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CHILDREN'S ENVIRONMENTAL HEALTH INDICATORS: A SURVEY

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FOREWORD

In the context of the work undertaken on the economic valuation of children's environmental health, an overview of the current programmes designed to elaborate children's environmental health indicators has been done. The report was written by Pascale Scapecchi under the supervision of the OECD Working Party on National Environmental Policy (WPNEP). It benefited from comments from Nick Johnstone and Myriam Linster (OECD Secretariat), Fiona Gore and Eva Rehfuess (WHO) as well as delegates from WPNEP and from the Working Group on Environmental Information and Outlooks (WGEIO). This report is published under the responsibility of the Secretary-General of the OECD.

CHILDREN'S ENVIRONMENTAL HEALTH INDICATORS: A SURVEY

EXECUTIVE SUMMARY

There is an increasing need and demand for environmental health indicators to support and monitor policy on environment and health.

Environmental health indicators can provide clear and concise information on the state of the environment and its potential effects on human health. They represent a useful tool to support policy, particularly environmental policies whose effects may only be detectable many years after their implementation due to their long time horizon.
Environmental health indicators can be of particular relevance to highlight the greater vulnerability of certain populations, such as children or the elderly, and to account for it in public policies related to health and the environment. In particular for children, an intervention in the early stages of life can have lifelong benefits for society as a whole. As such, the development of children's environmental health indicators appears to be essential.

The OECD has a long experience in developing, measuring and using environmental indicators to support public policies.

Given the increasing interest in the effects of the environment on children's health, an overview of existing projects and programmes elaborating children's environmental health indicators would allow for the examination of their consistency with OECD guidelines on the development and measurement of indicators, in order to determine their usefulness for OECD Member countries.

So far, only a few sets of children's environmental health indicators are available. This can be mainly explained by the lack of suitable data. Moreover, the lack of consensus about some key characteristics of indicator sets does not allow for comparability. Reliable environmental health indicators depend upon the existence of well established and definable relationships between environmental conditions and associated health outcomes. These relationships are particularly difficult to establish in the case of children, which does not facilitate the development of indicators.

The level of comparability and transferability of children's environmental health indicators is also currently limited, because of disparities in definitions, methodologies and standards in each country. Despite efforts to achieve a certain level of harmonisation, important gaps still remain with respect to methodological approaches. Further action is therefore needed in order to improve the comparability between these indicators over time and to identify the need for further research and co-operation on data collection and analysis.

Designing children's environmental health indicators is conceptually difficult.

When the "cause-effect" relationships are difficult to establish, as is the case for children, it is recommended to use a framework that allows for "many-to-many" relationships (*i.e.* an environmental pollutant may have several health impacts and a health impact may be generated or aggravated by several environmental pollutants). In addition, the framework should be as flexible as possible in order to reflect the needs and interests of all stakeholders. The Multiple Exposures-Multiple Effects (MEME) model, developed by the World Health Organisation, has all these characteristics and thus appears to be the most appropriate, relevant and flexible model in the context of children's environmental health.

Specific criteria have to be used to select priority issues of environmental health. The criteria recommended by the OECD for the development of environmental indicators (*e.g.* policy relevance, usefulness, analytical soundness and measurability), seem also relevant for developing children's environmental health indicators. Given empirical evidence of heterogeneity among children populations, children's environmental health indicators should be defined over five broad stages: 0-1 year, 1-5 years, 5-10 years, 10-15 years, and 15-18 years.

According to the MEME framework, children's environmental health indicators should be divided into four categories: context, exposures, health outcomes, and actions. A list of priority areas should be established. The focus should be placed on priority concerns for children's environmental health rather than on actual indicators. For more efficient policy advice, strong links with concerned public health systems should be established.
As children's environmental health indicators constitute an essential tool to carry out comparative analyses and draw lessons from international comparisons, further developmental work is required. .

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CHILDREN'S ENVIRONMENTAL HEALTH INDICATORS: A SURVEY

There is an increasing need and demand for environmental health indicators, from agencies to practitioners to help support and monitor policy on environment and health. Environmental effects occur on a long time horizon, on long latency times. As a result, the effects of a public intervention are detectable many years after undertaking actions. However, action requires clear, concise and reliable information. One way of providing information on the state of the environment and its potential effects on health is in the form of indicators. The development of a set of indicators may represent a useful tool to support policy.

In the case of environmental health, relevant indicators are those representing well-established links between health and the environment. The indicators may not be based on cause-effect relationships. In fact, there are a few established cause-effects relationships related to the health effects of environmental exposure because of the lag time between exposure and health outcome and the difficulty in identifying the dose or timing of exposures which may have occurred many years earlier.

WHO has identified five environmental health issues for indicator development at the global level, based on global burden of disease, such as respiratory diseases or physical injuries, for children under five at the global level. However, some of these issues may be more or less important in individual regions or countries, and some important regional or national issues may be missing. Moreover, certain populations may be at greater risk to poor health, such as children, those living in poverty, etc. Where, when and how to intervene and how policies aimed at reducing environmental health risks should better reflect the vulnerability of these sub-populations is a key consideration and an important dimension of public policy related to health and the environment. An intervention in the early stages of life can have lifelong benefits for the society as a whole. As such, the development of children's environmental health indicators appears as essential.

Several frameworks have been developed and used to derive environmental health indicators, more particularly for children. They include for example the DPSEEA framework, the DPSIR framework and the MEME model (Briggs, 2003).

The OECD uses indicators as a tool to support public policies. Together with its member countries it has established a common approach and framework for developing, measuring and using environmental indicators. The objective of this report is to provide an overview of the existing projects and programmes on children's environmental health indicators and examine their consistency with OECD guidelines on the development and measurement of indicators, in order to determine their usefulness to OECD Member countries.

1. Definition of an indicator

An indicator is defined as a parameter, or a value derived from parameters, which points to, provides information about and describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value.

The OECD terminology points to two major functions of indicators:

- They reduce the number of measurements and parameters that normally would be required to give an exact presentation of a situation. As a consequence, the size of an indicator set and the level of detail contained in the set need to be limited. A set with a large number of indicators will tend to clutter the overview it is meant to provide.
- They simplify the communication process by which the results of measurement are provided to the user. Due to this simplification and adaptation to user needs, indicators may not always meet strict scientific demands to demonstrate causal chains. Indicators should therefore be regarded as an expression of "the best knowledge available".

The use of indicators as policy support is commonly associated with economic analysis where economic indicators (such as GDP or GNP) have been used for a long time. A set of indicators, when appropriate, provides a simplified but nonetheless generally concise and precise picture of a system. Besides, when interpreted, indicators serve as "evidence" to highlight facts and identify emerging issues that need to be addressed.

Sets of indicators have been developed to evaluate the state of the environment. For instance, in the environmental context, indicators can either represent an issue in a broad sense (e.g. heavy metals in urban soils indicate the pattern of toxic pollution in general), or aggregate several pieces of information (e.g. a water quality index as a combination of several water quality parameters). The OECD has developed recommendations about design and measurement of environmental indicators, which are presented in what follows.

1.1 OECD's environmental indicators[1]

1.1.1 Background

Over the past 30 years, environmental policies and related activities adopted by OECD Member countries have evolved, largely driven by increased public awareness of environmental issues, their international aspect and their linkages with economic and social issues. Policy priorities have evolved as did the demand for reliable, harmonised and easily understandable information.

This has stimulated the production of environmental information that is more responsive to policy needs and public information requirements. The aim is to further strengthen countries' capacity to monitor and assess environmental conditions and trends so as to increase their accountability and to evaluate how well they are satisfying their domestic objectives and international commitments. In this context, environmental indicators are cost-effective and valuable tools.

[1] Based upon OECD (2003a).

Indicators can be used at international and national levels in state of the environment reporting, measurement of environmental performance and reporting on progress towards sustainable development. They can be used at national level in planning, clarifying policy objectives and setting priorities. The OECD work on environmental indicators is designed to:

- Contribute to the harmonisation of individual initiatives of OECD Member countries in the field of environmental indicators by developing a common approach and conceptual framework; assist in further development and use of environmental indicators in OECD Member countries; and, promote the exchange of related experience with non-members and other international organisations;
- Support the OECD's policy analysis and evaluation work by developing core sets of reliable, measurable and policy-relevant environmental indicators to:
  - Measure environmental progress and performance,
  - Monitor policy integration, and
  - Allow effective international comparisons.

The OECD work focuses mainly on indicators to be used in national, international and global decision making, yet the approach may also be used to develop indicators at sub-national or ecosystem level. The actual measurement of indicators at these levels is encouraged and lies within the responsibility of individual countries.

The development of harmonised international environmental indicators is done in close co-operation with OECD Member countries. It uses a pragmatic approach, recognising that there is no universal set of indicators; rather, several sets exist, serving several purposes and audiences. OECD work led particular to:

- Agreement on a common conceptual framework, based on a common understanding of concepts and definitions and on the pressure-state-response (PSR) model (see Annex 1);
- Identification of criteria to help in selecting indicators and validating their choice: all indicators are reviewed according to their policy relevance, analytical soundness and measurability;
- Identification and definition of indicators;
- Provision and guidance for the use of indicators in connection with the evaluation of environmental performance, stressing that indicators are only one tool and have to be interpreted in context to acquire their full meaning;
- Agreement to use the OECD approach at national level by adapting it to national circumstances.

Those indicators are a way to monitor the integration of economic and environmental decision making, to analyse environmental policies and to gauge the results.

1.1.2 Functions of environmental indicators

As indicators are used for various purposes, it is necessary to define general criteria for selecting indicators and validating their choice. Three basic criteria are used in OECD work: policy relevance and utility for users, analytical soundness, and measurability.

A) Policy relevance and utility for users
An environmental indicator should:

- Provide a representative picture of environmental conditions, pressures on the environment and society's responses,
- Be simple, easy to interpret and able to show trends over time
- Be responsive to changes in the environment and related human activities,
- Provide a basis for international comparisons,
- Be either national in scope or applicable to regional environmental issues of national significance
- Have a threshold or reference value against which to compare it, so that users can assess the significance of the values associated with it.

B) Analytical soundness

An environmental indicator should:

- Be theoretically founded in technical and scientific terms,
- Be based on international standards and international consensus about its validity,
- Lend itself to being linked to economic models, forecasting and information systems.

C) Measurability

The data required to support the indicator should be:

- Readily available or made available at a reasonable cost/benefit ratio,
- Adequately documented and of known quality,
- Updated at regular intervals in accordance with reliable procedures.

1.1.3 Using environmental indicators

A) Guiding principles

When using environmental indicators in data analysis and evaluation, the OECD and its Member countries apply the following commonly agreed upon principles.

Indicators are not designed to provide a full picture of environmental issues, but rather to help reveal trends and draw attention to phenomena or changes that require further analyses and possible action. Indicators are thus only one tool for evaluation; scientific and policy-oriented interpretation is required for them to acquire their full meaning. They need to be supplemented by other qualitative and scientific information, particularly in explaining driving forces behind indicators changes which form the basis for an assessment. One should also note that some topics do not lend themselves to evaluation by quantitative measures or indicators.

Indicators' relevance varies by country and by context. They must be reported and interpreted in the appropriate context, taking into account countries' different ecological, geographical, social, economic and institutional features.

Most OECD indicators focus on the national level and are designed to be used in an international context. This implies not only nationally aggregated indicators, but also an appropriate level of comparability among countries. There is no single method of standardisation for the comparison of environmental indicators across countries. The outcome of the assessment depends on the chosen denominator (e.g. GDP, population, land area) as well as on national definitions and measurement methods. It is therefore appropriate for different denominators to be used in parallel to balance the message conveyed. In some cases, absolute values may be the appropriate measure, for example when international commitments are linked to absolute values. Moreover, the choice of the initial level of an environmental pressure and of the time period considered can affect the interpretation of results, because countries do proceed according to different timetables.

Within a country a greater level of detail or breakdown may be needed, particularly when indicators are to support sub-national or sectoral decision-making. This is important, for example, when dealing with river basin or ecosystem management, when using indicators describing drivers which are relevant at the local level, or when national indicators hide major regional differences. The actual measurement of indicators at these levels is encouraged and lies within the responsibility of individual countries. At these levels, however, comparability problems may be further exacerbated.

B) Measurability and data quality

Measurability issues such as the quality of underlying data are important in the use of environmental indicators, and must be taken into account to avoid misinterpretation. Measurability and data quality vary greatly among individual indicators. Some indicators are immediately measurable, others need additional efforts before they can be published and used. For example, most indicators of societal responses have a shorter history than indicators of environmental pressures and many indicators of environmental conditions, and some are still in development both conceptually and in terms of data availability.

An important criterion affecting the usefulness and relevance of an indicator is the timeless of the underlying data. The interval between the period to which data refer and the date when data are released should be as short as is practicable. Current timeless of environmental data often remains insufficient for policy evaluation or public communication purposes. Unlike some economic data, environmental data lag behind, referring to two or three years (or even more) prior to the current year.

The availability of coherent data over longer periods is essential to keep track of earlier policy measures and to monitor changes over time. To date, the consistency and completeness of time series data vary greatly by issue and by country, and do not often allow a systematic and meaningful presentation of trends over longer periods.

Coherence or comparability among countries and international harmonisation are essential to make data and indicators meaningful for decision making and performance evaluation and for allowing policy makers to make effective international comparisons. Despite significant progress over the past twenty years, differences remain among countries as well as within countries where different information sources often provide different figures on the same item.

Coherence between environmental and economic information systems is essential to establish links between environmental and economic variables, to analyse environmental pressures exerted by different economic sectors and distinguish government responses for those of the business sector or private households. To date, breaking environmental indicators down at sectoral level remains difficult because of different definitions and classifications used. Further harmonisation work and closer links between accounting work and the development of indicators could help to overcome some of these difficulties.

1.2 OECD's health indicators[2]

The OECD has been publishing health statistics since the mid-1980s. The coverage of its health data files is very wide and for many indicators the series goes back as far as 1960 (OECD, 2003b). Criteria of selection of health indicators include:

- Relevance (to the description of the key aspects of health care systems);
- Sufficient consistency (to enable cross-national comparisons); and,
- Availability (in a significant number of countries).

Qualitative information gives the standard definition of the indicator and, where applicable, identifies any discrepancy between national data and the standard definitions.

The OECD health indicators are classified into ten parts:

1. Health status
2. Health care resources
3. Health care utilisation
4. Expenditures on health

[2] Based upon OECD (1998).

5. Financing and remuneration
6. Social protection
7. Pharmaceutical market
8. Non-medical determinants of health
9. Demographic references
10. Economic references

Health indicators constitute a powerful tool for outcome-oriented policy making (Table 1). In this context, where health policy sets priorities to improve the global health status, health indicators can be used to describe the level of health and the disparities across countries and over time. Health status of a population depends on a great number of factors, often beyond the medical-care system, such as social and economic environment. However, it is not always obvious to determine the direct impact of medical-care system on changes in health status. To address this issue, health indicators should be designed in order to reflect more closely the performance and quality of health-care systems in maintaining or improving health outcomes.

Health indicators can also be used for monitoring population health status. In this context, where factors including social, environmental, and lifestyle factors are crucial, health indicators were usually based on mortality data, such as life expectancy, standardised mortality rates, infant mortality, and potential years of life lost. These mortality indicators provide useful information for describing the mortality patterns of the population.

Table 1 – Health indicators for outcome-oriented policy making [3]

Health status indicators	
Mortality	• Life Expectancy • Infant Mortality • Standardised Causes of Mortality Rates • Premature Mortality: Potential Years of Life Lost (PYLL)
Morbidity and Quality-of-life • **General Morbidity** • **Disease-Specific Morbidity**	• Perceived health status • Measures of impairment, disability, and handicap • Multi-dimensional health status measures (e.g. SF-36, EuroQol, and Health Utility Index) • Prevalence and incidence of diseases
Composite Health Measures (mortality + morbidity)	• health expectancies (*e.g.* Disability-free life expectancy (DFLE) and Health-adjusted life expectancy (HALE)) • Disability-adjusted Life Years (DALYs)
Indicators of performance of the medical-care system	
Quality of medical care	• Rates of avoidable mortality and morbidity • Survival rates • Rates of effective health-care interventions which play important role in health gain • Rates of adverse events following treatment • Rates of satisfaction with health-care system

[3] Source: OECD (1998).

However, given the continuing increases of life expectancy and chronic diseases, more information on the non-fatal consequences of diseases is required. To this end, indicators on morbidity and quality of life have been developed. Increased emphasis has been placed on health goals, such as preventing disability, improving physical and mental functioning, and reducing the pain and distress caused by disease. In turn, these emerging concerns have created a demand for better data on the nature, causes, and distribution of diseases in the population and their impact on the well-being and quality of life.

National health surveys provide reliable information on general morbidity (such as perceived health status, disability, physical and mental functioning, and multi-dimensional concepts of health) to measure variations in health status among individuals and populations. However, there is a significant lack of international consensus on the concepts of health and morbidity to measure, on the methodology and administration of these surveys, making any international comparison extremely difficult, next to impossible.

At the same time, the role of medical care in determining health outcomes is not easily assessed since many factors outside the medical-care system have a significant impact on health status. Clear and robust links between health status and a specific medical-care intervention could not be determined without conducting multi-variable modelling or randomised controlled trials.

As such, the OECD has undertaken some parallel work to develop a group of indicators where the links between medical-care interventions and health are better established. These measures would prove valuable for monitoring what is being achieved in the medical-care system and health-care policies across OECD Member countries. As presented in OECD (1998), examples of commonly-used performance indicators could include the following:

- Rates of avoidable mortality and morbidity, where there is clear evidence that timely and appropriate medical interventions would either prevent the condition or treat the disease at an early stage.
- Rates of effective health-care interventions which have been proven to have an undisputed and important role in health gain, such as immunisation or breast cancer screening. In these cases, measurement of process --intervention or uptake rates -- could be used as a proxy for outcomes.
- Survival rates at a given point in time after an intervention or treatment.
- Rates of adverse health events which can only be a result of health-care interventions, such as hospital-acquired infections or complications in routine surgery.
- Rates of satisfaction with health-care systems.

To proceed with the development of these indicators, a set of selection criteria could include the following characteristics:

- Policy relevance, i.e. indicators reflect health problems that are a major concern in most OECD Member countries;
- Consistency, i.e. the relationship between medical care intervention and health status is well established;

- Utility, i.e. indicators clearly relate to areas involving substantial resources or burden of disease;
- Sensitivity, i.e. indicators should be sensitive to quality of care differences.

Applying these criteria could help design a set of health indicators for outcome-oriented policymaking.

While a universal composite health measure could constitute an attractive goal for many, an indicator addressing various types of health problems for any population group is not feasible. Each indicator serves its own purpose and together, they provide a more comprehensive picture of health status in the population than relying on one summary measure. As suggested by Briggs (2003), linked sets of indicators are usually better than single indicators since they can provide a fuller and more robust picture of what is being analysed.

Harmonisation of national indicators of health outcomes is in its infancy. However, there is broad agreement, in particular across OECD countries, on the necessity for a key set of relevant and coherent health indicators to assess and compare country performances and establish sustainable targets for health policy. International co-ordinated efforts need to be made to increase the comparability of health indicators. Mortality and morbidity data provide inputs to develop health indicators to monitor health status and appreciate the effectiveness of health policies and programmes. As such, the development of relevant and comparable mortality and morbidity statistics should be encouraged by collaborating with existing international projects.

In order to construct accurate, relevant and internationally comparable indicators of health, the development of a common and standardised information base of mortality and morbidity data is essential, as outlined in Table 2. Improvement of this core information is the first step to move towards more outcome-oriented policy making.

Table 2 – A framework for data development of selected health indicators[4]

Selected health indicator	Data requirement	Main data sources	Areas to improve
Life expectancy	• No. of deaths by age • Population counts	Death registries	
Potential years of life lost (PYLL)	No. of deaths by age and by causes	Death registries	Ascertainment and classification of the causes of death needs to be improved.
Perceived health status	Self report on one's health	Survey	Survey question needs to be standardised
Prevalence of impairment, disability or handicap	Self report on one's Impairment, Disability, or Handicap	Survey	• Definition of disability and handicap needs to be clarified; • Objective scales need to be developed for measurement; • Survey questions need to be standardised.
Disease prevalence	No. of existing cases of specific diseases	• Hospital and other medical records; • Survey;	Methods used in data gathering need to be standardised.

[4] Source: OECD (1998).

Selected health indicator	Data requirement	Main data sources	Areas to improve
		• Estimates based on incidence.	
Disease incidence	No. of new cases of specific diseases	Hospital, other medical and administrative records	Methods used in data gathering need to be standardised.
Health expectancies	• No. of deaths by age • Population counts • Prevalence of disease, disability, handicap, perceived health or multi-dimensional health status. .	• Death registries • Survey	• Definition of disability, handicap, etc. need to be clarified. • Methods and questions used in data gathering need to be standardised
Disability-adjusted life expectancy	• No. of deaths by age and cause, • Incidence and duration of specific diseases, • Severity weights	• Death registries • Hospital and other medical records • Survey of preferences of health states using person trade-off method	• Ascertainment and classification of causes of death needs to be improved. • Methods used to gather incidence data needs to be improved. • Weights and discount rates used in calculation need approval

2. Environmental health indicators

2.1 Definitions

As proposed by Corvalán et al. (1997), an environmental health indicator may be defined as "*An expression of the link between the environment and human health, targeted at an issue of specific policy or management concern and presented in a form which facilitates interpretation for effective decision-making"*.

An environment and health indicator has two major characteristics. Firstly, an environment and health indicator should embody a link between environment and health. As such, an environment and health indicator is more than either a health indicator or an environmental indicator. The element that turns a simple environmental or health indicator into an environment and health indicator is the knowledge of the relationship between exposure to environment factors and health effects. Any environment and health indicator must therefore be based on a clear and firm relationship between the environmental hazard and the health effect. The further removed the indicator is from the health effect, the weaker this link is liable to be.

Secondly, an environment and health indicator should be associated with policy. To be effective and useful to decision makers, an environment and health indicator should relate to aspects of environment-related health which are of high relevance to decision makers, understandable by concerned people and amenable to control. As suggested by Corvalán et al. (1997), an environment and health indicator should be expressed in terms of the health risk associated with a specific environmental hazard. Indicators should tend to provide a better early warning, both of impending environmental problems and of the effects of intervention.

The main objective of environment and health indicators is to support the decision-making process in environmental health. They are useful for highlighting problems, identifying trends and tracking of policy progress. Information on the local and national health impacts of environmental hazards are made available to

decision-makers, environmental health professionals and the community. Data is analysed and converted into valid information presented in a form which facilitates interpretation for effective decision-making, interpreted and acted upon by those responsible for environmental health protection.

The main objective is to gain knowledge about the structure of interdependency between environmental degradation and health risks and to identify vulnerable groups and individuals. This will offer the possibility to develop strategies for the increasing health impacts associated with environmental degradation and to understand how to promote awareness of these risks. In the end, this would allow to formulate prevention and mitigation strategies for policy makers – to develop and implement an action plan.

Indicators are neither neutral nor non-contextual things. They are targeted at specific policy concern. Like all other forms of information, they depend on the way in which they are designed and the purpose for which they were built. Up to now, only few indicators in the national sets are directly related to children. Few attempts to develop environment and health indicators have considered children case. As such, they do not serve children well. New indicators are therefore needed that explicitly focus on children's environmental health.

2.2 Frameworks for environment and health indicators

Frameworks are a methodology to describe the relationships between the causes and the impact on a system. In the environmental health context, frameworks are used to generate a link between health effects and ambient air pollutant concentrations.

Frameworks have been developed to emphasize the level of specificity or desired focus of a specific monitoring programme, and thus the adaptation of the framework is dictated by the goals and objectives of the monitoring exercise. Whether the interest of the monitoring programme is to look at the factors involved in greater detail leading to the pressures (or driving forces in Corvalán et al. (1996)) on a system, at the states or responses within the system (e.g. external dose, internal dose and effect at different levels), or at actions aimed at reducing negative impacts (e.g. government emission control legislation) is determined by the programme goals and its ultimate purpose. The terminology and degree of detail (number of compartments explicitly identified within the phenomenon being studied) developed in the framework also depends upon the programme objectives. The terminology must explicitly be defined in order for the framework to provide helpful tools (specified indicators) in identifying and selecting indicators to retain in a monitoring program.

Identifying vulnerable groups and individuals and gaining knowledge about the collective and individual risk perception and/or risk awareness will form a basis for effective action planning and taking. To this end, frameworks have been designed to develop and derive environmental and health indicators. The choice of a framework constitutes one of the most fundamental questions in developing environment and health indicators.

A conceptual framework for the development and use of environmental health indicators, the so-called DPSEEA-framework was developed. Other frameworks have then been developed to derived children's environmental health indicators, namely the DPSIR framework, and the MEME model. In what follows, we briefly present the frameworks most commonly used for the development of environment-related health indicators.

2.2.1 DPSEEA Framework[5]

The DPSEEA model, endorsed by the World Health Organization (WHO) to organise its own environmental health indicators, took a broader approach to include macro driving forces in the pressures on health and the environment. DPSEEA stands for Driving forces, Pressures, State, Exposures, Effects, and Actions. Inspired from the PSR model[6] successfully used for environmental indicators, it has been designed for setting a system of environmental health indicators within the decision making context.

The DPSEEA framework helps understand the interrelationships between the elements of driving force-pressure-state-exposure-effect-action and provides a simple way of presenting the indicators themselves. The DPSEAA model (Figure 1) is useful as it covers the full spectrum of potential forces and resulting actions and brings together professionals, practitioners, and managers from both environmental and public health fields to help orient them in the larger scheme of the problem.

The driving forces (D) component refers to the factors that motivate and push the environmental processes involved. These result in the generation of pressures on the environment (P). In response to the pressures, the state of the environment (S) is often modified. Deterioration in the state of the environment, however, poses risks to human well-being only when there is interplay between people and the hazards in the environment. Exposure (E) is therefore rarely an automatic consequence of the existence of a hazard: it requires that people are present both at the place and at the time that the hazard occurs. Exposure to environmental hazards, in turn, leads to a wide spectrum of health effects (E), which may be acute or chronic. Some hazards may have a rapid effect following exposure, whereas others may require a long time to produce an adverse health effect. The concept of exposure is best developed in relation to pollutants in environmental media. The amount of the pollutant absorbed, i.e. the "dose", depends on the duration and intensity of the exposure.

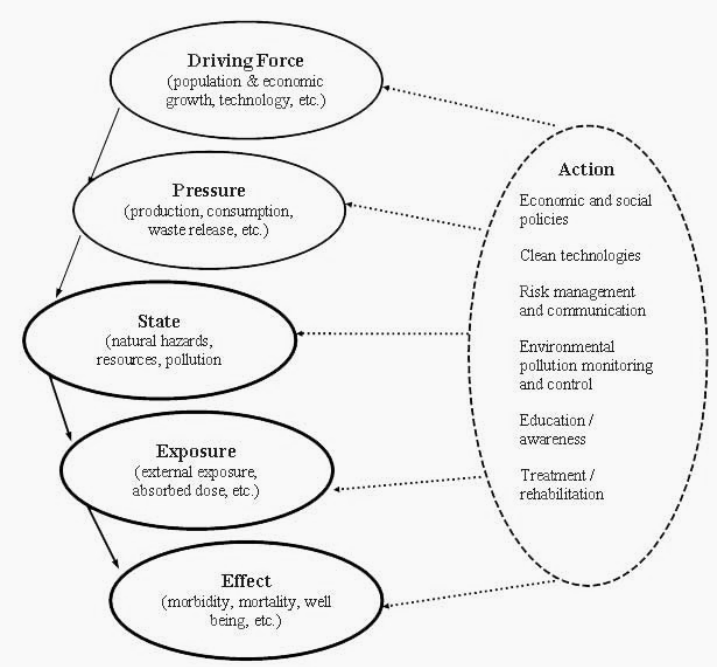
In the face of environmental problems and consequent health effects, society may attempt to adopt and implement a range of actions (A). These may take many forms and be targeted at different points within the environment–health continuum. Actions may be taken to reduce or control the hazards concerned, such as by limiting emissions of pollutants or introducing flood control measures. The most effective long-term actions, however, are those that are preventive in approach, aimed at eliminating or reducing the forces that drive the system.

The further down this causal pathway, the more difficult it gets to acquire relevant data. It means that often proxy indicators have to be used (Corvalán 1998).

[5] Source : WHO (2004a)

[6] For further details on the PSR model, see Annex 1.

Figure 1 – The DPSEEA framework[7]



2.2.2. DPSIR Framework

The DPSIR (Driving forces, Pressure, State, Impact, Resources) model is a general framework for organising information about state of the environment. Adopted by the European Environment Agency, in particular for the Environmental Information Systems in Europe, this framework is similar to the DPSEEA model and set environmental health indicators within policy making. Builds on the PSR model (OECD, 1993)[8], variation of the DPSIR framework includes the DSR model (UNCSD, 1996).

[7] Source of the figure: http://www.fep.paho.org/english/env/Indicadores/Page10.asp?Valida=ok

[8] The DPSIR model is a more desaggregated version of the PSR model. For more details on the PSR model, see Annex 1.

The purpose of this framework is to structure data and information on different environmental problems. This conceptual model was originally derived from social studies and then widely applied for organising systems of indicators in the context of environment and, later, sustainable development.

The framework (see Figure 2) assumes cause-effect relationships between interacting components of social, economic, and environmental systems, which are:

- **D**riving forces of environmental change (e.g. industrial production)
- **P**ressures on the environment (e.g. discharges of waste water)
- **S**tate of the environment (e.g. water quality in rivers and lakes)
- **I**mpacts on population, economy, ecosystems (e.g. water unsuitable for drinking)
- **R**esponse of the society (e.g. watershed protection)

The driving forces (D) are underlying sectoral factors, which lay behind pressures and influence a variety of relevant variables. Examples could include the GDP; the number of cars per inhabitant; and, the total industrial production.

The pressure indicators (P) describe the variables which directly cause (or may cause) environmental problems, such as toxic emissions, CO_2 emissions, and noise caused by road traffic; and, the amount of waste produced by scrap cars.

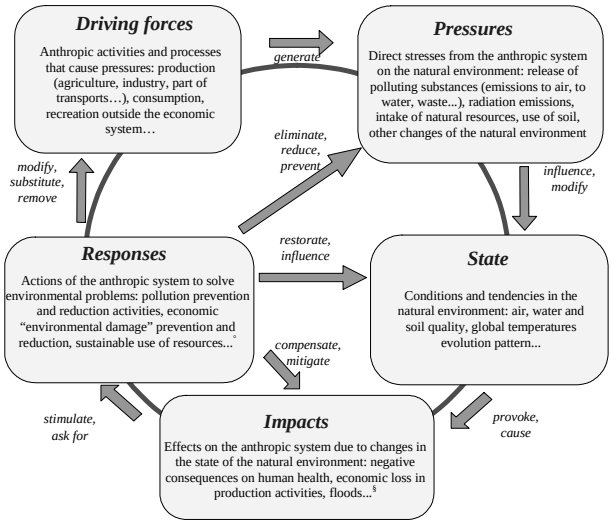
The state indicators (S) state the current condition of the environment. Examples could include the concentration of lead in urban areas; the noise levels near main roads; and, the global mean temperature.

The impact indicators (I) describe the ultimate effects of environmental pressures on the state of the environment. The percentage of children suffering from lead-induced health problems, the mortality due to respiratory diseases, and the morbidity cases resulting from lack of sanitation and hygiene constitute good examples of impact indicators.

The response indicators (R) represent the efforts decision-makers undertake to solve – or at least to mitigate – these problems. Examples could include the implementation of cars with catalytic converters; maximum allowed lead level in paints; the pesticide standard rate contained in baby food; and, the revenue coming from pollution levies.

This framework accounts for the fact that increased pressures do not necessarily lead to increased impacts and on the other hand, reduced pressures do not always lead to an enhanced state of the environment. In this sense, the DPSIR model is more analytical than the PSR model.

Figure 2 – The DPSIR model[9]



2.2.3 MEME Framework[10]

The Multiple Exposures-Multiple Effects (MEME) model has been developed by WHO. This framework provides the conceptual and theoretical basis for the development, collection and use of children's environmental health indicators. The name refers to the fact that combinations of exposures can result in different health outcomes in an individual and these health outcomes can be attributed to different types of exposures. The effects of these exposures are influenced by the social, economic and demographic factors which are part of children's life.

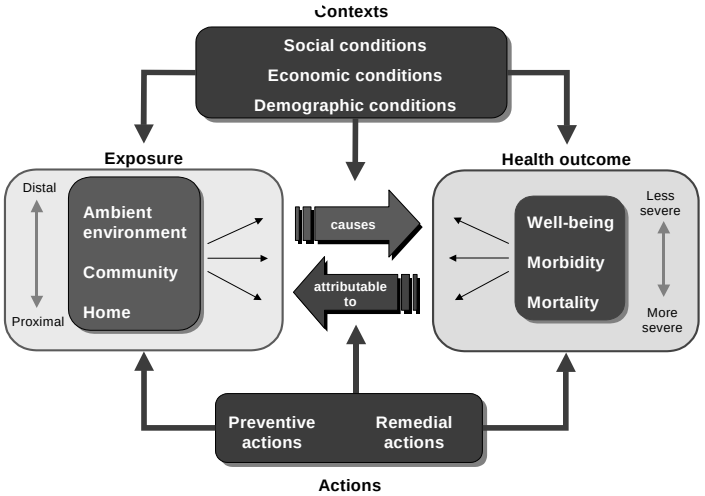
The model emphasises the complex relationships between environmental exposures and child health outcomes. Individual exposures can lead to many various health outcomes; specific health outcomes can be attributed to many different exposures. Both exposure and health outcomes – as well as associations between them – are affected by contextual conditions, such as social, economic or demographic factors. Beyond

[9] Source of the figure: Costantino et al. (2003).

[10] Source: Briggs (2003).

identifying these underlying driving forces for children's environmental health problems, information on socio-economic status is important for disaggregating exposure and health information to identify vulnerable groups. Actions can be aimed at reducing exposures or at reducing the severity of health outcomes. The MEME model (see Figure 3) thus describes the four elements required for monitoring children's environmental health: exposure indicators, health outcomes indicators, contextual indicators and action indicators.

Figure 3 – The MEME model[11]



As the model illustrates, one can identify indicators for environmental contaminants, such as pesticide residues, drinking water contaminants, and indoor or outdoor air pollution. Information on specific indicators that monitor the presence of these contaminants, for example in blood, can also be collected. Finally childhood diseases that result from various exposures can also be included in the model.

The MEME model is compatible with the DPSEEA framework, as the MEME model represents both a simplification and an extension of the DPSEEA framework. The main difference between the two methodologies comes from the definition of the state and pressure components. In the DPSEEA framework, it is – in practice – difficult to distinguish from state and pressure components. To avoid this practical difficulty, state, pressure and exposure components have been combined in the MEME model under the general heading of "exposure".

[11] Source of the figure: http://www.who.int/ceh/indicators/indiconcept/en/

2.3 Limits of these frameworks

The PSR, DPSIR and DPSEEA frameworks are widely used to structure and select environmental health indicators. However, as all models, they do not embrace perfection and are subject to limitations[12].

The first limitation that is common to these models is their unconformity to reality. Models constitute a simplification of reality, a tool serving specific needs. For many of them, in their attempt to simplify the complex associations existing between environment and health, they neglect the "many-to-many" relationship: a single health outcome may derive from many different exposure causes, while several individual hazards lead to a wide range of adverse health impacts. The DPSEEA, the PSR and the DPSIR models *are too linear* (Briggs, 2003). In addition, traditional frameworks do not reflect changes and flows occurring in real life, they are *static*. However, it is obvious that each link in the framework is itself dynamic and uncertain. Each step is subject to a wide range of influences and controls. As a consequence, frameworks do not provide basis for an in-depth understanding/analysis of the phenomenon, feedback interactions, and cumulative impacts.

Another major limitation of these three frameworks is that exogenous factors referring to the social and the economic dimensions, such as the policy context, social attitudes and the pre-existing economic infrastructure of the area concerned, are not taken into account in these frameworks. As such, important factors may be omitted in the conceptual model, though they may have a large influence on individuals' susceptibility to environmental risk factors. Neglecting these factors may be seriously misleading and may lead to inefficient policy advice. In addition, the DPSEEA, the DPSIR and the PSR models are "partial" models, in that they only refer and cover environmental issues

A third limit common to the DPSEEA, the PSR and the DPSIR models is their focus on the anthropogenic causes of environmental degradation and on environmental issues. As such, they may be more relevant for analysing environmental hazards such as air/water/soil pollution, than to establish indicators associated with natural hazards, such as floods, or social/occupational risks.

The weight given to indicators within policy advice is more and more important. Therefore, other representations of the links between environment and health are required, as realistic and as flexible as possible. A reasonable suggestion could be the MEME model. Unlike the traditional models (PSR, DPSIR and DPSEEA), this approach does not try to separate more proximal causes of disease (exposures) from more distal causes (the state and the pressure components): all these are combined under the general heading of exposures. In the MEME framework, exposures may be measured either more or less directly. In the same way, health effects may be expressed either in mortality or in morbidity terms. It recognises that both exposures and health outcomes may be affected by contextual factors, such as social conditions, demographics or economic development, which may influence the susceptibility of the population to environmental health effects. The MEME model also takes account for the many-to-many relationships between environment and health, meaning that neither environmental nor health indicators can be interpreted in terms of simple and direct relationships.

[12] It should be reminded that these models, in particular the PSR and the DPSIR models, have been designed for more general purpose than analysing health and environment relationships. They have been developed so as to be as simple as possible, to be easily understandable by the users. Therefore, they are not perfectly suited for in-depth analyses of the relationships between health and the environment.

Based upon these arguments, the MEME framework appears as the most appropriate, relevant and flexible model when developing environmental health indicators even though it shows similarities with the traditional frameworks.

3. Overview of empirical projects

The aforementioned frameworks provide a convenient tool to develop health indicators. They have been applied in various empirical projects for a couple of years to derive children's environmental health indicators. In what follows, we present the main projects undertaken to evaluate children's environmental health indicators. We then discuss how these projects help improve knowledge and promote better practices with respect to the development of children's environmental health indicators.

3.1 Environment and Health Indicators

The HEADLAMP Project[13]

Description: The HEADLAMP (Health and Environment Analysis for Decision-Making) project is a joint UNEP, USEPA and WHO project, which in 1994-1995 proposed methodologies for health risk assessment of environmental health hazards and indicators.

Participating countries:

Objectives: The project aims at improving information support for environmental health policies and at bringing valid and useful information on the local and national health impacts of environmental hazards to decision-makers. Based on these characteristics, a framework is proposed for the application of HEADLAMP for managing specific environmental health problems.

Methodology: Following the DPSEEA framework, the project combines methodologies in environmental epidemiology, human exposure assessment and other health and environment sciences to produce and analyse data, to convert these data into valuable and understandable information that can be interpreted and used by those responsible for environmental health protection. Its main tools are linkage methods of health and environment data, the use of environmental health indicators to quantify and monitor the local situation, and the interpretation and translation of resulting information into the decision-making process. The project has three main characteristics which differentiate it from *ad hoc* epidemiological studies: (1) it is based on scientifically established relationships between environmental exposures and health impacts; (2) it uses routinely-collected data, or where necessary, new data collected using low-cost techniques; and (3) it aims at providing information on which to base preventive action against environmental health problems.

Outcomes: The project stimulated the identification and use of local environment and health Indicators for priority setting and decision-making[14].

[13] Indicators derived from this project are not focused on children. However, as it constitutes one of the first projects attempting to develop environment and health indicators, it provides useful insights and should therefore be mentioned. In particular, some indicators developed in this project might have been of particular relevance for other projects directly dealing with children's environmental health indicators.

[14] Further information is available in the publication "Linkage methods for environment and health analysis – General guidelines", document WHO/EHG/95.26 available from the WHO.

The EHIS Project[15]

Description: The environmental health indicator system (EHIS) was developed by WHO. The indicators and main tools have been developed by an internationally co-ordinated network of experts. 15 WHO Member states, the EEA and EC DG SANCO participate in the WHO-EHIS project.

Participating countries: Albania, Armenia, Bulgaria, Czech Republic, Estonia, Finland, Germany, Hungary, Lithuania, Netherlands, Romania, Slovakia, Spain, Sweden and Switzerland.

Objectives: the EHIS was undertaken to provide a harmonised methodology of integrating environmental and health information.

Methodology: indicators are constructed as interlinked in terms of upstream determinants, environmental risks and health effects, actions according to the DPSEEA framework. A feasibility study was carried out to test data availability, to reach a consensus on a set of "core" indicators. An extended set was also developed with indicators which need further development.

Tools mainly consist of specialised software for uniform collection, processing and exchange of environment and health data.

Specific age groups are not analysed. Indicators are not focused on children. However, some may be of particular relevance (e.g. indoor/outdoor air pollution, water pollution).

Selection criteria of indicators were based on:

- Evidence for health-environment links
- Scale and severity of the problem
- Policy relevance
- Evidence for effective interventions
- Possibilities for actions

Outcomes: 10 health-relevant environmental issues were selected in the indicator set[16]:

- Air quality (ambient and indoor)
- Housing
- Traffic
- Noise
- Radiation

15 Source: WHO (2004a).

16 See Annex 2, table A for an overview of recommended indicators.

- Waste and contaminated lands
- Water and sanitation
- Food safety
- Chemical emergencies
- Workplace conditions

The ECOEHIS Project[17]

Description: the ECOEHIS ("Development of Environment and Health Indicators for European Union Countries") was undertaken by WHO to contribute to the EC health monitoring system. The project is developed in the context of the ECHI project (see below).

It will serve monitoring public health and environmental policies, will support national and multinational analyses, and will facilitate effective decision making related to environmental health risks in the Member States. The project is developed in the context of a broader WHO/Euro project on the establishment of Environmental Health (environment and health) indicator system in Europe. EC DG SANCO also participates in this project.

Participating countries: Austria, Belgium, Denmark, France, Finland, Germany, Italy, Netherlands, Portugal, Spain and Sweden.

Objectives: the main objective of the ECOEHIS project is to develop indicators on environmental health to serve the EC health monitoring system. The project will provide input to the ECHI process of selecting core set of indicators.

Methodology: The ECOEHIS project is based on the previous work undertaken by WHO on environment and health indicators. As ECOEHIS is part of the ECHI project, harmonisation of operational definition of selected environment and health diseases with the ECHI set will be realised.

Substantial part of the ECOEHIS project deals with the verification of the environment and health indicators compatibility with the EC legislation (WHO, 2003), to assess applicability and therefore support national policies and actions to reduce adverse health effects in the European Union.

The ECOEHIS scope covers the following areas of public health:

- Housing conditions
- Home and leisure activities
- Transport (road accidents)
- External environment (air pollution, water pollution, radiation and other types of pollution, including noise but excluding food safety)

17 Source: WHO (2004c).

Some of the topics covered by the ECOEHIS project are relevant for children, such as air pollution (indoor and outdoor) and water pollution. However, specific age groups are not analysed.

Selection criteria for indicators include:

- Policy relevance
- Availability/Feasibility, accessibility and quality of the data
- Evidence for health-environment links

Outcomes: 7 health-relevant environmental issues were selected in the indicator set:

- Air quality
- Noise
- Housing
- Traffic accidents
- Water, sanitation and health
- Chemical emergencies
- Radiation

The ECHI project[18]

Description: The European Community Health Indicator (ECHI) project was undertaken under the European Union Health Monitoring Programme (HMP) aiming at establishing a framework for data collection, exchange and reporting in the field of public health, in order to facilitate the monitoring of trends, differences and policy impact throughout the EU. The OECD and WHO-Europe also participate in this project.

Participating countries: Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden and United-Kingdom.

Objectives: the ECHI project has been developed in an attempt to provide a common frame for the construction, selection and classification of EU health indicators, for use at the Community and Member states level.

Methodology: The ECHI framework (Figure 4) defines the areas of data and indicators, following a set of explicit criteria, define generic indicators in these areas and subsets of indicators, only focusing on the medical/physical domain. It is based upon the traditional bio-medical/epidemiological/individual risk factor approach.

[18] Source: Kramers (2003), ECHI (2001).

As suggested by Figure 4, "Health improvement" is the public objective to be achieved. To this end, "Health Determinants" represent the factors that can be influenced to improve health, and "Health services" constitute the means to achieve this goal.

The choice of these categories has been based on considerations of conceptual coherence, on an optimal consensus among the classification used by other international organisations, as well as on new developments in public health monitoring (Kramers, 2003).

The project also provides guidance on the stratification of data by age, gender and, when data are available, socio-economic status and region. In particular, specific age groups are considered, and more particularly children, such as the specific entries on health and services for both mother and child, which provide indicators on children's health, family structure, etc.

The ECHI project does not rely on clear foundations/theoretical model for its indicator selection. The selection criteria applied in the design of the indicator set included the following characteristics:

- Comprehensiveness and conceptual consistency;
- Taking account of previous work; and,
- Coverage of Member States and Community interests.

The proposed indicators are "generic" indicators, what means that their actual operational definitions have not yet been tested. As availability and operationalisation of indicators were not the main focus of the project, indicators do not meet these criteria.

The flexibility appears as the main important characteristic. To this end, the ECHI framework has been emphasised around the definition of "user-windows". These are subsets of the overall indicator list, each of which reflecting a specific user's requirement or interest. This concept allows working with interested-oriented subsets of indicators (e.g. environment and health indicators). For different purposes, different sets of indicators can be examined (health indicators, environment and health indicators). The focus has been placed on ways of building user-windows for the different needs of the EC.

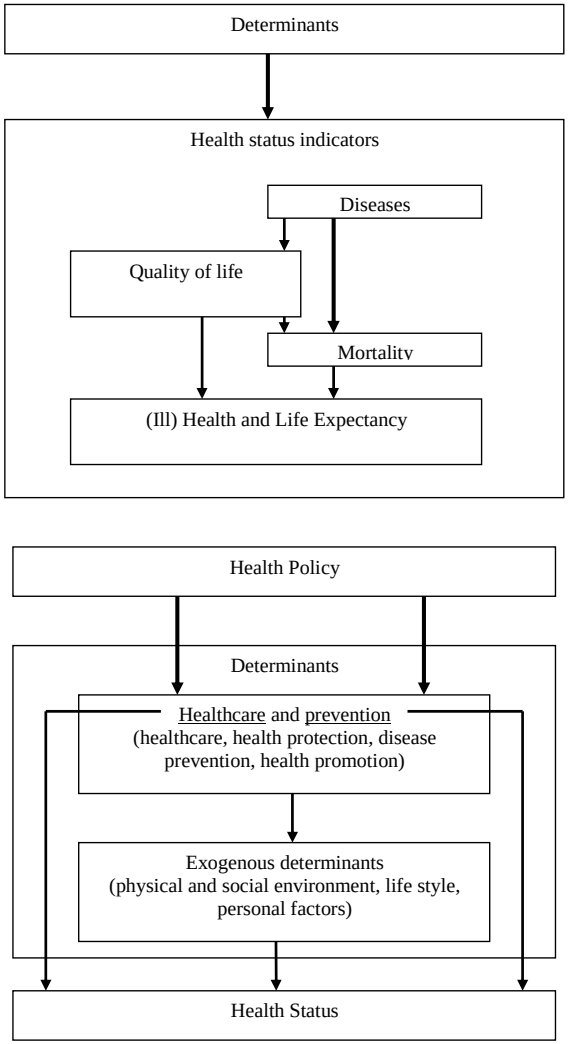
Outcomes[19]: The indicators cover all relevant domains within the field of public health, in particular those defined as priority for the EU Member states. The indicator set underlies on previous work, undertaken by WHO Europe, the OECD and EUROSTAT in this area, and consider the priority areas currently pursued in the Member States and through the Community health policies. This project is being carried out to a large part by other projects within the HMP, which cover specific areas of public health or areas of data collection.

The main categories of the health indicator set are the following:

- Demographic and socio-economic factors
- Health status
- Determinants of health
- Health services and health promotion

[19] See Annex 2, table B for an overview of recommended indicators.

Figure 4 – The ECHI conceptual scheme



3.2 Children's environmental health indicators

The Child Health Indicators of Life and Development project [20]

Description: The Child Health Indicators of Life and Development (CHILD) project is a third-wave project within the European Community Health Monitoring Programme (HMP) undertaken by the European Commission.

Participating countries: Austria, Belgium, Denmark, France, Finland, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, and the United-Kingdom.

Objectives: The objective of the CHILD project was to examine the issues affecting children's health and development, as well as the preventive and therapeutic services in order to measure and recommend indicators of children's health. In addition, adjustment of current services and policies became another important input of the project.

Methodology: The CHILD project is based on the framework adopted in the ECHI project. The project addresses all aspects of child's health and its determinants. A review of relevant literature was undertaken so as to identify and validate CH indicators. A systematic approach was adopted to identify appropriate indicators and to assemble a composite list.

As exposed in Rigby et al. (2003), childhood can be decomposed into different stages, traditionally into age bands of five-year. Each of these stages of childhood has its own health issues, determinants and needs. Therefore, indicators of children's health need to be designed over age groups. Children are defined over five broad stages: 0-1 year, 1-5 years, 5-10 years, 10-15 years, and 15-18 years.

Given empirical evidence that there is a gender differentiation in many aspects of child health, the CHILD project includes analysis of gender, in order to identify whether or not gender bias exists in regard to many health aspects.

A list of intrinsic characteristics required to select relevant indicators includes the following:

- Validity: face validity (ability to measure what is said to be measured), content validity (accounts for the qualities that the definition implies), and construct validity (demonstrates an expected empirical relationship with other related indicators);
- Consistency: reliability in the measurement;
- Sensitivity: can register possible changes;
- Feasibility: available and reliable source data; and,
- Definition: unambiguous in the data construct.

[20] The presentation of the CHILD Project is based upon Rigby et al. (2003).

Outcomes[21]: The project has identified 38 core indicators, providing purpose and evidence for each of these. It also identified 17 key health child topics on which further work is required to harmonise indicators across different national settings.

The recommended set of CH indicators covers the following four categories:

- Demographic and socio-economic situation;
- Health status and well-being;
- Determinants of health, risk and protective factors; and,
- Health systems and policy.

The CHILD project allows for the identification of tracer indicators (indicators related to tracer health conditions which will be indicative of other health aspects too, or related to tracer services). One of the most important additional benefits of the CHILD project is the extension of work to adjustment of policies and services related to child health.

Children's health and the environment indicators in North America[22]

Description: The Children's Health and the Environment Indicators in North America (CHEINA) project is the result of an initiative undertaken by the Commission for Environmental Co-operation (CEC) in order to develop children's environmental health indicators for North America.

Participating countries: Canada, Mexico and the United-States.

Objectives: Through the development of children's environmental health indicators, the objectives of CHEINA are three-fold:

- Provide a basis to help policy makers prioritise interventions at national and global level,
- Provide a basis to monitor and evaluate effectiveness of initiatives aimed at reducing environmental health risks to children,
- Provide a template for developing other indicators.

Methodology: The MEME was selected as the model and approach in creating a list of indicators into three topic areas:

- Asthma and respiratory diseases;
- Effects of lead and other toxic substances; and,
- Waterborne diseases.

21 See Annex 2, table C for an overview of recommended indicators.

22 Source: CEC (2003).

The recommendations reflect the environment and health indicator model developed by WHO (Briggs, 2003). The MEME model is recognized as best capturing the complex interactions between the environment and children's health and the flexibility required for preparing the North American children's environmental health indicators set[23].

The following criteria have been applied in selecting indicators:

- Useful and relevant: each indicator must be related to a specific question or condition of interest that highlights a trend or caution regarding children's health and the environment.
- Scientifically sound and credible: each indicator must be unbiased, reliable, valid, and based upon high-quality data. The methodology for collecting the data should be robust and repeatable. There must be a credible link between the environmental condition that the indicator addresses and the health outcome.
- Appropriateness and availability: as not all countries will be able to report on all selected indicators, countries will choose indicators from the list that are most appropriate and available from their national perspective and based on information that already exists.
- Applicable and understandable: the indicator must be useful for policy-makers and non-expert audience.

Indicators are organised into four categories:

- Context,
- Exposure,
- Health outcome, and,
- Action indicators.

Outcomes[24]: A set of 12 indicators is recommended for children's health and the environment indicators in North America. It covers the four priority areas identified by the CEC Council, which are: asthma and respiratory diseases, effects of lead, effects of exposure to other toxics substances, and water-borne diseases.

The SCALE Project[25]

Description: The SCALE initiative, launched by the European Commission, presents a systematic approach to the development of a European Environment and Health Strategy. It is based on **S**cientific evidence, focused on **C**hildren, meant to raise **A**wareness, improve the situation by use of **L**egal instruments and ensure a continual **E**valuation of the progress made, hence the name SCALE.

23 The priorities of this project are not derived in terms of analysis of the global burden of disease.

24 See Annex 2, table D for an overview of recommended indicators.

25 Source: SCALE (2004).

Participating countries: the SCALE project involves Governments of Austria, Belgium, France, Germany, Hungary, Italy, Sweden, The Netherlands, Portugal and Slovenia. International organisations: the WHO, the EEA, European Public Health Association (EUPHA), the European Network for smoking Prevention (ENSP). It also includes EUROFER, the European Confederation of Iron and Steel Industries.

Objectives: The SCALE project aims at assessing the adverse environment-related health impacts in order to provide harmonised methodology and dataset which would serve country needs and would enable international comparisons.

Methodology: To this end, the project will adopt a flexible, country-specific approach allowing for differences and changes in user needs and data availability.

It comprises the build-up of information systems as well as the compilation of adequate political measures. Feasibility studies and data collection will be implemented in accession countries and Member states. Co-operation with other organisations (WHO, EEA, EU) is envisioned, in particular during the data collection.

Indicators will be developed for adults and children, at the European scale. The focus will be placed on links between physical/chemical/biological factors living environment and health priority diseases (respiratory diseases, neuro-developmental diseases and childhood cancer).

The criteria for selection of indicators are the following:

- relevant: fitness to a purpose
- useful: highlight temporal/spatial trends or provide a warning
- scientifically credible: clear E&H relationship, good quality data
- data-availability & comparability
- understandable

Outcomes: a set of environment and health indicators will be proposed on the following categories:

- Childhood cancer
- Endocrine disruptors
- Respiratory health
- Neurodevelopment

Global Initiative on Children's Environmental Health Indicators[26]

Description: a Global Initiative on children's environmental health indicators (CEHI) was launched at the WSSD in 2002. It represents a global effort (see Partners below) to improve environmental conditions to children. The implementation of this Initiative is lead by the WHO.

Participating countries/Partners: the Global initiative involves Governments of Canada, Italy, Mexico, South Africa, and the United-States. International organisation: the CEC, the OECD, UNICEF, UNEP, and WHO. It also includes non-governmental organisations: the international network on children's health, environment and safety (INCHES); the international society of doctors for the environment (ISDE); and, the physicians for social responsibility (PSR).

Objectives: the objectives of the CEHI Global Initiative are to develop and promote the use of children's environmental health indicators in informing policy makers on the effectiveness of public interventions aiming at improving children's health. This should encourage the assessment of children's environmental health.

Methodology: the MEME model provides the conceptual and theoretical basis for the development, collection and use of children's environmental health. The project builds on previous work undertaken in the area to initiate a series of regional pilot studies on each continent to develop, collect and report children's environmental health indicators. Regional pilots have already started (in 2004) in North America, Latin America and the Caribbean, Europe, the Middle East and Africa.

The selection criteria used for environmental health indicator include the following:

- Scientific validity
  - Credible - i.e. base on a known linkage between environment and health
  - Sensitive to changes in the conditions of interest
  - Consistent and comparable over space and time
  - Robust - i.e. unaffected by minor changes in methodology, scale or data
  - Representative of the conditions and area of concern
  - Accurate - i.e. based on reliable data
  - Scalable - i.e. capable of being used at different scales
- Utility and practicability
  - Relevant to an issue of policy or practical concern
  - Actionable - i.e. related to a condition which is amenable to influence or control

[26] Source: WHO (2004b).

- Understandable by and acceptable to those at whom it is addressed
- Timely - i.e. up-to-date
- Specific - i.e. targeted at an explicit phenomenon or issue
- Measurable - i.e. base on available data and manageable methods
- Cost-effective - i.e. capable of being constructed and used at acceptable cost

Outcomes: This project has pre-selected indicators representing the five major causes of illness and death in children under 5, which are[27]:

- Perinatal diseases;
- Respiratory diseases;
- Diarrhoeal diseases;
- Insect-borne diseases; and,
- Physical injuries.

Limitations of these projects

All these projects provide considerable and valuable inputs to the development of indicators on children's environmental health. However, many of them present some limitations that should be examined in order to improve the quality of resulting indicators. Two broad categories can be identified: construction issues and measurement issues.

Construction issues

The main deficit common to past and current programmes developing environmental health indicators is related to the differences in indicator definitions and construction, which includes geographical scale, age groups, diagnosis, time periods and selection criteria. This issue increases the difficulty of comparing indicators. Indicators are tools that serve specific needs, what means that each project will provide different indicators according to its own objectives and interests. However, the lack of harmonisation in the definition of indicators and the variation in their national interpretation may be seriously problematic. Further developments are required in order to obtain comparable and reliable information.

The selection criteria used to determine which indicator is appropriate or not are another source of definition/construction disparity. The definition of an indicator contains some criteria for the selection of an indicator in the final set or its reject. However, the selection criteria have not been fully standardised yet. In the literature, a wide array of selection criteria are referred to as a precondition for including an indicator into an indicator set. In the end, all studies seem to use the same criteria, defined differently but basically identical.

[27] See Annex 2, table E for an overview of recommended indicators.

The most commonly used criteria of indicator selection apply OECD recommendations for environmental indicators, meaning that indicator's characteristics include policy relevance, utility, analytical soundness and measurability, as presented in Section 1.

Measurement issues

The differences in the system of data collection between the different countries – and therefore between the various projects – are another major problem. The lack of harmonisation in the methodological approaches does not facilitate the comparison. Further development is required in order to provide comparable information.

Another common result is the lack of data: when data are missing or difficult to collect, inappropriate data may be used instead. There is an obvious lack of socio-demographic data in the data analysis, though lots of data sources are available. Diet, lifestyle, education data are also missing though they could contribute a lot to indicators construction. Appropriate indicators for housing, long-term exposure chemicals, indicators of early effects would also be extremely useful to better understanding these issues and to find efficient way to reduce or mitigate them.

The scarcity of data may also cause problems of reliability and compliance to quality control in using not appropriate or irrelevant environment and health data. Feasibility studies for new indicators would help improve reliance and quality of the data.

The division of information source may also cause problems of technical comparability[28]. It implies data exchange with many holders which is time consuming and use more resources than necessary. Centralisation of data could facilitate the development of relevant indicators for environment-related health problems.

Harmonisation of definitions, selection criteria and methodological approaches would constitute an important step forward and would help providing more efficient policy advice. A harmonised set of environment and health indicators would help better understand the health risk associated with specific environmental hazard, and this is even more important when considering indicators on children's health. By enhancing data comparability, it would enable international comparisons and would result in a better use of existing data, taking into account different user needs at different levels (i.e. by developing different subsets or user-windows as in the ECHI project). As a consequence, it will save resources.

In order to avoid duplication of work, future projects (or projects just about to be launched) should account for previous work undertaken in WHO, the EEA, the EU and the OECD. Even though the associated projects are not perfect and some are not specifically focused on children or on other specific age groups, they provide guidance on the various aspects of the development process of an environment and health indicators set and highlight difficulties that may be encountered when considering children as well. Mechanisms for co-operation between international agencies should thus be encouraged in order to develop sound children's environmental health indicators.

[28] This issue is not specific to environmental health data but is common to environmental data more generally.

Concluding remarks

The valuation of the environmental health risks to children requires a better understanding of the relationship between environment and health. To evaluate the state of children's environmental health, sets of indicators are being developed to inform and help policy makers appreciate the effectiveness of current environment and health policies aiming at reducing adverse health effects, thus facilitating priorities setting.

So far, only a few sets of children's environmental health indicators are available. This can be mainly explained by the lack of suitable data. In the meantime, this scarcity may encourage second-best solutions, such as using/transferring available data even though they may not be appropriate. However, developing children's environmental health indicators cannot be based on these sources alone, making new data collection urgently needed.

Moreover, the lack of consensus about some key characteristics of indicator sets does not enable any comparability. Reliable environmental health indicators highly depend upon the existence of well established and definable relationships between environmental conditions and associated health outcomes. Difficulties in establishing these relationships are particularly true for children, which may make the assessment of indicators set difficult.

The range of environmental threats to children's health is quite broad and differences exist among various regions of the world. The level of comparability/transferability of children's environmental health indicators is currently limited, because of disparities in definitions, methodologies and standards in each country. Despite efforts made to achieve a certain level of harmonisation, important gaps still remain with respect to methodological approaches. Efforts need therefore to be made in order to improve the comparability between these indicators over time and to identify the need for further research and co-operation on the data collection and analysis.

Designing children's environmental health indicators: a way forward

The main aspect of the design of children's environmental health indicators is the choice of the **underlying framework**. In the case of environmental health, and more particularly children's environmental health, the cause-effect relationships are particularly complex to establish, mainly because of the confounding factors and other sources of complex interactions. Unlike traditional frameworks used to elaborate environmental health indicators, the MEME model accounts for the many-to-many relationships between environment and health, thus appearing as the most appropriate, relevant and flexible model in this context.

As the framework is supposed to reflect the needs and interests of involved parties, a flexible approach should be recommended. For example, adjustments should be possible in order to fit country own interests and applied collection data methodology.

Selection criteria are another source of concern. In order to facilitate the "mapping" of policy questions over the indicator set, the issues must relate to aspects of environment and health which are of both relevance to the decision-makers and – directly or indirectly – amenable to control. A number of criteria and evaluations have been used to select priority issues of environmental health concern. However, they are more or less equivalent to those recommended by the OECD (1993) for its work on environmental indicators, namely:

- Policy relevant: fits to a specific purpose

- Usable: highlights temporal/spatial trends or provides a warning
- Analytically sound: clear E&H relationship, good quality data
- Measurable: available and comparable

Empirical evidence suggests existence of heterogeneity among **children populations** (Tamburlini, 2003). As exposed in Rigby et al. (2003), childhood can be decomposed into different stages, traditionally into age bands of five-year. Each of these stages of childhood has its own health issues, determinants and needs. Therefore, indicators of children's health need to be designed over age groups, as done in the CEHI Project. Children's environmental health indicators should then be defined over five broad stages: 0-1 year, 1-5 years, 5-10 years, 10-15 years, and 15-18 years.

Given the recommended use of the MEME framework, **children's environmental health indicators should be categorised** as the following:

- Context
- Exposures
- Health outcomes
- Actions

Harmonised agreement on a list of **priority areas** should be pursued. As suggested in SCALE (2004), priority areas could include noise, water, food, housing, air pollution, allergy and asthma, and traffic, since they represent new policy issues in most OECD countries. The focus should be placed on priority children's environmental health concerns rather than on the actual indicators, such as is done in the CHEINA project (in the short term). And, for a more efficient policy advice, strong links with concerned public health systems should be established.

Concerning the lack of suitable data, a good compromise would consist in using existing data and indicators, and further promote data collection to achieve a more harmonised and complete assessment of the state of children's environmental health in the long term, as undertaken in the Global Initiative (INCHES et al., 2002). To this end, the CEHI core set of children's environmental health indicators should constitute the best starting point (see Annex 2 Table E for an overview of CEHI core set of children's environmental health indicators).

Environment and health indicators, and more particularly children's environmental health indicators, constitute an essential tool for related-field researchers and policy advisors in governments, the private sector and the academic community, to carry out comparative analyses and draw lessons from international comparisons. Reliable children's environmental health indicators would help policymakers identify and prioritise the environmental health issues that need to be addressed, evaluate the effectiveness of past and current environment and health policies focused on children, and respond to emerging policy issues (Corvalàn et al., 1997). The development and use of children's environmental health indicators requires further work while remaining a priority.

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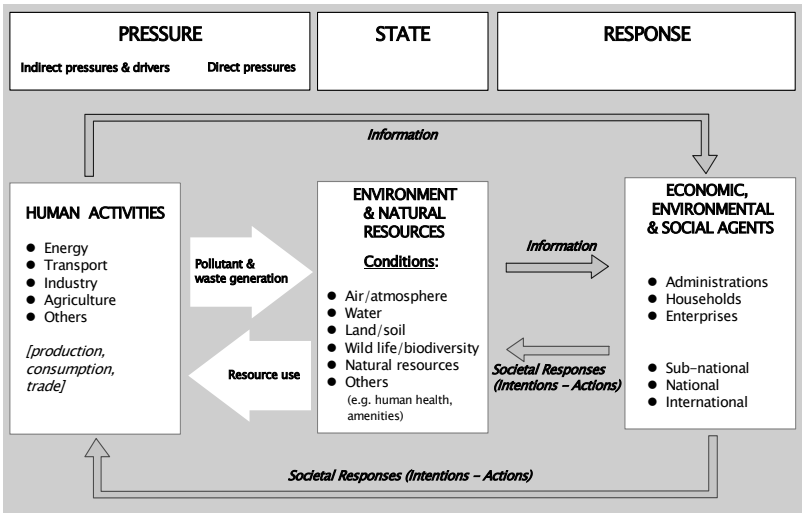
Annex 1 – The Pressure-State-Response Model

The PSR model has initially been developed by the OECD to structure its work on environmental policies and reporting (e.g. OECD, 1985). It considers that: human activities exert pressures on the environment and affect its quality and the quantity of natural resources ("state"); society responds to these changes through environmental, general economic and sectoral policies and through changes in awareness and behaviour ("societal response").

- The PSR model highlights these cause-effect relationships, and helps decision makers and the public see environmental, economic, and other issues as interconnected. It thus provides a means of selecting and organising indicators (or state of the environment reports) in a way useful for decision-makers and the public, and of ensuring that nothing important has been overlooked.
- The PSR model has the advantage of being one of the easiest frameworks to understand and use, and of being neutral in the sense that it just says which linkages exist, and not whether these have negative or positive impacts. This should however not obscure the view of more complex relationships in ecosystems, and in environment-economy and environment-social interactions.
- Depending on the purpose for which the PSR model is to be used, it can easily be adjusted to account for greater details or for specific features. Examples of adjusted versions are the Driving force - State - Response (DSR) model formerly used by the UNCSD in its work on sustainable development indicators, the framework used for OECD sectoral environmental indicators and the Driving force-Pressure-State-Impact-Response (DPSIR) model used by the EEA.



Environmental pressures describe pressures from human activities exerted on the environment, including natural resources. "Pressures" here cover underlying or indirect pressures (i.e. human activities themselves and trends and patterns of environmental significance) as well as proximate or direct pressures (i.e. the use of resources and the discharge of pollutants and waste materials). Indicators of environmental pressures are closely related to production and consumption patterns; they often reflect emission or resource use intensities, along with related trends and changes over a given period. They can be used to show progress in decoupling economic activities from related environmental pressures, or in meeting national objectives and international commitments (e.g. emission reduction targets).

Environmental conditions relate to the quality of the environment and the quality and quantity of natural resources. As such they reflect the ultimate objective of environmental policies. Indicators of environmental conditions are designed to give an overview of the situation (the state) concerning the environment and its development over time. Examples of indicators of environmental conditions are: concentration of pollutants in environmental media, exceedance of critical loads, population exposure to certain levels of pollution or degraded environmental quality and related effects on health, the status of wildlife and ecosystems and of natural resource stocks. In practice, measuring environmental conditions can be difficult or very costly. Therefore, environmental pressures are often measured instead as a substitute.

Societal responses show the extent to which society responds to environmental concerns. They refer to individual and collective actions and reactions, intended to:

- mitigate, adapt to or prevent human-induced negative effects on the environment;
- halt or reverse environmental damage already inflicted; and,
- preserve and conserve nature and natural resources.

Examples of indicators of societal responses are environmental expenditure, environment-related taxes and subsidies, price structures, market shares of environmentally friendly goods and services, pollution abatement rates, waste recycling rates, enforcement and compliance activities. In practice, indicators mostly relate to abatement and control measures; those showing preventive and integrative measures and actions are more difficult to obtain.

Annex 2 – Overview of recommended environment and health indicators.

Table A – The EHIS project[29]

	Driving Forces	Pressures	State	Exposure	Effects	Actions
Air quality	Road transport fuel Tonne-kilometres Passenger-kilometres	Pollutant emissions to air		Population-weighted urban annual average concentration of: NO_2, PM_{10}, $PM_{2.5}$, SO_2 Distribution of daily O_3	Years of Expected Life Lost (YLL) attributed to long-term exposure to fine particles	Policies on ETS exposure
Noise				Population exposed to noise by sources	Attributable risk for cardiovascular morbidity, mortality Self-reported annoyance and sleep disturbance	National regulations for leisure events Urban/ national action plans EU Noise Directive country enforcement
Housing				Affordability Accessibility Crowding Dampness and mould Radon in dwellings Household hygiene Crime and fear of crime	Extremes of indoor temperature Domestic accidents: injuries and fatalities	
Traffic Accidents			Renewal rate of passenger cars Road accident rates Speed limit	Time spent on the road Use of vehicle safety devices	Mortality due to transport accidents Potential YLL attributable to traffic	

[29] Source : http://www.who.dk/EHindicators/Indicators/20030528_1

	Driving Forces	Pressures	State	Exposure	Effects	Actions
			exceedences		accidents Injury rates DALY lost due to traffic accidents Mortality due to driving drinking	
Water and Sanitation		Wastewater treatment	Recreational water compliance Drinking water compliance	Safe drinking waters: access to piped regulated water supply	Outbreaks of water-borne diseases	Bathing waters management systems Water safety management
Chemical Emergencies		Industrial facilities under EU 'Seveso II' directive				Government preparedness Land-use planning Active register of chemical incidents
Radiation					Skin cancer incidence	Effective monitoring of radiation activity

Table B – The ECHI project

Source: http://europa.eu.int/comm/health/ph_projects/1998/monitoring/monitoring_project_1998_full_en.htm#8

Class 1: Demography and socioeconomic situation	• Population • Socio-economic factors		
Class 2: **Health Status**	• Mortality	• Life expectancy and related indicators • General mortality • Cause specific mortality	
	• Morbidity	• Morbidity, disease-specific	• Diseases/disorders of large impact • Diseases selected for other reasons
	• Generic health status		
	• Composite measures of health status		
Class 3: **Determinants**	• Personal and biological factors	• Biological risk factors • Personal conditions	
	• Health behaviours	• Substance use • Nutrition • Other health related behaviours	
	• Living and working conditions	• Physical environment	• Outdoor air • Housing • Drinking water supply • Sewage system • Ionising radiation • Noise
		• Working conditions	• Physical workplace exposure • Mental workplace exposure • Accidents related to work • Occupational diseases
		• Social and cultural environment	• Social support • Social isolation/networks • Live events

Class 4: **Health systems**	• Prevention, health protection and promotion	• Disease prevention • Health promotion • Health protection	
	• Health care resources	• Facilities • Manpower • Education • Technology	
	• Health care utilisation	• In-patient care utilisation • Pu-patient care utilisation • Surgical operations • Medicine use/medical aids	
	• Health expenditures /financing	• Health care system • National expenditures on health • Expenditures on medical services • Medical goods dispended to outpatients • Total health expenditure by age group • Health expenditure by fund source	
	• Health care	• Subjective indicators • Health care process indicators • Health outcomes	

Table C – The CHILD project

Source: http://europa.eu.int/comm/health/ph_projects/2000/monitoring/fp_monitoring_2000_exs_08_en.pdf

Class 1: **Demography and socioeconomic situation** **(upstream health determinants**	• economic circumstances • poverty • parental education • education attainment • single parent household • asylum seeking		
Class 2: **Health status and well-being**	• mortality	• total mortality • selected cause- specific child mortality rates	• infectuous diseases • congenital malformations • malignant neoplasm (cancer) • unintentional injuries • (burns, poisoning, transport, drowning, suicide, assault and homicide, perinatal).
	• morbidity	• incidence of childhood caner • incidence of childhood diabetes • prevalence of asthma • incidence of specific childhood infectional diseases • child dental morbidity	
	• injuries	• burns • poisoning • fractures	
	• mental health	• attempted suicide	
	• mental health (indicators to be developed)	• child abuse	
	• mental health (indicators to be developed)	• behavioural disorders	• hyperactivity • conduct disorders • adolescence depression • adolescence anxiety • learning disorders • educational development • perceived well-being • permanent or severe

			disability
Class 3: **Determinants of health, risk and protective factors**	• parental determinants	• breastfeeding • exposure to household environmental tobacco smoke • parental support	
	• lifestyle determinants	Physical activity • tobacco smoking • alcohol abuse • substance misuse	
	• other health determinant factors	• overweight/obesity • children in care • early school leavers • pre-primary education enrolment • air pollution exposure of children	
Class 4: **Health systems and policy**	• health systems policy		
	• health systems quality		
	• social policy indicators		
	• physical protection policy	• transportation safety • protection from exposure to lead • protection from exposure to potentially hazardous noise • reduction of exposure to environmental tobacco smoke	
		• play and leisure (to be developed)	• access to safe facilities
		• healthy parenting (to be developed)	• percentage of children whose parents have attended educational programmes

Table D – The CHEINA project

Source: CEC (2003).

Priority Area	Indicator Name	Type of Measure	Description/Comment
Asthma and Respiratory Disease	Percent of children living in urban areas where air pollution levels exceed relevant air quality standards	Exposure surrogate	Obtainable by cross-referencing air quality data with census data for urban areas. Either national or WHO air quality standards can be used.
	Indoor Air Quality	Exposure surrogate	Measure of children exposed to secondhand smoke in Canada and the US, and biomass fuels in Mexico.
	Prevalence of asthma cases	Effect	Can be the number of children under 18, 14, 5, or a combination of ages. In Canada and US, information is obtained by household surveys. In Mexico, doctors report cases on a diagnosis form.
Effects of Lead and Other Toxic Substances on Children's Health	Blood lead levels (presented by range, e.g., below detectable level; detection limit - 2.5 ug/dl; > 2.5-10 ug/dl; > 10 ug/dl)	Exposure	Although lead may have health effects at lower levels, 10 ug/dl is considered a trigger for medical intervention.
	Children living in homes with a source of lead	Exposure	Sources of lead reflected in the indicators may vary by country, depending on the major sources of concern and data availability.
	Pesticides (body burden, residue levels on food, use or sales)	Exposure	Best measure is body burden, followed by residue levels on food and use data. Sales data is not desirable.
	Pollutant Release and Transfer Register (PRTR) data	Exposure	PRTR data exist in all three countries. These data can highlight releases of a range of chemicals.
Water-borne Diseases and Children's Health	Percent of children (households) served with treated water	Exposure	Counts how many children/ homes/people have access in their home to water piped from a centrally treated system. Alternative indicator could be children (households) without access to treated water.
	Percent of children (households) served with sanitary sewers	Exposure	The percentage of children (households) who have sewage removed from their immediate surroundings will require further discussion and refinement.
	Morbidity (number of childhood illnesses attributed to waterborne disease)	Effect	
	Mortality (number of child deaths attributed to waterborne disease)	Effect	
	Percentage of children served by drinking water systems in violation of local standards	Action	Consider additional criteria, such as systems with <x violations per year, number of days in violation, etc.

Table E – The CEHI Project

Source: Briggs (2003)

	Contexts	Exposures	Health Outcomes	Actions
Perinatal diseases	Children aged 0-14 years being in poverty	Famine risk People living in informal settlements Women of childbearing age who are malnourished Women of childbearing age working in unregulated workplaces Births to mothers living in unsafe or hazardous housing	Perinatal mortality rate Intrauterine growth retardation in newborn children Congenital malformations requiring surgical correction in children under one year of age	Women of childbearing age within one hour's travel of specialist maternity and perinatal care Attributable change in number of households lacking basic services Prevalence of stunting in children aged 0-4 years
Respiratory Diseases	Children aged 0-14 years living in poverty	Children aged 0-14 living in unsafe, unhealthy or hazardous housing Overcrowding Children aged 0-14 years living in proximity to heavily trafficked roads Mean annual exposure of children aged 0-4 years to atmospheric particulate pollution Children aged 0-4 years living in households using biomass fuels or coal as the main source of heating and cooking Children aged 0-14 years living in households in which at least one adult smokes on a regular basis Intrauterine growth retardation in newborn children	Mortality rate for children aged 0-4 years due to acute respiratory illness Morbidity rate for children aged 0-4 years due to acute respiratory illness Prevalence of chronic respiratory illnesses in children aged 0-14 years	Attributable change in tobacco consumption Attributable change in atmospheric pollutant concentrations Attributable change in numbers of households relying on biomass fuels or coal as the main source of heating or cooking
Diarrhoeal diseases	Children aged 0-14 years living in poverty	Drinking water supplies failing national microbiological water quality standards People living in informal settlements Children aged 0-14 years living in disaster-affected areas Children aged 0-14 years living households without basic services for water supply, sanitation, and hygiene	Diarrhoea mortality rate in children aged 0-14 years Diarrhoea morbidity rate in children aged 0-4 years Recurrence rate of outbreaks of diarrhoeal disease among children aged 0-4 years	Attributable change in the number of households lacking basic services Attributable change in the number of food outlets failing food hygiene standards Children aged 0-4 tears able to obtain rehydration therapy within 24 hours of need
Insect-borne diseases	Population growth rate in areas endemic for insect-borne diseases	Total area of insect vector habitats Children aged 0-14 years living in households providing suitable	Mortality rate of children aged 0-4 years due to insect-borne diseases Prevalence of insect-borne diseases in children aged	At-risk children aged 0-14 years covered by effective, integrated vector control and management systems.

	Contexts	**Exposures**	**Health Outcomes**	**Actions**
		conditions for insect-borne disease transmission Children aged 0-14 years living in areas endemic for insect-borne diseases	0-14 years	
Physical injuries	Children aged 0-14 years living in poverty	Children aged 0-14 years living in disaster-affected areas Children aged 0-14 years living in proximity to heavily trafficked roads Children aged 0-14 years involved in routing employment Children aged 0-14 years living in unsafe, unhealthy or hazardous housing Children aged 0-14 years living in homes lacking access to a piped water supply	Mortality rate of children aged 0-14 years due to physical injuries Incidence of physical injuries to children aged 0-14 years	Children aged 0-14 years living within reach of specialist emergency medical services Attributable change in physical injuries to children aged 0-14 years requiring treatment