

Health, Environment and Sustainable Development. Identifying Links and Indicators to Promote Action

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This paper discusses the links among health, environment, and sustainable development and presents a framework that extends from the epidemiological domain to the policy domain and includes the driving forces that generate environmental pressures, creating changes in the state of the environment and eventually contributing to human exposures. Health effects are the end result of this complex net of events. Environmental health interventions should not be limited to treatment of

cases and directly reducing human exposures. The paper discusses the need for integrated action at all levels and, in particular, on the need to focus on long-term action directed at reducing the driving forces that generate the environmental health threats. Only this approach can achieve sustained health benefits and environmental protection in accord with the principles of sustainable development. (*Epidemiology* 1999;10:656-660)

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In 1992, the world's leaders adopted the principles of the Rio Declaration and Agenda 21 as the route to sustainable development in the 21st century. Thus, the importance of investing in improvements to people's health and their environment as a prerequisite for sustainable development was recognized at the highest decision-making levels. Human health was highlighted as a central aspect of sustainable development; Principle 1 of the Rio Declaration stated, "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature."¹

In the 5 years since the Earth Summit, commitment to securing human health and a healthy environment has become widespread, as evidenced by a number of declarations and statements that have emanated from recent international conferences.² Many countries have formulated or are in the process of formulating national plans for sustainable development that give increased weight to health and environment concerns. These plans, however, need to be supported and implemented by all sectors contributing to economic development,

and progress toward sustainable development needs to be monitored. The links between development, environment and health have been described in Agenda 21,¹ discussed by others,^{3,4} and integrated at the global level in a recent World Health Organization report.⁵

All of these developments at the national and international political levels have promoted a more holistic perspective on health. Health is now a concern for almost every sector of society, not just the health sector. Thus, it is understood that appropriate developments must occur in agriculture, industry, and energy if sustainable health improvements are to be attained. That said, the health sector has an important role as advocate and guide for healthy development.

From a historical perspective, we have evidence that the decline in morbidity and mortality in the past century was due in great part by changes in health determinants: limitation of family size, improvement of nutrition, a healthier physical environment, and specific preventive measures.⁵ The importance of clean water and sanitation for health was accepted by the hygiene and sanitation movement in the United Kingdom and other countries as early as the 19th century.⁶

Successful public health interventions, therefore, are those that concentrate on improving human environments, a task that cannot be achieved by the health sector on its own.⁷ However, as pointed out recently by Beaglehole and Bonita⁶ the ongoing debate about health care reform is generally taking a narrow focus on medical care services and has not properly considered the role of public health and environmental health services.

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Environmental Threats to Human Health

People experience the environment in which they live as a combination of physical, chemical, biological, so-

cial, cultural, and economic conditions that differ according to the local geography, infrastructure, season, time of day, and activity undertaken. The different environmental health threats can be divided into "traditional hazards, which are associated with lack of development, and the "modern hazards," which are associated with unsustainable development.⁸ The changing pattern of environmental health hazards and associated health risks from traditional to modern with time and economic development has been called the "risk transition."⁸⁻¹⁰ This transition in risks occurs before the "epidemiologic transition," which is the term applied to the frequently observed shift in the relative importance of traditional (for example, infectious) and modern (for example, chronic) diseases that accompanies development.

Traditional hazards are related to poverty and insufficient development. They include lack of access to safe drinking water; inadequate basic sanitation in the household and the community; food contamination with pathogens; indoor air pollution from cooking and heating using biomass fuel or coal; inadequate solid waste disposal; occupational injury hazards in agriculture and cottage industries; natural disasters, including floods, droughts, and earthquakes; and disease vectors, mainly insects and rodents.

Modern hazards are related to rapid development that lacks health and environment safeguards and to unsustainable consumption of natural resources. These hazards include water pollution from populated areas, industry, and intensive agriculture; urban air pollution from automobiles, coal power stations, and industry; solid and hazardous waste accumulation; chemical and radiation hazards due to introduction of industrial and agricultural technologies; emerging and re-emerging infectious disease hazards; deforestation, land degradation, and other major ecological change at local and regional level; climate change; stratospheric ozone depletion; and transboundary pollution.

One of the differences between traditional and modern environmental health hazards is that the former are often rather quickly expressed as disease. A person drinks polluted water today and develops severe diarrhea tomorrow, for example. The incidence of diarrhea can accordingly be a relatively useful measure of the risk and of our efforts to control it. For many modern environmental health hazards, however, a long period may pass before the health effect manifests itself. A cancer-causing chemical released into the environment today may not reach a person until it has passed through the food chain for months or years, for instance, and even then may not cause development of a noticeable tumor for decades. Similarly, environmental change, caused by human activities, that occurs over several decades, such as stratospheric ozone depletion due to chlorofluorocarbon emissions, may undermine the life-supporting functions of Earth.¹¹ So, for modern environmental health hazards, understanding the environmental pathways through which the hazards move is particularly important.

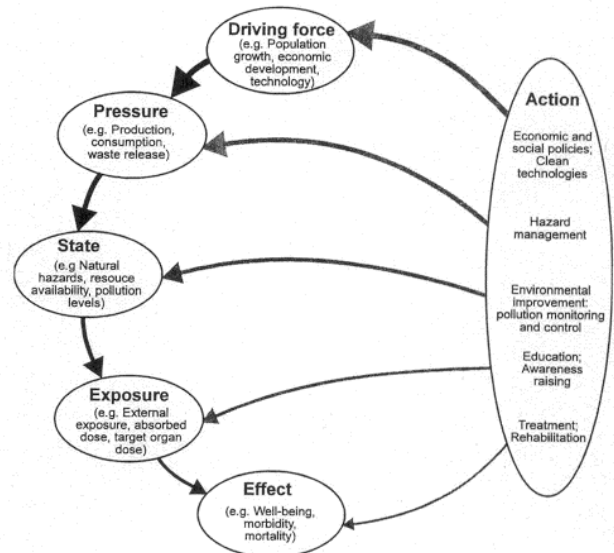


FIGURE 1. Health and environment cause-effect framework: a simplified diagram (modified from Ref 15 and 16).

A Health and Environment Cause-Effect Framework

Clearly, the relation between human health and the environment is complex. Each of the traditional and modern hazards is associated with a variety of aspects of economic and social development. Moreover, there is no single best way of organizing and viewing the development/environment/health relationship that reveals all of the important interactions and possible entry points for public health actions. Several descriptions of the environmental health causal pathway have been proposed.¹²⁻¹⁵ Extending from these, and recognizing the links between development, environment, and human health (and the need for specific "actions" at each step), a comprehensive framework can be devised¹⁶ (Figure 1).

The framework in Figure 1 explicitly recognizes that although exposure to a pollutant or other environmentally mediated health hazard may be the immediate cause of ill health, the "driving force" and "pressures" leading to environmental degradation may be the most effective points of control of the hazard. The "network" of connections within the framework can be used to identify cause-effect "pathways" or "trees," depending on whether the framework is used to analyze the multiple health effects of a single driving force (eg, transport policy relying on car transport leading to increase motor vehicle-related injuries, effects on the respiratory system, noise disturbance, etc) or to analyze the multiple causes of a single health effect [eg, acute respiratory infections (ARI) in children resulting from driving forces such as poverty, household energy policies, housing policies, and agricultural policies (Figure 2).

Specifically, *driving forces* create the conditions in which environmental health hazards can develop or be averted or that are generated by large numbers of people in their pursuit of the basic necessities of life (food and

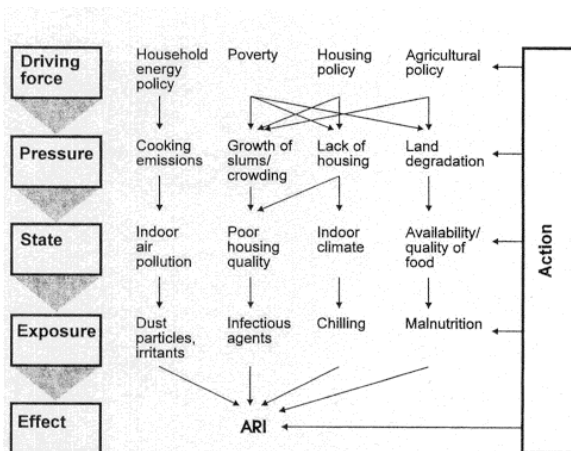


FIGURE 2. Health and environment cause-effect framework: acute respiratory infections in children (modified from Ref 2).

shelter) or in their appropriation and use of consumer goods. Driving forces include policies that determine trends in economic development, technology development, consumption patterns, and population growth.

The driving forces in turn generate different kinds of pressures on the environment, in such forms as waste from human settlements and depletion of natural resources or emission of pollutants from activities such as energy production, manufacturing, transport, mineral extraction, agriculture, forestry, fish harvesting, and tourism. These pressures can lead to changes in the state of the environment, as seen when land use is changed (deforestation or drainage problems) or when discharges of toxic chemicals or other forms of waste increase concentrations of chemicals in air, soil, water, or plants. The pressures are potentially associated with all stages in the life cycle of industrial products, from initial resource extraction and transportation of raw materials, to processing and distribution, to final consumption and disposal.

Whether a resultant altered state of the environment creates a hazard to human health depends on many factors, including the degree to which humans may actually be exposed. Exposure requires that people are present both at the place and at the time when the state of the environment changed and became hazardous. *Exposure* thus refers to the intersection between people and environmental hazards. Levels of exposure may range from harmless and acceptable to dangerous and unacceptable, depending on the potential for physical harm. Given known exposures and the knowledge of dose-response relations, estimates can be made of the health *risk* of specific hazards to the extent that current knowledge allows. But although "hazard" describes the potential for causing harm to human health, it says nothing about the statistical probability that such harm will occur. In contrast, "risk" is a quantitative estimate of the probability of damage associated with an exposure.

Environmental hazards, in turn, can lead to a wide range of health effects. These may vary in type, intensity,

and magnitude depending on the type of hazard to which people have been exposed, the level of exposure, and the number of people affected. Most important diseases are associated with more than one type of exposure, and environmental hazards interact with genetic factors, nutrition, life-style hazards, and other factors in causing disease. The framework (Figure 1) is intended to highlight the important links between different aspects of development, environment, and health and to help identify effective policies and actions to control and prevent health effects. This framework was used in describing and analyzing the global situation concerning development, environment, and health relationships in a recent report entitled "Health and Environment in Sustainable Development,"² which was the World Health Organization's contribution to the 5-year anniversary of United Nations Conference on Environment and Development (UNCED), which was held in New York in June 1997.

Information for Decision-Making and Action

The linkages between the different levels in the framework are the focus of quantitative research and modeling for prediction and health impact assessment. Health policy research would seek quantitative links between driving forces and the ultimate health effect, or intermediate level variables. Environmental science and engineering research seeks links between pressure and state variables. Human exposure assessment research focuses on the links between state and exposure variables, whereas environmental epidemiology deals primarily with the exposure to effect linkages.

As discussed above, environmental health exposures are the result of a complex set of events, and often, environmental epidemiologists must search at "higher" levels of the cause-effect framework for surrogates of exposures. This complexity calls for the environmental epidemiologist to be involved in a more complete description of the risk factors at different levels of the framework when analyzing data and when interpreting and reporting research findings. The traditional way of analyzing epidemiological data only at the immediate level of the actual associations measured does not encourage a broader analysis of the consequences for policy and prevention of the associations found. Meaningful interpretation of any indicator in the framework in relation to decision making about policies or actions should be based on an understanding of these linkages.

The leaders of the hygiene and sanitation movement of the 19th century made these linkages in their use of health statistics to promote environmental health policies and actions to deal with communicable diseases.⁶ There are also more recent examples of the use of environmental epidemiology to demonstrate such linkages, for example, the reduction of lead exposure and lead poisoning in children resulting from the elimination of lead from gasoline and from soldering in food cans¹⁷ and the reduction of traffic accident mortality resulting from a combination of seat belt laws, speed

TABLE 1. Environmental Health Indicators within the DPSEEA* Framework: example of Microbiological Water Contamination (Modified from Ref 16)

	Descriptive Indicator	Action Indicator
Driving force Pressure	Level of poverty in the community Percentage of households without safe drinking-water supply	Expenditure on water and sanitation improvements Number of unserved households provided with clean water supply per year
State	Coliforms in water	Extent of water quality surveillance and water treatment
Exposure	Percentage of population exposed to hazardous water contaminants	Extent of public education programmes on water hazards and treatment in the home
Effect	Morbidity and mortality from diarrheal diseases	Number of cases treated in hospitals and clinics

* DPSEEA = driving force, pressure, state, exposure, effect, action.

limits, legislation on driving while intoxicated, and other policy measures.¹⁸

Information on the health impacts attributable to environmental pollution at local and national levels is urgently needed so that the implications of environmental health decisions can be assessed, the potential effects of different decisions and choices compared, and irreversible and costly health and environmental damage prevented.¹⁶ The term "indicator" has been used to identify types of information used for decision making. These indicators can be defined at the different levels of the health and environment cause-effect framework; examples for a common hazard are given in Table 1.

An understanding of the steps in Fig 1 is necessary if solutions to environmental hazards are to be found and appropriate action taken. Action can be taken at each step in the framework as exemplified in Table 1. In the short term, interventions are often corrective or remedial at the level of the health effect, such as treatment of individuals affected. In the longer term, they should be protective or preventive (for example, various measures to prevent people from being exposed). Preventive interventions may be implemented to reduce or control the hazards at the source (for example, by limiting emissions or installing flood-control systems). The most effective long-term interventions aim at eliminating or reducing the effects of the driving forces or the environmental pressures that produce the hazards. Interventions at the level of driving forces often have multiple implications, because major driving forces exert influence via several causal pathways. Sometimes this can multiply benefits, but care must be taken that the overall impact is beneficial.

The different levels of interventions are illustrated in Figure 2, which is based on ARI in children. ARI is a major cause of death in children under 5 years of age in most countries. As can be seen in Figure 2, several steps in the health and environment cause-effect framework contribute simultaneously to the overall environmental hazard and subsequent damage to children's health. When quantified, this multiple causation framework can be a powerful guide to designing cost-effective and timely interventions. It also provides a means for starting to examine possible synergies among interventions. For example, healthy-child programs that focus on dietary supplements, household ventilation and sanitation, case management, and vaccination, using the same local

health team, can be a beneficial and cost-effective way of addressing ARI mortality in remote rural areas. Depending on the risk factors and ameliorative conditions at play, the same health program would also be expected to make contributions to reducing the mortality rates of several other childhood diseases, such as measles and diarrhea.

Such a framework can also be used to weigh alternatives and to design step-by-step programs for dealing with a particular health problem. For example, environmental improvement, such as air pollution control, housing improvement, and development of nutrition programs, might be the most efficient measures for controlling ARI mortality. They take a relatively long time to implement, though, and an even longer time to produce results. Alternatively, expanded vaccination programs and improved case management could bring the problem under control more quickly. However, to achieve a long-lasting reduction in the incidence of ARI, environmental interventions are essential.

Conclusions

Sustainable development policies should incline us toward longer-term, broad-spectrum interventions, touching upon the driving forces operating in human society. In many developing countries, this would mean tackling inequities, poverty, and population growth and thereby contributing, for example, to the control of land degradation and deforestation, biodiversity loss, soil erosion, food insecurity, and decline in water quality. In developed countries, inequities are also of importance, as sizeable population groups live in squalor and relative poverty. In addition, emphasis should be placed on reducing unsustainable consumption, curbing the use of nonrenewable fuels, and reducing generation of solid wastes to minimize transboundary pollution, toxic waste problems, and global environmental change. All of these actions would have long-term and sustained beneficial effects on human health.

To implement successfully proactive preventive approaches, development policies and planning need a long time horizon. In addition, health and environment concerns must become an integral part of the planning within the framework of sustainable development.

References

1. United Nations. Agenda 21: the United Nations programme of action from Rio. New York: United Nations, 1993.
2. World Health Organization. Health and Environment in Sustainable Development: Five Years after the Earth Summit. Geneva: World Health Organization, 1997.
3. Litsios S. Sustainable development is healthy development. *World Health Forum* 1994;15:193-195.
4. Warford JJ. Environment, health and sustainable development: the role of economic instruments and policies. *Bull World Health Organ* 1995;73:387-395.
5. McKeown T. *The Role of Medicine: Dream, Mirage or Nemesis?* London: Nuffield Provincial Hospitals Trust, 1976.
6. Beaglehole R, Bonita R. *Public health at the crossroads: achievements and prospects.* Cambridge, United Kingdom: Cambridge University Press, 1997.
7. Brown V, Ritchie J, Rotem A. Health promotion and environmental management: a partnership for the future. *Health Promotion Int* 1992;7:219-230.
8. Smith KR. The risk transition. *Int Environ Aff* 1990;2:227-251.
9. Kjellström T, Rosenstock L. The role of environmental and occupational hazards in the adult health transition. *World Health Stat Q* 1990;43:188-196.
10. Smith K. Development, health and the environmental risk transition. In: Shahi OS, Levy BS, Binger A, Kjellström T, Lawrence R, eds. *International Perspectives on Environment, Development, and Health: Towards a Sustainable World.* New York: Springer Publishing Co, 1997;51-62.
11. McMichael AJ, Haffies A, Sloof R, Kovats S, eds. *Climate change and human health.* Geneva: World Health Organization, 1996.
12. Liroy PJ. Assessing total human exposure to contaminants: a multidisciplinary approach. *Environ Sci Technol* 1990;24:938-945.
13. Sexton K, Selevan SG, Wagener DK, Lybarger JA. Estimating human exposures to environmental pollutants: availability and utility of existing databases. *Arch Environ Health* 1992;47:398-407.
14. Sexton K, Callahan MA, Bryan EF. Estimating exposure and dose to characterize health risks: the role of human tissue monitoring in exposure assessment. *Environ Health Perspect* 1995;103(suppl 3):13-29.
15. Kjellström T, Corvalán C. Framework for the development of environmental health indicators. *World Health Stat Q* 1995;48:144-154.
16. Briggs D, Corvalán C, Nurminen M, eds. *Linkage Methods for Environment and Health Analysis: General Guidelines.* Geneva: World Health Organization, 1996.
17. World Health Organization. *Inorganic Lead. Environmental Health Criteria, No. 165.* Geneva: World Health Organization, 1995.
18. Brulming E. Injuries and deaths on the roads: an international perspective. In: Fletcher T, McMichael AJ. *Health at the Crossroads: Transport Policy and Urban Health.* Chichester, United Kingdom: John Wiley and Sons, 1997;109-121.