< 5 years old),
- on the association between air pollution and childhood cancer, intra uterine mortality, mortality in infants and school absenteeism,
- on the relation between pulmonary function reduction in childhood and reduction in life expectancy,
- on specific baseline frequency measures of health outcomes in the target children population,
- to promote long-term studies investigating the relationship between the decrease of pulmonary function observed in children and life expectancy.
- to recommend a more extensive use of GIS for accurate evaluation of populations living near main streets, roads and freeways. The distance from the residence address to the main traffic road gives a good indication on the exposure to traffic related air pollutants. Hence, it should be kept in mind that distances have to be transformed in "predicted" concentrations using a numerical factor established on the basis of local data from the air monitoring network.

## LESSONS LEARNED

### Climate Change

#### Key issues

- CO<sub>2</sub> emissions of road traffic will further increase in the future under business as usual assumption. This is despite the voluntary commitment of the European Automotive Industry to achieve an average 140 CO<sub>2</sub> g/km for their fleet of new passenger cars sold in the EU in 2008. (see Figure)



Source: Auto-Oil II 1999, DG Transport and Energy, Brussels

#### Lessons for Health Impact Assessment

Evidence shows that transport is one of the sectors contributing significantly to greenhouse gas emissions and it is expected to grow in the future. There is a need to reduce the transport related greenhouse gas emissions now in order to ensure the future of our children's health tomorrow. The promotion of sustainable mobility, transport management and development in alternative propulsion options, as well as energy efficient technologies need to be further developed as both are of low impact to the climate system as well as to human health.

The subject 'climate change and health' poses many challenges to scientists and policy makers. There is an increased need for understanding climate change

exposures, improving scientific consensus building, monitoring observed impacts and developing responses to the climate change threat. Research needs to include developing innovative approaches to analysing weather and climate in relation to human health; setting up long-term data sets to answer key questions; and improving understanding of how to incorporate outputs from Global Climate Models into human health studies. The current events have guided development of early warning systems for predicting disease outbreaks and extreme weather events and the understanding on how recurring extreme events may weaken health care systems' adaptive capacity.

## LESSONS LEARNED

### Noise

#### Recommended Approach for HIA of Traffic Noise Exposure

- 1) Assess exposure of populations using a noise-propagation model or, if not available, a more crude model taking into account traffic and population density. Use the EC-guideline for noise calculations and metrics.
- 2) Select specific health end-points for which there is sufficient evidence.
- 3) Select ERFs based on reviewed epidemiological studies (see guidance report for evaluating epidemiological evidence; WHO, 2002).
- 4) Calculate proportion of cases in study population that can be attributed to noise, based on baseline prevalence study population.
- 5) Calculate total disease burden, if needed to compare outcomes with impacts other pollutants.

#### Lessons for HIA

- When comparing the results of HIAs from different countries one should be aware of (a) possible methodological differences in exposure assessment which may lead to differences in noise levels of 10 - 15 dB(A) and (b) differences in outcome of national surveys due to the use of different annoyance questions. The EU Directive 2002/49/EC and ISO technical specification ISO/TS 15666:2003 provide a basis for further harmonisation and improved monitoring.
- Exposure will have to be assessed in metrics, selected ERFs are based on
- Add weight factor for uncertainty when effects are included for which the evidence is limited (hypertension).
- Transferability of estimates to populations other than the study population from which the estimate has been derived. Take into account potential differences between populations/residential situations.
- Take into account prerequisites of certain curves (e.g. some may only be used for strategic, comparative assessments; not for assessment of local and changing situations)
- Lack of generalised ERFs for children (except for aircraft noise and reading, annoyance)

#### Recommended Approach (ERFs)

- Annoyance: use risk estimates from national surveys. If not available, use relations as described in the EU-guidelines (Miedema, 2001), but include correction factors for insulation, window used and for socio-economic modulation factors, if needed.
- (perceived) Sleep disturbance: use the curves proposed by Miedema (Miedema& Passchier-Vermeer, 2003).
- Cardiovascular disease-risk: use estimates for road traffic and aircraft noise from recent meta-analysis (Kempen, V. et al, 2002), include weight factor for uncertainty.
- Cognition: to assess the potential impact of aircraft noise on reading and annoyance in children the coefficients from the RANCH-study may be used (in press).

#### Lessons for Cost-benefit Analyses

Apart from annoyance, noise related health effects have rarely been given a monetary value. The EU-funded project UNITE derived monetary values based on medical costs and lost productivity. However, it has to be kept in mind that considerable uncertainty is attached to the economic estimates of myocardial infarction, hypertension and sleep disturbance, due to the uncertainties in the used ERFs and estimations of duration and severity of impacts.

#### Recommendations

- Economic values are available for health and social impact of road noise and aircraft noise which can be used for calculating external costs of noise
- The use of Cost of illness (COI) is limited since effects on cognition and well being (annoyance) are not included in this type of valuation.
- The monetary values derived for the health impacts of noise within the UNITE framework need further validation by health professionals.

## Noise abatement in the Netherlands Works but Silence is Getting Scarce

Noise levels due to motorway, rail and air traffic have not increased significantly since 1980, despite the doubling of traffic volumes.

However, more people are exposed and the availability of quiet areas is decreasing.

Erection of noise barriers (5-15 dB(A) reduction), the use of highly pervious asphalt (reduction of 2-6 dB(A)) and quieter lorries have helped to reduce average motorway noise levels in residential areas. Renewal of the aircraft fleet and optimisation of runway use and flight paths have reduced average levels of aircraft noise in residential areas, despite a quadrupling of the number of flights. The noisiest aircrafts are no longer permitted to use Amsterdam airport.

Nevertheless, a considerable number of homes in the Netherlands still experience high levels of noise and annoyance levels are not decreasing. In particular, city centre traffic noise has not been reduced at all.

At 40,000 to 60,000 dwellings in the Netherlands facade noise levels exceed 70 dB(A). Extra measures are needed to meet this limit value.

## Research Recommendations with a Special Focus on Children

- Study long-term consequences of noise exposure on cognitive development by periodically collecting nationwide data on individual performance of children for selected subjects as well as data on the actual noise levels.
- Include other stressors (air pollution) and markers of effect (annoyance, quality of life, behaviour, stress responses). Identify psychological, social and physical protective factors (e.g. restoration). Better information on the context (soundscape) in which adverse effects occur can help architects and land use planners in designing environments which better fit the needs not only of children (Lercher, 2003).
- Promote intervention studies and identification of best practices of preventing harmful effects of noise in children.
- Assess the health gain of reduction of exposures vs. effectiveness and costs of intervention measures e.g. by using the DALY method. An approach limited to Cost of Illness (COI) is not sufficient since no estimates are available for effects on cognition.
- Support further research on the effects of traffic noise on sleep and cardiovascular risk in children. Evaluate findings from ongoing field studies where the effect of combined exposure of noise and air pollution is studied.
- Support assessments of sociocultural, economical, and also political factors (Faburel, 2003) which influence annoyance and disturbance responses in order to feed the decision makers toolbox (e.g. public participation).



## LESSONS LEARNED

### Physical Activity

#### Effectiveness of Interventions Physical Activity

The importance of physical activity for health in all age groups is well documented and the great potential of transport-related physical activity in this field is widely acknowledged. However, the quantification of the effects remains a challenge.

#### Interventions in Adults

In general, most experience regarding design, feasibility and effects is available for interventions in adults on the individual and group level. There is good evidence that interventions on these levels as well as worksite interventions can increase physical activity among the inactive. So far, there are only a few studies assessing the impact of interventions targeting transport policies and environmental changes on physical activity.

#### In Children

Many interventions to increase physical activity in children have been developed, but only few of them have had their effectiveness evaluated. Currently, prompts to encourage stair use, community-wide campaigns, school-based physical education, social support in community settings, and creation of or enhanced access to places for physical activity combined with information dissemination outreach activities can be deemed effective. For a number of other interventions evidence remains insufficient to assess their effectiveness.

#### Challenges

There is a clear need to develop more interventions to increase physical activity and more specifically transport-related physical activity and to assess their effectiveness. In particular, traffic interventions should be identified that are most likely to increase health-enhancing physical activity and to reach physically inactive population groups.

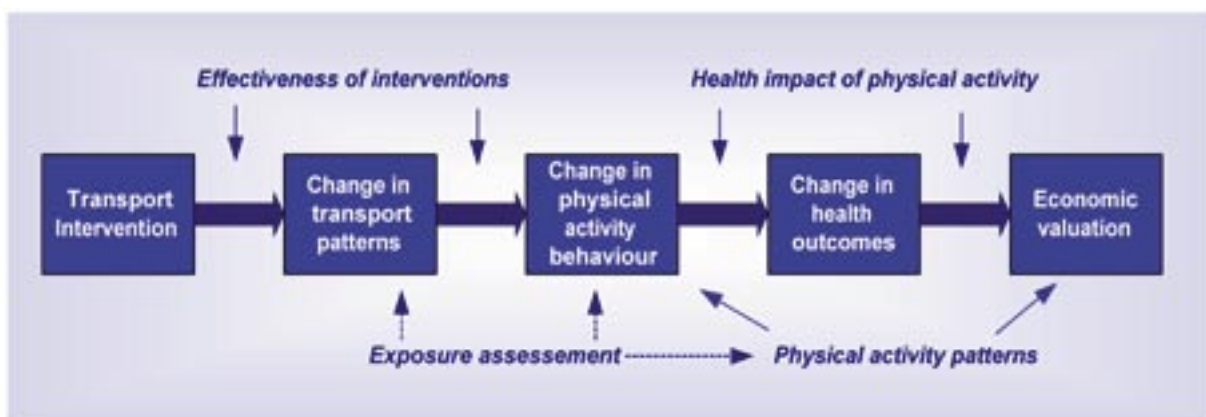
#### The Swiss Case Study

**In view of the situation described, in view of the need to identify means to promote physical activity, in particular among the sedentary population, a case study was launched in Switzerland by the University of Basle with the Federal Offices of Sports and Public Health.**

**The objective of the study was to identify transport interventions with the potential to promote Human Powered Mobility (HPM) or daily physical activity especially in formerly inactive people.**

**Though a number of projects with this potential were identified and described in the first phase of the project, in none of them data was available to quantify the effects. Data collection in a number of selected projects has begun in 2004 in order to estimate their effectiveness in the promotion of physical activity.**

Overview of the chain from transport intervention to economic valuation of the health effects of transport-related physical activity. Though quantification and statistical modelling still represent some challenges, the overall causal relationship (indicated by the bold arrows) is well accepted.



## LESSONS LEARNED

### Psychological and Social Effects

#### Outreach and Limits of Economic Valuation

Cost-benefit analysis is very popular among professionals and policy makers as it provides a financial justification of decisions regarding important investments. Nevertheless it should be noted that present estimates of the costs and benefits of transport developments are limited by the lack of adequate means of capturing important elements of physical and social well-being, which however are not easily expressed in monetary terms.

- For example, fear from traffic dangers is an important effect and a powerful modifier of travel behaviour (e.g. parents driving children to school). Also such indirect effects and their costs should be captured by economic valuations.
- Some highly important effects like influences on creativity cannot be valued.
- There are a number of physiological effects (e.g. EEG changes) that can be detected even if people do not perceive them and are not annoyed.
- Effects that are not perceived cannot be assessed in Stated Preference studies.
- Some of the effects could be valued if the exposure causes longer time periods to perform the task.

#### Performance, compensation, and effort

In evaluating environmental impairments well-being, annoyance, and medical symptoms are usually assessed. Sometimes cognitive performance and behaviour are assessed. The latter attempts ignore the possibilities and abilities of the individuals in adapting to the environment and compensating for certain restraints and stresses. Such moderating influences may completely cover all directly measurable impacts when the exposure is low or of short duration. Therefore it is suggested that the effort to compensate for a toxic or at least irritating environment should be considered in evaluating “well-being”.



#### Dualism paradigm

There is a lack of integration of natural and social science. The dualism of body and soul is deeply rooted in our current paradigm. Even when speaking about the same phenomenon the two approaches of science use different terms or the same terms might have a different meaning. Natural and social sciences do use slightly different tools (e.g. statistical methods) to handle their problems. A sort of meta-theory is needed that overcomes the dualism both in our perception of the world and in our methodology. Only this would enable us to understand all the interactions and develop a coherent theory on the impact of the entire environment (both natural and social) on our health (in its broadest meaning).

#### Improving methodology in a complex field

Psychological effects result from complex interactions of different impacts. Personal traits and the given situation at the time of impact must be considered. In many aspects traffic is just one stress factor among others. Some effects e.g. on mobility behaviour are quite specific. There is still a need for improvements of data on psychological and social parameters. This is true for the validity, specificity, and sensitivity of questionnaires and for the statistical methods dealing with results of questionnaires. The interconnection and correlation of several different effects and parameters make it nearly impossible to quantify the impact of one single parameter independently. Several impacts from the natural, technical, and social environment interact with personal coping styles, habits and beliefs in the production of psychological effects that themselves again have an impact of the individual's biophysical and social environment.

## LESSONS LEARNED

### Road Traffic Injuries

#### Lessons for Surveillance

To improve the measurement of the magnitude of the problem and to monitor the effect of different transport and preventive policies, there is a need for:

- More complete and accurate data on death, especially in the eastern and southern parts of the Region
- Better health service data on the causes and health consequences of RTIs, especially on non-fatal outcomes, which are largely under-reported
- Community surveys in areas of poor data to inform policy makers on the size of the burden and prompt corrective actions
- Developing and monitoring indicators that measure exposure to risk and assess the safety performance of preventive measures (e.g. speed controls, alcoholic limits, seat belts, child car safety seat and helmet use).

#### Lessons for Effective Implementation of Preventive Strategies

The following steps have been identified for effective implementation:

- obtaining political commitment;
- ensuring that there is a road safety leadership role (a road safety champion);
- making stakeholders responsible for implementation of policy items accountable;
- organizing coordination between the key stakeholders;
- establishing a well-founded relationship between objectives and targets, plans, organization and financing;
- making the best possible knowledge and information available through an information system;
- monitoring and evaluating systematically the implementation of plans and programmes;
- making trained road safety professionals available;
- including the following target groups in the preparation and implementation of policy: politicians, administrators, policy-makers, road safety practitioners and the population and road users; and
- raising awareness of the problem and any preventive programmes

#### Lessons for HIA

- Road safety should be integrated into sustainable transport policies and become an integral part of impact assessments (e.g. Environmental Impact Assessment, Strategic Environmental Assessments, HIA). Area-wide safety impact assessments should be included as a component of impact assessments of transport and land use programs and strategies.
- Quantitative targets for health outcomes and exposure to risk should be used to evaluate road safety initiatives and transport and land use policies.
- Assessments need to include an analysis of the effects on the most vulnerable population groups (children, pedestrians, cyclists, motorbike riders and elderly people).
- Road safety, including danger reduction, should become a governing parameter of road transport, and not a tradable variable. To do so there is a need for an explicit statement that society will no longer tolerate levels of danger posed by motor traffic nor deaths and serious injuries as an unavoidable consequence of road transport activities.
- When comparing safety performance across different countries and even within different parts of the same country, attention should be paid to standardisation of definitions, data collection procedures, data quality and completeness.
- Methodologies need to be developed that can better measure the combined safety impact of “packages” of different measures, such as a combination of traffic calming, regulation enforcement, improvement of public transport and infrastructures for cyclists and pedestrians, demand management.



## LESSONS LEARNED

### Economic Valuations

#### Considerations regarding methodological challenges, interpretation and use of results

##### Different studies give different results

Different economic studies produce different results. Lack of transparency in making explicit their underlying assumptions, boundaries of validity, objectives and methodological approaches may have a negative impact on the credibility of the use of economic valuation of health effects and gives rise to a number of questions, e.g.:

- Why are the results so different?
- Are the differences justified and can we accept them?
- Is there a need for (and the possibility of) harmonization?

While it is acceptable that results differ, the reasons for the differences should be made explicit. Such differences may well be justified as different methods, approaches and variables are to be used to answer very different questions. What is necessary is that the methods and assumptions are made transparent in order to judge whether the studies can answer the questions they are meant to address.

An aspect deserving attention comes from the possibility that, regardless of the original purpose of the study, its results may be used (or miss-used) for purposes different to those originally envisaged. Therefore, it becomes necessary that clear statements are made about the range of applicability, boundaries of validity and limitations of the study results.

#### Main variables that intervene in explaining the possible reasons for differences in outcome of economic valuations

- Emission inventories can cover emission sources to a different extent.
- Air pollution concentrations or noise levels may be measured or calculated/modelled.
- Different studies may use different pollutants as indicators.
- Exposure calculations may be done in different ways.
- Different ERFs may be used.
- Different health effects may be included.
- Different population groups (children, elderly) may be vulnerable to different health risks.
- When valuing mortality, different measures may be used.
- Different types of costs may be taken into account.
- WTP may be different across countries, cultures, ages, socioeconomic groups etc.
- Depending on the aim of the study, the total costs (TC), the average costs (AC) or the marginal costs (MC) may be calculated.
- Different methods for estimating WTP may be used, revealed preferences or stated preferences.
- Different ways to assess and explain individual perceptions of environmental impacts, perceptions on which individual WTP are generally based on.

## Lessons on Key Issues

### Importance of transparency by using Value of statistical life (VOSL):

Reasons for having different VOSL may exist, but it is important to explain why using a different value. Using different VOSL between countries in the same study may cause inconsistency, as well as distort the competition between countries (g.g. by internalising the external costs in road tolls).

### Different countries value morbidity differently:

The fact that different countries have different WTP does not mean that they value people less. It can be explained by different hospital costs in different countries and that people in different countries have different preferences.

### Need for achieving consensus and providing guidance:

Harmonization on methods and input data to be used for different purposes (e.g. across different health effects, and for different groups of the population).

### Take into account all health impacts.

Also those effects for which currently no cost estimates are available.

### Approaches to Evaluate and Monetize Health Effects for Mortality and Morbidity

Willingness to Pay (WTP): Measures WTP of the population for a reduction of risk e.g. for the exposure to air pollution. Currently methods are aimed at adults only. The effects on children should be valued at least at the same WTP as adults until there are children specific values available. The focus should be on mortality.

The Willingness to Accept (WTA): Measures the WTA of compensation for increased risk.

WTP and WTA satisfy the condition of economic welfare theory by evaluating people's preferences.

Cost of Illness (COI): Takes material costs of mortality and morbidity into account. It is based on the determination of the damage for the entire society without regarding the individual difference in valuing risks of mortality or morbidity.

### There are different concepts to evaluate mortality or the risk of mortality.

Value of statistical life (VOSL): This is the conventional approach. When discussing VOSL it is also important to consider in which context it is going to be used in. The question of age also arises. The latter is mainly an ethical question, and different studies have dealt with this issue differently. Instead of looking at the probability of death one can look at the years of life lost to value the mortality risk due to acute effects. A value of a life year lost (VLYL) can be derived from VOSL.

For chronic effects the calculation is more complicated because after exposure impacts can occur with a latency that is variable.

Years of life lost (YOLL): E.g. for estimation the chronic effects.

Quality-adjusted life years (QALY): Converts all health impacts (both mortality and morbidity) into changes in quality adjusted life years.

Disability-adjusted life years (DALY): Measures the loss compared to a hypothetical life profile, whilst QALY measures the actual health quality integrated over time.

Quantification and monetary valuation of psychological and social effects, as well as benefits of physical activity requires substantial work to be done for reaching the same level of acceptability as air pollution and noise external cost estimates. The same holds with respect to cost estimates for the specific situation of children.

Focusing on only one environmental target at a time can underestimate the benefits of a measure, as it does not consider other “collateral benefits”. For example, if a calculation of the benefits of a CO<sub>2</sub> reduction policy only focuses on the benefits due to reduced CO<sub>2</sub> emissions it can underestimate the benefits, as it does not consider reduction in air pollution, noise, congestion and possible improvements in safety, cycling and walking.

For air pollution a few health end-points have been identified, for which ERFs could be derived from ongoing international review meta-analysis.

Little is known about health effects of noise in children, and no economic valuations exist to date.

## Recommendations

As we cannot measure the WTP for children the effects of the children should be valued at least at the same WTP as adults until there are specific values available. The focus should be on mortality.

The consideration of the specific exposure and health impacts for children is desirable.

There is a need for interdisciplinary collaboration of epidemiologists and health experts with economists to clarify on which of the identified outcomes could be valued in economic terms.

## The applicability of methods and use of their results should be specified as a function of:

- special interest in different specified effects and impacts
- different temporal or special scales
- local, national or international policy settings
- special interest in effects for specified groups (e.g. children and older people)
- total costs or cost changes due to policy changes
- limitations regarding the availability of the necessary input data (e.g. availability of the appropriate measures, indicators and statistics)
- type of analysis being performed (e.g. Cost-Benefit vs. Cost-Effectiveness Analysis)

## GOOD PRACTICES - ILLUSTRATIVE EXAMPLES

### Severe health impacts due to road traffic related air pollution – key evidence: Tri-lateral study on “Health Costs due to Road Traffic-related Air Pollution”

With this project Austria, France and Switzerland contributed to the 3rd WHO Ministerial Conference on Environment and Health, London 1999. The main tasks of the tri-lateral impact assessment project “Health Costs due to Road Traffic-related Air Pollution” was to evaluate the exposure due to (road traffic related) air pollution. For this, an evaluation of the exposure - response relationship between air pollution and health impacts has been provided as well as an economic valuation of the road traffic-related health impacts. The main results in brief are stated below (for more details please refer also to [www.euro.who.int/transport/HIA](http://www.euro.who.int/transport/HIA))

- More than 50 % of the total mortality due to ambient air pollution is related to road traffic related air pollution.

Air Pollution Attributable Health Outcomes in Austria, France and Switzerland (1996)		
Total Mortality (adults >=30 y)	Annual Attributable Cases	Annual Costs
Total Air Pollution	40,000	49,700 million EUR
Road Traffic-related Air Pollution	22,000	26,000 million EUR

### Integrative strategy helps - key evidence:

#### Baden (bei Wien), Austria

- Baden (population 25,000) is a health and tourist resort with traffic problems that derive from its role as a district capital.
- The Austrian Road Safety Board prepared an integrated transport and safety plan in 1988.
- The project involved a comprehensive list of measures: constructing an underpass, enlarging an existing pedestrian area, improving the network of cycling facilities, constructing roundabouts, implementing 30 km/h zones, setting up city bus lanes, applying area-wide traffic calming, implementing parking management and car parks, strictly enforcing traffic rules, and treating crash black spots.
- This resulted in a fall in road traffic injuries by 60 % from 1986 to 1999 as assessed by the Developing Urban Management and Safety project.

## Slowing down helps - key evidence:

### The Overschie Case, The Netherlands

At some hot spots, where all (technical) measures have already been taken, a reduction of speed to e.g. 80 km/h supports several aims from an integrative point of view:

- Reduction of noise levels by 2-3 dB(A)
- About 10 km/h speed reduction leads to approximately
- 1 dB(A) noise level reduction
- Reduction of NO<sub>2</sub>-levels by 10 % [RIVM, 2003]
- Reduction of severe car accidents (fatalities)

## Investment in walking- and cycle track networks improve welfare - key evidence:

### Case Study in three Norwegian cities, Norway

Based on a request from the Norwegian Parliament in 2001 to "prepare a National Cycling Strategy where the main goal is to make it safer and more attractive to choose bicycle as means of transport" a cost-benefit analysis on walking- and cycle track networks was carried out. As a key result the need for a "complete" cost-benefit analysis was stated.

- Barrier costs caused by road traffic have to be taken into account as benefit losses, too. E.g. road traffic also obstructs people from choosing to cycle or to walk. This fact has to be recognized as non-realized benefits to the society.
- Benefits of cycle networks are estimated to at least 4-5 times the costs. Such investments are thus more profitable to society than other transport investments.

## Mobility Management for school is making its way – key evidence:

### Modal Projects: School mobility management plans in Austria

Throughout Europe the trend continues: ever more schools, cities and communities take a joint approach to tackling traffic problems on the premises by developing school mobility management plans, i.e. a joint implementation of measures to avoid car traffic on the way to school and in the school surroundings. After a pioneer project in Graz a nationwide spread of this successful form is being implemented. Key results are:

- Reduction of car-traffic on the way to school of 12 %
- Profiting of new forms of co-operation among schools, civic administrations and external counselling agencies
- Higher identification and self-responsibility of teachers, parents and students due to the long term process of three years
- Continuity of the process because of external consultants
- More success of the measures through key messages like "Winning instead of losing" and "fun"

Three Austrian Federal Ministries (BMLFUW, BMVIT, BMBWK), the Fund for Healthy Austria and the Traffic Safety Fund have now launched a Austrian Wide School Mobility Management Initiative as contribution to the CEHAPE.

# KEY MESSAGES AND POLICY DIRECTIONS

These “Key Messages” present a synthesis of the main results of this project, integrating the findings in terms of the evidence of transport-related health effects on children with the outcomes of the Workshop on “Synthesis and policy recommendations” which took place in Malta on 19-20 February and the results of an expert-based assessment of a comprehensive list of policies addressing different aspects of transport-related effects on environment and health. This assessment resulted in the identification of several policies meeting the criteria of addressing simultaneously different transport-related effects, reflecting an integrated approach and providing opportunities for synergies and efficiencies.

## **Children are vulnerable and their needs should be taken first.**

- Children are vulnerable from a physiological, psychological and economic point of view.
- Experience of a “healthy” environment as a child will influence future choices towards a healthy environment as an adult.
- Investments to improve health and environmental conditions for children benefit the entire society and avoid future costs.
- The UN Convention on the Rights of the Child (1989) specifically addresses children’s rights to express views freely and be given due weight in accordance with age and maturity (Article 12).

## **There is an increasing dependence on private car use leading to severe restrictions for children’s choice of mobility and physical activity.**

- This is the result of the large investments in road infrastructure, the significant growth in road traffic and the rising car ownership and use among families.
- Urban sprawl is inter-related with car-dependent mobility and impediments to short distance trips on foot or bicycle.
- Children are the main losers of car dominated patterns of mobility as they have less opportunities for physical exercise and choice in modes of mobility.
- Consumers’ behaviour (bigger faster/more cars) offsets progress in cleaner technologies.
- Lack of investment and modernization of infrastructure and rolling stock has resulted in a stagnation or even a sharp decline of public transport and rail, particularly in the countries of Eastern Europe, the Caucasus, Central Asia (EECCA).

## **Present transport patterns and future trends pose a significant threat to children’s health and development.**

- Children’s health is at risk due to traffic related accidents, air pollution, greenhouse gas emissions, noise, and restricted opportunities for safe walking, cycling and other outdoor activities.
- Present transport patterns are major contributors to ill health in children, for example through road traffic injuries and respiratory illness, and have contributed to the epidemic of childhood obesity and adult illnesses such as heart disease and osteoporosis.

## **Healthy mobility makes a difference.**

- A minimum of 30 minutes a day of moderately intense physical activity significantly reduces the risks of important diseases such as cardiovascular disease, hypertension, Type II diabetes and some forms of cancer and enhances psychological wellbeing.
- Moderate physical activity will bring the biggest benefits to the sedentary.
- Safety concerns need to be addressed, by providing appropriate infrastructures in order to make walking and cycling realistic options (rather than being an excuse for a lack of action).
- Substituting car trips by journeys undertaken on foot, by bicycle and other forms of human powered mobility as well as public transport will also contribute to reducing congestion, exhaust emissions and noise.

**Prioritising health and environment considerations as part of transport decision making, (particularly those addressing children's needs), would increase the efficiency and sustainability of transport systems. Policy makers should focus on implementing measures, which are highly beneficial to children, as they would also bring benefit to everyone.**

## **Integrated policies for making transport children friendlier:**

- Integrate a „children friendly mobility“ vision into transport and transport related policies as well as infrastructure and human settlement planning. This could be facilitated by developing environment and health targets specific to children i.e. reductions in road traffic injuries, increase in physical activity.
- Implement sustainable mobility management plans in schools including kindergarten and pre-schools. These plans should be developed and implemented in cooperation with pupils, teachers, parents organisations, local authorities and transport operators, with a view to promoting walking, cycling and public transport and less car use on the way to and from school.
- Give priority to speed reduction and control, for example by establishing 30 km/h as maximum speed limit in urban residential areas, implementing traffic calming, reducing car traffic and restricting access for motorised vehicles particularly around schools, playgrounds and kindergarten.
- Develop policies facilitating the reduction of car dependence and promote car-free settlements, housing and shopping, leisure activities and tourism.

## **Tools to support the integration of health concerns and children's needs into transport policies and decision-making**

- Make use of tools for decision making such as Environmental Impact Assessments (EIA), Health Impact Assessment (HIA) and Strategic Environmental Assessments (SEA) in bringing health and environmental considerations at the core of decisions related to transport and land use planning.

- Children Impact Assessment (CIA) should be one of the tools used to measure effects of planned interventions at national/regional/local levels in order to identify areas of high concern for children. This approach can be used to assess health impacts, costs and benefits, and support the identification of recommended policy actions and implementation tools.
- Undertake and use economic studies and valuation methods for valuing and prioritising road safety and health benefits of walking and cycling in the development of transport policies.

## **Awareness raising, education and communication strategies:**

- Launch national awareness-raising programmes on child friendly mobility, highlighting in particular the benefits of human powered mobility.
- Use communication strategies, which are action-oriented and tailored for different target groups.
- Promote more ecological and safer driving behaviour, such as “eco-driving”, by implementing eco-driving measures including training of the drivers in safe and children-friendly driving styles.

## **Infrastructural measures and planning**

- Extend and improve safe and attractive infrastructure for bicycles and pedestrians.
- Improve and extend public transport infrastructure and services, increase service quality and the use of fleets with child friendly low floor vehicles, and prioritize public transport in road traffic schemes.
- Reform design-standards and planning guidelines for infrastructure, transport codes, and zoning regulations according to children's needs.
- Implement noise abatement plans and measures, tighter noise requirements for sensitive areas such as schools and residential areas to minimize harmful educational and psychological effects.

## **Technical measures and standards**

- Substantially reduce particle emissions by advocating the installation of particle filters or other appropriate technologies in cars and further tighten the particle emission standards for motorized vehicles in particular passenger cars.
- Implement safety measures, which are known to save children's lives such as child car safety seats, seat belt use, improving visibility, helmet use.

## Research programmes should focus more on children specific concerns.

- Give more priority and support to assessments and monitoring of the transport related environment and health threats posed on children including epidemiological research on air pollution and noise, research on cumulative effects and inter-linkages with psychological and social issues as well as the positive impacts of mobility patterns relying on physical exercise.

## Children's health can also be promoted by general policy using economic instruments and normative interventions.

- Implement mobility management in communities including parking fee schemes, car traffic restrictions and prioritization of walking, cycling and public transport.
- Enforce speed limits and speed control.
- Enforce maximum permissible alcohol blood level for drivers of less than 0.05 g/dl.
- Reduce traffic emissions by restricting traffic and improving vehicle technologies to meet the requirements set by the EU National Emission Ceilings of air pollutants.
- Further tighten emission standards (air pollutants as well as noise) for all motorized vehicles and improve safety for both their occupants and other road users (e.g. pedestrians, cyclists).
- Enforce periodic maintenance checks and improve emission remote control systems.

- Use CO<sub>2</sub> / energy taxes and incentives for introducing energy-saving technologies.
- Establish fiscal incentives for public transport and cycling.
- Consider pricing of road infrastructure - road pricing, parking fees, charging of car purchase and ownership.
- Provide incentives for zero or ultra-low emission vehicles (noise, pollution).

## Individual costs of mobility do not reflect the full costs to society. In particular children's specific costs and needs for mobility are not yet accounted for: it is necessary to improve economic assessments and internalisation of costs and benefits, correct pricing-signals and include children specific costs in economic valuations.

- Promote and improve economic valuation of the transport related health impacts on children, including negative health effects of transport such as exhaust emissions and noise, as well as the positive health effects of walking and cycling.
- Integrate transport related health impacts on children and their costs and benefits into policy instruments e.g. when conducting cost-benefit-analysis of infrastructure and when considering internalisation of the external costs of transport.



**There is a need to redesign human settlements and infrastructure to provide more space for physical, mental and social development of children. Integration of children's needs in planning and decision-making would help overcoming segregation effects and social deficits.**

- Consider needs of children in the decision making process of transport, human settlements, land use and infrastructure planning, etc.
- Make children's needs and aspirations an important reference point in the creative planning process of human settlements and mobility management and follow a participative approach by involving children.
- Bring all relevant partners together for implementation; build new partnerships with children's interest groups.

**Incorporating children's needs requires a shared responsibility of families, the educational, health, environment, transport and urban planning sectors as well as of the private sector, industry and civil society.**

- Enforce better integration of children's needs and the related specific requirements into relevant policies at all political levels (international, national, local).
- Intensify pan-European co-operations and use the implementation of international agreements such as the WHO-CEHAPE, WHO/UNECE THE PEP, the EU-Environment & Health Strategy as driving forces for child friendly adaptation of existing policies and the formulation of new policies and actions.
- Strengthen the role of the health as well as of the education sector e.g. extending the concept of "healthy schools" by encompassing the journey to school.
- Promote the notion of liability for children's health and the environment in industry (vehicle manufacturers, public transport companies) and amongst transport providers and infrastructure planners.

**There is a world to win: Start to act now!!**

- Collect and disseminate examples of best practices and assessments, establish new partnerships and co-operation among sectors.
- Develop and implement children friendly mobility plans and monitor their achievements.
- Design a "package" of integrative measures with a timeframe for implementation. These could start with pilot projects.
- Assess the transferability of different strategies across different cultural, political, economic and social settings.
- Start assessments of transport related health effects which include their costs and benefits with a particular focus on children.



# ABBREVIATIONS

AC	Average costs	NCNPA	The National Council on Nutrition and Physical Activity, Oslo, Norway
ASEK	An abbreviation (in Swedish) for working group for cost benefit calculations	NGOs	Non-Governmental Organisations
BaP	Benzo-(a)-Pyrene	NIS	The Newly Independent States
BHR	Bronchial hyper-responsiveness	NM	Non methane
BS	Black smoke	VOC	Volatile organic compounds
BT	Benefit transfer	NO <sub>2</sub>	Nitrogen dioxide
CA	Conjoint analysis	NOx	Oxides of nitrogen
CBA	Cost benefit analysis	NSDI	Noise Sensitivity Depreciation Index
CE	Choice experiments	OECD	Organization for Economic Co-operation and Development
CEE	Central and Eastern Europe	O <sub>3</sub>	Ozone
CEHAPE	Children's environment and health action plan for Europe, WHO Regional Office for Europe	PAH	Polycyclic aromatic hydrocarbons
CIS	Commonwealth of Independent States (12 countries)	PM2.5	Particle matter with a diameter of 2.5 µm or less
CO	Carbon monoxide	PM10	Particle matter with a diameter of 10 µm or less
CO <sub>2</sub>	Carbon dioxide	QALY	Quality-adjusted life years
COI	Cost of illness	RANCH	Road traffic Aircraft Noise exposure and Children's cognition and Health
COPERT III	Computer Programme to Calculate Emissions from Road Transport	RECORDIT	Real cost reduction of door-to-door intermodal transport
CSERGE	Centre for Social and Economic Research on Global Environment, University Collage London and East Anglia	RP	Revealed preferences
CSEE	Central and South-Eastern Europe (15 countries)	RR	Relative risk
CV	Contingent Valuation	RTI	Road traffic injuries
DALY	Disability-adjusted life years	SEA	Strategic Environmental Assessment
DFA	Damage function approach	SIKA	Swedish Institute for Transport and Communications Analysis
DPSEEA	Driving forces, Pressures, State, Exposures, health Effects and Actions	SNRA	Swedish National Road Administration
EC	European Commission	SO <sub>2</sub>	Sulphur dioxide
EEA	European Environment Agency	SP	Stated preferences
EECCA	Eastern Europe, Caucasus, Central Asia	TC	Total cost
EIA	Environmental Impact Assessment	THE PEP	Transport, Health and the Environment Pan- European Programme
ERF	Exposure-response function	TSP	Total suspended particulate
EU	European Union (15 countries, pre May 2004)	UNECE	United Nations Economic Commission for Europe
FHI	Swedish National Institute of Public Health	UNITE	Unification of accounts and marginal costs of transport efficiency
GDP	Gross domestic product	VLYL	Value of life year lost
GIS	Geographical Information System	VOCs	Volatile organic compounds
GHG	Greenhouse gases	VOSL	Value of statistical life
HA	Highly annoyed	VPF	Value of prevented fatality
HDV	Heavy duty vehicle	VTI	Swedish National Road and Transport Research Institute
HIA	Health impact assessment	WHO	World Health Organisation
HP	Hedonic pricing	WTA	Willingness to accept
IER	Institute of Energy Economics and the Rational Use of Energy, University of Stuttgart, Germany	WTP	Willingness to pay
IFI	International Financial Institutions	YLD	Years lived with disability
IPA	Impact pathway approach	YOLL	Years of life lost
LB and Lden	Noise pressure during day, evening, night		
MC	Marginal costs		

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# LINKS FOR FURTHER INFORMATION

Children' Environment and Health Action Plan for Europe

[www.euro.who.int/budapest2004](http://www.euro.who.int/budapest2004)

THE PEP - Transport Health and Environment Trans-European Programme

<http://unece.unog.ch/the-pep/en/welcome.htm>

“Transport-related Health Effects with a Particular Focus on Children” (Transnational study and workshop series by Austria, France, Malta, the Netherlands, Sweden and Switzerland, 2004)

[www.herry.at/the-pep](http://www.herry.at/the-pep)

“Health Costs due to Road Traffic-related Air Pollution” (Tri-lateral study by Austria, France and Switzerland, 1999)

[www.euro.who.int/transport/HIA/20021107\\_3](http://www.euro.who.int/transport/HIA/20021107_3)

World Health Organization

[www.euro.who.int/transport/HIA/20021009\\_2](http://www.euro.who.int/transport/HIA/20021009_2)

UNECE

[www.unece.org/env/welcome.html](http://www.unece.org/env/welcome.html)

ADEME - Agency for Environment and Energy Management, France

[www.ademe.fr](http://www.ademe.fr)

AFSSE – Agence Française de Sécurité Sanitaire et Environnementale, France

[www.afsse.fr](http://www.afsse.fr)

BMLFUW - Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management

[www.lebensministerium.at](http://www.lebensministerium.at)

BMVIT - Austrian Federal Ministry of Transport, Innovation and Technology

[www.bmvit.gv.at](http://www.bmvit.gv.at)

BMGF - Austrian Federal Ministry of Health and Women

[www.bmgf.gv.at](http://www.bmgf.gv.at)

EEA – European Environment Agency

[www.eea.eu.int/](http://www.eea.eu.int/)

Federal Office of Public Health, Switzerland

[www.bag.admin.ch](http://www.bag.admin.ch)

FOSPO - Federal Office of Sports, Switzerland

[www.baspo.admin.ch](http://www.baspo.admin.ch)

InVS – Institut de Veille Sanitaire, France

[www.invs.sante.fr](http://www.invs.sante.fr)

Medical University Vienna, Environmental Health Institute, Austria

[www.univie.ac.at/umwelthygiene/](http://www.univie.ac.at/umwelthygiene/)

Ministry of Health, Elderly & Community Care, Malta

[www.health.gov.mt](http://www.health.gov.mt)

Ministry of Housing, Spatial Planning and the Environment of the Netherlands (VROM)

[www.vrom.nl](http://www.vrom.nl)

Ministry of Transport, Public Works and Water Management of the Netherlands (VenW)

[www.minvenw.nl](http://www.minvenw.nl)

OECD – EST Environmentally Sustainable Transport

[http://www.oecd.org/department/0,2688,en\\_2649\\_34363\\_1\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/department/0,2688,en_2649_34363_1_1_1_1_1,00.html)

RIVM - National Institute of Public Health and Environment, the Netherlands

[www.rivm.nl](http://www.rivm.nl)

Schoolway.net

[www.schoolway.net](http://www.schoolway.net)

Swedish Institute for Transport and Communications Analysis (SIKA)

[www.sika-institute.se](http://www.sika-institute.se)

Vincent Nedellec Consultants, France

[www.vnc-sante.fr](http://www.vnc-sante.fr)



