In August 2000, the World Health Organization organised an expert consultation on Methodology for the assessment of the environmental burden of disease (EBD) in Buffalo, NY, to further advance the agenda of quantifying health impacts caused by environmental factors. The consultation took place following the 12th Annual Meeting of the International Society for Environmental Epidemiology, which also dedicated a special symposium to the environmental burden of disease. This Symposium reported on the progress on estimating the health impacts of indoor air pollution, noise, lead and climate change. Current efforts build on previous results obtained in the 1997 consultation “Methods for Health Impact Assessment in Environmental and Occupational Health”, to which Epidemiology devoted a special section in the September 1999 issue (1). This consultation was part of WHO’s intensified effort to develop methods and support countries by providing guidance to assess their environmental burden of disease in a consistent way.

The Consultation was part of an ongoing process aiming at the following:

- To create a network of experts interested in developing the conceptual and practical implementation of environmental burden of disease assessment and sharing experiences to define priorities in future developments;
- To provide methodological guidance on the quantitative assessment of the environmental burden of disease at national or regional level.

Increasingly, countries wish to use information about disease burdens for priority setting and resource allocation in health, including environmental health. The concept of disease burden refers to a systematic and internally consistent quantification of health problems of a defined population, preferably using a summary measure of population health which integrates mortality and morbidity information. Together with information on cost-effectiveness of...
interventions within a social and ethical framework, the policy environment and available technologies, the burden of disease can provide a rational basis for research, implementation and policy development. Several countries are currently engaged in national burden of disease studies. Most of them primarily focus on the national pattern of disease burden in order to determine what disease groups cause the largest burden at the national level. Increasing interest is, however, directed towards causative life-style, social or environmental factors that contribute to this disease burden in a relevant manner, such as alcohol intake, physical inactivity, or air pollution.

The quantification of environmental burden of disease has an array of potential uses:

- At the national level it provides information about the contribution of risk factors to the national burden of disease “picture” and its preventable part, and feeds into the decision-making process;
- It assists in monitoring progress;
- It points to vulnerable population subgroups and compares environmental health to other areas;
- At the international level, the environmental burden of disease assessment provides a worldwide picture of disease burden due to environmental risk factors;
- It provides information for major policy directions and highlights main problems at the global level;
- It points to countries in greatest need for support on selected issues and provides information to donors.

A harmonized method of assessing the environmental burden of disease (EBD) would facilitate such initiatives around the world, and support the development of consistent estimates. A number of challenging methodological issues will need to be addressed, taking into account the reality of environmental health data availability and the evidence base. Also, resulting data should be tied into the general framework for decision-making in environmental health (2).

**General issues**

Given the type of data and evidence in environmental health, balancing accuracy and feasibility will drive practical aspects of the assessment methodology. Environmental risk factors with a certain exposure pattern in the population will probably be easiest to assess (patterns can be area-based, such as similar air pollution levels within one area; exposure can also have patterns based on local practices or culture, for instance fuel use for indoor air pollution).

The distribution of the EBD within a population should be assessed in the addition to the absolute numbers. This distribution will provide information about the equity in exposures and health outcomes among relevant subgroups of the population. Such information will be a valuable input for policy making in view of the protection of vulnerable groups or high-risk communities. Guidance about assessing the distribution of environmental burdens has not been a focus of method development to date; more research is warranted.

To facilitate policy making, EBD assessments should be embedded into the decision-making process through established frameworks. One such framework, for example, is the DPSEEA approach which identifies the following components or stages: Driving Force – Pressure – State – Exposure – Effect – Action (3).

Agreement on a general method for EBD assessment will enhance comparability. The method should, however, be flexible enough to take into account the various issues specific to environmental health, which are raised below. For completeness, positive health impacts should also be considered when evaluating disease burden from health determinants, such as the positive effects of development or increasing living standards.

**Categorization of risk factors**

Various types of categories can be chosen for estimating the related health impacts: the type of human activity (e.g. energy generation, transportation), the type of pollutant (e.g. exposure to lead, arsenic) or the pathway (e.g. air pollution, water). Furthermore, the categories can be aggregated or split into subcategories, for instance water & sanitation could theoretically be split into exposure to recreational water, drinking water intake, access to sanitation etc. However, categorizing risk factors should be carefully considered, as this may have an impact on the decision-making process. In particular, their grouping or splitting into several subcategories may seemingly reduce or increase their importance.

The choice of risk factor categories should be relevant to policy and seek to address parameters...
policy makers can directly influence (e.g. include sector policies as risk factors, such as transportation policy or energy policy, in addition to specific risk factors such as ‘air quality’, ‘noise’ etc.).

Selection of summary measures of population health
Summary measures of population health are measures that combine mortality and morbidity in a single unit to represent the health of a population. The assessment of EBD needs to be flexible and describe areas such as “quality of life” or “annoyance”, which may result in indirect health impacts. The summary measures of population health (the most widely used being the Disability-Adjusted Life Year, or DALY (4)) should satisfy these needs.

Alternative scenarios
Alternative scenarios are baseline (or “counterfactual”) scenarios for comparison with the exposure scenario to be studied. Alternative scenarios should also be relevant in terms of policy setting, as for example alternative energy scenarios, or alternative transport policies. Their choice should also depend on the planned use of the resulting estimates, as well as the planned user (e.g. water sector, health or environment ministry, urban planning etc.).

The strength of evidence
The strength of evidence underlying a burden of disease estimate should be described and evaluated in a systematic and comparable way. It is questionable whether the policy maker will make use of information on strength of evidence or level of uncertainty. Nevertheless, an association that is not reflective of an underlying causal chain will not provide a robust basis for reducing disease burden. Furthermore, EBD assessment should draw upon the best available evidence, rather than be restricted to the best evidence. An analysis of the uncertainty around estimates should therefore accompany the EBD estimate.

Suitable approaches
Suitable approaches need to be developed on a variety of issues.

The often limited availability of data needs to be reflected in the type of analysis carried out. For example, it may be possible (or necessary) to use “observational data” in the estimation of disease burden. For example, use of a certain cooking fuel has been associated with acute respiratory infections. Although personal exposures are not generally assessed in most of these studies, such observed associations could be used in evaluating the burden of disease. It would, in such circumstances, be useful to assess the relationships between distal causes (such as ‘use of cooking fuel’) and personal exposures examined in smaller scale investigations to obtain additional information on the links within the causal web. Also, very large data sets may be available for distal causes, whereas information on proximal causes, such as personal exposure, may be much more limited.

Wherever possible, the assessment of disease burden should be based on comprehensive models integrating the various interacting or competing risk factors. Occupational exposures and environmental exposures to chemicals, for example, should be part of integrated risk factor assessments where they play a role. As risks are not merely additive, a combined assessment would usually provide better results. Also for modelling water and sanitation, a common framework is essential to take into account the interactions between the various exposures and health and the circulation of chemical and microbiological agents.

Probability-density functions, rather than point estimates, have shown to be useful tools in modelling exposure. This is particularly the case when only the most extreme exposures cause severe health outcomes, or when the dose-response relationship is not linear.

Prioritisation of risk factors to assess
If data are available, ‘the environment’ should be considered in a much broader manner than would be the case by simple consideration of the ‘exposure’ or easily quantifiable ‘risk factors’.

For example, environments promoting certain behaviours or risks, such as ‘accident promoting environments’ could also be considered.

The development of methods is based on the estimation of the burden of disease attributable to six environmental risk factors (indoor air pollution, outdoor air pollution, water and sanitation, lead, occupation and climate change) at global level, which is currently being performed. The next step consists in the preparation of a practical guide for national and regional assessment.

A detailed report on the Consultation and the Special Symposium of the 12th ISEE meeting is available on the WHO web site http://www.who.int/peh/ under “Environmental burden of disease”.

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