Health Canada Santé Canada

Canadian Handbook on Health Impact Assessment

Volume 3: The Multidisciplinary Team

Canada

About the cover illustration:

The painting has been created in the woodland style (also known as legend painting or medicine painting). This artistic style is a shamanic tradition that dates back thousands of years and is found in petroglyphs and birchbark scrolls. This style recorded healing practices that have been handed down through generations. These images portrayed messages to be interpreted by future healers. This style has only recently been translated to paint on canvass, as shown by the works of Norval Morisseau (Objibwe, born 1932) and Carl Ray (Cree, 1944-1979). Both of these artists, born at the Sandy Lake reserve (Ontario), conceptualized the woodland style. This style is entirely appropriate for Brant's painting, as it concerns health and the environment. The artist, Kirk Brant, describes what the painting means to him:

> "It struck me that before any policies are made or actions taken concerning health and environmental issues, there must be dialogue. The painting describes two medicine people in dialogue concerning environmental issues. They are surrounded by circles that facilitate the exchange of energy and power. The archetypal imagery of fish and serpents are present as reminders of the other living things that we share with the environment. The serpent that has a head at both ends of its body symbolises eternity, or something without end. I believe that the environment, our Mother Earth is like that. As people we have done damage to her; we have wounded her. We see many instances of our damaging actions. But I don't see an end to her. The Earth will take care of itself regardless of our actions. Damaged ecosystems and species extinctions are sad facts of our actions. If we keep acting like a hurtful organism our existence will become just as fragile and perhaps end but the Earth will continue regardless of our demise. I think that much of the damage and sickness is the result of ignorance. Dialogue must be an important first step in changing things."

As with the original woodland style birchbark scrolls, the meaning of the painting, for example, of the colours and circles, is at the discretion of the viewer. As this painting is passed along, it becomes imbued with meaning not only from the artist but also that of those who appreciate and interpret the images.

CANADIAN HANDBOOK ON HEALTH IMPACT ASSESSMENT

VOLUME 3: THE MULTIDISCIPLINARY TEAM

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A Report of the Federal/Provincial/Territorial Committee on Environmental and Occupational Health

Our mission is to help the people of Canada maintain and improve their health.

Health Canada

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ACKNOWLEDGMENTS

The *Canadian Handbook on Health Impact Assessment* has a long history, evolving over time with input from a significant number of individuals. Only some are specifically mentioned here, though the contributions of all were crucial to the finalization of the Handbook. The Handbook was prepared under the general guidance of the Health Impact Assessment Task Force reporting to the Federal/Provincial/Territorial Committee on Environmental and Occupational Health (CEOH). The CEOH had membership from all provinces, territories, and the federal government. Membership on the CEOH and Task Force represented environment, health, and labour sectors. The Task Force members included representatives of Health Canada and Labour Canada, as well as the following representatives of provincial government bodies:

- Mark Allan, Department of Health and Community Services, New Brunswick
- George Flynn, Alberta Health, Alberta
- Pierre Gosselin, World Health Organization–Pan American Health Organization Collaborating Centre on Environmental and Occupational Health Impact Assessment and Surveillance, Quebec City University Hospital, Public Health Institute, and Public Health Agency, Quebec
- Jerry Spiegel, Department of Environment, Manitoba

The Handbook started as a discussion paper prepared under contract by Kate Davies and entitled *The National Health Guide for Environmental Assessment: A Discussion Paper*. Consultations on the discussion paper took place in 1995 at six multisectoral workshops held in Dartmouth, Nova Scotia; Montreal, Quebec; Toronto, Ontario; Winnipeg, Manitoba; Vancouver, British Columbia; and Ottawa, Ontario.

Based on input from the 1995 workshops, a draft Handbook was written with contributions from several authors. Special thanks go to staff of Health Canada's Environmental Health Assessment Services for coordinating the preparation of the 1998 draft Handbook. In 2000, multistakeholder consultations on the draft Handbook were held in Dartmouth, Nova Scotia; Montreal, Quebec; Toronto, Ontario; Regina, Saskatchewan; Vancouver, British Columbia; and Ottawa, Ontario.

For both the 1995 and 2000 workshops, numerous provincial government and Health Canada regional staff assisted in the planning and delivery of and reporting on the workshops.

The final version of the *Canadian Handbook on Health Impact Assessment* was prepared on the basis of discussions at the workshops held in 2000 and contributions from several authors. Special thanks go to staff of Health Canada's Environmental Health Assessment Services, Healthy Environments and Consumer Safety Branch (HECSB), for their efforts in coordinating input to the Handbook.

Individual authors were involved in the writing of the various chapters of the Handbook. Their input is greatly appreciated. Significant contributions were made by Reiner Banken, Ugis Bickis, Marci Burgess, Pierre Chevalier, Wesley Cragg, Kate Davies, Pierre Dubé, Alan Emery, Pierre Gosselin, Philippe Guerrier, Henry Lickers, Pascale Méra, Robert Rattle, and Alain Webster; Industrial Economics Inc. in Cambridge, Massachusetts; and Health Canada staff in the Department's Environmental Health Assessment Services, the Biostatistics and Epidemiology Division, and the HECSB Office of Policy Coordination and Economics.

Finally, special recognition is given to Pierre Gosselin for his efforts in coordinating input into and finalizing Volumes 2 and 4 of this Handbook.

EXECUTIVE SUMMARY

Volume 3 of the *Canadian Handbook on Health Impact Assessment* addresses key concepts and issues that traditionally had not been adequately considered within the context of environmental assessment (EA) or environmental impact assessment (EIA) and health impact assessment (HIA) – for example, due consideration of stakeholder values, social impact assessment (SIA), economic evaluation of development projects, indigenous HIA, concepts and methods of environmental epidemiology, occupational health, and food issues.

The third volume expands on important elements of Volume 1 with respect to determinants of health, health indicators, Aboriginal health and traditional knowledge, risk perception, and greater public consideration and community action. It is also consistent with Volume 2 regarding the role of health professionals, the development and implementation of projects based on sustainable development principles, and the importance of credible communication with stakeholders, including the general public. As well, the concepts, principles, and approaches outlined in Volume 3 are applied to the Volume 4 discussion of the impacts of development projects in Canada's major economic sectors, which includes information on, for example, economic context, social impacts, Aboriginal values and considerations, and occupational health.

The major topics presented in Volume 3 comprise key concepts and issues that are increasingly recognized as essential to the conduct of effective and accepted HIA within the context of EA. Each of these topics is summarized below.

Values, Health, and Environmental Assessments: Chapter 2 describes how values-based analysis can assist health professionals involved in EAs. Values provide a good foundation for building consensus or solving public policy issues and provide the framework for evaluating the worth or merit of projects under assessment. Values allow us to differentiate between costs and benefits and play an essential role in decision-making. Deciding on whether to proceed with a given project will therefore depend on how the values of the project's stakeholders are factored into the decision-making process.

To assess the impact of a project on the health of those likely to be affected by it, an EA must identify how the project will affect the capacity of its stakeholders to realize their needs and aspirations. This requires: 1) identifying those likely to be affected by a proposed project; 2) identifying and including the full range of values important to those likely to be affected; and 3) properly understanding the stakeholders' values.

Understanding stakeholder values involves understanding the function of values. Essentially, values can be of two types: core values and use values. Core values (e.g., health, public participation) recognize things that identify the ends or the fundamental goals and objectives that in turn define the stake or the interest that makes an individual, group, or company a project stakeholder. For health professionals participating in an EA, the key core value is health. Impact on health is therefore the key issue and the central criterion for assessing the positive or negative value of a project. Use values identify things (e.g., water) whose value derives from their utility or usefulness in realizing goals and objectives of fundamental importance. Use values in turn can be instrumental, essential, or symbolic values. Failure to recognize the different roles played by use values can result in serious misunderstandings and conflict.

In addition, it is important to realize that identifying values for which traditional remedies such as compensation are not appropriate, can create conflict. If health and respect for culture are core values in EA, then problems that cannot be mitigated, and for which substitution and compensation are inappropriate, cannot be ignored. Also, direct and indirect impacts on core values can be negotiated. In some cases, negotiation will result in radically redesigned projects. In other cases, it will result in recommendations that projects not go ahead.

This chapter also provides advice on how to build values into each step in the EA process. Acknowledging core values in particular and responding to them with respect are the foundation of effective problem-solving, which, together with health as a core value, is a key goal of effective EA.

Social Impact Assessment in Environmental Impact Assessment Protocols: SIA is a powerful tool for project planning and decision-making in EA. It describes the social context within which development projects are undertaken; assesses, in advance, the social impacts of a policy, program, or project on affected communities; and proposes mitigation measures to avoid, reduce, or compensate for the impacts. SIA also identifies those groups at risk or at benefit and, when possible, the extent of the impacts.

SIAs are of value to health practitioners involved in HIA and EA, especially in terms of the research process. SIAs rely heavily on public involvement and participatory methods and collect qualitative information that is related to the determinants of health – for example, public perception of the project's positive and negative effects (including risk); and consequences that induce stress or anxiety at the individual or community level (e.g., loss of land, loss of economic security, resettlement). SIAs are also a main source of quantitative health data.

Linkages between SIA and HIA are important, especially given the various risks associated with a project and the fact that perception and acceptance of risk vary, depending on the interests and agendas of different stakeholders. Integrating SIA and HIA generates a more holistic assessment; reduces duplication of data and information resources, thereby enhancing financial efficiency; avoids inconsistencies; enhances the strengths and complementarity; enhances the value of social and health sciences in EA; and balances the trend towards reductionism.

The SIA process consists of seven steps: 1) design the public involvement plan; 2) describe the proposed project and identify alternatives; 3) describe baseline conditions (social environment and area of influence); 4) identify the key issues to be considered in the SIA and the information required to assess the key issues; 5) evaluate impacts and determine their significance; 6) identify mitigation measures to prevent, reduce, or compensate for the impacts; and 7) develop a monitoring program that is capable of identifying deviations from the proposed action and any important unanticipated impacts.

SIAs that involve stakeholders can reduce local resistance to projects and increase acceptance, thereby preventing costly delays. SIAs can improve the planning process and also can prevent or minimize negative impacts. As well, by developing approaches and practices that are appropriate to local conditions, SIAs can enhance project benefits. Lastly, by identifying all stakeholders and analysing how specific impacts (both positive and negative) affect different stakeholder groups, SIAs have the potential to ensure that the benefits of the project are equitable.

The social environment is described in SIAs in terms of demographics and population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources. The types of social impacts identified in SIAs include 1) impacts on population; 2) impacts on community resources; 3) land use and occupancy patterns; and 4) economic impacts.

Overall, Chapter 3 emphasizes that changes in the social environment can effect changes in variables related to health. HIA practitioners can use SIA to identify the type of information they require from SIA in order to assess changes in health; and they can contribute to SIA by defining, during the SIA design phase, what type of health information is required from the SIA in order to identify health impacts. Although there are many avenues for collaboration between SIA and HIA practitioners, more effort is needed to generate understanding of how they can work together and how SIA and HIA contribute to one another.

Economic Appraisal/Evaluation of Projects: Economics is most often defined as the study of the allocation of scarce resources among competing ends. This definition emphasizes two important considerations. The first is that resources are limited – i.e., they do not exist in sufficient amounts to satisfy all human wants. The scarcity of resources implies that society and its members must choose how to use them and leads to the second feature of the definition of economics: the concern with understanding how choices are made among competing ends.

By helping decision-makers to understand the value that individuals place on different allocations of goods and services, economics can help shape the development of policies that allocate resources towards the greatest social good. In the context of EA, economic analysis can help government decision-makers enumerate and valuate the effects of a proposed project. This allows them – whether acting as project proponents, regulators, land managers, or sources of financial assistance – to incorporate the environmental impacts of a project into an overall assessment of its costs and benefits. This assessment can help to determine whether government support of the project is warranted – i.e., whether the project represents a reasonable allocation of society's resources – and can shape decisions concerning the use of measures to eliminate or reduce adverse health or environmental impacts.

Appropriate economic evaluation of environmental projects requires an understanding of basic economic concepts and of the analytical methods that economists employ. These generally include a benefit-cost analysis, a distributional analysis, and an equity assessment.

The basic principles used to measure benefits and costs include "willingness to pay/accept" as the measure of project benefits and "opportunity cost" as the measure of project costs (i.e., the value of goods and services that society loses by forgoing allocation of the resource to its best alternative use). These principles are applied to the valuation of health effects associated with the development of a particular project.

The two primary research methods used to valuate the health effects that may be associated with a project are 1) stated preference methods and 2) revealed preference methods. The former methods include techniques such as contingent valuation, conjoint analysis, and risk-risk trade-offs. Revealed preference methods include wage-risk studies and cost-of-illness studies, but these generally do not provide estimates of willingness to pay. A third revealed preference method, averting-behaviour analysis, uses data on consumer behaviour to infer willingness to pay from actions taken to prevent or mitigate adverse health effects, particularly those associated with exposure to pollution. Thus, averting actions may be intended to avoid environmental exposures or to mitigate related health effects.

An economic tool known as the "benefit transfer" technique is often used to valuate potential health effects. This technique involves using estimates from existing research (based on the primary methods cited above) to valuate the health benefits and detriments of the development scenarios under consideration. The main advantage of benefit transfer is that the process is less expensive and time-consuming than primary valuation techniques.

Chapter 4 also describes "best practices" in applying the transfer approach. It outlines a general approach to benefit transfer in valuing morbidity and mortality risks and introduces the steps used by analysts to implement the benefit transfer methodology. Finally, advice is provided on integrating the valuation of health impacts into the overall economic analysis (i.e., what baseline should be used; how to account for the timing of benefits and costs and also for inflation; how to treat non-quantified benefits and costs; how to account for uncertainty; and how to treat distributive effects and equity considerations).

Indigenous Health Impact Assessment: Chapter 5 outlines HIA methods and approaches identified by indigenous communities in Canada. It points out certain general trends, activities, and needs in the area of HIA that are recognized by all or most of the indigenous communities, as well as by some national organizations of indigenous peoples.

Indigenous HIA is based on three concepts: 1) indigenous communities rely heavily on naturalized knowledge systems (NKS); 2) HIA is very closely linked to EIA; and 3) HIA as a process depends on measurement and evaluation of health indicators, and indigenous communities themselves must develop their own specific community health indicators.

NKS are an essential part of indigenous HIA and focus on the importance of environmental knowledge of First Nations communities and the complexity of traditional approaches to environmental systems. NKS are based on the principles of respect, equity, and empowerment – all essential to form even-handed partnerships and to stimulate First Nations' involvement in decision-making and in environmental health research. Researchers must respect the NKS philosophy while adhering to the key research goals of community-level HIA by 1) linking the needs, requirements, and perceptions of indigenous communities with the non-indigenous knowledge from individual Western scientific disciplines; 2) determining and funding community-defined research priorities; and 3) documenting the transfer of indigenous environmental knowledge and linking this knowledge with Western science.

Indigenous health-related EA methods are consistent with EA processes defined by provincial/territorial and federal legislation and practised by Health Canada and others. Although there is no single, standardized, and generally applicable indigenous EA process, there are common underlying principles, beliefs, and ways. For example, the Mohawks of Akwesasne have developed their own EA process (a permanent cyclical process of evaluation of any outside intervention), consisting of four stages that ensure that the full life cycle of the intervention is assessed: 1) preliminary assessment (i.e., project proposal); 2) cooperative planning (project development); 3) monitoring (project performance control); and 4) final review (controlled dismantling of the project).

The Life Indicators Wheel is an important part of the indigenous EA process. It holds that community health depends on some balance of the corporal and spiritual “opposites” and of the intellectual/visceral. Community life indicators – i.e., values, morale, responsibility, spirituality, economics, environment, politics, and religion – are represented on the perimeter of the wheel. The health of the community is the balance point in the centre of the wheel, and community health indicators are developed from one-on-one links across the centre (i.e., environment-morale, economics-values, religion-spirituality, and politics-responsibility). By integrating these community life indicators with appropriate indicators of health outcomes within a community, a reliable model for community health indicators can be developed. From the model, a matrix of specific health indicators is then developed to provide a basis from which community health can be measured/monitored. It should also be noted that both the Life Indicators Wheel and community health indicators reflect and support the values of cultural sustainability of traditional First Nations societies.

The development of health indicators within an indigenous EA process can make use of the knowledge of the communities affected. The indicators can then be used and monitored by those communities. The methodology for indicator development is based on an approach suggested by the Little Red River Cree Nation. The stages have been modified from the basic concept developed for the International Development Research Centre and are to be used for an analysis of impacts of small-scale (local) changes in economic and environmental conditions caused by the intensive use of natural resources and by societal changes imposed on First Nations communities.

The five basic stages of the process can be summarized as follows: 1) critical issues are defined and selected, as recommended by communities, and are assessed for linkages (environment-morale, economics-values, religion-spirituality, and politics-responsibility); 2) the most relevant institutional and social patterns are defined; 3) indicators are selected (e.g., moose can serve as an environmental indicator, and the impact of species decline can be a morale indicator); 4) a set of measurement endpoints is defined and assigned to individual indicators (e.g., the number of moose as a measurable endpoint for an environmental indicator, and moose accessibility as a measurable endpoint for a morale indicator); and 5) corrective action is designed (if needed) by the community, encompassing both continuity, to maintain cultural sustainability, and change, required to adjust to existing economic, environmental, and political conditions differing from the past.

Environmental Epidemiology and Health Impact Assessment: Epidemiology combines statistical and medical investigation methods to study the distribution and the determinants of health-related states and events in populations. Its ultimate purpose is to improve the public's health by contributing to the prevention, mitigation, or treatment of health problems. Chapter 6 focuses on development projects that have potential health impacts on the surrounding population and for which studies of an epidemiological nature need to be considered.

In this context, environmental epidemiology is simply the application of epidemiology to suspected environmental health problems. Environmental epidemiological studies serve a number of purposes: 1) to assess the health status of populations exposed to suspected environmental sources of pollution and to identify potential health problems; 2) to identify more vulnerable subgroups within environmentally exposed populations; 3) to assess the health risks or effects of environmental exposures; and 4) to assess the contribution of environmental factors to suspected environmental diseases, deaths, or other health conditions.

Epidemiological health investigations can be complex due to the fact that health outcomes generally result from multifactorial processes involving the interplay of genetic, lifestyle, occupational, environmental, or other factors. Also, these factors may multiply the effect of one another. Consequently, for any health outcome, it is difficult to determine the contribution of a specific environmental factor. An added difficulty relates to health outcomes (cancers in particular) that manifest themselves decades after the exposure took place. For health outcomes with acute or subacute manifestations triggered by an environmental factor, a link between an environmental factor and the health outcome (e.g., asthma) is often easier to identify.

A variety of methodologies can be used in epidemiological studies. These include 1) experimental studies (e.g., randomized controlled studies or intervention studies); and 2) observational studies (e.g., cohort, case-control, cross-sectional, and ecological studies). The nature, uses, advantages, and limitations of each of these study types are described in detail in this chapter.

Since the health impacts associated with a development project may be multiple, indirect, or unexpected, epidemiological studies must take a more exploratory perspective than that of classic hypothesis-testing epidemiological studies. This "look-out" approach implies broader and more systematic data collection systems. Thus, HIA entails both retrospective and prospective epidemiological studies – the former to investigate suspected health effects of past exposures, and the latter to determine whether present or new environmental conditions will influence future health outcomes. The importance of follow-up monitoring cannot be overstated. During and after the implementation of a new project, stakeholders should ensure that actual exposures and health outcomes do not exceed those anticipated and acceptable. Hence, HIAs rely heavily on exposure monitoring and on health surveillance (follow-up) to control potential side-effects of a project.

Once baseline data have been acquired on population health status, occupational health risk, and environmental conditions, prospective studies are considered for the HIA. Cohort studies would normally be preferred, but are costly and time-consuming; in view of the relatively low levels of environmental exposures, they may fail to document a health risk in an exposed population, especially if the population under study is small. Instead, a two-phased approach is suggested. Phase 1 involves collecting monitoring data on health status and on occupational and environmental risk factors and then integrating these data. Phase 2 involves designing analytical epidemiological studies to explain the underlying causes of any specific health outcome found to be significantly increased over baseline levels during the monitoring phase of the HIA process. By definition, this phase needs to be considered only if the above conditions exist. Furthermore, in view of the long latency of many diseases to which environmental factors may contribute, these studies are unlikely to be envisioned until several decades after the development project has been implemented.

Exceptions may occur, however. Since disease risks are multifactorial, the aim of epidemiological studies at this stage is to determine the contribution of environmental and occupational factors relative to other risk factors such as lifestyle or genetics. The epidemiological methods most appropriate will depend on the condition encountered. Among the possibilities to be considered are: 1) for health outcomes affecting the general population: case-control studies with detailed residential information; and 2) for health outcomes in an occupational setting: a cohort study of workers that includes exposure assessment. In both cases, the baseline and monitoring data should provide much of the required background information.

Finally, transparency and communication with the public must prevail throughout the HIA process. The population must be informed on a continuing basis of the rationale for the methods used, of the types of data collected, and of the results and their interpretation. Health authorities and collaborative stakeholders should first be advised and the results should be definite before making them public, so as to avoid confusion and to develop credibility and mutual confidence. This will ensure a level of understanding and of trust on the part of the population, without which an HIA would be compromised.

Considerations Relating to Worker Health Protection: Workers are the individuals most likely to be exposed to high levels of hazardous substances on a daily basis over a working lifetime. They are most at risk by virtue of the "dose-response relationship" that is fundamental to toxicology. Thus, when conducting an HIA relating to a development or remediation project, it is important to consider the potential impacts – both positive (e.g., jobs and related benefits) and negative (potential hazards/risks).

In an HIA, occupational health risks need to be anticipated in advance and mitigated in the design stage, and post-project assessments (i.e., monitoring of actual exposures to risk factors and of worker health status) need to be incorporated into the EIA. It is now incumbent upon the owner/employer to carry out a variety of risk assessments.

Occupational health involves diverse workplace parties, including a joint health and safety committee, off-site therapists, including occupational therapists and physiotherapists, as well as various other clinical specialists, in the case of a need for after-the-fact therapeutic intervention. However, the focus in HIA is the prevention of negative health outcomes in populations, rather than the treatment of affected workers.

The field of occupational hygiene is generally defined as the art and science dedicated to the anticipation, recognition, evaluation, communication, and control of environmental stressors in, or arising from, the workplace that may result in injury, illness, or impairment or affect the well-being of workers and members of the community. The occupational hygiene practitioner has comprehensive knowledge of workplace chemical, physical, biological, ergonomic, and psychosocial factors and related safety concepts, but in many cases would work in conjunction with (or defer to) practitioners with specific expertise in these areas, as well as in health physics, occupational psychology, safety, etc. Thus, their knowledge in these areas would normally be more limited. It is imperative that a registered occupational hygienist accredited by the Canadian Registration Board of Occupational Hygienists be involved in any HIA relating to a substantive project with a job-related element.

In the general occupational context, exposure to chemicals, particularly airborne contaminants, is a major concern. The focus is on keeping exposures well below the levels recognized as having the potential to cause disease. The best recognized and accepted occupational exposure limits (OELs) are the Threshold Limit Values (TLV®s) established by the American Conference of Governmental Industrial Hygienists (ACGIH). TLV®s can be expressed as a time-weighted average – i.e., the average exposure over the working day (usually considered an 8-hour period) – or as short-term exposure limits and "ceiling" limits. The individual OELs generally assume that exposure is occurring only by the airborne route and to only one substance. With the typical concurrent exposure to multiple toxicants, additive or synergistic relationships between the contaminants must be considered. It may also be helpful to consider several exposure criteria intended to protect members of the general public and workers from chronic and acute health effects. It is also customary to dichotomize toxicants into "threshold" and "non-threshold" types. The latter category includes genotoxic carcinogens and mutagens. The TLV®s designate by "A" codes those substances that are categorized as to workplace carcinogenicity.

In applying the principles of occupational hygiene (i.e., workplace risk assessment) to a prospective HIA, there are various items that should be assembled, including a clearly articulated and written statement of goals and an identification of the standard(s) to be used; the layout of the plant; a description of process flow and a chemicals inventory; documentation of previous hygiene work that may have been conducted at predecessor or sister plants; a record of summarized health/disease data; and a review of the scientific and professional literature for reports of detrimental effects associated with the materials and processes in question.

The "borrowing" of exposure data from similar types of facilities operating elsewhere can be very effective in anticipating and preventing contamination problems. In addition, mathematical and/or physical modelling may be useful, particularly in cases where there are adequate data (however, it should be noted that models can overpredict actual exposures, especially in the absence of good input data). Chapter 7 discusses three general types of accepted or generally used workplace models: 1) "box" (mixed-space); 2) "multicompartment" (e.g., two-zone); and 3) "eddy diffusivity" (also known as the "hemisphere diffusion model" or "uniform diffusion model"). These models largely differ in how they pattern the movement of the contaminant; each has its own fundamental assumptions, specific input parameters, and limitations.

In a post-project assessment, the evaluation of worker exposures has a well-established set of approaches and methodologies. Worker exposures are typically evaluated under "representative" or "worst-case" conditions and are compared with the corresponding OELs. However, exposures of workers at various tasks are often not determined empirically, because such factors as fundamental physicochemical principles, the assessment of control system effectiveness, etc., would indicate that such exposures should be insignificant (i.e., well below the existing OELs). In these cases, only those situations that are in doubt or of concern are assessed empirically. However, since such a data set generally illustrates only the upper end of the exposure range, guidance is offered on sampling protocols to provide representative exposures of workers.

Another approach to the assessment of worker exposure involves biological monitoring – i.e., measuring levels of contaminants in body fluids or tissues (e.g., urine, blood, etc.) – and a comparison of the results with, for example, the ACGIH biological exposure indices (BEIs).

The pitfalls of occupational hygiene are associated with uncertainty, as in all HIAs. When the required data are unavailable or questionable, one must rely on professional judgment, both in the case of prospective appraisal and to ensure that the determination of post-project exposures is done in accordance with accepted practices.

Food Issues in Environmental Impact Assessment: As an integral part of EAs for both development and remediation (contaminated site) projects, risk assessments of contaminant levels in foods must be undertaken. In general, it has been the practice to develop models to estimate levels of contaminants in country foods harvested in the study area. Although this modelling approach is considered acceptable, it does result in an uncertain degree of conservatism due to the variety of methodologies, calculations, and assumptions involved. In any case, a standardized procedure in regard to potential contaminants in country foods is imperative for risk assessment and sound management decision-making. The risk assessment methodology described in Chapter 8 has been designed to serve as a general outline.

Potential contaminants can be identified using the results of available studies, if any, of naturally occurring contaminants in the area of the project; where such studies do not exist, soil and water analysis for the levels of metals and organic chemicals would then be required. A comprehensive list of potential contaminants (e.g., metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, polychlorinated biphenyls (PCBs), dioxins, furans) should be provided in the EA report. It is especially important for risk assessment purposes to analyse for levels of individual PAHs, individual dioxins and furans, and/or individual PCB congeners in mixtures, as required.

Studies of all country foods available for gathering and consumption by local residents in the study area are necessary for evaluation purposes. It is important to emphasize the significance of determining actual food consumption by the local residents for use as a basis for designing sampling studies. It is also vital that foods that may be available but are not consumed are excluded from the study. A comprehensive list of all country foods that are consumed is to be included in the EA report. Mention should also be made of foods that are harvested from the area of the project site and are intended for the retail market.

Exposure pathway refers to the route of contaminant transport from source to receptor. Based on the information collected on the identification of potential contaminants and of foods available in the area, the feasibility of pathways of potential contaminants into foods can be determined. Air, soil, and water sources must be considered in the case of country foods.

Identifying contaminants of potential concern (COPCs) can be based on the full list of potential contaminants initially identified, the country foods consumed by residents in the area of the project, the measured levels of contaminants, and the identified potential pathways into foods. Based on the background data collected, it may be possible to estimate the potential impact of project activities on contamination of country foods before the project begins. To estimate contaminant levels in foods after the project proceeds, various models can be designed, and periodic monitoring studies can be done to verify the predictions of the models developed. The risk assessor can then evaluate if further risk assessment or monitoring is required.

For risk assessment purposes, it is necessary to identify toxicological reference values (TRVs) for the contaminants of special concern. These values will be used to determine the human health risk issues associated with the levels of the contaminants found in foods collected from the project area. TRVs specific to food-borne contaminants and approved by Health Canada are preferable for the assessment of human health risks posed by contaminants in country foods.

Food consumption information is needed to estimate exposures to COPCs found in foods consumed by residents in the area of the development project and can be obtained from reliable local survey information (preferable) or other well-documented sources of food consumption figures. The consumption information should be representative of the food intake of Canadians (based on, for example, nutrition surveys) and is also required for any unique local consumption of country foods (e.g., various tissues of fish and wild game). Eaters-only statistics for the foods of interest are typically used to estimate levels of exposure to contaminants.

Before the development/remediation project proceeds, an initial monitoring study should be conducted to collect background data on levels of potential contaminants in country foods. These data may already be available from studies done in the area. If such data are unavailable, other options may be considered – e.g., published papers on total-diet studies. Periodic monitoring of the levels of COPCs in the foods under study would then be done upon commencement of remediation or, for development projects, operation of the new facility. Results can be compared with background levels to confirm modelling predictions and exposure estimates and to determine the need for human health risk assessments and/or additional or extended monitoring. Follow-up monitoring may also be considered after the project has been completed. Monitoring efforts can also result in initiating mitigative measures to avoid potentially higher exposures to contaminants.

For the purposes of a human health risk assessment in regard to contaminants in foods, analytical methodologies are required that are capable of measuring contaminants at levels consistent with known toxicity and health risks. In most cases, methodologies exist that can measure levels of contaminants in certain foods, with detection limits expressed in parts per billion (ppb) or micrograms per kilogram (µg/kg). In order to verify the reliability of the analytical results, a standard analytical methodology must be used.

Based on the levels of contaminants found in country foods, estimates of exposure to COPCs can be calculated and then compared with established TRVs. In addition, recommended maximum weekly intakes (RMWIs) can be determined for each of the country foods consumed; these are particularly useful where food consumption data are not available and also for developing consumption advisories. This chapter also includes examples of formulas typically used to estimate contaminant exposure via food consumption, as well as formulas used for risk characterization. Two hypothetical case studies are presented to illustrate calculations using these formulas: one concerning a development project, and the other a contaminated site remediation project. Examples of contaminant intake calculations – i.e., doses, exposure ratios, and RMWIs (before and after construction or remediation) – are provided for different receptors (young children, women of child-bearing age, and adults other than women of child-bearing age). Key details needed for the risk assessment of the food issues are also discussed.

The focus of a risk assessment of the levels of contaminants found in foods is to estimate potential risk to the local human population from consumption of country foods harvested from the area. Possible further evaluation can provide the relative level of potential risk in order to determine if there are, indeed, reasons for concern from a human health perspective. Risk management tools are available in those cases where a potential human health hazard has been determined – e.g., fish advisories, vegetable consumption advisories, etc. Risk management actions can serve to greatly reduce or, in some cases, eliminate potential risk to human health.

The results of a risk assessment cannot be considered absolute. A degree (often a large degree) of uncertainty is inherent in any estimation of risk. There are uncertainties in the quantity and quality of the information available to make the exposure estimate as well as in the assumptions used in the derivation of the safe or tolerable dose (such as species and low-dose extrapolations). In this regard, some of the factors that can contribute to uncertainty in risk assessment are outlined in Chapter 8. The review of a risk assessment should consider whether the evidence provided adequately supports the conclusions that are reached in light of the uncertainties involved.

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Notes:

1 INTRODUCTION

Volume 3 of the *Canadian Handbook on Health Impact Assessment* addresses key concepts and issues that traditionally had not been adequately considered within the context of environmental assessment (EA) or environmental impact assessment (EIA) and health impact assessment (HIA) – for example, due consideration of stakeholder values, social impact assessment (SIA), economic evaluation of development projects, indigenous HIA, concepts and methods of environmental epidemiology, occupational health, and food issues.

The third volume expands on important elements of Volume 1 with respect to determinants of health, health indicators, Aboriginal health and traditional knowledge, risk perception, and greater public consideration and community action. It is also consistent with Volume 2 regarding the role of health professionals, the development and implementation of projects based on sustainable development principles, and the importance of credible communication with stakeholders, including the general public. As well, the concepts, principles, and approaches outlined in Volume 3 are applied to the Volume 4 discussion of the impacts of development projects in Canada's major economic sectors, which includes information on, for example, economic context, social impacts, Aboriginal values and considerations, and occupational health.

Specifically, the major topics presented in Volume 3 comprise the following key concepts and issues, which are increasingly recognized as essential to the conduct of effective and accepted HIA within the context of EA:

- *Values, health, and environmental assessments*: incorporation of stakeholder values into EA, including identifying and understanding the full range of relevant values; and guidance on how to build these values into the EA process (Chapter 2).
- *Social impact assessment in environmental impact assessment protocols*: linkages between SIA and HIA; the key steps and benefits of SIA; public involvement and misconceptions; the types of social impacts; methods and tools in SIA; and challenges facing SIA practitioners (Chapter 3).

- *Economic appraisal/evaluation of projects*: basic elements and principles of economic analysis; methods to valuate health effects; benefit transfer techniques (e.g., in valuing morbidity and mortality risks); and integrating the valuation of health impacts into the overall economic evaluation of projects (Chapter 4).
- *Indigenous health impact assessment*: naturalized knowledge systems (NKS); a comparison of indigenous and non-indigenous health-related EA methods; and indigenous community health indicators and the process and methodology for developing them (Chapter 5).
- *Environmental epidemiology and health impact assessment*: epidemiological study designs (e.g., experimental studies and observational studies); data sources for epidemiological HIA (e.g., population data, disease/health outcome data); and a suggested approach for HIA, incorporating health, occupation, environment, and the use of prospective data (Chapter 6).
- *Considerations relating to worker health protection*: occupational health risks and HIA; facets of, and professional disciplines in, occupational health; occupational/environmental hygiene; occupational disease and its prevention, including the use of occupational exposure limits (OELs) as a tool; occupational hygiene applied to HIA, including aspects of biological monitoring; pitfalls of occupational hygiene in HIA (Chapter 7); and an appendix on guidelines on the selection of an occupational hygiene specialist (Appendix B).
- *Food issues in environmental impact assessment*: the regulatory context; potential contaminants, available foods, and exposure pathways; contaminants of special concern; hazard assessment – toxicology; required food consumption information; monitoring and background data needs; analytical data; human health risk assessment as it pertains to contaminant levels in foods, including risk characterization; review requirements for a draft EIA report; uncertainty in risk assessment; and risk management.

2 VALUES, HEALTH, AND ENVIRONMENTAL ASSESSMENTS

2.1 Introduction

The purpose of this chapter is to describe how values-based analysis can assist health professionals in contributing to EAs. Explicit attention to values is often avoided by professionals engaged in EAs. In our culture, values are widely thought to be personal, subjective, and emotion laden. This view seems to imply that values are not a good foundation for building consensus or solving public policy issues. It is easy to think of what is personal, subjective, or emotional as irrational.

This view is unfortunate, because values form the framework for EA. EA is defined in Volume 1, Chapter 1, as "a comprehensive and systematic process, designed to identify, analyse and evaluate the environmental effects of a project in a public and participatory manner." The goal is to anticipate and prevent adverse effects of projects by determining and evaluating the positive and negative impacts a project or action will have on our surroundings. A positive impact is one that adds something of value. A negative impact is one that destroys or interferes with something we value or something we consider to be of value. The purpose of an EA, then, is to ensure that a project will contribute something of value to those affected.

2.2 What Values Are

The Oxford English Dictionary defines value as "worth, desirability, utility." Things around us have value if they have these qualities. Good health is something virtually everyone desires or hopes for. It is so central to our welfare that it is often built into best wishes on important occasions. We desire health for its own sake because of the sense of well-being that comes simply from feeling well. We also desire health because of its importance to us in meeting our needs and realizing our goals and objectives. For this reason, good health is valued also because of its utility. Poor health has negative value because it interferes not simply with our ability to enjoy life, but with our ability to earn a living, put food on the table, or contribute in a meaningful way to family or community life.

The values we attach to things indicate their importance or significance to us. We value economic development when it creates value by facilitating our ability to realize our goals and aspirations or to live the kind of life to which we aspire. Economic development that results in an improved water supply, added educational opportunities, or new jobs would have this character. We attach negative value to things that impede our ability to realize our goals and aspirations or destroy things we value. Economic development that pollutes a river, thereby damaging a source of drinking water or food, or threatens a valued wilderness area or an endangered species would, in the normal course of events, be seen as having a negative value. Our values therefore provide the framework for evaluating the worth or merit of projects under assessment.

Values allow us to differentiate between costs and benefits. Costs are negative values. Benefits are positive values. A cost is anything that absorbs resources that could be used to achieve something else of value. A cost limits our ability to do other things. Benefits are things that are valued for their own sake or because they help us to realize our goals and objectives.

Finally, values play an essential role in decisions and choices. The purpose of an EA is to put people into a position where they can decide whether, in their view, a project will contribute something of value to their lives. Deciding whether a project should go ahead will therefore depend on how the values of the project's stakeholders are factored into the decision-making process. One of the goals of this chapter is to explain why health values should play a central role in this decision-making process.

How, then, are values revealed and identified? How do we know what people's values really are? Answering this question is not nearly as difficult as it may first seem. This is because people's values are reflected in their preferences, priorities, goals, objectives, choices, and decisions. The values are therefore reflected in and revealed by people's words and actions. This leads to an obvious conclusion: the best way to find out what people value is simply to ask them. This is why public participation is such an important part of the EA process. Public participation opens the door to the exploration of the values the public believes should guide economic development decisions and choices.

2.3 Stakeholder Values in the Environmental Assessment Process

The World Health Organization (WHO) has defined human health in terms of the capacity of people to realize their needs and aspirations. To assess the impact of a project on the health of those likely to be affected by it, an EA must identify how the project will affect the capacity of its stakeholders to realize their needs and aspirations.

Identifying for its stakeholders the health implications of a project requires three things. First, it requires accurate identification of those likely to be affected by a project proposal undergoing EA. Second, it requires that the full range of values important to those likely to be affected is taken into account in the assessment process. Third, it requires that the stakeholder values are properly understood.

2.3.1 Step 1: Stakeholder Analysis

A stake is defined by the Oxford English Dictionary as an interest, something to be gained or lost, or something at risk. In the Glossary of this volume (see Appendix F), a stakeholder is described as "any individual, organization, or company that has an interest, financial or otherwise, in a project." A stakeholder can also be described as someone who stands to gain or lose directly from a project or someone who is put at risk by a project or the decision process that will determine whether and how a project will proceed and how it will be managed.

It is important, early in the assessment process, to acknowledge and then identify two quite different kinds of stakeholders: voluntary and involuntary. Every project under assessment will have voluntary stakeholders. These will be individuals, groups, organizations, and institutions: employees, investors, governments, and government departments that are free to decide whether or not to get involved in the project. For the most part, the involvement of voluntary stakeholders will be contractual in nature.

Genuinely voluntary contractual involvement requires informed choice. Informed choice requires, in turn, that voluntary stakeholders be fully informed about all aspects of a project, aspects that could reasonably be expected to affect, in a material way, their decision to become involved. This is a widely accepted requirement for establishing the existence of a contract in law. It is also a recognized requirement in investment regulations and other areas of business where ensuring informed choice is a recognized obligation.

One of the goals of an EA should therefore be to ensure that voluntary stakeholders have the information they need to make informed choices about their involvement. Information about potential health impacts on voluntary stakeholders is an example of the kind of information that will be required by voluntary stakeholders.

A conscientious effort should also be made to identify involuntary stakeholders and to identify carefully the nature of their stake in a project. An involuntary stake is created whenever a decision-making process exposes people to direct and significant risks that they would not willingly assume or about which they have no knowledge.

When involuntary stakeholders are not identified, the costs and risks that the project creates for those stakeholders are almost certain to be ignored. The effect is to transfer those costs from a project proponent to people who may have little to gain by way of benefits in return. Failure to require clean-up and land reclamation following mine closure and failure to assess the effects of the release of chemicals into a body of water on the fish on which a local population depends for food or tourism are both examples externalizing costs to involuntary stakeholders.

When a project's stakeholders are not carefully identified, important values that ought to be considered in the assessment process are likely to be ignored. This may then mean that a careful assessment of the impacts of a project on the health of its stakeholders cannot be accurately conducted.

2.3.2 Step 2: Identifying the Full Range of Relevant Values

Many people seem to think that the purpose of EA is to balance economic and environmental values. In fact, a much wider range of values needs to be included if the health impacts of projects under assessment are going to be properly understood. For example, a recent study of four Canadian resource extraction projects identified 15 types of values that the stakeholders of those projects wanted to have considered in the assessment process (see Appendix A for definitions of these values):

- aesthetic;
- ecological;
- economic;
- educational;
- environmental;
- health/safety;
- legal;
- moral;
- personal;
- political;
- recreational;
- religious/spiritual;
- scientific;
- social; and
- subsistence.

Failure to identify the full range of values that stakeholders want taken into account in the decision-making process can lead to serious oversimplification. One obvious casualty is health values. Simplifying to a small number of categories may also mean that many values will be indirectly connected to health – for example, aesthetic, educational, recreational, moral, social, religious/spiritual, and (for Aboriginals, for example) subsistence values. To ignore these values is to ignore issues that are central to human well-being and therefore central to human health (see the Preface to this Handbook, Volume 1).

Oversimplifying the range of values that stakeholders want taken into consideration in the assessment process has other effects as well. For example, individuals and groups who have a stake in the assessment process and whose interests in the project are quite different will tend to be lumped together. A good example is Aboriginal stakeholders. Frequently, those involved in the public discussion of environmental issues assume that Aboriginal groups will be aligned with environmentalists and opposed to economic development. In fact, if careful identification of the values these two distinct groups typically bring to EAs is undertaken, quite important differences are likely to emerge (a careful reading of Chapter 5 of Volume 1 of this Handbook should confirm this observation). For example, Aboriginal groups typically place a high priority on the social impacts of projects undergoing EA in which they have an interest. Religious/spiritual, subsistence, and environmental values are also likely to be prominent. This may not be the case for environmental groups, whose interests are likely to be more narrowly focused on just environmental and ecological values.

Finally, careful identification of the values of the project's stakeholders, including those who may be politically invisible, will ensure that those values will be considered. This is an important factor. For example, involuntary stakeholders may not even be aware that an EA is taking place, yet their health may well be at risk. Values-based analysis that is sensitive to the whole range of values that those likely to be affected by a project would like to see considered in the decision-making process will help to ensure that no one's interests and concerns go unaddressed.

2.3.3 Step 3: Understanding Stakeholder Values

The third requirement in incorporating values-based analysis into the EA process is ensuring that the values that those affected by a project want to have included in planning and project evaluation are properly understood. Errors in the interpretation of these values can cause harm and generate serious resentment.

The language of values is in some respects quite simple. Essentially, values have one of two functions. One of those functions is to identify the ends or fundamental goals and objectives that define the stake or the interests that establish an individual, group, or company as a project stakeholder. These are best described as *core values*. One of the reasons for incorporating health into EAs is the belief that good health is a core value for virtually everyone. Consequently, it is important to take it into account when deciding on the merits of a project.

We also value things for their usefulness or utility in helping us get to where we want to go. Values of this sort are frequently described as *use values*. Water is valued for drinking; it is essential for life and therefore has significant use value for all human beings. Water is also an important ingredient in many industrial processes; water has significant use value to these processes as a means for accomplishing industrial objectives. Of course, water is valued for many other reasons as well.

Economic development is valued for the benefits it will bring – for example, an improved standard of living. Development is valued because it is a means to the achievement of such benefits. Development that generates benefits has a positive use value. Development that has harmful impacts has a negative use value relative to the goals and objectives with which it interferes.

2.4 Identifying Core Values

Core values are the values that identify the fundamental goals, purposes, objectives, principles, or ideals of a project's stakeholders. They are the values that identify things that are regarded as valuable for their own sake. For many people, health, family, or work will have core value. Protecting biological diversity, endangered species, or a place of great natural beauty can also take on the character of a core value.

Core values reflect people's aspirations and are linked to their sense of well-being. Consequently, if the core values that define someone's interest or stake in a project are not respected, the project will be seen as damaging, harmful, or offensive. If a project does not interfere with people's core values, it will likely generate few, if any, objections. If a project contributes to the realization of core values, it will be supported.

Effective EA is possible only if the core values of those who have a stake in a project are carefully identified. This is less difficult than it may sound, for two reasons. First, some of the core values will be defined by the legislation governing the assessment process; EAs are mandated with particular goals and objectives in mind. These will be core values for those responsible for carrying out the assessment. For example, the definition of "environmental assessment" as presented in Chapter 2 of Volume 1 of this Handbook indicates that one of the central objectives of an assessment is to ensure that the environmental effects of a project are known and evaluated before the project gets under way. Another core value is public participation.

The task of identifying core values is less difficult than it may sound for a second reason. For health professionals participating in an EA, the key core value is health.

Impact on health is therefore the key issue and the central criterion for assessing the positive or negative value of a project.

Not all impacts on health will be direct impacts, however, and this does add a complication. The WHO definition of health makes it clear that the impact of a project on health will depend in part on how it enhances or inhibits the capacity of stakeholders to meet their basic needs and realize their goals and aspirations. For this reason, the core values that the various stakeholders bring to projects under assessment will have to be identified if a project's health impacts are to be understood.

Once again, identifying the values that stakeholders want to have considered in an assessment process is less complicated than it might seem at first glance. This is because, as a rule, in any given situation, the core values that individual stakeholders or groups will bring to a development project will be relatively small in number. Further, quite a number of those values will be shared by all the stakeholders, and, for the most part, those shared values will become obvious from public input.

For example, fishing will almost certainly be a core value for a community that relies on fishing as a basic source of nourishment. Protecting that resource will therefore have important direct and indirect health implications. For a community with high unemployment, job creation might well be a core value. A project that promises job creation would assist that community to achieve a core value or objective and thus would have positive health implications for stakeholders, assuming, of course, that other important values (e.g., access to clean water) were also respected.

2.5 Identifying Use Values

Core values identify the goals, objectives, and other things of fundamental importance that define people's stake in a project. Goals and objectives have value, however, only if they are realizable. Hence, core values always connect to questions about means: How do we get there? Can we get there? What resources are available to achieve our goals and objectives? What are the obstacles? Is it worth the effort? Anything that can help us get to where we want to go will have use value as a tool or means allowing us to accomplish what is important to us. Thus, a proposal to build a saw mill in a remote community may well be supported because of the jobs it promises to create. Its job creation potential will be its use value for those wanting jobs. The logging needed to supply the saw mill will also have use value for the same reason. On the other hand, both the saw mill and the logging needed to support it will have negative value if the mill threatens to pollute a river that a community depends on for drinking water or for fishing.

The most common values relating to an EA will be use or non-core values. Hence, assessing the use value or utility of a project from the perspective of its various stakeholders is a basic task of EAs. The task of EA is to ensure that the development will be genuinely beneficial and that adverse impacts (negative use values) can be mitigated or adequately compensated for. Will the development generate employment? Will it support or undermine community development? Will it bring social problems that will be hard to deal with? Will it enhance or undermine the health of those affected by it? All of which is to say, will the project help people realize their goals and aspirations or undermine their efforts in this regard?

There are three kinds of use or non-core values that play a role in EAs:

1) instrumental values;
2) essential values; and
3) symbolic values.

Distinguishing these three kinds of non-core values will be, for many assessors, the most difficult part of the process. Failure to recognize the different roles played by non-core values, on the other hand, can result in serious misunderstandings and conflict.

2.5.1 Instrumental Values

In mainstream North American culture, instrumental values are the most easily recognized kind of non-core or use value. This is because one of the most common ways of determining the value of something is by determining its instrumental value. Everything we use to accomplish our goals and objectives has this kind of use value. Houses, cars, tools, and artifacts of all kinds are normally created or invented for their instrumental value. The more useful something is, the greater its instrumental value. The more important a goal or objective is, the greater the value of anything that is a means to achieving it. On the other hand, if an end or objective loses its value, everything that acquired value as a means for accomplishing that objective or end will lose its value as well. Thus, as gold loses its value, gold mines decline in value as well. Computers that are as little as a few years old are worth practically nothing because they have been replaced with computers that do much more, and do it more efficiently. New technology makes old technology worthless.

Instrumental values have a number of characteristics, of which two are particularly important. First, the instrumental value of things can almost always be monetized. That is to say, the instrumental value of things can usually be captured in dollar terms. We determine the costs of acquiring or building or creating things and set these costs against their value for doing a particular job or accomplishing a particular objective. If the benefits exceed the cost measured this way, it is easy to think that the project should go ahead. For this reason, cost-benefit analysis will normally focus on the instrumental value of the things being analysed.

2.5.2 Essential Values

There is a second kind of use value at work in EA settings that is at times confused with instrumental value, but is really quite different. Sometimes we value things not because they are helpful in realizing core values but because they are essential. That is to say, in some cases, the value attached to things by stakeholders will derive from the fact that in the absence of that thing, something seen as having core value will become unattainable. Imagine, for example, that a tract of wilderness has qualities that are essential to the survival of a threatened species. There are no alternative habitats. If ensuring the survival of that species is a core value, then threatening the integrity of that tract of wilderness will threaten a core value directly. When this is the case, insensitivity to importance of the use value in question constitutes insensitivity or lack of concern for the core value it supports. Insensitivity to values of this sort can have health implications as well, though clearly it will not have these implications in every case. Projects that destroy things seen as essential components in a way of life, for example, will have damaging cultural impacts and indirect health implications.

One of the challenges of EA is to differentiate those things that stakeholders value for instrumental reasons as useful tools or means to accomplish things they believe are important from things that are not simply useful but rather essential. The difficulty here lies in the fact that stakeholders themselves may not always recognize the difference. Sometimes stakeholders will resist change, believing something to be essential when it really is not. And sometimes people will agree to change without understanding the serious implications of that change for their way of life. Effective EAs can go a long way in ensuring that these kinds of mistakes are not made. However, serious resistance to a project by stakeholders on the grounds of the harm that the project would cause if allowed to go ahead is an important indication that the values at stake are not just instrumental values.

2.5.3 Symbolic Values

Symbolic value is a third kind of use value; people also attach value to things for their symbolic significance. Good examples of symbolic value in our culture are flags, wedding rings, or objects associated with religious observance. What is less commonly recognized is the wide range of things and activities that can come to have symbolic value. Equally important is the fact that in our culture the symbolic significance of things is frequently unnoticed or ignored.

A good example is the value we attach to jobs. Jobs have instrumental value; they provide income that allows people to provide for their families, for example. Seen from this perspective, their value can be determined by the income they generate. However, jobs can also acquire great symbolic significance. Seen from this perspective, their value is quite different. For example, if a job has become invested with symbolic significance, another job generating the same income will not have the same value. Thus, offering someone who has been a trapper all his life a job as a construction worker on a hydro-electric dam project will likely not be accepted as a fair trade-off by the trapper or his community. Those who are offering the trade-off may well fail to understand the resistance and chalk it up to bargaining or obstinacy. However, on the contrary, the resistance may reflect the fact that trapping, for those involved, has become a symbol of a way of life, in which case those offering the trade-off will have misunderstood what is at stake for the trapper or for his community or family.

Similarly, a forestry company may be tempted to measure the value of a tract of wilderness by the market value of the fibre it contains. A mining company may be tempted to measure the value of the same tract of land by reference to the market value of the mineral deposits it is thought to contain. In contrast, that same tract of land may have great symbolic significance for environmentalists and their supporters, for its Aboriginal inhabitants, or for hunters or fishers. In each case, the core values whose importance the land symbolizes may well be different. What each of those assigning the land symbolic value will have in common, however, will be emotional resistance to an assessment process that measures value only in instrumental terms.

The reason for this is that symbolic values have characteristics that are quite different from instrumental values. Typically, things that have symbolic value are not replaceable in the way in which tools or instruments are replaceable. Their value cannot be measured or calculated in monetary terms, as opposed to things whose value is instrumental in nature. Symbols are not instruments in this sense. A job that has taken on symbolic value for an individual or group of people cannot be replaced with just any other job generating the same income. A tract of land that has become identified as a national park cannot simply be replaced with another tract of land having similar characteristics. The value of a type of employment will be quite different for two people; for one person, it may be a source of income only, while the other person sees it as symbolizing a way of life. Substitution or compensation will normally work quite well for things whose value is purely instrumental. However, for people for whom a certain type of employment is a symbol, the most likely effect of substitution or compensation will be to arouse anger and resentment. Symbols are not interchangeable in the way that things having only instrumental value are.

The reason for the difference lies in the way in which symbols express core values; i.e., symbols stand for core values. They may symbolize a way of life or particularly significant social relationships (e.g., a marriage) or environmental commitments, such as a commitment to protect endangered species. In contrast, things whose value lies only in their utility are easily replaced when something that can do the job better comes along.

Symbols are particularly important for HIA, for two reasons. First, health itself is frequently invested with symbolic significance. For example, a community may well measure its own health by the health of a nearby river, stream, or lake, even though none of these is a source of drinking water. Similarly, environmental destruction can symbolize insensitivity to health issues, even though no direct damage to the health of anyone can be traced to the environmental impacts themselves. Fortunately, the converse is true as well. Cleaning up a river or a lake or rehabilitating wild lands or parks can have impacts that go well beyond any results that could be predicted if only instrumental evaluation were in play.

Second, insensitive treatment of symbols is likely to be interpreted as a lack of concern or respect for the people for whom they are symbols. This in turn can have a damaging impact on the quality of life of those affected, with subsequent implications for their health and welfare.

Two examples will help to illustrate these points. Historically, hydro-electric development in northern Canada was undertaken with little concern for its impact on Aboriginal communities living there. More recently, sensitivity on the part of developers, including public utilities, to environmental impacts has increased, due to a certain extent to the requirement that large new developments must undergo EAs. Indeed, one of the core values now frequently attached to resource development is sustainable development. The problem for project developers, however, is to assess the impact of hydro-electric projects from a sustainability perspective. For example, building dams that cause extensive flooding results in the release of methylmercury from sediments and subsequent bioaccumulation/biomagnification of mercury in fish. Aboriginal communities must then be advised not to use the fish as a source of food. Because environmental legislation no longer permits this kind of cost to be simply externalized, development proponents have concluded that sustainable development requires either substitution or compensation.

One solution offered over the past two decades on at least three different occasions by companies committed to sustainable development has been to bring in frozen fish as a substitute. This offer is reasonable if fishing is assessed from a purely instrumental perspective – i.e., if the value of the fish no longer available to native fishers were measured from an instrumental perspective only. This solution would provide adequate compensation for the fishers affected. Indeed, some people might think that it was more than fair since it would mean that the people affected could maintain their diet without exerting any effort. However, for the Aboriginal people involved, fishing symbolized a way of life. The activity and the food gathered were important because they symbolized a complex web of social and spiritual values. Frozen fish produced commercially could not have this kind of value. Hence, the offer devalued the core values of the people affected and caused anger and resentment.

Similar examples have been generated in recent years by environmentalists proposing that land be closed to logging and returned to wilderness status. Projects of this kind have obvious implications for loggers who face a loss of work if the project goes ahead. This is an obvious cost. The problem is to decide how to address it. One solution has been to propose that displaced loggers be guaranteed alternative forms of employment generating a similar income, sometimes in their own community and sometimes elsewhere. Loggers faced with proposals of this sort commonly respond with anger and resentment. This is because people living in small northern communities often see logging not simply as a job but rather as a symbol of a way of life to which they are strongly committed.

2.6 How to Build Values into the Environmental Assessment Process

EA is a process involving the following five steps (see Chapter 2, Volume 1):

1) project description;
2) scoping;
3) determining the significance of a project's impacts;
4) determining mitigation and follow-up; and
5) recommendations regarding the project.

Values-based analysis in turn has three elements. Four of the five steps in the EA process emphasize one of these three elements and are described below.

Box 2.1
Summary of the Function of Values

Values serve one of two functions:

- *Core values* recognize things that identify the ends or the fundamental goals and objectives that in turn define the stake or the interest that makes an individual, group, or company a project stakeholder.
- *Use values*, on the other hand, identify things whose value derives from their usefulness in realizing goals and objectives of fundamental importance. Use values in turn fall into one of three categories:
  - *Instrumental values*: Some things will be valued for their utility as tools or instruments useful in pursuing goals identified as having core value.
  - *Essential values*: Some things will be valued because in their absence, core values would not be realizable.
  - *Symbolic values*: Other things will acquire value as symbols.

A sound EA will deal with each way of identifying the significance of environmental impacts on its own terms.

2.6.1 Step 1: Project Description

The first task in EA is to provide basic information about the project. The first task in values-based assessment is stakeholder identification. It is important, therefore, that the project description include the information that will be needed to identify the project's stakeholders. It should also contain the basic information that stakeholders will need to identify the nature of their stake in the project. Unless the stakeholders are identified in the project description, it will be difficult to determine whether the project is likely to generate health concerns and the general nature of those concerns. Stakeholder identification at Step 1 does not require a more elaborate process than that which is set out in Volume 1. What it does require is careful consideration of the factors presented in Table 2.1 in Volume 1.

Once stakeholders have been identified, it is important to ensure that information in the project description is communicated in a way that allows the stakeholders to understand in general terms what they have at stake.

If the project description accomplishes these two goals, it will also ensure that the public generally knows who the stakeholders are and has the information it needs to build an adequate understanding of the nature of the project and its implications for the individuals, groups, and communities that will be affected by it.

2.6.2 Step 2: Scoping

Scoping builds on Step 1. It requires identifying the biophysical and social environmental effects of a project that need to be assessed. Building a values component into this second step of the assessment process will help to ensure that what is at stake for each stakeholder and stakeholder group is properly identified. This requires two things. First, it will be important to identify the full range of values that stakeholders want to see taken into account in the assessment process. An EA is not likely to be effective if it identifies the relevant stakeholders but fails to consider the full range of stakeholder values likely to be affected. Ensuring that the full range of stakeholder values is considered will be particularly important if the indirect health impacts are to be accurately identified. For example, if Aboriginal stakeholders are identified as stakeholders, but the values that they think are important are not part of the assessment process, impacts that may turn out to be vital to their health and welfare will simply be ignored. If impacts on social patterns are identified as important, but impacts on recreational patterns or things of scientific value or political importance are deliberately or inadvertently ignored, things of value to some stakeholders will not be factored into the assessment process.

Second, scoping should include an assessment of stakeholder core values. Does the project intersect with goals and objectives or values that are of fundamental importance to the project's stakeholders? What are those goals, objectives, and values? What is the nature of the impacts? Are the impacts direct or indirect?

How are core values identified? In some cases they will be obvious. Health is a core value; hence, identifying direct impacts on health ought to be a central objective of EA. It is the impact of a project on the core values of the stakeholders that will pose a challenge, since these impacts will affect the health of stakeholders only indirectly. However, identifying indirect impacts on health will be crucial to an effective assessment, since indirect impacts on health can alter the quality of life of stakeholders in significant ways.

One way to identify a project's impact on core values is to determine how a project is likely to affect the lives of its stakeholders. If significant changes are the likely result, it is almost certain that core values will be affected. The challenge will then be to identify how the project will affect the capacity of those affected to realize their core values. A second, more direct way is simply to ask informed stakeholders whether a project raises fundamental concerns for them, what those concerns are, and why. It is the "why" that leads towards core values. Core values will be in play when strong emotional attachments are exhibited or when answers to the questions "Why is this important?" and "Why do you value this?" are no longer forthcoming. One indicator of a core value is the fact that when asked why something is important, the person being questioned can offer no reasons beyond sayings things such as "it simply is," "that is the way we have always done it," "I cannot say anything more than I already have," or, simply, "it is a core value or something of fundamental or intrinsic importance for me."

Projects that do not put core values at stake are unlikely to arouse serious debate. It does not follow, of course, that core values are not in play just because a project has not generated serious debate. The lack of public concern is a reliable indicator only where a comprehensive project description has been undertaken and shared in a comprehensible form with all the project's stakeholders.

2.6.3 Step 3: Determining the Significance of Project Impacts

Determining the significance of a project's impacts will benefit from careful identification and analysis of non-core or use values. How will the project under assessment affect the ability of the parties concerned to realize their core values? Will the project damage things they consider to be of fundamental importance? Will it open the door to new and better ways to accomplish ends of fundamental importance to stakeholders, or will it close doors that are currently open without replacing them with something better?

The objective here is to ensure that the impact on the ability or capacity of stakeholders to realize core values or live in accordance with their core values is carefully identified. Equally important, however, will be carefully identifying the nature of that impact. Will the project provide stakeholders with new and more effective ways to do the things that are important to them, or will it reduce their capacity by removing or damaging valuable existing resources or practices on which people have come to rely? The focus here will be instrumental evaluation and the negative and positive impacts on things of instrumental value. It will also be important to determine whether the project is likely to put at risk something whose value is irreplaceable, because without it core values cannot be realized. Project impacts having this character will sometimes be obvious. A project that puts at risk an endangered species would be an example. Understanding the nature of an impact may be more complex. For people used to thinking about jobs from a purely utilitarian perspective, understanding the integral role of work-related activities in a minority culture will be difficult and challenging. Failure to do so, however, may leave undetected impacts having important indirect health-related significance.

Finally, identifying impacts that have symbolic significance for stakeholders will be important and often challenging, in part because it will not always be obvious, even to the stakeholders involved, which among the things important to them are so for their symbolic significance. A complicating factor will be the fact that some things having symbolic value will have instrumental value as well. Water and food are examples. Both have obvious instrumental value. Both can come to be invested with symbolic value as well. Failing to capture both kinds of value in Step 3 of the assessment would have serious consequences for Step 4.

2.6.4 Step 4: Determining Mitigation and Follow-up

If values have been accurately factored into the first three steps of an EA, determining where mitigation is important and follow-up necessary will be greatly facilitated. Understanding how and why something is valued will make it easier to communicate and to find responses that are seen as appropriate by the stakeholders affected. If the value being disturbed is an instrumental value, compensation and/or substitution may well be appropriate, and negotiating an appropriate solution (based on the determination of market value, for example) will offer, in most situations, a fair approach to achieving agreement. Mitigation will be the most obviously appropriate response where factors integral to the achievement of core values are at play. Here, substitution will likely not solve the problem. Nor will compensation, unless a project is seen by those affected as generating new opportunities or new values that the stakeholders come to regard as equally attractive. What should be clear, however, is that inappropriate solutions when dealing with values of this nature might well have indirect but significant health implications.

Finally, responding to impacts having symbolic significance will require ingenuity and perseverance. Offering compensation, particularly monetary compensation based on calculations of market value, will almost always generate hostility and resentment – for example, offering market value for land occupied by a cemetery or used as a traditional burial ground. Nor will substitution constitute an effective response. Providing people whose lives and social relationships have evolved from traditional ways of working the land with a factory job will not normally be perceived as fair or equitable. Offering to contribute a significant sum of money to an environmental cause as compensation for risking an endangered species is unlikely to be accepted as an appropriate solution by environmentalists or a community committed to environmental values. Solutions to these kinds of problems will have to be arrived at in quite different ways.

2.7 Concluding Observations

These last comments may, to some readers, seem to expose a serious flaw with values-based EA. Identifying values for which traditional remedies such as compensation are not appropriate is surely to create conflict, not resolve it. And why should development be held up by symbolism or traditional lifestyles that may well be regarded as economically unsustainable in modern economies?

There are two answers to this concern. First, ignoring symbolism and forcing significant cultural change are likely to have serious repercussions for the health of those affected. If protection and fostering health are core values for EA, then problems that cannot be mitigated and for which substitution and compensation are inappropriate cannot be ignored. Second, direct and indirect impacts on core values can be negotiated. In some cases, negotiation will result in radically redesigned projects. In other cases, it will result in recommendations that projects not go ahead. People are capable of rethinking, reevaluating, and restructuring their values. It is a process that is characteristic of all living cultures. Key to this process, however, is mutual respect. Dismissing other people's values as not worthy of notice or attention is the ultimate form of disrespect and humiliation. Acknowledging core values and responding to them with respect are the foundation of effective problem-solving. Effective problem-solving with health as a core value ought to be the goal of effective EA.

2.8 References and Suggested Readings

Cragg W and Schwartz M (1996). Sustainability and historical injustice: lessons from the Moose River Basin. *Journal of Canadian Studies* 31(1), spring [reprinted in *Contemporary Moral Issues*, 4th Edition, McGraw-Hill/Ryerson, Toronto, 1997; and in *Canadian Issues in Applied Environmental Ethics*, Broadview Press, Calgary, 1997].

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Notes:

3 SOCIAL IMPACT ASSESSMENT IN ENVIRONMENTAL IMPACT ASSESSMENT PROTOCOLS: A SOCIAL SCIENCE PERSPECTIVE

3.1 Introduction

SIA is a powerful tool for project planning and decision-making in EIA. SIA gained recognition in North America as an important field of inquiry through two important events: the U.S. *National Environmental Policy Act* and the inauguration of the Canadian Environmental Assessment and Review Process. These provided the main impetus to integrate social and cultural concerns into EIAs (Craig, 1990; Burdge and Vanclay, 1995).

Box 3.1
Social Impact Assessment in the Context of Environmental Impact Assessment

Although SIA is a process and methodology in its own right and can be applied outside the realm of EIAs, this discussion will be based on SIA in the context of EIA.

SIAs create a social profile of the existing situation, identify impacts that might occur as a result of a project, and predict the significance of those impacts on affected communities. SIAs can be of value to health practitioners involved in HIA and EIA in terms of the research process and the type of data collected. SIAs are a main source of quantitative health data (number of health clinics in the area, mortality and morbidity data, etc.). SIAs rely heavily on public involvement and participatory methods and collect qualitative information that is related to the determinants of health (see Volume 1, Chapter 1) – for example, the public perception of the project's positive and negative effects (including risk) and consequences that induce stress or anxiety at the individual or community level (e.g., loss of land, loss of economic security, resettlement, split-community effect).

These quantitative and qualitative data provide critical insight for health professionals who conduct HIAs or advise on health issues in EIAs. The health practitioner must ensure that negative health effects are evaluated, that adequate mitigation measures and monitoring programs are suggested, and that negative impacts are balanced with potential positive health impacts, such as a greater infrastructure for emergency (search and rescue) operations, additional health care facilities, economic spin-offs, an increase in the active population of the labour market, or greater spending power for the workers. To maximize their input, health professionals must be able to participate in all phases of environmental evaluations, from the preparation of the EA guidelines to the review of completed environmental impact statements.

SIAs are similar and complementary to HIAs and can be of use to health practitioners in several ways. The goal of this chapter is therefore to make a useful contribution to HIA by providing an overview of SIA and identifying the relationship between SIA and HIA within the context of EIA. The chapter identifies the linkages between SIA and HIA, defines SIA, discusses the usual elements found in SIAs, and highlights the methods used by SIA practitioners.

3.2 Social Impact Assessment and Health Impact Assessment Linkages

There is increasing recognition that SIA and HIA bear considerable similarities and complementarity and that integrating the two practices could prove advantageous. This section draws largely on the Rattle and Kwiatkowski (2003) discussion of SIA/HIA integration.

The process and outputs of SIA provide valuable insight to health practitioners who conduct HIAs or advise on health issues in EIAs. Health professionals can use SIAs to translate social data into predictions on health issues. In turn, health practitioners can contribute to the SIA process by translating health determinant concerns into research questions for the SIA consultant.

In order to understand the linkages between SIA and HIA, it is important to understand that health is defined broadly as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1967). Health encompasses social, economic, cultural, and psychological well-being and includes the ability to adapt to daily stresses and change (Rattle and Kwiatkowski, 2003). Based on this definition, it is clear that health is influenced by a number of interrelated factors. These are income and social status, education, employment and working conditions, physical environment, biology and genetic endowment, social support networks, personal health practices and coping skills, healthy child development, health services, culture, and gender (FPTACPH, 1996; see also Chapter 1 in Volume 1 and Chapter 2 and Appendix B in Volume 2 for discussions of these factors, or determinants of health). These determinants of health are similar to the elements of SIAs discussed below – i.e., population characteristics, community and institutional structures, political and social resources, individual family changes, and community resources.

With this in mind, the linkages between SIA and HIA become clearer. First, in terms of data, there is significant overlap in the social information and indicators of SIAs and HIAs. This is particularly true when considering the effects on social well-being (income, socioeconomic status, employment, migration, and resettlement), community health (effects on culture and way of life), services (health, education, social support networks), and psychological well-being (stress, anxiety, and nuisance produced as a result of the project). Rattle and Kwiatkowski (2003) assert that:

> "How people and communities are affected and the social and economic consequences of development provide critical information for a HIA. Similarly, knowledge of the impacts on the quality of life and health of people and communities is vital to SIA."

Second, both HIA and SIA practitioners (particularly public health professionals) use participatory methodologies and tools to uncover and examine qualitative social information related to well-being and quality of life. They introduce people to the research process by bringing concerns and issues of different groups into the forefront and giving people the opportunity to take control over the direction of the project. SIA practitioners produce data that are related to social determinants of health and have the potential to foster trust within the community. In turn, health professionals facilitate dialogue between local communities and promoters and thereby help to ensure equity in the EIA process. Their contribution is invaluable, given the various risks associated with a project and the fact that perception and acceptance of risk vary depending on the interests and agendas of different stakeholders (i.e., the proponent, government authorities, consultants, and affected communities).

The linkages between SIA and HIA have stimulated discussion about the merits of better integrating the two practices (Sadler, 1996; Rattle and Kwiatkowski, 2003).

Several fundamental factors are critical for this integration to happen. First, cooperation between SIA and HIA practitioners must be strengthened. As external reviewers and collaborators, health professionals contribute to SIAs by translating health determinant concerns into research questions for the SIA practitioners. In turn, HIA practitioners use SIAs to translate the social outputs into useful predictions on health issues. This relationship could be broadened and deepened. Second, an increased understanding and awareness of health, in its broadest sense, are needed among SIA and EIA practitioners in order to understand the importance of health in EIA. And, third, there needs to be increased understanding of linkages between social, health, and environmental effects.

Box 3.2
Advantages of Integrating Social Impact Assessment and Health Impact Assessment

The integration of SIA and HIA would:

- generate a more holistic assessment;
- reduce duplication of data and information resources, thereby enhancing financial efficiency;
- avoid inconsistencies;
- enhance the strengths and complementarity;
- enhance the value of social and health sciences in EIA; and
- balance the trend towards reductionism.

Source: Rattle and Kwiatkowski (2003)

The following sections aim to contribute to a broader understanding of SIA and the linkages discussed above.

3.3 Mandate for Social Impact Assessment

In Canada, each jurisdiction has different requirements for social assessments within the EIA process. At the federal level, the *Canadian Environmental Assessment Act* requires an SIA if the project causes social impacts that are causally linked to change in the environment. At the provincial level, British Columbia's *Environmental Assessment Act* provides for the "thorough, timely, and integrated assessment of the environmental, economic, social, cultural, heritage, and health effects of reviewable projects." Ontario's *Environment Act* defines environment as including "the social, economic, and cultural conditions that influence the life of humans or a community"; and the EIA will describe 1) the environment that will be affected or that might reasonably be expected to be affected, directly or indirectly, and 2) the environmental effects that will be caused or that might reasonably be expected to be caused.

At the international level, multilateral development banks and bilateral donor agencies have developed operational policies, directives, and guidelines on incorporating social aspects into projects and EAs. For instance, in its Environmental Assessment Operational Policy, the World Bank clearly states that EAs need to take into account social aspects, specifically involuntary resettlement, indigenous peoples, and cultural property. As a result, SIA has evolved as a tool for assessing the social impacts of development projects.

3.4 Social Impact Assessment Defined and Described

3.4.1 Definition

SIA is the assessment, in advance, of the social effects of a policy, program, or project. Social impacts are defined as the "social and cultural consequences to a human population of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society" (ICGP, 1994). SIAs describe the social context within which projects are undertaken, identify and assess the significance of potential social impacts of development projects, and propose mitigation measures to avoid, reduce, or compensate for the impacts.

SIAs examine both positive and negative effects (measured in terms of qualitative social change), the goal being to reduce negative effects and enhance project benefits. The impacts are then expressed in terms of their significance – i.e., minor, major, or nil disturbance. This exercise summarizes the necessary mitigation, compensation, or monitoring measures. The quantitative outputs of SIAs are sometimes used in cost-benefit analysis.

SIAs are predictive. That is, they describe and assess the types of effects that will likely occur in the affected communities, identifying those groups at risk or at benefit and, when possible, the extent of the impacts (time frame, degree of pervasiveness, proximity indicators, etc.). SIAs do not provide a guarantee that the impact will occur, but rather alert the proponent that the impact is likely. Thus, once the project is implemented and monitoring activities are set up, what was deemed a major impact in the pre-project evaluation may be less significant or may result in unpredicted effects. Such is the nature of social change. The key is to identify the issues and put in place effective mitigation and monitoring measures.

3.4.2 The Social Impact Assessment Team

The project proponent or its consultant is responsible for preparing the SIA. SIAs should be conducted by a social scientist (e.g., sociologist, anthropologist) or other professional trained in SIA methods. Resources permitting, the SIA should involve a multidisciplinary team of specialists with expertise and experience in different relevant fields (e.g., health, demographics). As well, a peer review of the SIA report should be carried out by an external reviewer.

3.4.3 Benefits of Social Impact Assessments

Substantial benefits can be gained from conducting SIAs. These include the following:

1) SIAs that involve stakeholders can reduce local resistance to projects and increase acceptance, thereby preventing costly delays.
2) SIAs can improve the planning process.
3) SIAs can prevent or minimize negative impacts.
4) By developing approaches and practices that are appropriate to local conditions, SIAs can enhance project benefits.
5) By identifying all stakeholders and analysing how specific impacts (both positive and negative) affect different stakeholder groups, SIA has the potential to ensure that the benefits of the project are equitable.

3.4.4 Key Steps in a Social Impact Assessment

As part of the EIA process, SIAs should be synchronized with the EA process, which in turn is ideally conducted as an integral part of the project development process. The steps for conducting an SIA mirror those of an EIA. Although many models for SIA exist, they are all quite similar in content. The seven steps outlined in Box 3.3 are adapted from Burdge and Vanclay (1995).

The final SIA report is often divided into three parts: 1) the description of baseline conditions; 2) the evaluation of potential impacts; and 3) the proposed mitigation measures and monitoring plan. It can be integrated into the EIA report or submitted as a self-standing report.

Box 3.3
Key Steps in a Social Impact Assessment

Step 1: Design the Public Involvement Plan: Design an effective public involvement plan to involve all potentially affected publics. This step will include a stakeholder analysis to identify all affected groups, including groups that may be required to relocate or groups adversely affected by loss of income, loss of traditional lands and cultural heritage resources, and possible exposure to health hazards. The implementation of the public involvement plan should be carried out throughout the life of the project; it should be an ongoing activity that cuts through all of the steps mentioned below.

Step 2: Describe the Proposed Project and Identify Alternatives: Describe the proposed action and reasonable alternatives, including alternatives within the project and alternatives to the project. Information will be required about locations; land requirements; the need for ancillary facilities such as roads, sewer and water plants, and transmission lines; construction schedule; size of workforce; facility size and shape; capacity to utilize locals; and institutional resources.

Step 3: Describe Baseline Conditions (Social Environment and Area of Influence): The baseline conditions are the existing conditions and past trends associated with the social environment in which the project, policy, or program is to take place. The description of baseline social conditions is an important component of the SIA process. It includes the political, social, cultural, historical (in terms of past experiences with development projects, for instance), and economic (labour and market considerations) dimensions; inferences on social carrying capacity (e.g., limits pertaining to population size or group composition that given resources or services in a community can support without destruction of the social fabric); political and social structures; social infrastructure; cultural heritage resources; indigenous peoples' issues; attitudes and social-psychological conditions; basic population characteristics such as age, sex, family size, and gender and ethnic differentiation; and so forth. Once this context has been described, then potential impacts can be projected.

Step 4: Scoping: Identify the key issues to be considered in the SIA and the information required to assess the key issues. A key part of scoping is defining the spatial boundaries and the affected communities of the project. Spatial boundaries are often determined by considering the location of the project area, the spread of the project's impacts, and time and budget constraints (Krawetz, 1991). In EIAs, the definition of affected communities is usually based on the extent of predicted spatial coverage of impacts on the physical environment, and SIAs are often guided by this definition. In resource development projects, for example, SIAs have traditionally focused on the communities closest to the work site, even though communities farther away may also be affected by related infrastructure development (e.g., construction of a transformation plant, shipping and transportation logistics, long-distance commuting labour, and so on).

Box 3.3 (Cont'd)

However, there is increasing recognition that SIAs also need to examine the impacts on communities affected by the project even if they are far from the project site or have an indirect linkage to the project. The World Commission on Dams, for example, calls for the analysis of downstream and transboundary social effects. SIAs need to consider all affected groups, including those who will benefit and those who will be negatively affected. Vulnerable groups need to be identified and included in the assessment process.

Step 5: Evaluate Impacts and Determine Significance: Assess all probable social impacts, determine the importance of the identified social impacts to the affected publics, and estimate indirect and cumulative impacts. Included in this is an analysis of impact equity – i.e., the identification of who will win and who will lose, emphasizing vulnerable and underrepresented groups.

Step 6: Mitigation: Identify mitigation measures to prevent, reduce, or compensate for the impacts.

Step 7: Monitoring: Develop a monitoring program that is capable of identifying deviations from the proposed action and any important unanticipated impacts.

Source: Burdge and Vanclay (1995)

3.4.5 Public Involvement in Social Impact Assessment

Public involvement is a process for involving the general public in the decision-making process of an organization. In a broad context, it plays an integrating function within the planning and assessment processes and is a critical tool for SIA practitioners (Roberts, 1996). Public participation is discussed at length in other parts of this Handbook (Volume 1, Chapter 2; and Volume 3, Chapter 3). This chapter will therefore discuss it only briefly as it applies to SIA.

One of the first steps in an SIA is the development of a public involvement plan. This involves the identification of all stakeholders, the development of consultation methods (different strategies and techniques for different stakeholders), methods for communication and feedback, and an action plan for public involvement throughout the SIA. Public involvement in SIA can take different forms, ranging from persuasion, through education and information and two-way consultation, to participation (Roberts, 1996). The greater the level of public involvement, the deeper the SIA can delve into public issues and concerns.

Public involvement is critical to the SIA process for several reasons. By consulting the public, SIAs seek to identify and understand the points of view of different stakeholder groups in order to better identify potential problems and to provide insight into the community's acceptance of and concerns regarding the project. These perspectives are then articulated in the SIA report. A major characteristic of SIA work is the premise that "perception is reality" – i.e., the different perspectives held by stakeholders concerning a proposed project are all valid and valuable. Public involvement helps to reveal these perspectives.

By consulting the public, SIA also provides a wealth of community-based knowledge about the political, social, and cultural environment. Community input is useful in pointing out potential impacts and appropriate mitigation measures that the SIA consultant may not otherwise identify.

By involving the public at a deeper level – i.e., by enabling the public to participate in decisions about the project (e.g., to identify alternatives within the project) – the SIA process can lead to greater community acceptance of the project and enhanced confidence in the proponent.

The success of a public involvement process hinges on the capacity of the public to participate and on the provision of open and free access to the process. It is therefore critical that different methods be used depending on the public and the goal of the public involvement activity. For instance, open-ended interviews or focus groups enable people to express their concerns, while directive interviews can test impact hypotheses. Visual appraisal techniques can be used where language barriers are an issue. Drafts of the SIA conclusions can be presented to the communities to seek further input, to test evaluation acceptance, or to validate projections.

The public involvement process implemented throughout an SIA can be a valuable asset to HIA specialists. The SIA will have identified stakeholder groups and established consultation mechanisms. The SIA consultant will have begun to gain the public's confidence and trust and is therefore in a good position to introduce the HIA consultant if follow-up work is required.

3.4.6 Misconceptions about Social Impact Assessments

It is important that the proponent, EIA practitioners, and the public have realistic expectations of SIA. This section discusses three commonly held misconceptions about SIAs: 1) SIAs are a source of information on the proposed projects; 2) SIAs assess the proponent or the project; and 3) SIAs are directly concerned with following up on the implementation or monitoring phases of the proposed projects.

As mentioned above, the purpose and scope of SIA are to describe the existing social environment, to predict what might occur as a result of the project, and to propose mitigation and monitoring measures. The purpose of SIA is not to answer the questions or concerns of the affected communities, to help the proponent gain project acceptance, or to give the community project information. In practice, however, through the public involvement process, the SIA practitioner often acts as an intermediary between the affected communities, the proponent, and other EIA consultants. While SIA practitioners do not play a formal advocacy role to ensure effective decision-making, their input and contacts with the public can assist in the transmission of information between the promoters and the community. Because promoters do not always provide project information to all stakeholders, the SIA practitioner often needs to give stakeholders project information to enable them to participate in the SIA effectively.

SIAs assess the project impacts. They do not evaluate the project proponent or the validity of the project. In some cases, however, SIAs do provide insight on the social interactions of the project workers and promoters and their possible relationship with the affected communities.

SIAs do not assess the extent to which the policy, program, or project is implemented as designed. Nor do they identify problems that arise during project implementation. The SIA does, however, review related studies, predict potential problems, and propose mitigation and monitoring measures for all phases of the project cycle in order to avoid, minimize, or compensate for identified impacts.

Once the project has started, it is up to the proponent to put in place the proposed mitigation and monitoring measures. Routine data (indicator follow-up, social, physical, biological, or other data) are not collected and analysed on an ongoing basis in SIA. SIA consultants most often provide a one-shot evaluation of potential impacts (positive and negative) and provide insight on indicators that should be monitored. If monitoring occurs during a project's definition or during its negotiation phase, data are usually collected by the project proponent, by representatives of the affected community (e.g., by their consultants, negotiators, or special interest groups, provided that the community has the necessary resources), or through regular activities of governmental agencies and departments.

3.5 Social Environment Described in Social Impact Assessments

SIAs describe and analyse the social and cultural environment in the project area. Social information is typically divided into the following headings (ICGP, 1994; Burdge, 1999):

- demographics;
- community and institutional structures;
- political and social resources;
- individual and family changes; and
- community resources.

This information is used to develop a social profile (or baseline report), which in turn is used to predict impacts. The factors included in a given SIA depend on the provincial/territorial regulations, the EIA terms of reference, financial resources, personal expertise and familiarity of the assessor with SIA literature, and the nature of the project. This section describes the elements described in SIAs.

3.5.1 Demographics and Population Characteristics

SIAs describe and analyse the characteristics of the population in order to predict population impacts. The data include demographic information disaggregated by gender, age, race, and ethnic composition; population distribution; growth rate; seasonal migration patterns due to work, leisure, etc.; major economic activities; employment/unemployment information; and education rates.

Data on population and demographics are useful for HIA practitioners. Sex ratios, age pyramids, and in- and out-migration mobility patterns are used to simulate economic impacts, to define the characteristics of the potential local workforce, and to evaluate the impacts of a transient or new in-migration workforce. Health professionals can use the data in their assessment of the effects on health and well-being of job loss/creation within the community, out-migration of local residents, and influx of a migrant workforce.

Health-related data such as mortality and morbidity rates, incidence of alcohol and drug abuse and sexually transmitted diseases (STDs), use of health clinics, etc., can assist HIA professionals in putting impact assessments into context or proposing adequate monitoring measures. To contribute even more to HIA monitoring measures, SIA studies could be strengthened by adding indicators of psychosocial stress or social morbidity to monitoring procedures. These would include mental pathologies, substance abuse, depression, suicides, and so on. In the case of physical health, it should be possible to follow the pattern of accidents related to changing land use configurations and transportation corridors and certain pathologies indicative of physical or social stress directly or indirectly related to the projects (e.g., STDs).

Education data are compiled essentially to determine the potential labour basin and skilled personnel locally available. The data are used to evaluate potential employment creation benefits and to determine the need for, or possibility of, setting up specific training programs. Insofar as education is a determinant of health, positive impacts such as increased training and improvements in education can be deemed as having a positive indirect effect on health.

3.5.2 Community and Institutional Structures

Community and institutional structures include public administration (the size, structure, and level of organization of local government), used to predict the capacity to deal with issues that might arise; community structures such as the voluntary sector, religious and interest groups, and relationships among communities and social organizations; and patterns of employment and industrial diversification. The interaction between the community and institutional structures can shed light on people's sense of belonging and institutional support within the community, both of which are linked to well-being. Changes in these structures may affect changes in health.

3.5.3 Political and Social Resources

Political and social resources include the distribution of power and authority; stakeholders and affected public; and community or regional leadership properties. Issues of marginalization, community hierarchies, and empowerment may be highlighted.

3.5.4 Individual and Family Changes

Individual and family changes, such as changes in attitudes, perceptions, and friendship networks, are factors that influence the daily lives of individuals and families. The changes range from attitudes towards the policy, to changes in family and friendship networks, to perception of risk, health, and safety. Community concerns, norms, values, beliefs, and attitudes are typically documented in relation to local social structures (identity, family, community, gender relations, etc.), land use and occupancy patterns, and the proposed project. The social scientist assesses individual stakeholder insight into attitudes towards the project, project acceptance, and potential social impacts.

Community concerns, norms, values, beliefs, and attitudes (referred to by some authors as "ideology") are fundamental determinants of illness, disease, and health (Fabrega, 1974; Zimmerman, 1980; Eisenberg and Kleinman, 1981). Because SIAs consider local "ideology," they generate information that can be useful to HIA practitioners in predicting the impact of individual and family changes on health.

3.5.5 Community Resources

Community resources include information on natural resource and land use patterns, housing, and community services such as schools, health facilities, police and fire protection, sanitation, and local transportation infrastructure. Also included are historical and cultural resources such as historical monuments, archaeological sites, and cultural landscapes. HIA practitioners can use land use and natural resource data to evaluate health effects related to nutrition, recreation, and livelihood. Information on community services is used to identify potential impacts on the carrying capacity of existing services and impacts.

Box 3.4
Ideology and Health

Some authors refer to community concerns, norms, values, beliefs, and attitudes as "ideology" and have made linkages between ideology and health.

3.6 Types of Social Impacts Identified in Social Impact Assessment

The social environment information discussed above is collected in order to predict changes that might occur in the social environment as a result of the proposed project. Impacts are likely to differ in type and magnitude depending on the project stage. Accordingly, social impacts should be considered for all stages of the project cycle (planning, construction and implementation, operation and maintenance, and decommissioning).

3.6.1 Impacts on Population

The most common impacts considered under this heading are:

- out-migration of local workers and impact on families remaining in the community;
- job creation for local people through training;
- job loss;
- resettlement; and
- workforce in-migration and its impact on the host community (e.g., tensions due to differences in cultural background and socioeconomic status; this is particularly prominent in cases where the host community is an ethnic minority or Aboriginal group).

3.6.2 Impacts on Community Resources

The most common impacts on community resources are those related to the influx of a large workforce and to disturbance of cultural resources.

3.6.2.1 Impacts of a Large Workforce

While the presence of a large workforce can have a positive effect in terms of generating business for restaurants, catering companies, etc., the negative impacts are more significant. The large workforce can create substantial pressure on community services (e.g., housing, sewage and sanitation, potable water supply, health services). This can generate health problems and create conflict.

3.6.2.2 Impacts on Cultural Resources

Development projects, particularly infrastructure projects, can have a significant impact on archaeological and historical sites, indigenous cultural property, and landscape.

The SIA includes a survey of existing cultural resources, including archaeological and historical sites. The SIA practitioner identifies the sites (historical monuments, archaeological sites, cultural landscapes, etc.) through consultation with the public and assesses the social value of these resources, the impact on the community of disturbance to the sites, and appropriate and acceptable mitigation measures. Archaeologists are often called in to conduct a full-scale archaeological study, if required. Once they have identified and officially catalogued all sites, safeguard measures and exploratory or salvage excavations can be undertaken in accordance with provincial/territorial regulations.

The SIA specialist can help to pinpoint areas of interest and to document past activities associated with these areas, values attributed to these places of interest, and community feelings regarding the need to protect the sites or correct disturbances resulting from past development activities.

Effects on archaeological or historical resources have few direct impacts on health. However, most community concerns and issues are of a sociocultural nature (e.g., values, equity, and empowerment issues), which may have indirect impacts on health. For example, if sites that are highly valued by the communities are not identified and are ultimately disturbed by the project, communities may make popular hindsight associations between taboo breaches, for instance, and apparent or perceived illness episodes. (See Chapter 2 for more information on values.)

The landscape parameters examined most often are aesthetic visual impacts of transportation or other infrastructure projects. Through their linkages with local communities, SIA consultants can help identify where, when, and why potential visual impacts may be more than a simple disturbance and may emphasize perceived or actual risks.

3.6.3 Impacts on Land Use and Occupancy Patterns

Development projects may have significant impacts on the use of lands and resources. A change in the use of land and/or resource may in turn have an impact on livelihood, nutrition, and recreation.

3.6.4 Economic Impacts

Economic impact assessment, conducted by economists, is often integrated in the SIA reports. Economic evaluations in SIA cover the project's impacts on the general economy (jobs created, taxes paid, services and goods bought, etc.) rather than the profitability of the project. The main issues that relate to the affected communities are employment and personnel, activity sectors, businesses, income, and expenditures. SIA consultants can contribute valuable community-based information to the economic assessment. They can identify both negative and positive indirect economic impacts (e.g., on property value) and direct economic impacts (e.g., on local purchasing power and spending patterns). The fact that SIAs identify negative impacts is important, because these tend to be left out of traditional economic impact assessments. This is perhaps due to two factors:

1) Economic valuations are generally based on the premise that projects are driven by economic imperatives and therefore must be positive.
2) Economists rarely have direct access to knowledge on local dynamics and thus are often unable to identify local economic resistance or promotion factors.

There is a fundamental difference between the evaluation of economic spin-offs and the use of cost-benefit studies. Economic spin-offs are always considered positive when undertaken in SIAs because the level of economic activity is increased every time money is spent, whether to build a factory, to clean up a river bank, or to hire workers. As for cost-benefit or cost-efficiency studies of various options, the focus is on evaluating the distribution of impacts – i.e., who “wins” versus who “loses.” (See Chapter 4 for more information on economic appraisals.)

Regarding employment, SIA practitioners will often generate data on equity in labour recruitment or personnel turnover rates by considering local expectancies, needs, qualifications, education levels, and customs. They may also look at other related issues such as potential “skimming effects” of jobs offered by the project (i.e., new development projects often drain some of the leaders and some of the most qualified workers from the communities in which the project is undertaken, thereby generating indirect social impacts).

Because they are more likely than economists to have access to local data concerning the informal economy, social scientists can help to document project-related externalities, such as revenue losses incurred due to diminished resources or reduced access, and to identify those groups at risk of having to bear these losses.

Health practitioners may be interested in the impacts of increased spending power or diminished access to natural resources on quality of life and on nutrition.

3.7 Methods and Tools in Social Impact Assessment

The major strengths of SIA methodology are the gathering and compilation of baseline data through secondary data collection to describe the existing social environment and the use of participatory research methods to identify community-level concerns and solutions. Since a significant number of the data collected are qualitative, community-level information, the methods are designed to be participatory and inclusive.

The following subsections discuss the sampling and data collection methods and tools used in SIA.

Box 3.5
Baseline Social Impact Assessment Data

Baseline SIA data can be used during monitoring activities as reference points to evaluate the real effects of development projects (via follow-up monitoring).

3.7.1 Sampling

In an SIA, the sample is generally composed of both key informants and other relevant stakeholders. Key informants are those people who are the most knowledgeable of those most directly concerned by what is being measured.

To supplement and complement key informant information, the SIA consultant also talks to members of other affected groups. This is critical, because key informants alone do not necessarily represent all affected communities. This is a variant of stratified sampling, which is used when an important subgroup is likely to be underrepresented in the sampling approach. For example, if the key informants are those who currently use a given resource that might be affected by a project, then the social scientist might also want to get representation from previous users (e.g., elders) or future users (e.g., youth). This type of sampling, however, remains disproportionate, in that key informants are often oversampled compared with the other strata since they may provide essential data to evaluate the project's impacts.

The three most often used sampling strategies in SIAs are clustering, snowball sampling, and haphazard sampling. *Clustering* is a technique used to identify those natural groupings or associations where key informants are likely to congregate (hunters' and trappers' associations, ecological groups, neighbourhood organizations, etc.). *Snowball sampling* consists of asking key informants to identify other potential informants. In small communities, this can be very effective, because most people are likely to be in contact with each other. In large communities, however, this technique may lead to oversampling of specific subgroups of informants. Finally, *haphazard sampling* is when the consultant relies on those who are willing to participate or have a vested interest in doing so. In some cases, haphazard sampling is the only technique feasible (e.g., the timing of the study is not convenient for participants; local populations are reluctant to participate in the EIA because they disapprove of the project; etc.).

SIA practitioners rarely choose to undertake random sampling procedures because the proposed project normally affects only a small part of a large community (e.g., those people living closest to the project, those using resources potentially affected by the project, those commuting through the impacted area, etc.). Because survey conditions used in SIAs are rarely based on random sampling, they nearly always have a non-probabilistic approach. This has caused some concern over the validity of SIA sampling methods. However, if the sampling methods are discussed, justified, and supported by adequate baseline data, SIAs do in fact lead to credible analyses. SIA reports do not always discuss sampling techniques or limiting conditions; thus, the burden rests on the readers of SIAs to interpret how the sampling was undertaken in order to determine the limitations of the studies.

3.7.2 Data Collection

An important feature of SIAs is the adoption of participatory research methodology – i.e., an approach and tools and techniques that enable stakeholders to participate in and have some degree of control over the research process. Different methods are developed for different publics, and differences in literacy levels, language, culture, and availability are considered in order to design an inclusive process.

Within the participatory framework, SIA combines a broad range of qualitative and quantitative data collection methods, the use of which depends on the originality and expertise of the consultant, the funding and time available, the latitude given to the consultant by the proponent, and the willingness and capacity of the different stakeholders to participate. In general, the tools include literature reviews for secondary data and observations, interviews, focus groups, and household surveys and questionnaires for primary data (Olsen and Merwin, 1977; Livesay et al., 1984; Jaakson, 1985; Krawetz, 1991; Sayer, 1992; Grawitz, 1993; Bernard, 1994). Participatory methods such as participatory rural appraisal and related activities are also used to access local knowledge and actively bring stakeholders into the process. These are discussed below.

In order to ensure validity in data collection, SIAs use an approach called triangulation. That is, they integrate two or more research methodologies. For example, SIAs typically combine quantitative data from surveys or questionnaires with qualitative data from group discussions, participant observation, and interviews. Triangulation puts the data provided by informants into perspective and gives an added measure of validity to the study.

3.7.2.1 Literature Review

The first essential step in an SIA is a review of the literature, both published and unpublished. In cases where this is the only data-gathering phase, the evaluator should read the literature on the social and cultural organization of these communities and gather data/information on:

- the social environment relating to the affected communities;
- the important historical evolution of the area;
- the project itself; and
- land use and occupancy in the EIA area – often available as “grey” literature or through municipal or provincial/territorial land planning and resource management agencies.

The SIA consultant should be able to base his/her projected impacts on a comparison of impacts or SIAs undertaken in similar contexts (i.e., similar project type and size, as well as characteristics of the affected communities).

3.7.2.2 Observation

Observation is a commonly employed fieldwork technique used to collect qualitative and quantitative data. There are two types of observation: participant and non-participant. *Participant observation* entails living for an extended period among beneficiaries, during which interviews, observations, and analyses are recorded and discussed (World Bank, 1996). The evaluator establishes an intimate rapport with a given group and shares or helps in its activities. This is very useful to gain insight into the practices, motivations, and attitudes of people and is therefore typical of ethnographic work. However, the time and energy needed to build sufficient trust and to justify the presence of an outside observer make it prohibitive for SIA.

SIAs therefore rely more on *non-participant* observation, which consists of studying the general characteristics of a population or of trends such as the number of people who access an area or use a specific public utility during a given period. Non-participant observation does not consist of living within a community or taking part in daily activities. It is therefore more feasible given the time and resource constraints that are often involved in conducting SIAs.

3.7.2.3 Interviews

Interviews with individuals or a group of informants are frequently used in SIAs. There are three types of interviews: unstructured, semi-structured, and structured.

Unstructured interviews are common in ethnographic work, where time is not a factor, but are very rare in SIAs because they imply (once the informant has been briefed on the interview objectives) that the interviewer intervenes only when absolutely necessary during the responses.

Semi-structured interviews are the most commonly used tool in SIAs. The consultant designs a flexible interview guide that lists a limited number of pre-set questions. This ensures that the interview remains focused on the topic at hand while allowing enough conversation for the participant to introduce and discuss new ideas or associations. If they deviate too far from the topic, the participants are probed with specific questions. This tool is often used in focus group discussions.

Structured interviews are used when comparisons between informant responses are required. They provide information that can be categorized and analysed quantitatively. The evaluator words the questions in a specific manner and requires all participants to answer the questions in a predetermined order. Structured interviews are not often used in SIAs since they do not add to the predictive power of unstructured interviews. The different techniques (free listings, sentence framing, triads, taxonomies, ranking and rating, etc.) associated with structured interviews to elicit underlying meanings or knowledge are seldom used because the degree of analysis required to interpret the data generally surpasses the resources available for SIAs. Moreover, the measures obtained often exceed what is expected of EIAs.

3.7.2.4 Household Surveys and Questionnaires

Where funding and logistics permit, SIAs use different types of questionnaires (household surveys, self-administered, interviewer-assisted, telephone or mail surveys, etc.) to gather quantitative data. Each type of questionnaire has its advantages and limitations, but the main drawback to using a questionnaire to collect social data is that communities may be reluctant to answer sensitive issues in a questionnaire perceived to be issued by a proponent. Thus, the response rate can be quite low, and different potential biases can seriously compromise the validity of the data obtained.

3.7.2.5 Participatory Tools

A number of participatory methods and tools are used in SIAs because they encourage stakeholder participation and are effective at accessing community-level information. Participatory rural appraisal, for example, is used for its emphasis on local knowledge. Participatory rural appraisal uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders (World Bank, 1996). Participatory rural appraisal exercises include activity profiles, community mapping, and wealth ranking. Other participatory activities include stakeholder workshops, focus groups, informal interviews, and access to resource profiles (World Bank, 1996).

3.7.3 Concerns about Social Impact Assessment Methodology

While reading an SIA, one might wonder if the evaluation was well done or if it meets professional standards and principles. It is difficult to answer these questions, because SIAs do not always indicate all the data necessary to undertake a meta-evaluation. Moreover, the only formal agencies that usually evaluate SIAs are EA review boards and the authorities in charge of permitting procedures. In most cases, when evaluating SIAs, best-practice judgments usually apply.

SIA methodology does not aim to experiment or gather “hard science” data. This may be of concern to other consultants, the proponent, or reviewers who may be accustomed to scientific methods or traditional social science research based on the principles of ideal experimentation, value neutrality, and positivism and are intent on control. They may refute the validity of the data if they are not collected under “scientific” conditions. However, SIAs use participatory social science methodology that is designed to gather qualitative community-level information – i.e., methodology that brings to the foreground people’s lives, experiences, and knowledge. They do not aim to necessarily use or meet scientific standards used in environmental health research.

Moreover, the mandate and nature of SIA do not lend themselves to work within the confines of ideal experimentation. Control groups are rarely considered because the SIAs cover only those communities most directly affected by a proposed project. Random sampling is not used because the proposed project normally affects a small part of a larger community, and sampling therefore needs to be more targeted. Finally, SIAs do not undertake any post-testing because, by definition, they include only a baseline description of the social environment, a projection of potential impacts, and suggestions for mitigation and monitoring measures.

In the process of assessing potential risks, many uncertainties must be addressed, whether they be within an SIA, an HIA, or an EIA. These uncertainties can be reduced (made measurable or more predictable) in some cases by gathering more data and evaluating more parameters. In other cases, however, some uncertainties are apparently irreducible, either because of their nature (such as in non-linear, chaotic systems) or because of our structure of knowledge – for example, when we try to interpret meanings cross-culturally or when we try to synthesize complex, dynamic, and multi-oriented social systems (Faber *et al.*, 1992).

Box 3.6
Ideal Experimentation

Ideal experimentation (i.e., the basic set-up for a two-group randomized pretest/post-test design) builds on four basic principles: 1) two groups are needed at least, an intervention group and a control group; 2) people must be assigned randomly to one or the other group; 3) different variables (e.g., knowledge, attitudes, values, health indicators, economic status, etc.) are measured before an intervention (e.g., a development project, a policy, or a program) is implemented (pretest); and 4) the same variables are measured again and the extent of changes is evaluated after the intervention is implemented (post-test).

3.8 Challenges Facing Social Impact Assessment Practitioners

SIA practitioners face one or many of the following challenges:

- The elements required to be assessed are not clearly formulated or are not really measurable – i.e., the terms of reference are not adequately defined.
- Stakeholders hold unrealistic expectations (too high or too low) about the role of SIA practitioners.
- The project definition and parameters change during the course of the evaluation.
- Time and resources allocated to SIA are often limited.
- The proponent or the population (or both) is not cooperative.
- The availability of baseline information is limited.
- Stakeholders try to force their agendas on the SIA practitioner.

3.9 Conclusion

This chapter has identified the linkages between SIA and HIA and defined and described SIA. It has shown that changes in the social environment can effect changes in variables related to health. HIA practitioners can use SIA to identify the type of information they require from SIA in order to assess changes in health, and they can contribute to SIA by defining, during the SIA design phase, what type of health information is required from the SIA in order to identify health impacts. Although there are many avenues for collaboration between SIA and HIA practitioners, more effort is needed to generate understanding of how they can work together and how SIA and HIA contribute to one another.

3.10 References and Suggested Readings

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4 ECONOMIC APPRAISAL/ EVALUATION OF PROJECTS

4.1 Introduction

Economics is most often defined as the study of the allocation of scarce resources among competing ends. This definition emphasizes two important considerations. The first is that resources are limited – i.e., they do not exist in sufficient amounts to satisfy all human wants. The scarcity of resources implies that society and its members must choose how to use them and leads to the second feature of the definition of economics: the concern with understanding how choices are made among competing ends (Nicholson, 1978).

By helping decision-makers understand the value that individuals place on different allocations of goods and services, economics can help shape the development of policies that allocate resources towards the greatest social good. In the context of EIA, economic analysis can help government decision-makers enumerate and valuate the effects of a proposed project. This allows them – whether acting as project proponents, regulators, land managers, or sources of financial assistance – to incorporate the environmental impacts of a project into an overall assessment of its costs and benefits. This assessment can help to determine whether government support of the project is warranted – i.e., whether the project represents a reasonable allocation of society's resources – and can shape decisions concerning the use of measures to eliminate or reduce adverse health or environmental impacts.

Appropriate economic evaluation of environmental projects requires an understanding of basic economic concepts and of the analytical methods that economists employ. These concepts and methods are the focus of this chapter. The discussion includes an overview of economic analysis, a summary of the methods employed in primary economic research on the valuation of health effects, an introduction to valuation techniques that analysts can employ in lieu of primary research, and a synopsis of methods for integrating the valuation of health impacts into a comprehensive economic analysis.

4.2 Economic Analysis: An Overview

This section addresses the major components of an economic analysis, the basic principles used to measure benefits and costs, and the application of these principles to the valuation of health effects. (The discussion draws upon two key sources, both of which provide excellent introductions to the theory and practice of economic analysis: Stokey and Zeckhauser, 1978; and U.S. EPA, 2000a.)

4.2.1 What Are the Major Components of an Economic Analysis?

There is no simple formula for economic analysis of a development project. The evaluation of different projects may call for different analytical approaches and techniques and the formulation of a variety of assumptions based upon professional judgment. In general, however, a complete economic analysis will include a benefit-cost analysis, a distributional analysis, and an equity assessment.

Benefit-cost analysis is the principal analytical framework used to evaluate public expenditure decisions. It attempts to evaluate a project before it is undertaken to help decision-makers determine in what form and at what scale it should be undertaken, and indeed whether it should be undertaken at all. Benefit-cost analysis involves the following steps:

- identification of the project or projects to be analysed;
- enumeration of all project impacts, both favourable and unfavourable, present and future, on all members of society if a particular project is adopted;
- valuation of these impacts in monetary terms; favourable impacts are registered as benefits, and unfavourable impacts as costs; and
- calculation of the project's net benefits (total benefits minus total costs).

The rationale for benefit-cost analysis is economic efficiency; it aims to ensure that resources are put to their most valuable use. Within the framework of benefit-cost analysis, decisions hinge on the *net efficiency criterion* (see Box 4.1). This criterion guarantees that the benefits of any projects undertaken will be sufficiently large that those who gain by a project could compensate those who lose, with all members of society thus made better off. Further, this decision criterion guarantees that the alternative selected is superior to all others in this respect. Thus, application of the net efficiency criterion will produce the most efficient allocation of society's resources.

Box 4.1
The Net Efficiency Criterion in Benefit-Cost Analysis

Decision-making within the context of benefit-cost analysis depends on the net efficiency criterion – i.e., in any choice situation, one selects the alternative that produces the greatest net benefit. In some cases, of course, the net benefits of all alternatives evaluated may be negative – i.e., their costs outweigh their benefits. In such cases, the best alternative is to do nothing, which produces a net benefit of $0.

It is important to emphasize that the net efficiency criterion does not require those who benefit from a project to compensate those who lose; it only requires that such compensation be possible. As conventionally applied, benefit-cost analysis does not take such distributional issues into account. Instead, decision-makers employ two additional tools to assess the distribution of project costs and benefits: distributional analysis and equity assessments.

Distributional analysis evaluates the distribution of project impacts across segments of the economy. For example, an economic impact analysis might examine the impacts of a project on the revenues and profits of particular industries or on employment in those industries. Economic impact analyses often concentrate on impacts within the city or region in which the project is to be located, identifying the segments of the economy within the local area/region that stand to gain or lose from a project's development. However, they can also help to predict the likely distribution of impacts between geographic regions.

Equity assessments examine the distribution of project impacts on different segments of society. An equity assessment might consider the distribution of impacts across a range of demographic variables, such as income group, race or ethnicity, age, gender, and others. Equity assessments are often designed to provide information on how a project is likely to affect groups that are significantly disadvantaged (e.g., low-income households) or particularly vulnerable to adverse impacts (e.g., children or the elderly).

By describing and, when possible, quantifying the magnitude and likely distribution of effects associated with a project, economic impact analyses and equity assessments can help decision-makers determine whether steps to mitigate impacts on particular industries, areas, or demographic groups are warranted.

4.2.2 What Basic Principles Do Economists Employ to Measure Benefits and Costs?

As already noted, benefit-cost analysis entails the valuation of a project's favourable and unfavourable impacts in monetary terms. The most obvious means of valuing a project's impacts is by referring to the market values of the resources it consumes and the goods or services it generates. In many cases, however, market prices are inadequate measures of the benefits and costs of a project. This is particularly true in evaluating a project's environmental impacts. Since environmental quality is not directly bought and sold, market prices for valuing changes in environmental quality are not available. In the absence of market data, economists must rely on other methods to assess the value of such changes. These methods are based on the economic principles described below.

4.2.2.1 Willingness to Pay/Accept as the Measure of Project Benefits

A fundamental tenet of economics is that individuals can maintain the same level of satisfaction or well-being – what economists call "utility" – while trading off different bundles of goods and services. Thus, the trade-offs that individuals make reveal the values that they place on these goods and services.

An individual's willingness to trade compensation for goods or services can be measured in two ways: his or her *willingness* to pay to receive the goods or services or *willingness to accept* compensation to forgo them. Willingness to pay is the maximum amount of money an individual would voluntarily exchange to obtain a good or service, given the individual's budget constraints. Willingness to accept is the least amount of money an individual would accept to forgo the good or service.

These two measures are not necessarily equal. One reason for the difference is that the two measures have different starting points. Willingness to pay uses the level of utility *without* the good or service as a reference point, while willingness to accept uses as its reference point the level of utility *with* the good or service. Under conventional assumptions, economists expect that the difference between these measures will usually be small (i.e., as long as the amount involved does not represent a significant proportion of the individual's income). In the case of changes in environmental quality, additional considerations may lead to larger differences between willingness to pay and willingness to accept, as discussed in Hanemann (1991). In practice, benefit-cost studies typically rely on measures of willingness to pay because they are relatively easy to quantify. In addition, willingness to pay is generally the more appropriate approach for valuing the benefits of a development project, since it takes as its starting point the level of utility prior to the project's development.

In principle, the sum of all individuals' willingness to pay for a project – i.e., the maximum amount that each individual would be willing to pay rather than go without the project – represents the total value of the project to society. As such, this sum represents the most appropriate measure of the project's benefits. It considers the interests of all individuals and provides an appropriate basis for weighing a project's benefits against its costs.

4.2.2.2 Opportunity Cost as the Measure of Project Costs

From a practical standpoint, the quantification of project costs is generally easier than the quantification of benefits, because market prices for the resources devoted to the project's development (e.g., labour, materials, and equipment) are generally available. In certain situations, however, market prices may not reflect a resource's true costs. This may be the case, for example, when government intervention in a market – whether in the form of subsidies, price controls, or other policies – distorts market prices. In these cases, economists must ensure that their cost analysis reflects the resource's true cost: its opportunity cost. The *opportunity cost* of a resource represents the value of goods and services that society loses by forgoing allocation of the resource to its best alternative use. While market prices generally reflect opportunity costs, adjustments may be necessary in the instances already noted or when the size of a project is so substantial that it may actually influence the market price of a resource.

In addition to accounting for the opportunity costs of the resources devoted to a project's development, cost analyses must consider any unfavourable impacts the project may cause. In valuing such impacts, the basic principle described in the discussion of beneficial impacts still applies: the cost of an unfavourable impact is the sum of all individuals' willingness to pay to avoid the impact. Such impacts may be difficult to quantify, let alone value. Nonetheless, recognition of such impacts is critical to the integrity of the overall benefit-cost study.

4.2.3 How Do These Principles Apply to the Valuation of Health Effects?

The principles discussed above have direct application to the valuation of health effects that may be associated with the development of a particular project. If a project is expected to have a favourable effect on human health (e.g., by reducing the potential for contaminants to pollute drinking water supplies), the benefit should be valuated by gauging individuals' willingness to pay for the anticipated reduction in adverse effects. Similarly, if a project is expected to have unfavourable health effects (e.g., by increasing pollutant concentrations in soil, air, or water), then individuals' willingness to pay to avoid these effects should be added to the project's cost. By valuating health effects in this manner, economic analysis can integrate such impacts into a benefit-cost framework.

4.3 Primary Methods Applied to the Valuation of Health Effects

Economists use two primary research methods to valuate the health effects that may be associated with a project: stated preference methods and revealed preference methods. These methods are grounded in the principles outlined above and are described below.

Stated preference methods typically employ survey techniques and ask respondents to "state" what they would pay for the anticipated reduction in adverse health effects (or what they would pay to avoid unfavourable health effects). These methods can be used to directly valuate the project of concern (e.g., "How much would you be willing to pay for a project that would reduce the concentrations of fine particulate matter ($PM_{2.5}$) in air by 10% over a period of five years?"), in which case the survey must be designed to fully inform respondents about the health effects of the reduction. Such studies can also be used to assess specific effects (e.g., "How much would you be willing to pay for a project that would reduce the risks of incurring respiratory illness from 10/100 000 to 5/100 000 annually?"). Stated preference methods are attractive in theory because they allow researchers to directly elicit values for particular effects. However, conducting a study that yields accurate and reliable results can be expensive and time-consuming.

Revealed preference methods are based on observed behaviours that can "reveal" the values of non-market goods based on prices and preferences for related market goods or services. For example, consider an individual who would be charged $40 a month for all uses of metered tap water in her home (e.g., drinking, cooking, cleaning, personal hygiene, etc.). However, she prefers to drink and cook with bottled water, which she believes to be cleaner and safer and which costs $50 per month. Using tap water just for cleaning and other uses costs her only $20 per month. She now pays $70 per month ($50 + $20). Presumably, this individual values the additional cleanliness and safety at no less than $30 per month ($70 - $40 = $30). These methods use actual market data for related goods instead of relying on individuals' predictions of their own behaviour. However, there is often an imperfect match between the particular health effects valuated in these studies and individuals' willingness to pay for the effects associated with a particular project.

These two primary research methods most likely to be used in valuing the health effects associated with a particular project are described below in greater detail.

4.3.1 Stated Preference Methods

4.3.1.1 Contingent Valuation

Contingent valuation is a stated preference method that uses consumer surveys to directly elicit statements of willingness to pay for a commodity. The values derived from the surveys are "contingent" on the realization of the scenarios described in the study. For example, a survey might ask individuals what they would be willing to pay for a specified reduction in the risk of developing kidney disease from long-term exposure to contaminants in drinking water. The researcher can define the scenario to address all the factors that may influence total willingness to pay, including willingness to pay to avoid the pain and suffering associated with an illness.

Contingent valuation surveys can be used to derive estimates for the full range of health effects associated with a project, including changes in mortality (fatal) and morbidity (non-fatal) risks. Contingent valuation methods have been used to valuate a range of health benefits, including avoidance of respiratory and other symptoms of air pollution exposure, avoidance of asthma-related illness, reductions in skin cancer risk, and reductions in risk of chronic bronchitis. When individuals express their willingness to pay through a well-thought decision, they are taking into consideration everything that they value in life. For example, if individuals were asked to put a value on cleaner air, they might consider reduced likelihood of illness for themselves and their families, more freedom to take part in outdoor activities, and healthier communities. The contingent valuation method estimates willingness to pay, accounts for all effects of illness on individual well-being, and at present appears to be the only method capable of eliciting dollar values for altruism towards persons outside the household.

Despite the widespread applicability and use of contingent valuation, the method has been heavily criticized in recent years. This criticism, however, focuses largely on the measurement of environmental non-use values (the value of simply knowing that a resource exists, as opposed to the value of actively using it); in general, the application of contingent valuation surveys to valuate health effects has been less controversial. Nonetheless, contingent valuation studies of health effects must be carefully designed and implemented if individuals are to understand fully the scenario presented in the survey and to provide honest, accurate, and reliable estimates of willingness to pay.

4.3.1.2 Conjoint Analysis

Economists recently have been experimenting with other stated preference methods, particularly those referred to as conjoint analyses (Smith, 1997). These methods are relatively complex and include presenting respondents with several scenarios involving various amenities and prices. Estimates of willingness to pay may be elicited based on the way in which respondents rank, rate, or construct equivalent sets of alternatives. For example, respondents may be asked to rank or rate their preference for living in one of two areas where residents face a risk of incurring an adverse health effect (e.g., kidney disease at one location versus lung disease at another). Alternatively, respondents may be asked to indicate what change in the level of risk associated with one alternative would make them indifferent between two competing alternatives (e.g., how would the risks of incurring kidney disease from exposure in one location need to change to make the respondent indifferent about the two locations?).

One advantage of conjoint methods in health valuation is the ability to construct scenarios that provide information on the valuation of disease attributes or symptoms. This is accomplished by identifying individual preferences for alternatives that differ with respect to a single "characteristic" (in this case, a symptom); the difference in value between the alternatives is the marginal value of the symptom. An example of the application of conjoint analysis to the valuation of health symptoms is a recent effort funded by Health Canada and Environment Canada that developed values for the health benefits of air quality programs (Johnson *et al.*, 1997).

4.3.1.3 Risk-Risk Trade-offs

The risk-risk trade-off method is closely related to conjoint analysis and has been used in economic research to valuate changes in health risks. For example, Viscusi *et al.* (1991) developed a computerized questionnaire that asked respondents to choose between places to live that varied with respect to the cost of living, the risks of chronic bronchitis, and/or the risks of automobile fatalities (Viscusi *et al.*, 1991). The results indicated that the median value of avoiding a case of chronic bronchitis is 32% of the value of avoiding an automobile fatality. When asked to trade off changes in the cost of living for changes in risk, respondents indicated that the mean value of avoiding a case of chronic bronchitis was US$801 000.

4.3.2 Revealed Preference Methods

4.3.2.1 Wage-Risk Studies

A wage-risk (or hedonic wage) study is a revealed preference method that valuates changes in risk by examining the additional compensation that workers demand for taking jobs with higher risks. Typically, these studies focus on small changes in the risks of accidental workplace fatalities. Application of the theory requires that careful consideration be given to the many factors causing wages to differ. For example, while accounting is less dangerous than logging, the differences in compensation for these occupations is clearly affected by a range of factors, including differences in the education and training required to perform the job. In practice, studies that adopt this approach must carefully consider and control for all factors that significantly affect employment compensation in order to isolate the "wage-risk premium" demanded by workers to compensate for choosing a more risky occupation. (For more information on wage-risk studies, see Viscusi, 1993.)

Many economists regard estimated wage-risk trade-offs as the most successful application of the economic theory of health valuation. Unfortunately, wage-risk trade-offs are often unsuitable for morbidity valuation. Apart from premature death, the health effects of environmental contamination generally are quite different from the types of injuries occurring on the job. It would be difficult, for example, to infer the value of an avoided asthma attack from the wage-death risk relationship. The risk-risk trade-off method discussed above, however, offers one way of linking wage-risk trade-offs to the valuation of serious illnesses.

The wage-risk approach has several advantages. For example, the data and methods for estimating risk reduction and associated wage differentials have been well established through a number of studies. In addition, the approach directly measures changes in the risk of premature mortality. A number of factors, however, may complicate the use of wage-risk studies to valuate the health effects associated with development of a particular project. For example, workplace risks usually involve some degree of voluntary acceptance, while the health risks associated with development of a project may affect individuals involuntarily. In addition, most wage-risk studies use data on middle-aged labourers (often male), who may not be representative of the members of the population most significantly affected by the risks associated with a particular project (e.g., children or the elderly). Despite these limitations, these revealed preference studies may at present provide the most defensible estimates of the value of mortality risk reductions.

4.3.2.2 Cost-of-Illness Studies

Cost-of-illness studies are frequently used to valuate morbidity (i.e., non-fatal health effects). These studies examine the actual direct (e.g., medical expenses such as doctor visits, medication, and hospital stays) and indirect (e.g., lost wages) costs incurred by affected individuals. (See Hartunian *et al.*, 1981; Hu and Sandifer, 1981; and U.S. EPA, 2001 for more information on cost-of-illness methods.) While cost of illness is sometimes categorized as a revealed preference method, it does not directly measure willingness to pay. In general, the logic for using these studies to valuate health effects is as follows: if illness imposes the costs of medical expenditures and foregone earnings, then a project leading to a reduction in illness yields benefits equal at minimum to the costs saved; conversely, a project that causes additional incidents of illness imposes costs equal at minimum to the direct and indirect costs of illness (Tolley *et al.*, 1994).

The cost-of-illness method has several advantages, including the following:

- It is well developed, widely applied, and easily explained.
- Many of the types of costs it includes are readily measured.
- Existing studies provide estimates for a large number of illnesses. These studies can be designed to address all expenditures associated with an illness, regardless of whether they are paid by the patient or a third party (i.e., insurance). Lost productivity can be estimated by lost wages for those in the paid labour force; however, lost productivity for unpaid labour in the home and lost leisure time can be more difficult to measure.

Although these studies are widely used for valuation, they generally do not provide estimates of willingness to pay. In many cases, cost-of-illness estimates may significantly underestimate individual willingness to pay because they do not address the value of avoiding the pain and suffering associated with the illness, costs that an individual may have incurred in order to avoid the illness, and other factors. Cost-of-illness estimates may also occasionally overstate willingness to pay because the availability of insurance may lead people to agree to treatments that they would not willingly finance themselves. In addition, cost-of-illness estimates do not reflect value associated with an individual's risk aversion – i.e., his or her willingness to pay to avoid future risks. Treatment also often does not return people to their original health state and hence does not address all of the benefits of avoiding the illness entirely.

4.3.2.3 Averting-behaviour Studies

Averting-behaviour analysis is a revealed preference method that uses data on consumer behaviour to infer willingness to pay from actions taken to prevent or to mitigate adverse health effects, particularly those associated with exposure to pollution. Averting behaviour can take several forms, including:

- the purchase of a durable good, such as an air purifier or water purifier;
- the purchase of a non-durable good, such as bottled water, or a service, such as medical care; and
- a change in daily activities, such as staying indoors during periods of heavy air pollution.

(For more information on averting-behaviour studies, see Courant and Porter, 1981; Bartik, 1988; Cropper and Freeman, 1991; and Desvousges *et al.*, 1998.)

Thus, averting actions may be intended to avoid exposure to environmental contamination or to mitigate the health effects of exposure. Averting-behaviour studies have involved actions taken to avoid contaminated water supplies (Abdallah *et al.*, 1992), reduce radon concentrations in the home (Akerman *et al.*, 1991; Doyle *et al.*, 1991; Smith *et al.*, 1995), or reduce asthma or angina symptoms (Chestnut *et al.*, 1988). Researchers have also examined use of medical care to offset effects of air pollution exposure (Cropper, 1981; Gerking and Stanley, 1986; Dickie and Gerking, 1991a). This offsetting behaviour method incorporates the willingness-to-pay aspect, because individuals are able to choose medical care to most effectively alleviate the illness. In addition, researchers have investigated the use of air conditioners (Dickie and Gerking, 1991b) and reductions in time spent outdoors on days of poor air quality (Bresnahan *et al.*, 1997) to reduce exposure to pollutants.

Use of these studies for benefits valuation can pose problems related to separating out different motives for the behaviour. For example, bottled water purchases may reflect the desire for convenience or for better taste, as well as the desire to avoid the perceived risks of tap water ingestion. In addition, use of bottled water may reflect concerns about a wide variety of contaminants and health effects. It may be difficult to disentangle the various complex motives for engaging in these behaviours.

The extent to which such studies provide an estimate of willingness to pay is a subject of debate in the literature and depends in part on the nature of the policy problem and the types of expenditures considered by the researcher. For example, bottled water expenditures may overstate the value of risk reductions if they also reflect convenience and taste. However, studies that consider only the money and time expended on boiling or purchasing water in response to drinking water contamination are likely to understate willingness to pay to avoid the contamination, since they leave out other responses to these incidents and do not address the value of averting the dread of such incidents.

In theory, researchers could combine data on averting behaviour with other types of information (e.g., data on the associated changes in risk) to estimate willingness to pay for risk reductions. They could then apply statistical methods to separate the value of the risk reduction from the value of other effects. Because separating the value of the different effects of averting behaviour is difficult (requiring a relatively large number of data and the application of complex analytical techniques), such analysis is rarely, if ever, attempted.

4.4 Benefit Transfer Techniques

4.4.1 Overview of Benefit Transfer

The time and resources available for the evaluation of a particular project are often insufficient to permit primary research on the valuation of potential health effects. In lieu of primary research, economic analysts frequently employ what is known as the "benefit transfer" technique to valuate potential health effects. This technique involves using estimates from existing research (based on the primary methods described above) to valuate the health benefits and detriments of the development scenarios under consideration. (For general information on benefit transfer techniques, see *Water Resources Research*, Vol. 28, No. 3, 1992; Desvousges *et al.*, 1998; and Bergstrom and De Civita, 1999.)

Box 4.2
Benefit Transfer vs. Value Transfer

In the context of project evaluation, a more appropriate description of this technique might be "value" transfer rather than "benefit" transfer, since a project may generate adverse as well as beneficial health effects. The lexicon of "benefit" transfer, however, is widely recognized among economists; to minimize confusion, we employ the common terminology here.

Benefit transfer is considered a "secondary" methodology because it does not involve collecting primary valuation data. Rather, benefit transfer is a process for reviewing and adjusting existing data to arrive at valuation estimates for the subject under consideration. The study that is the source of existing data is typically called the "study case," and the subject under consideration is called the "project case." The main advantage of benefit transfer is that the process is less expensive and time-consuming than primary valuation techniques. Thus, benefit transfer is useful when limited time and resources preclude conducting primary research to inform project decisions. It can also be used as part of a preliminary or screening analysis to determine whether additional primary research to inform the early phases of a development project is warranted.

The overall quality of a benefit transfer relies heavily on the good judgment of the analyst. Even under the best circumstances, however, benefit transfer is likely to yield estimates that are less accurate than those that would result from a carefully designed and implemented primary valuation study. Hence, the analyst generally presents the implications of the assumptions and uncertainties in the transfer along with the analytical results, so that decision-makers can take these implications into account when evaluating a project.

The following discussion describes "best practices" in applying the benefit transfer approach to valuing morbidity and mortality risks and introduces the steps used by analysts to implement the benefit transfer methodology.

4.4.2 General Approach to Benefit Transfer in Valuing Morbidity Risks

The use of the transfer method to valuate non-fatal health effects (i.e., morbidity risks) requires the analyst to exercise a significant degree of discretion and judgment. The range of potential health effects must be accurately characterized, relevant studies must be identified and evaluated for quality and applicability, transfer of the benefit estimates from the study to the project case must be applied, and uncertainties must be addressed. Box 4.3 summarizes the critical steps in applying the transfer method to the valuation of morbidity risks. Each of these steps is described in greater detail below.

Box 4.3
Key Steps in Implementing the Benefit Transfer Technique

- *Step 1: Describe the Project Case*: Describe in detail the health effects relevant to the proposed project, the impacts of these effects, and the demographic characteristics of the affected population.
- *Step 2: Identify Relevant Studies*: Search the economics valuation literature for studies that address similar types of health effects.
- *Step 3: Review Relevant Studies for Quality and Applicability*: Assess the quality of the identified studies by determining whether they follow generally accepted best practices for the methods used. Assess applicability in terms of 1) the similarity of the health effects; 2) the similarity of the populations experiencing the health effects; and 3) the ability to adjust for differences between the study scenario and the project scenario.
- *Step 4: Transfer the Benefit Estimates*: Conduct the transfer, making any necessary adjustments to existing estimates and applying them to the project scenario. The transfer may be based on the results of a single study or of several studies.
- *Step 5: Address Uncertainty*: Address uncertainties in the estimates – for example, by conducting sensitivity or other types of analysis as appropriate. (The economics profession sometimes uses the term "uncertainty" to refer to situations where probabilities are unknowable and "risk" where probabilities are known. Here, we use the more general definition of uncertainty as "lack of knowledge.")

4.4.2.1 Step 1: Describe the Project Case

To conduct a benefit transfer, the analyst must first construct a detailed description of the project case, describing the health effects of concern (i.e., all health effects that the project may cause or avert) and other dimensions of the problem that may affect valuation (e.g., whether onset of the effects is likely to be delayed or immediate). (Note: The discussion of applicability issues, presented in Step 3, provides additional information on the characteristics of health risks that may affect their valuation.) Economic analysts generally rely on health scientists, engineers, and other experts to provide information on the health effects of interest. The role of the analyst is to ensure that he or she develops a full understanding of each effect to be assessed, including any uncertainties in its description. The elements to be included in the detailed description of each health effect of interest are outlined in Box 4.4.

Box 4.4
Elements to Include in the Description of Each Health Effect

- *The Physical Symptoms Associated with the Health Effect*: For example, for kidney disease, the analyst would describe in detail conditions such as impaired mobility, muscle cramps, hypertension, and infections, as well as associated lifestyle changes and emotional stresses. Emotional stresses could include effects such as depression or anxiety related to symptoms, prognosis, or other aspects of the illness. The severity of the effects and the extent to which the symptoms curtail normal activities are also considered, as is information on fatality rates.
- *The Timing and Duration of the Health Effect*: An effect may occur immediately upon exposure, or there may be a significant delay between exposure and manifestation of a health effect (i.e., latency). The health effect may be a short-lived (acute) or a long-term (chronic) condition, perhaps worsening over time. The extent to which the effect is reversible (i.e., can be "cured") is also characterized.
- *The Population Affected*: Exposure to a contaminant may be more or less likely to lead to adverse effects depending on factors such as age and current health status. The description of the population most likely to be affected by the disease includes the factors that lead to heightened vulnerability, such as lifestyle issues (e.g., smoking) or pre-existing conditions (e.g., depressed immune system). It also addresses factors that may affect willingness to pay, such as demographic or socioeconomic characteristics (e.g., age, sex, geographic location, income level, or race). Analysts also describe the extent to which the health effect is likely to be prevalent – i.e., likely to occur in most persons exposed to the contaminant or only in a fraction of the exposed population.

This information is accompanied by a description of the key uncertainties in the health science data related to each of these factors. Uncertainties could, for example, include a lack of knowledge about the physiology of the effect, the emotional stresses of the effect, the risk factors that make individuals or populations susceptible to the effect, or the prevalence of the effect. In addition, uncertainties related to the causative link between a contaminant and a particular health effect may be significant. It is not unusual to find that uncertainties in the risk assessment far outweigh uncertainties in other aspects of the benefit-cost analysis.

4.4.2.2 Step 2: Identify Relevant Studies

Once the analyst fully understands the health effects of concern, the next step is to conduct a comprehensive literature search to identify existing valuation literature that focuses on similar health effects. The analyst explores journal articles, research reports, dissertations, and published texts identified through a review of databases of environmental, economic, and medical literature, as relevant. Among the sources of greatest potential use is the Environmental Valuation Reference Inventory™ (EVRI™) (De Civita *et al.*, 1998), which was developed by Environment Canada in collaboration with the U.S. Environmental Protection Agency (EPA), the World Bank, the European Union, the Economy and Environment Program for Southeast Asia, the Mexican Secretaria de Medio Ambiente y Recursos Naturales, and the Chilean Comisión Nacional del Medio Ambiente. The information provided by EVRI™ includes:

- a study reference and abstract (basic bibliographic information);
- a description of the study area and population characteristics;
- a description of the focus of the study, including the health effects and environmental goods and services valued;
- a summary of study methods;
- a summary of the study's results, including the monetary values presented in the study and the specific units of measure; and
- an alternative language summary (an abstract of the study in French, English, and Spanish).

Additional on-line bibliographic databases of potential value include Dialog, Lexis/Nexis, Dow Jones, Enviroline, Pollution Abstracts, EconLit (Economic Literature Index), Social SciSearch, SciSearch, Medline, ABI/Inform, IAC Business A.R.T.S., Water Resources Abstracts, and WATERNET.

4.4.2.3 Step 3: Review Relevant Studies for Quality and Applicability

Assessing the quality of existing research and its applicability to the project scenario is the third step in benefit transfer. The guidelines in this section can serve as a road map for the analyst to follow in evaluating studies. In addition to reviewing the quality and applicability of existing studies, the analyst considers transferability issues, which are intertwined with the concept of applicability but refer to the steps followed in conducting the transfer. To avoid repetition, these "transferability" concerns are addressed under Step 4 below.

Quality Issues

Quality refers to the appropriateness of the research methodology a study employs, the care with which it implements this methodology, and the accuracy and reliability of the resulting estimates. Considering these quality issues will allow the analyst to identify sources of uncertainty related to the methods used to estimate values. Because it is not possible to develop absolute standards for assessing a study's quality, analysts must assess the relative limitations and advantages of available studies to determine whether and how to use a particular study in a benefit transfer. For those studies ultimately used in the transfer, the analyst should discuss the findings of the quality review when presenting the results. As indicated under Step 5, this discussion describes the extent to which the transfer is likely to overestimate or underestimate the value of the benefits (or decrements) derived from the proposed project, given the uncertainties in the original study and in the transfer process.

Applicability Issues

In the context of benefit transfer, applicability refers to the extent to which the existing research (the study case) matches the project case. The three main areas of concern are the similarity of the health effect, the population, and the baseline conditions applicable to each case.

Similarity of Health Effect: The similarity of the health effect can be determined by an "item-by-item" comparison of the description of the project case (developed under Step 1) to the description of the case addressed in each existing study. The analyst generally considers the divergence in physical attributes, severity, timing and duration, etc., as well as the magnitude of the differences. For example, if the health effects of concern are associated with developmental effects and the existing research focuses on the effects of lead, the analyst would consider the extent to which the developmental problems caused by lead are similar to the developmental problems that may be caused (or averted) by the proposed project.

In reviewing the similarity of the effects, analysts may consider dimensions of risk in addition to the physical manifestation of the effect, such as the following:

- voluntary/involuntary;
- ordinary/catastrophic;
- delayed/immediate;
- natural/human-made;
- old/new;
- controllable/uncontrollable;
- treatable/untreatable;
- necessary/unnecessary;
- occasional/continuous; and
- acute/chronic.

These risk dimensions may affect willingness to pay to avoid different types of risks. For example, individuals may hold different values for averting lung cancer from smoking (e.g., if they perceive it as a personal lifestyle choice) compared with lung cancer from environmental causes (e.g., if they perceive these risks as beyond their control) (Fischoff *et al.*, 1978). The impact of risk characteristics on valuation estimates is generally discussed qualitatively because the empirical data needed to adjust for these impacts have not yet been developed.

For certain effects, high-quality valuation literature on similar effects may not exist, and the analyst will have to make judgments about the suitability of other valuation studies. For example, the U.S. EPA recently used data on chronic bronchitis to valuate the benefits of avoiding non-fatal bladder cancer associated with regulating drinking water disinfection by-products (Cadmus Group and Science Applications International Corporation, 1998). The researchers did not find any willingness-to-pay studies on non-fatal bladder cancers or other similar cancers. They decided to use chronic bronchitis as a proxy effect, on the grounds that chronic bronchitis and bladder cancer have certain commonalities, such as severity and long-term impacts. They compared the resulting willingness-to-pay values with cost-of-illness values for non-fatal bladder cancers as a check on the reasonableness of the estimates.

The use of proxy effects that have dissimilar manifestations to the effects of the project case may provide useful information for decision-making (e.g., by indicating the range or potential magnitude of benefit values). However, this approach is controversial and requires careful consideration of the limitations of the analysis. Decisions regarding whether to use valuation information for dissimilar effects are made on a case-by-case basis because they will depend on the nature of the issues being addressed as well as the available valuation data. In these situations, analysts work to clearly communicate the advantages and drawbacks of using the chosen study case and the implications of these concerns for related decision-making. For example, analysts may list and compare characteristics of the proxy and the health effects associated with the proposed project and discuss their expected net impact on willingness to pay when describing the results of the analysis.

Similarity of Population: In addition to reviewing the similarity of the effects, the analyst compares the population studied with the population affected in the project case. Populations can differ by geographic location as well as by demographic or socioeconomic factors such as age, sex, income, and race. The analyst generally focuses on those dimensions that are associated with potentially significant differences in willingness to pay. (Note: Addressing some of these factors may be controversial. For example, if willingness to pay appears to vary by income or race, consideration of this variation may raise environmental justice concerns.)

Similarity of Baseline: The third major area to consider is whether baseline health status is similar between the project case and the study case. Willingness to pay to avoid health effects may vary depending on whether the individuals affected are in good or poor health or have a particularly high risk of being affected, compared with others exposed. This difference in baseline health status may be particularly important for sensitive populations (e.g., those with suppressed immune systems, the elderly, or children), who are more vulnerable to the effects of certain contaminants.

4.4.2.4 Step 4: Transfer the Benefit Estimates

The fourth step of the benefit transfer process is to derive values from the study case and apply them to the project case. The researcher can adjust and transfer values in a number of different ways, but the techniques generally fall into three categories:

1) applying a point estimate (i.e., a single value);
2) using a valuation function (an equation that relates values to characteristics of the effect and/or the population affected); or
3) using meta-analysis or Bayesian approaches (which combine the results of several studies).

These approaches are listed in order of increasing complexity, and (all other things being equal) the more complex approaches will often lead to better estimates. The available literature, however, may not be sufficient to support use of the more sophisticated approaches; analysts generally assess these transferability issues when reviewing the available studies.

Point Estimate

A point estimate refers to the process of taking a single estimate for a particular value (often the mean or median) and using it to directly approximate the value in the project case. Reasonable high and low values (e.g., the 10th and 90th percentiles of a distribution) may also be used for bounding or sensitivity analysis. In the simplest case, the analyst will multiply the mean or median health effect value from the study case by the number of statistical health effect cases estimated to be averted (or caused) by the project. (A statistical case is calculated by multiplying the number of individuals affected by quantified risk factors. An example of this calculation is provided in the discussion of mortality risks below.) This type of simple transfer may be useful particularly for initial screening analysis, but does not account for any dissimilarities in the nature of the effects, the population characteristics, or the baseline status. Hence, its use is generally limited to cases where the underlying research will not permit a more sophisticated approach. In such cases, the differences between the project case and the study case are usually discussed qualitatively when presenting the results.

A more sophisticated approach involves tailoring point estimates to the particulars of the project case through simple adjustments – e.g., adjusting for changes in income over time. This type of tailoring improves the transferability of the estimates and may be the only technique an analyst can employ when the valuation function for the study case is not available.

Benefit Function

The benefit function approach is possible when a valuation function is provided in the study case or can be calculated from the data set. For example, the study may include age and income in an econometric equation that predicts willingness to pay. The benefit function approach utilizes the additional information provided by the function and tailors it by substituting values from the project case into the function. In other words, data on the age and income of individuals affected by a particular regulation can replace the data from the study case to yield an appropriate value or range of values. In some cases, the valuation function provided in the original study will include information not available for the project case, such as attitudinal variables. In this case, the analyst may wish to reestimate the equation based on the variables for which data are available.

Because the benefits function approach is better tailored to the project case than the point estimate approach, it can provide an improved estimate of the value of related health effects. However, one potential problem with this approach is its reliance on the equality of coefficients between the study and project cases. This approach will still involve additional uncertainty if the two cases differ in ways that are not addressed by the valuation function (e.g., if baseline health conditions differ but are not included in the function resulting from the original case).

Meta-analysis or Bayesian Approaches

The most complex transfers use statistical methods such as meta-analysis or Bayesian approaches, which combine estimates from several studies of similar effects (for more information, see Atkinson *et al.*, 1992; and Desvousges *et al.*, 1998). Meta-analysis can be used to integrate the results when many relevant studies are available; the Bayesian approach includes data on the project case as well as data from existing studies (for an example of meta-analysis, see Boyle *et al.*, 1994). These approaches have been used more frequently for ecological effects than for health effects because of the availability of larger numbers of applicable studies. Because these approaches draw on more data sources than a single study and use statistical techniques to explore the variation in the results, the resulting estimates may be more accurate and reliable than point estimates or valuation functions. However, meta-analysis and Bayesian approaches require a high level of technical expertise and can be very time-consuming to implement. These approaches are also data intensive and may not be feasible for many effects due to the lack of relevant studies. Thus, analysts generally apply these techniques with caution and involve relevant experts in developing and reviewing the analysis.

With all of these transfer techniques, the analyst needs to aggregate individual estimates over the population experiencing the effect. The aggregation process may be designed to take into consideration such issues as bias and distributional effects. For example, if separate values are available for a sensitive subpopulation and for the remainder of the general population (minus the sensitive subpopulation), the total value of the benefits for each group can be calculated separately and then added together to estimate benefits for the entire population. (It is also important to note that new methods of conducting transfers are currently under development. A discussion paper on one such approach, the "preference calibration" technique, is available on-line; see Smith *et al.*, 1999.)

4.4.2.5 Step 5: Address Uncertainty

Uncertainty permeates all the steps of the transfer process, from selecting appropriate studies and manipulating data to establishing a range of values. Each of the existing studies used in the transfer will itself contain uncertainties that result both from the data and analytical approach used as well as from difficulties related to thoroughly understanding the preferences of the individuals studied. However, the presence of uncertainty does not imply that the resulting values are random or indeterminable. By using techniques such as sensitivity analysis, the analyst can, to a certain degree, quantify the effects of uncertainties in the estimates used in the benefit transfer. (For more information on uncertainty analysis, see Morgan and Henrion, 1990.) As noted above, those uncertainties that cannot be quantified are generally discussed in qualitative terms; in this discussion, analysts describe the relative importance of each source of uncertainty and, if known, the direction of the possible bias.

4.4.3 General Approach to Benefit Transfer in Valuing Mortality Risks

4.4.3.1 Value of Statistical Life

The use of the transfer method to valuate changes in fatal risks associated with the development of a project follows an approach similar to that applied in valuing changes in non-fatal risks. In general, however, changes in mortality risks are valuated based upon empirical estimates of the value of a statistical life. The value of a statistical life does not refer to the value of an identifiable life, but instead to the value of small reductions in mortality risks in a population. A "statistical" life can be thought of as the sum of small individual risk reductions across an entire exposed population.

For example, if 100 000 people would each experience a reduction of 1/100 000 in their risk of premature death as the result of a project, the project can be said to "save" one statistical life (i.e., 100 000 × 1/100 000). The sum of the individual willingness-to-pay values for the given risk reduction across the population provides a value per statistical life. Continuing with the previous example, if each member of the population of 100 000 were willing to pay $50 for the risk reduction, the corresponding value of a statistical life would be $5 million (i.e., $50 × 100 000). Note that these estimates rely on studies of relatively small changes in risk; they are not values for saving a specific individual's life.

4.4.3.2 Value of Statistical Life-Years

A variation on the value of a statistical life approach involves accounting for the effect of risk reductions on the number of life-years remaining. The value of statistical life-year approach assigns a value to each year of life extended. In its simplest form, the value of statistical life-year approach translates the value of statistical life into annual values, implicitly assuming a linear relationship in which each discounted life-year is valuated equally. There is significant controversy over this approach, particularly because the value of remaining life-years is likely to vary depending on the age of the individual and other factors. Therefore, its use is not generally recommended except for application in (carefully caveated) sensitivity analyses.

4.4.3.3 Summary of Studies

Table 4.1 presents value of statistical life estimates derived from a number of wage-risk and contingent valuation studies. These values range from $1.0 million to $22.6 million, with a median value of $6.8 million and a mean value of $8.4 million. Economic analysts have applied these or similarly derived values in many analyses due to the substantial research and peer review used to develop this range of estimates.

Table 4.1
Value of Statistical Life Estimates (Mean Values in Year 2000 Canadian Dollars)

Study[1]	Method	Value of Statistical Life ($million)
Kneisner and Leeth (1991) – United States	Wage-risk	1.0
Smith and Gilbert (1984)	Wage-risk	1.1
Butler (1983)	Wage-risk	1.3
Miller and Guria (1991)	Contingent valuation	2.1
Gegax *et al.* (1985)	Contingent valuation	3.6
Moore and Viscusi (1988)	Wage-risk	3.9
Viscusi *et al.* (1991)	Contingent valuation	4.2
Dillingham (1985)	Wage-risk	4.9
Kneisner and Leeth (1991) – Australia	Wage-risk	5.1
Gerking *et al.* (1988)	Contingent valuation	5.4
Cousineau *et al.* (1992)	Wage-risk	5.9
Viscusi (1978, 1979)	Wage-risk	6.5
Jones-Lee (1989)	Contingent valuation	6.8
Marin and Psacharopoulos (1982)	Wage-risk	6.9
V.K. Smith (1976)	Wage-risk	7.3
Kneisner and Leeth (1991) – Japan	Wage-risk	8.8
Moore and Viscusi (1988)	Wage-risk	9.7
Viscusi (1981)	Wage-risk	10.3
Smith (1974)	Wage-risk	14.1
R.S. Smith (1976)	Wage-risk	14.3
Leigh and Folson (1984)	Wage-risk	14.7
Olson (1981)	Wage-risk	14.8
Leigh (1987)	Wage-risk	17.4
Herzog and Schlottman (1990)	Wage-risk	17.7
Garen (1988)	Wage-risk	22.6

[1]See Viscusi (1992) or Viscusi (1993) for full references to these studies. Values obtained from the original studies have been converted to Canadian currency using Purchasing Power Parity factors developed by the Organisation for Economic Co-operation and Development and adjusted to year 2000 dollars using the Canadian Consumer Price Index.

Use of these estimates to valuate the mortality risks associated with a proposed project is an example of the use of benefit transfer techniques, since the subject of most of the studies (i.e., job-related risks) differs from the fatal risks that may be averted by a project. When applying such estimates to a particular project, analysts must consider differences between the scenarios the studies consider and the health effects associated with the project under evaluation. Issues of concern in transferring value of statistical life estimates include those related to *risk characteristics* (risk perception, altruism, baseline risk, and latency of effect) and those related to *population characteristics* (income, age, and health status). In most cases, reliable methods for adjusting value of statistical life estimates to address potential biases have yet to be fully developed or adequately tested. The existing literature, however, can be used to support a qualitative discussion of the direction and magnitude of potential biases and their implications for decision-making.

4.5 Integrating the Valuation of Health Impacts into the Overall Economic Analysis

In estimating the value of the health effects associated with a particular project, analysts must be careful to coordinate their efforts with those of others engaged in evaluation of the project. This will ensure that the results of the health effects valuation exercise can be readily incorporated into the broader economic analysis. The discussion below briefly touches on a number of key considerations in integrating the valuation of health impacts into an overall assessment of a project's costs, benefits, and impacts.

4.5.1 What Baseline Should Be Employed?

The "baseline" in an economic analysis refers to conditions now and in the future in the absence of a project's development. The effects of the project are compared with this baseline to determine the project's costs and benefits. Correct specification of the baseline is needed to accurately capture a project's impacts and may require consideration of a wide range of factors, particularly if baseline conditions are likely to evolve over time. Consider, for example, a mass transit project designed to relieve congestion on local roads. In this case, correct specification of the baseline requires consideration of how the volume of traffic on local roads might change in the absence of the project. Would it remain at current levels? Would it increase over time, perhaps as a result of anticipated growth in the local population? Or might it diminish with the completion of a highway development project already under way? The answers to questions like these will determine the specification of the baseline and will in turn influence estimates of the transit project's net effect on traffic volume, as well as related measures of project benefits, such as reductions in health effects caused by the pollutants contained in automobile exhaust. Analysts should be certain to consider all such factors in characterizing baseline conditions. In addition, analysts should take care to ensure that their cost and benefit assessments employ consistent baseline scenarios; otherwise, the results of the cost and benefit assessments will not be comparable.

4.5.2 How Should the Timing of Benefits and Costs Be Accounted for?

Assessments of a project's costs and benefits may be conducted based on assessment of a single year, or they may consider impacts over a number of years. Consideration of a single year is sufficient when costs and benefits are expected to be constant from year to year. More often, however, a project's costs and benefits are realized in different time periods or are expected to change over time; in these cases, an economic analysis must evaluate the annual stream of costs and benefits from project initiation forward.

To permit meaningful comparison of costs and benefits that occur in different time periods, economic analysts employ a method known as discounting. This method is designed to account for 1) people's general preference to have resources available now rather than in the future, so that they can invest the resources productively and thus receive a positive return on their investment; and 2) the fact that people generally are willing to pay more for goods and services that they can consume today than for goods and services that they must wait to consume. Discounting adjusts monetary values to reflect these time preferences. It gives progressively lower weight to future costs and benefits, taking into account both the number of years before a cost or benefit is likely to be realized and the degree to which current investment (or consumption) is valued over future investment (or consumption). Discounting allows costs and benefits that occur in different time periods to be compared by stating them all in current-year terms, referred to as their "present value." The present value of a stream of costs or benefits is calculated by multiplying the costs or benefits anticipated to occur in each year by a time-dependent weighting factor, then summing the results. The rate at which the weighting factor changes from year to year is referred to as the "discount rate."

While the concept of discounting is relatively straightforward, the choice of an appropriate discount rate can be controversial. In Canada, the Treasury Board recommends a range of discount rates for the evaluation of public projects; these rates approximate the marginal pre-tax rate of return on an average investment in the private sector in recent years and thus represent the opportunity costs of investing in the project under consideration. Analysts may wish to consider a discount rate based upon the "social rate of time preference," which reflects the discount rate at which society is willing to exchange consumption through time. Economists generally favour this approach when discounting measures of social welfare, such as the values assigned to the estimated impacts of a project on public health. Current literature suggests that a central value of 2-3% should be used as the discount rate.

Special considerations arise in the case of projects that are expected to generate significant benefits or impose large costs on future generations (e.g., the construction of a high-level nuclear waste repository). Since the preferences of future generations cannot be known, there is significant debate and little consensus among economists concerning the derivation of an appropriate intergenerational discount rate. Until a consensus emerges, benefit-cost analyses of projects with potentially significant intergenerational effects should consult the literature concerning intergenerational discounting and evaluate the sensitivity of their findings to the use of alternative discount rates. They should also present, numerically and/or graphically, the flow of undiscounted project benefits and costs over time. This will help to highlight cases in which the timing of costs and benefits raises serious questions of intergenerational equity, demanding heightened attention on the part of decision-makers.

4.5.3 How Should the Analysis Account for Inflation?

In addition to the use of discounting to account for the timing of project costs and benefits, economic analysts must frequently work with data on monetary values that were collected at different points in time. For example, analysts may have access to current construction cost data, but may find it necessary to rely on health effects valuation studies that are several years old. In such circumstances, analysts must adjust these values to control for the effects of inflation, which refers to an overall rise in general prices throughout the economy and is often measured by comparing the average price of a standard bundle of goods and services in different years. Inflation does not reflect a real increase in value; rather, it indicates that the same goods and services now command higher prices.

Box 4.5
Inflation and Deflation

The opposite of inflation is deflation: an overall decline in general prices throughout the economy. The discussion here focuses on inflation because the general trend in prices in recent decades has been upward; however, the concepts and methods that apply to the treatment of inflation in an economic analysis apply with equal weight to the treatment of deflation.

To permit consistent comparison of project impacts across time, economic analysts remove the effects of inflation from the monetary values reported in their benefit-cost estimates. They do so by employing an index, such as the Canadian Consumer

Price Index (CPI), that compares historic price levels year by year. (A range of price indices is available, including specialized indices for particular types of goods and services; selection of the appropriate price index depends on the types of goods or services under consideration.) The annual values reported for such indices can be used to inflate prices from prior years to the present level. For example, if a study reports willingness to pay to avoid a certain health effect in 1996 dollars and an analyst wishes to convert to year 2000 dollars using the CPI, he or she would first determine the change in the CPI during this period. According to Statistics Canada, the CPI rose from 105.9 in 1996 to 113.5 in 2000, about 7.2%. Thus, to convert the 1996 value to its 2000 equivalent, the analyst would simply multiply by 1.072 (i.e., 113.5/105.9). (Analysts should adjust annual cost and benefit estimates to constant dollar terms before discounting and calculating present values.)

For consistency and clarity, economic assessments typically specify that monetary values are expressed based on price levels in a given year (e.g., "all values are reported in 2000 dollars"). Both costs and benefits are generally reported as of the most recent year for which inflation rates are available. For example, an analysis completed in 2001 would likely be reported in 2000 dollars.

4.5.4 How Should Non-quantified Benefits and Costs Be Treated?

To the extent feasible within the confines of a project evaluation, economic analyses should strive to quantify and valuate all of a project's potential health impacts, favourable or unfavourable. A variety of factors, however, may make quantifying and valuing all such impacts difficult or impossible. If an analysis cannot quantify and/or valuate all of a project's potential health effects, it should explain why, present any relevant quantitative information, and describe the unquantified or unvaluated impacts, including the nature, timing, likelihood, and possible distribution of such effects. Providing a summary table that lists all unquantified or unvaluated effects will make it easier for decision-makers to integrate such impacts into their overall assessment of project costs and benefits.

4.5.5 How Should Uncertainty Be Accounted for?

Economic analyses of a project's health impacts are often subject to a considerable degree of uncertainty due to a lack of economic data, limitations in the underlying health science, unpredictability of a project's long-term effects, and other factors. In some instances, decision-makers can reduce the degree of uncertainty by investing in efforts to gather better data or improve scientific understanding of key issues. In general, however, project evaluations are conducted with imperfect information and knowledge. Economic analyses should explicitly note key uncertainties and attempt to describe the effect of these uncertainties on the overall evaluation of a project's costs and benefits. In some instances, it may be possible to rely upon statistical probability distributions to characterize the degree of uncertainty around particular parameters. In others, attempts to characterize the degree of uncertainty may be limited to evaluations of project impacts under alternative sets of assumptions designed to bound the plausible range of impacts. In any event, it is critically important that economic analyses fully disclose key assumptions and uncertainties; otherwise, the analysis may suggest a degree of precision or statistical confidence that the current state of knowledge cannot support.

In addition to the suggestions offered above, it is important to note that as a project moves forward, analysts may develop a better understanding of its health impacts. By monitoring and evaluating these impacts, economic analysts can help decision-makers ascertain whether continued support for the project is warranted and whether modifications to the project's design or operation are needed to enhance its health benefits or mitigate its adverse effects. In this sense, economic evaluation of a project's costs and benefits need not be viewed solely as an *a priori* exercise; regular evaluations can support continuous improvement in the design and operation of ongoing projects, and retrospective assessments can identify lessons from the past that will serve to improve the design and operation of future projects.

4.5.6 How Should Distributive Effects and Equity Considerations Be Treated?

As noted above, conventional benefit-cost analysis can provide significant insight into the efficient allocation of resources, but other tools – specifically, distributional assessments and equity assessments – are needed to evaluate the distribution of a project's impacts on different economic sectors or segments of society. Equity assessments are particularly important if the distribution of a project's health impacts across different groups is likely to be uneven. In evaluating the equity of a project's potential health impacts, analysts should focus in particular on the geographic distribution of effects (e.g., are adverse health effects likely to be concentrated in a particular neighbourhood or community?); the temporal distribution of effects (e.g., are the potential effects likely to be greater for future generations?); and the distribution of effects across key demographic variables, such as income group, race or ethnicity, age, or gender. The equity assessment should describe and, to the extent possible, quantify the likely distribution of effects across key groups. By providing this information, equity assessments can help decision-makers determine whether the project should go forward and, if so, whether steps to eliminate or mitigate impacts on particular groups are necessary.

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Notes:

5 INDIGENOUS HEALTH IMPACT ASSESSMENT

5.1 Introduction

This chapter deals specifically with HIA methods and approaches identified by indigenous communities in Canada. It points out certain general trends, activities, and needs in the area of HIA that are recognized by all or most of the indigenous communities, as well as by some national organizations of indigenous peoples.

Indigenous HIA is based on three concepts:

1) Indigenous communities rely heavily on naturalized knowledge systems (NKS).
2) HIA is very closely linked to EIA.
3) HIA as a process depends on measurement and evaluation of health indicators, and indigenous communities themselves must develop their own specific community health indicators.

The goal of this chapter is to contribute to the linkage of indigenous and "mainstream" HIA processes. The main principle is that these two approaches are parallel processes that can nevertheless be linked and compared. Specifically, this chapter provides:

- background information on NKS;
- a comparison of indigenous and non-indigenous health-related EIA methods;
- information on indigenous community health indicators, as related to HIA; and
- information on EIA and the Life Indicators Wheel.

5.2 Naturalized Knowledge Systems

NKS focus on the understanding of the importance of the environmental knowledge of First Nations communities and on understanding the complexity of traditional approaches to environmental systems. NKS link the observation and appreciation of the physical world with the philosophy and attitudes created and supported by the close interaction among the environment, health, and lifestyle.

Box 5.1
Naturalized Knowledge Systems

NKS are bodies of ideas, values, and concepts that social systems utilize to function within their environment. This process is dynamic and cumulative, which is to say that it adapts itself to new technological and socioeconomic conditions as they come along (Lickers *et al*., 1995).

NKS are based on the principles of respect, equity, and empowerment.

Respect emerges between partners (government, business, First Nations) only through communication and comprehension. This process is a first and necessary stage in healing the hurts and eliminating the negative stereotypes that have been associated with research and cooperative projects linking First Nations and other partners in the past.

Historically, *equity* was often related only to financial resources. However, equity encompasses more than just money, as assets can include people, technical resources, and diversity in knowledge systems.

Empowerment is "the act of enabling." It is the most difficult of the principles to achieve, as it can be achieved only once respect and equity among all parties have been attained. Empowerment includes financing, acknowledgment of First Nations NKS, and the belief in cultural and economic self-determination.

The principles of respect, equity, and empowerment can contribute to a healing process that will encourage First Nations peoples and non-First Nations participants to form even-handed partnerships and to stimulate the long-term goal of First Nations' involvement in decision-making and in environmental health research.

Researchers using NKS must respect community protocols, discover and grasp the NKS specific to the community, proceed within a reciprocal information-feedback loop, and assist in organizing community-based health research and services.

The key research goals related to community-level HIA are:

- linking the needs, requirements, and perceptions of indigenous communities with the non-indigenous knowledge and information from individual Western scientific disciplines;
- determining and funding community-defined research priorities; and

- documenting the transfer of indigenous environmental knowledge and linking this knowledge with Western science.

5.3 Comparison of Indigenous and Non-indigenous Health-related Environmental Impact Assessment Methods

5.3.1 Context

EIA is an instrument used for development planning and decision-making. It is widely recognized that First Nations jurisdictions must have distinctive EIA processes in place that accommodate the specific requirements of First Nations and at the same time are in agreement with EIA processes defined by provincial/territorial and federal legislation.

The main requirements of an EIA system are (Doyle and Sadler, 1996):

- an institutional framework;
- processes and procedures of EIA application; and
- interjurisdictional cooperation.

All three of these requirements are also relevant to the First Nations EIA. At the national level, the Assembly of First Nations is in the process of developing a First Nations Environmental Assessment Framework that will provide useful processes and procedures for further interjurisdictional cooperative work in EIA.

A study by the Environmental Assessment Branch of the Ontario Ministry of Environment and Energy (Lickers *et al.*, 1995) found that no single, standardized, and generally applicable indigenous EA process exists; however, there are common underlying principles, beliefs, and ways of assessment. An example of indigenous environmental HIA is shown in Box 5.2.

The Mohawk Council of Akwesasne has played an important role in environmental protection, EA, and HIA since the 1970s. Akwesasne's Department of the Environment has defined goals and objectives that reflect the environmental needs, conscience, lifestyle, and health requirements of the Haudenosaunee. In 1993, the Mohawk Council of Akwesasne started organizing a network of First Nations communities with the purpose of providing the necessary structure for NKS environmental and health-related research and management at the community level.

Box 5.2
Indigenous Environmental Health Impact Assessment

The *Maliseets in Tobique*, New Brunswick, fish mainly for salmon, bass, eel, and sturgeon. The most important is salmon, which is viewed as a key “environmental indicator,” and the Maliseets claim that the “bathtub” salmon fishery (where fish cannot migrate and are artificially restocked) has an impact on their health. The issue is one concerning the quality of the fish, not their quantity.

The *Mohawks of Akwesasne* have described and analysed the behaviour and changes of the St. Lawrence River ecosystem over the last 300 years and have linked these changes to the declining health in the indigenous communities along the St. Lawrence.

The *Cree community of Cumberland House*, located on the Lower Saskatchewan River, consists of fishers and hunters. They used to follow a strict and complex community-based health code dealing with hunting and fishing (Anne Acco and Chief Pierre Settee, personal communication). Adherence to the code stopped, leading to a rapid decline in sturgeon abundance and declining health of community members. The community now has in place a risk assessment framework for lake sturgeon (*Acipenser fulvescens*), with the clearly defined endpoints of sturgeon abundance, the determination of the ecosystem at risk, and the identification of stressors (major dams, minor dams and dikes, contaminants, bird predation, overexploitation).

Historically, people of the *Little Red River Cree Nation* (LLRCN) ranged across a land base of over 70 000 km^2. Their traditional knowledge supported a lifestyle and economy that was forest-based (Jim Webb and Celestine Nanooch, personal communication). The community has conducted a study linking a decline in environment-oriented activities with declining health of young males in the community. As a result, in the mid-1980s, the First Nations’ leadership decided to initiate a forest-based development process as a means of revitalizing the economy and providing jobs for their members (LLRCN Action Plan). The community also plans to be more active in the research and management of wood buffalo in the proposed Special Management Area located southwest of Wood Buffalo National Park. The long-term plan involves the screening of buffalo, elimination of diseases (brucellosis, tuberculosis), an expansion of the habitat suitable for bison, methods and possibilities of herd control, and buffalo-based economic activities.

Box 5.3
The Mohawk Council of Akwesasne

The Mohawk Council of Akwesasne Department of the Environment was established by the Mohawk Council of Akwesasne in 1976 to maintain, protect, and enhance the natural environment of the Mohawk Community of Akwesasne. It is to act as a remediation and research organization for the Mohawk Community and to assist other native and non-native nations that may require environmental expertise. The department is composed of native people with expertise in various environmental and traditional science fields and reports directly to the Mohawk Council of Akwesasne. Similar models have been established by other First Nations communities (e.g., the Walpole Island Heritage Centre).

5.3.2 The Akwesasne Environmental Impact Assessment Process

The Mohawks of Akwesasne have developed their own EIA process (a permanent cyclical process of evaluation of any outside intervention), consisting of the following four stages, which ensure that the full life cycle of the intervention is assessed:

1) preliminary assessment (i.e., project proposal);
2) cooperative planning (project development);
3) monitoring (project performance control); and
4) final review (controlled dismantling of the project).

All four of the Akwesasne EIA steps are based on the successful application of the Haudenosaunee problem-solving approach to the relatively new problem of human-made environmental impact. Even though this approach is rooted in a very old knowledge-based system, it still meets the three conditions of effectiveness within an EIA process – the so-called 3 R's (Sadler, 1996):

- rigorous analysis (i.e., employs best-practices science);
- responsive public involvement (provides for involvement of interested parties); and
- responsible process administration (consistent, impartial enforcement).

Box 5.4
The Haudenosaunee Problem-solving Approach: The Great Way of Peace of the Haudenosaunee

The *Great Way of Peace of the Haudenosaunee* can be interpreted in many ways, but all entail the concepts of Respect, Equity, and Empowerment; and Respect, Power, and Peace. All of these concepts are integrated to form a problem-solving approach that is mindful of:

- the respect one must have for the other party;
- the equity that is needed to carry out the task; and
- the level of empowerment or peace that is generated.

When one achieves this state of agreement, it is said that one exists in the "Good Mind," which is mindful of all things in creation.

Linking NKS and Western science provides valuable advantages to both. The main advantages for First Nations communities are the following:

- Documenting existing indigenous knowledge makes it more accessible to all, but also raises the extremely important question of intellectual property rights.
- Western science is a valuable source of information and can be used to validate NKS.
- Development of in-house scientific expertise through the melding of Western science and NKS is another way of empowering communities by reducing indigenous communities' reliance on outside "experts."

The following are the main advantages for universities, research institutions, and different levels of government:

- NKS is a valuable source of hypotheses about how nature works, most of which are implicit rather than explicit. Western science can formalize these hypotheses and bring its methods to bear in testing them.
- NKS is a valuable source of information related to experimental design. The personal experiences of people living on the land can be of invaluable assistance in deciding where, when, and how to sample.

- Indigenous people versed in NKS are a valuable source of research personnel. In many instances, the best people to carry out field research are those with long experience of working in the field, albeit not within the standard scientific framework.
- NKS is a valuable source of information for scientific validation. The key to any scientific progress is the uncovering of inconsistencies between predictions and actual observations. NKS provides an additional source of data for the testing of scientific hypotheses. For example, if Western science makes a prediction that is inconsistent with existing traditional knowledge, then identifying the source of the inconsistency will lead to better scientific/indigenous understanding of the phenomenon in question.

There is no single "indigenous" EIA process. Every community has its own distinct method of looking at environment health linkages (see Box 5.2). For some communities, the processes used are very simple; for other communities, the processes in place are quite advanced; for still others, although a process exists, it is no longer in active use.

5.4 Indigenous Community Health Indicators

An indigenous EIA process requires health indicators, which make use of the knowledge of the communities affected and which can be used and monitored by those communities. In July 2000, a collaborative effort to develop community health indicators was undertaken by the Assembly of First Nations and three Aboriginal communities: the Mohawk Council of Akwesasne (Ontario/Quebec), Little Red River Cree Nation (Alberta), and Conne First Nation (Newfoundland and Labrador). The project is supported by the Institute of the Environment at the University of Ottawa and is funded by Health Canada.

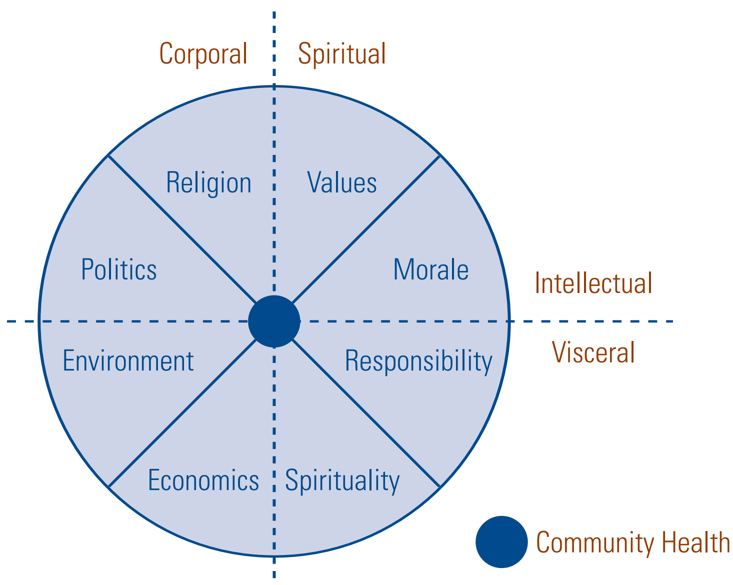
5.4.1 The Need for Community Health Indicators

First Nations communities face multiple social and economic challenges, including poverty, overcrowding, and lack of employment opportunities. These difficulties compound environmental problems, which may include a decline in their traditional economies, especially hunting, trapping, and fishing, and potential contamination of their soil, air, and water. To help assess their progress in meeting these challenges, Aboriginal communities need a broad set of indicators to measure changes over time in their health and well-being, environment, economy, and spiritual and civic life.

5.4.2 The Life Indicators Wheel

The Life Indicators Wheel resembles the Medicine Wheel and shares with it a common feature of interconnectedness (see Figure 5.1). The wheel was developed by a group of First Nation Elders for the EAGLE (Effects on Aboriginals from Great Lakes Environment) project and is vital to the development of community health indicators. The right half of the wheel is said to represent the spiritual side of the model. The left side represents the corporal or physical world. If the circle is then divided in half horizontally, the upper half will represent the intellectual aspect of the community, while the lower half represents the visceral or bodily aspects of the community. The health of the community will be the balance point in the centre of the circle, which could be represented by all the disease/health outcome indicators and community life indicators. In order to keep the disease/health outcome indicators in balance, the community must maintain a balanced approach to life as represented by the community life indicators. In this way, all aspects of the world are represented on the wheel.

Figure 5.1
Community Life Indicators Wheel



Around the wheel, different aspects of community life are placed within the sector that they most suitably represent:

- Values and morale are seen as the intellectual and spiritual aspect of the community.
- Responsibility and spirituality are seen as the visceral and spiritual aspects of the community.
- Politics and religion are seen as the corporal and intellectual aspects of the community.
- Environment and economics are seen as the corporal and visceral aspects of the community.

By integrating these community life indicators with appropriate indicators of disease/health outcomes within a community, a reliable model for community health indicators can be developed (based on one-on-one links across the centre of the Life Indicators Wheel – i.e., environment-morale, economics-values, religion-spirituality, and politics-responsibility). From the model, a matrix of specific health indicators is developed to provide a basis from which community health can be measured/monitored. (For a Western perspective on values, see Chapter 2 of this volume.)

5.4.3 Comments from the Communities

In December 2000, the concept of the Life Indicators Wheel was discussed not only with representatives of the Mohawk Council of Akwesasne and Little Red River Cree Nation, but also with representatives of the Maliseet Nation in Tobique, New Brunswick; the Kitigan Zibi Anishinabeg near Maniwaki, Quebec; the Opaskwayak Cree Nation near Le Pas, Manitoba; the Dunne-Za and Saulteau First Nations in British Columbia; and the Environmental Secretariat of the Assembly of First Nations. All those consulted consider the Life Indicators Wheel to be a viable base for the development of community health indicators.

Further, there is broad agreement that the "spiritual" issue of cultural sustainability (with its values, morale, responsibility, and spirituality aspects) is closely linked with the "corporal" issue or issues of economics, environment, political implications, and place of religion in the spiritual life of communities.

5.4.4 Methodology for Indicator Development

From the start of the project, the team of researchers focused on a methodology for developing indicators that would ensure feedback and response from the communities. The methodology is based on the approach suggested by the Little Red River Cree Nation (Webb, 2000), and the stages of indicator development have been modified from the basic concept used by Mwadime (1996) and developed for the International Development Research Centre (IDRC). Mwadine's (1996) concept deals with the community-level reaction to environmental changes caused by global or regional fluctuations in climatic conditions (e.g., changes in precipitation and temperature and their seasonal distribution). Mwadine's (1996) indicator development approach has four stages:

1) definition of issues;
2) selection of indicators;
3) definition of the (qualitative) measurement endpoints; and
4) analysis of corrective action in the community.

In this project, Mwadine's (1996) indicator development approach was modified to be used for an analysis of impacts of small-scale (local) changes in economic and environmental conditions caused by the intensive use of natural resources and by societal changes imposed on First Nations communities.

As a result, the first stage of Mwadine's (1996) approach, the definition of issues, is now separated into two stages. First, critical issues (e.g., preservation of cultural sustainability) are identified and selected, as recommended by communities. Second, the most relevant institutional and social patterns are defined. For example, for the preservation of cultural identity, the relevant institutional and social patterns are the preservation of language and of elements of cultural life, adherence to traditional nutrition patterns, and – generally recognized as the most important – continued use and production of natural resources for subsistence purposes.

It is worth noting that in the Life Indicators Wheel context, both spiritual and corporal elements are addressed in a single indicator in order to achieve "balance."

The next three stages are the selection of indicators that could measure change, measurement of the change, and the analysis and design of any needed corrective action. Corrective action would encompass both continuity, to maintain cultural sustainability, and change, required to adjust to existing economic, environmental, and political conditions differing from the past. Thus, the five basic stages of the process for developing community health indicators can be summarized as follows:

1) Definition and selection of critical issues, as recommended by communities. (Issues are identified for linkages – e.g., environment-morale, economics-values, religion-spirituality, and politics-responsibility.)
2) Definition of the most relevant institutional and social patterns.
3) Selection of indicators (e.g., moose can serve as an environmental indicator, and the impact of species decline can be a morale indicator).
4) Definition of endpoints and measurement of change. (A set of measurement endpoints is assigned to individual indicators – e.g., the number of moose in the area as a measurable endpoint for an environmental indicator; moose accessibility as a measurable endpoint for a morale indicator.)
5) Analysis and design of any needed corrective action, determined by the communities themselves and encompassing both continuity, to maintain cultural sustainability, and change, required to adjust to existing economic, environmental, and political conditions differing from the past.

The first year of the project focused on Stages 1-3. A preliminary list of proposed indicators has been developed and will be further evaluated within the three participating communities to establish the final list. The indicators are categorized into the four domains of the Life Indicators Wheel. For each of the domains (environment-morale, economics-values, religion-spirituality, and politics-responsibility), a review of the existing indicators that have been applied in other contexts has been completed.

Although the basic analysis of the quantification of indicators (e.g., Stage 4) has been provided, a detailed analysis of this stage will be proposed for the second year of the project. Upon completion of the project, a set of indicators and parameters to measure dimensions of environment-morale, economics-values, religion-spirituality, and politics-responsibility for subsequent testing in the communities will be available. Actual testing of the indicators will be undertaken in the second year of the process, should funding be available.

The critical Stage 5 (i.e., an analysis and design of corrective actions) will require a long-term effort that exceeds the scope of this project, as well as new funding.

5.4.5 Cultural Sustainability and Community Health Indicators

To continue their existence as separate entities (communities and nations), First Nations communities have to maintain their cultural sustainability. A serious decline or disappearance of cultural sustainability results in either assimilation or dependency, with social and health consequences.

Cultural sustainability is closely linked to (it could be said that it consists of) maintaining traditional economies, traditional environmental views, traditional spirituality, and preservation of traditional political concepts and structures. Any significant and rapid change in these components of cultural sustainability leads to the dilution of traditional values, morale, and responsibilities. A meaningful traditional spirituality can be replaced by other religious values, which can be foreign to a traditional cultural life. This illustrates the importance of the Life Indicators Wheel. The wheel summarizes, in a graphic form, empirical observations that point out the fundamental components and linkages of cultural sustainability of traditional First Nations societies. It illustrates a loss of "balance" caused by a decline in the traditional economy and changes in the environment, political responsiveness of community life, and traditional spirituality. The experience of the last decades and centuries seems to indicate that this loss of "balance" has fatal consequences. As pointed out, it leads to assimilation or dependency.

The specificity of the Life Indicators Wheel characteristics is determined by the fundamentals of traditional economy, linked to (and often an inseparable part of) traditional environmental, spiritual, and political views. The traditional economy of Canadian First Nations was (with the exception of the Haudenosaunee or Iroquois Confederacy) hunting and gathering. The hunting and gathering economy is characterized by relatively small communities (typically consisting of several dozen to a maximum of several hundred people) that require a large territory to hunt, trap, fish, and gather plants, nuts, and berries for subsistence and for medicinal purposes. This economy is based on extensive use of natural resources and requires a nomadic or semi-nomadic lifestyle. Although this lifestyle is now practically non-existent in Canada, maintenance of at least some aspects of this type of economy seems to be necessary from the standpoint of the Little Red River and Tall Cree First Nations. The most critical institutional pattern for cultural sustainability is the continued use and production of natural resources for subsistence purposes (Webb, 2000).

The Haudenosaunee society (represented in Canada by Mohawk communities) was traditionally characterized by a mixed economy based on agriculture combined with fishing and, to a lesser degree, trapping and hunting. This allowed for a sedentary lifestyle and a different level of organization. Mohawk communities were much larger than other First Nations communities, usually consisting of several thousand people with highly sophisticated political structures. However, even Mohawk communities used to base their economy on the extensive use of natural resources, and they consider a resource-based economy as one of the conditions of their cultural sustainability (Lickers, 1992).

The 21st century poses a fundamental problem for First Nations people, as they no longer live in isolation. They now lead sedentary lives and live in relatively large communities, often of several thousand people. In the past, practically all community members of a productive age were involved in a subsistence economy or (in the case of Mohawks) in a combination of agriculture and subsistence economy. In today's First Nations societies, only a segment of the population is still involved in the "original" subsistence economies.

The critical questions facing First Nations people in the 21st century are:

1) How far can the change or adaptation go without the loss of cultural identity?
2) Is there a way of replacing original activities by similar ones (e.g., replacement of fishing by aquaculture farms, as is being done by Mohawks; or replacement of moose, elk, or bison hunting by ranching, as is considered and planned by the Little Red River Cree Nation)?

These two questions underline the importance and the practical usefulness of the Life Indicators Wheel philosophy. It illustrates the link of the "corporal" components of the wheel (economics, environment, politics, and religion) with its "spiritual" components (values, morale, responsibility, spirituality) over the "centre." In other words, it postulates that community health (i.e., stability, physical and mental health of people, prosperity, freedom, and tolerance) depends on some balance of the corporal and spiritual "opposites." However, the wheel takes the issue of balance one step further; it illustrates that balance can be restored by replacement by similar, but not necessarily identical, activities. If this is possible, then a reasonable degree of cultural sustainability can be achieved.

"First Nations can and want to adjust, but on their own terms" (J. Webb, personal communication).

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6 ENVIRONMENTAL EPIDEMIOLOGY AND HEALTH IMPACT ASSESSMENT

6.1 Introduction

Although it is recognized that the concept of health encompasses many facets, including psychological, social, and other factors, the focus of this chapter is on physical health. The discussion will focus on environmental development projects that potentially have a health impact on the surrounding population and for which studies of an epidemiological nature need to be considered.

Epidemiology is a public health discipline combining statistical and medical investigation methods to study the distribution and the determinants of health-related states and events in populations (MacMahon and Pugh, 1970). The ultimate purpose of epidemiology is to improve the public's health by contributing to the prevention, mitigation, or treatment of health problems (Tarcher, 1992).

Environmental epidemiology is simply the application of epidemiology to suspected environmental health problems. It seeks to determine whether a link exists between disease/health outcomes (e.g., cancer, asthma, stroke, immunological diseases) and environmental factors/determinants (e.g., concentrations of heavy metals, toxic organics, etc., in the environment).

Environmental epidemiological studies are used:

- to assess the health status of populations exposed to suspected environmental sources of pollution and to identify potential health problems;
- to identify more vulnerable subgroups within environmentally exposed populations;
- to assess the health risks or effects of environmental exposures; and
- to assess the contribution of environmental factors to suspected environmental diseases, deaths, or other health conditions.

Typical applications of environmental epidemiology include assessing the health outcomes of exposures such as:

- sidestream cigarette smoke;
- electromagnetic fields;
- childhood lead exposure;
- airborne particles (resulting in asthma and other respiratory diseases);
- contaminated waste;
- contaminated drinking water;
- pesticides;
- methylmercury (especially relevant to native populations residing near hydro-electric power dams and reservoirs);
- radon gas;
- waterborne microbes (resulting in infectious diseases);
- asbestos; and
- human-caused pollution disasters (e.g., Bhopal, Seveso, Three-Mile Island, Chernobyl, Love Canal).

The complexity of epidemiological health investigations stems from the fact that diseases/health outcomes generally result from multifactorial processes involving the interplay of genetic, lifestyle, occupational, environmental, or other factors. Moreover, the respective importance of these factors changes according to the disease and exposure circumstances. For instance, lifestyle (e.g., cigarette smoking) and occupational factors (e.g., coke oven work, uranium mining, asbestos work) are major determinants of the risk of lung cancer and, moreover, multiply the effect of one another; genetic and lifestyle factors (e.g., diet, smoking, lack of physical exercise) contribute greatly to the development of arteriosclerosis; while genetic, lifestyle, and hormonal factors play a major role in the development of breast cancer. It is difficult to disentangle for any disease/health outcome the effect of each potential risk factor and to determine the contribution of a specific environmental factor. An added difficulty relates to the long latency of many diseases/health outcomes (cancers in particular), which manifest themselves decades after the exposure took place. For health outcomes with acute or subacute manifestations triggered by an environmental factor, such as asthmatic reactions, a link between an environmental factor and the disease/health outcome is often easier to identify.

6.2 Epidemiological Study Designs

The way in which a study is structured depends on a number of factors:

- the size and characteristics of the study population;
- the frequency of exposures and diseases involved;
- available data sources;
- the timing of the study with respect to the exposures and health effects;
- whether one seeks to describe or to explain phenomena; and
- budgetary and time constraints for producing results.

However, all “epidemiologic study types have their roots in the concepts of scientific experimentation” (Rothman and Greenland, 1998).

6.2.1 Experimental Studies

The question addressed in an experimental epidemiological study is: what are the health effects of a purportedly *beneficial* exposure? This is usually in the context of experimental epidemiological studies having to do with medical trials and “intervention studies” (e.g., positive health effects of a new drug, medical procedure, or a health policy such as a vaccination campaign).

The ideal epidemiological study design is the *randomized controlled trial*, where individuals or groups are randomly assigned to different exposure levels of a “treatment” (e.g., medication, health intervention) and then followed prospectively to assess any difference in outcome. The main advantage of such experiments is that subjects’ exposures are assigned randomly. This tends to make study groups comparable in every respect that can affect the outcome – i.e., they should have the same “baseline risk” of developing the disease/health outcome.

A second feature of randomized controlled trial studies is that they are “blind”; participants do not know which treatment/exposure they are receiving. Most often, randomized controlled trials are “double blind”; neither the participants nor the observers (caregivers, surveyors, and investigators) know which treatment/exposure is given to whom until the end of the trial.

In the example shown in Figure 6.1, 120 subjects were treated, of whom 90 improved in condition; among 120 subjects not treated (they usually receive a placebo, an ineffective look-alike treatment), only 60 improved. So, over the study period, those treated had a 75% probability ("cumulative risk") of improving their health status, while those not treated had only a 50% probability of a similar outcome (see also Table 6.1). The ratio of these probabilities is called the "risk ratio" (RR), which in this case is 1.5 – i.e., 75% ÷ 50%. This means that the treated group showed 1.5 times the improvement shown in the reference group, or, put another way, there was 50% more improvement in the treated group, which suggests a positive effect of the treatment.

Figure 6.1
Experimental Study of 240 Subjects

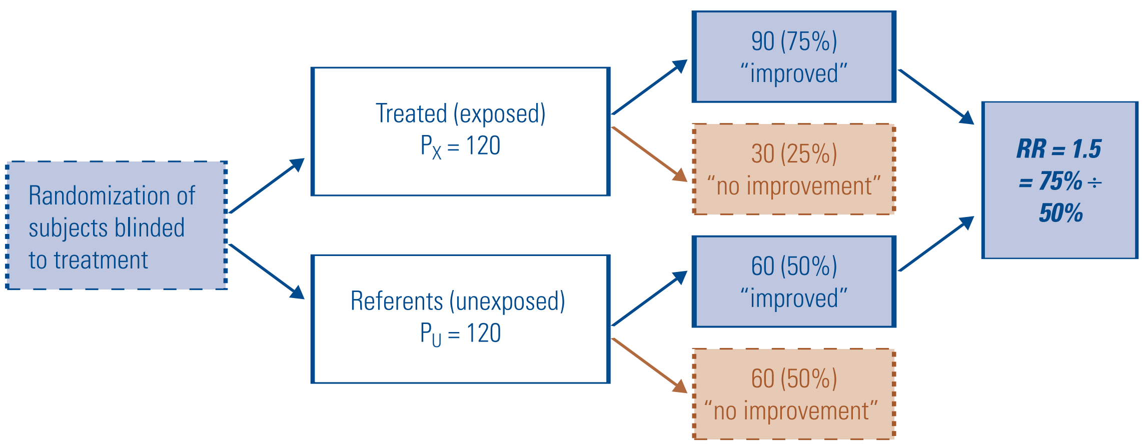


Table 6.1
Experimental Study of 240 Subjects

	Randomized Groups		Total
	Treated	Untreated	
Positive outcome	90	60	150
Negative outcome	30	60	90
Total	120	120	240
Risk of positive	75%	50%	62.5%
"Risk ratio"	Point estimate 1.5		95% confidence interval 1.22-1.84

Is there a sizeable chance that this study exhibits an effect as large as or larger than that observed (RR = 1.5) simply by random chance, even if the treatment were really ineffective? Here, the outcome ratio of 1.5 had a *95% confidence interval* of

1.22-1.84. This means that the true effect of the treatment most likely lies within this range. Since this confidence interval does not comprise the null-effect value (i.e., RR = 1.0), the "point estimate" of 1.5 is said to be *statistically significant* – i.e., unlikely to be a random fluke in the absence of a true effect. The width of the confidence interval depends on the *sample size* of the study; thus, larger studies produce narrower confidence intervals and thus more significant results. The same statistical principles apply to observational studies (see below) as well.

Only therapeutic and preventive experimental studies can ethically be conducted on human individuals or communities. Exposing humans voluntarily to hazardous substances for scientific research is unethical; hence, epidemiological studies conducted under HIAs rely on "observational" (non-experimental) epidemiological studies.

6.2.2 Observational Studies

There are four different types of observational epidemiological studies:

- cohort;
- case-control;
- cross-sectional; and
- ecological.

These study designs are complementary to each other, as they address different questions. Each study design has its own economic and scientific pros and cons.

6.2.2.1 Cohort Study

The question addressed in a cohort study is: what are the possible health effects of a given exposure (be it beneficial or detrimental)?

A cohort study is the observational study design that most closely resembles the experimental epidemiological study. Exposed and unexposed populations enter the study at one point in time (e.g., date of hire in a job; arrival in a community; date of birth; date individual was knowingly or accidentally exposed to a known health hazard) and are followed from then until the end of the study period to assess the occurrence of health outcomes in each group. This natural investigation sequence from exposure to outcome/effect is the key feature shared by both experimental and cohort studies; the outcome disease or health effect is observed *after* the exposure status of the subject has been determined by the investigator.

However, a key difference between experimental and cohort studies is that in the latter the investigator controls neither the exposure conditions nor the attribution of exposures to study subjects. Contrary to experimental studies where exposures are randomly assigned by the investigator after subjects have been selected into the study, subjects in the cohort are selected into the study based on their exposure status, which may be associated with risk factors other than those under study. As a result, the baseline risk of the disease/health outcome under study will often differ between exposed and unexposed groups, thereby biasing the crude results. Epidemiologists use study design characteristics (e.g., selection criteria for the unexposed subjects) and data analysis methods (e.g., regression techniques) to improve comparability or to make statistical adjustments to alleviate biases.

Cohort studies may be either *prospective* (i.e., subjects are identified at the present time and followed into the future) or *retrospective* (i.e., subjects are identified at some time in the past and are followed up to the present). With prospective cohorts, the data collected can be tailored to the needs of the study. With retrospective cohorts, one must rely partly on less complete and less accurate available data previously collected for other purposes (e.g., personnel payroll, census, market surveys, medical files). Prospective studies, although more accurate, are costly and often impractical due to their time requirement. They are more applicable to frequent, acute, or rapidly induced health effects or to recent, massive, and sudden exposures (e.g., Bhopal, Seveso, Three-Mile Island). Retrospective cohort studies are faster to carry out and are less expensive, particularly for rare, long-term, or chronic health effects (e.g., most cancers, asbestos-related diseases); or simply because exposures of interest have changed drastically (e.g., Hiroshima nuclear bomb, Agent Orange in Vietnam).

Below are two examples of environmental cohort studies – one prospective and one retrospective:

- ***Seveso's Dioxin Release in 1976*:** Bertazzi *et al*. (1998) conducted a *prospective cohort study* of residents who lived near Seveso, Italy, in 1976, at the time of a heavy atmospheric release of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). They identified three exposure zones, classified from higher to lower exposures. Mortality and cancer incidences in the exposed residents were compared with those of a large population in the surrounding non-contaminated area. The incidences of gastrointestinal and digestive cancers, leukemia, multiple myeloma, and Hodgkin's disease and mortality due to cardiovascular disease, chronic rheumatic heart disease, chronic obstructive pulmonary disease, and diabetes were higher in the zone most exposed and closest to the source of the TCDD release. Although all effects were likely attributable to the TCDD release, the excess mortality from cardiovascular and respiratory diseases was partly attributed to the psychosocial stress resulting from the accident, in addition to the chemical contamination (Bertazzi *et al*., 1998).

- ***Mothers' Drinking Water and Birth Outcomes in Nova Scotia*:** Dodds *et al.* (1999) conducted a *retrospective cohort* study of the relationship between stillbirth and levels of chlorination-induced trihalomethanes (THMs) in public water supplies. A cohort of 50 000 singleton deliveries between 1988 and 1995 was assembled from a population-based perinatal database in Nova Scotia. The risk of stillbirth was largest among women who had an average THM exposure during pregnancy of ≥100 µg/L in drinking water, relative to those with less than 50 µg/L THM exposure; the RR was 1.66 (95% confidence interval = 1.09-2.52). Specifically, bromodichloromethane was most strongly associated with asphyxia-related stillbirths. THM exposure during pregnancy was not associated, however, with fetal weight, gestational age, or congenital anomalies (Dodds *et al.*, 1999).

Measures of Effect Used in Cohort Studies

Several measures of effect can be used in cohort studies. One such measure, the "cumulative risk ratio" or *relative risk (RR)*, is the proportion of the exposed cohort developing the disease/health outcome of interest, relative to the proportion in the unexposed cohort. This measure is appropriate if the disease is "rare" (i.e., incidence rate <10%).

The *incidence (or mortality) rate ratio (IRR)* is the incidence rate (IR) of the outcome in the exposed group relative to the IR in the unexposed group. (Sometimes, the difference between rates is used rather than their ratio.) The IRR is usually the preferred measure of effect because it accounts for duration of exposure and follow-up time for each member of the cohort(s). It is based on the gold-standard "person-years" method, according to which a person followed up for 10 years counts 10 times more than one followed up for 1 year. When the disease is rare (i.e., IR of <10% in the exposed), the RR is a good approximation of the IRR.

Hypothetical and Computational Example

In the example of a cohort study shown in Figure 6.2, 10 000 workers were hired by the steel-making company ZTL between 1950 and 1990. Two thousand (20%) of these worked on average 20 years in job(s) with high exposures to polycyclic aromatic hydrocarbons (PAHs), totalling 40 000 person-years (PYs) of exposure. The other 8000 worked on average 25 years for ZTL over the 1950-1990 study period, for a total of 200 000 PYs. If 200 lung cancer cases occurred in this unexposed group while they worked for ZTL between 1950 and 1990, this would translate to an IR of 200 cases/200 000 PYs, or 1.0 per 1000 PYs. If 60 lung cancers occurred among the exposed workers while they were under study, this would result in an IR of 60 cases/40 000 PYs, i.e., 1.5 per 1000 PYs. The IRR would thus be 1.5 (with a 95% confidence interval of 1.1-2.0); this is a "statistically significant" ratio, since the "null" value of 1.0 (if there were no effect) is not within the confidence interval

(Table 6.2). Because this is a cohort study, one could also assess the effects of PAH exposures on other health outcomes, as one is not limited to assessing only one effect.

Figure 6.2
Cohort Study of 10 000 Subjects

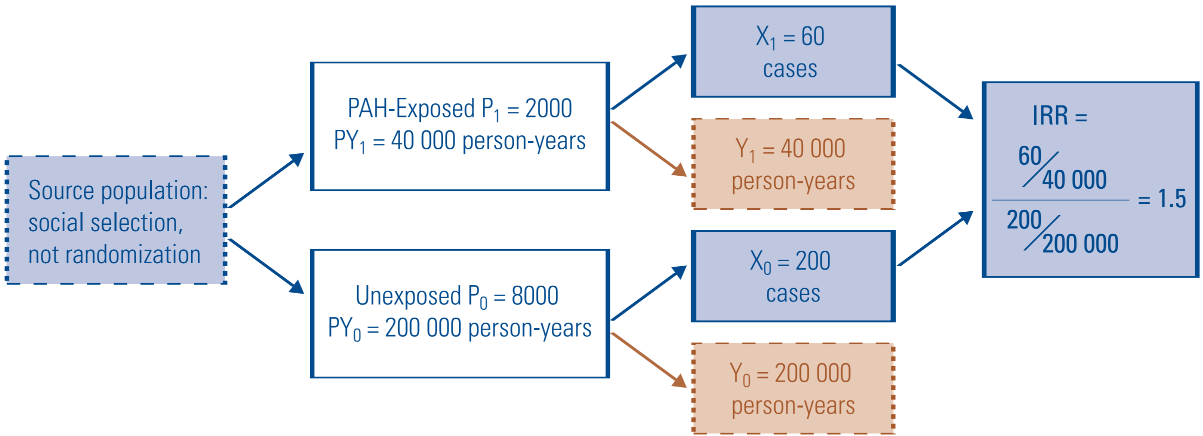


Table 6.2
Cohort Study of 10 000 Subjects

	Cohort Groups		Total
	Exposed	**Unexposed**	
Individuals	2 000	8 000	10 000
Cases	60	200	260
Person-years (PYs)	40 000	200 000	240 000
Incidence rate (IR)	1.5/1000 PYs	1.0/1000 PYs	
Incidence rate ratio (IRR)	Point estimate 1.5		95% confidence interval 1.105-2.011

6.2.2.2 Case-Control Study

In a case-control study, the question addressed is: what are the contributing causes of a given disease/health outcome?

Case-control studies (also called case-referent studies) are the most frequently used epidemiological study design. They are particularly well suited to study infrequent diseases/health outcomes. Case-control studies examine cause-effect relationships from a chronologically reverse perspective to that of cohort studies. Investigators first identify and select cases – i.e., subjects with the disease/health outcome of interest (e.g., cancer, high blood pressure, asthma). In a second step, investigators select *controls/referents* – i.e., subjects without the disease/health outcome of interest. Usually, all cases occurring in the population of interest are included in the study, while only a small fraction of the potential controls is selected. This makes case-control studies more efficient than cohort studies. These two groups are then “followed backward” in time to assess whether their respective past exposures differed before the individuals actually developed the disease/health outcome. Tracking backward from outcome to antecedent causes is characteristic of case-control studies; it is inferred that differences in exposure patterns between cases and controls are the likely causes of the outcome.

Case-Control Design

The case-control design is shown schematically in Figure 6.3. The same underlying population and association presented in the experimental and cohort studies outlined in Figure 6.2 are assumed, and all 260 cases (60 exposed and 200 unexposed) that occurred in the 10 000 ZTL cohort are selected. A representative subset of 520 controls (a 2:1 controls:case ratio; a ratio is chosen usually between 1:1 and 4:1) is selected from the 9740 non-cases in the cohort. These controls should represent the person-time experience of the cohort and hence would be distributed proportionately among the exposed and unexposed person-years in the cohort. In this hypothetical example, there are (520 × 40 000/240 000 =) 87 exposed and (520 × 200 000/240 000 =) 433 unexposed controls out of the 520. In the case-control sampling scheme, it is impossible to compute IRs or even RRs. For instance, in the example in Table 6.3, the proportion of cases among exposed subjects is 40.8% (60/147), and that among unexposed subjects 31.6% (200/633), and thus their ratio would be 1.29. This value is an underestimate of the IRR (1.5 calculated in Table 6.1) because, although a case-control study usually collects all the cases available in a population, it studies only a small sample of all the potential controls, thus exaggerating the proportions of cases among exposed and unexposed subjects and distorting the ratio.

Figure 6.3
Case-Control Study of 780 Subjects

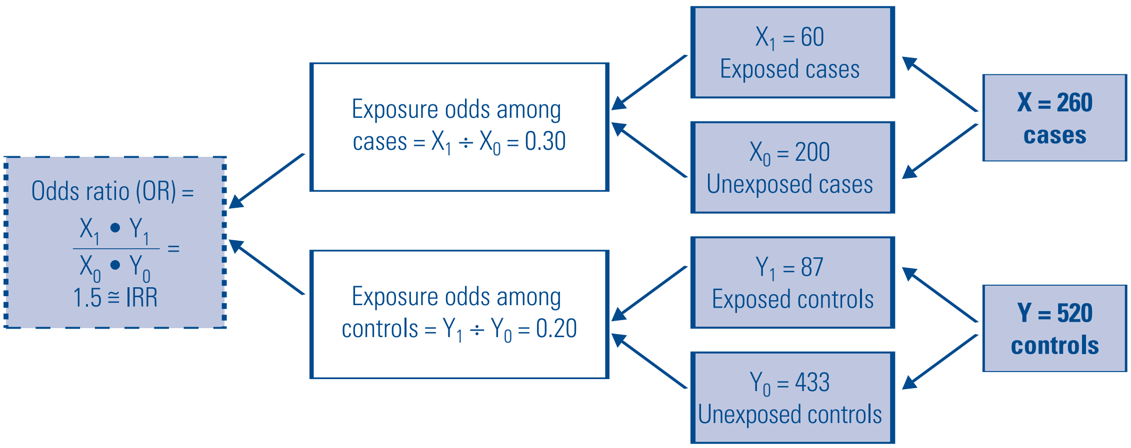


Table 6.3
Case-Control Study of 780 Subjects

	Case-Control Groups		Total	Exposure Odds
	Exposed	Unexposed		
Cases	60	200	260	0.3000
Controls	87	433	520	0.2009
Total	147	633	780	Ratio = 1.493
Case odds	0.6897	0.4619		Ratio = 1.493
Odds ratio (OR)	Point estimate 1.493		95% confidence interval 1.012-2.192	

Odds Ratios

The correct way to approximate the IRR is to compute a ratio of the *odds*. It does not matter in which direction the odds are computed. While a risk is a proportion (a part divided by the total = A/(A+B)), an odds is the number of persons *with* a characteristic divided by the number of persons *without* that characteristic; it is not a proportion. In Table 6.3, for instance, the right side of the table shows the "exposure odds" (60/200 = 0.3; and 87/433 = 0.201) and the ratio of these exposure odds (0.3/0.201), 1.49. The "case odds" are 0.690 (60/87) and 0.462 (200/433), and their ratio is also

1.49. This symmetry is characteristic of odds ratios (ORs), the standard measure of effect used in case-control studies.

An essential characteristic of the OR in a case-control study is that it approximates very well the IRR in the source population either when the disease/health outcome is rare or when the controls are selected at the time of incidence of the cases (i.e., an "incidence-density" case-control study). The incidence-density case-control study is the most used epidemiological study design.

Case-control studies are particularly well suited to study causes of rare diseases/ health outcomes, even more so when outcomes have long latency or induction periods. They are often the only feasible study design when information on past exposures is not available at the onset of the study. Moreover, the effects of potential confounders (i.e., extraneous determinants of outcome that correlate with exposure) may be more easily controlled statistically in case-control studies relative to cohort studies because it is usually easier to gather information on confounders in case-control studies.

Case-control studies are more likely to be valid if they are *population-based* – i.e., when all incident cases in a well-defined population are selected over a specified period of time from a population database, such as a regional or national cancer registry, for instance. *Hospital-based* case-control studies are less desirable for a number of reasons, particularly because cases referred to a given hospital for a given disease/health outcome may differ considerably from the hospital's neighbouring population or from other patients in that hospital (potential controls). For instance, a hospital may be specialized in occupational respiratory diseases, and those patients will come from different areas compared with locals who come for routine exams or because of small emergencies.

One potential important bias of case-control studies regards the *absence of blinding to outcome status* – i.e., people know that they are cases or controls at the time that past exposures are assessed. Therefore, cases may *recall* past exposures more easily than controls do because they have been trying to find the cause of their disease/health outcome before, making the responses of cases and controls less comparable. Great care can and should be taken to minimize or avoid such biases as the *recall bias*.

6.2.2.3 Cross-sectional Study

In a cross-sectional study, the question addressed is: how frequent or prevalent are various health determinants and health/disease outcomes in a given population at a given moment in time, and how do they correlate with one another?

In a cross-sectional or prevalence study, exposure and health status are usually measured *at the same point in time*. The cross-sectional design involves taking a representative sample of a whole population available at one point in time and interviewing sampled subjects (i.e., a survey) about prevalent health conditions and exposures. If information on past diseases/health outcomes and past exposures is obtained, then the study may resemble a cumulative incidence case-control study. Subjects are selected on the basis of their current membership in a population of interest rather than on the basis of their exposure status (cohort study) or on the basis of their disease/health status (case-control study). In a cross-sectional study, many outcomes and exposures can be looked for simultaneously, but the number of subjects for a given outcome and exposure will usually be small, making statistical interpretation difficult.

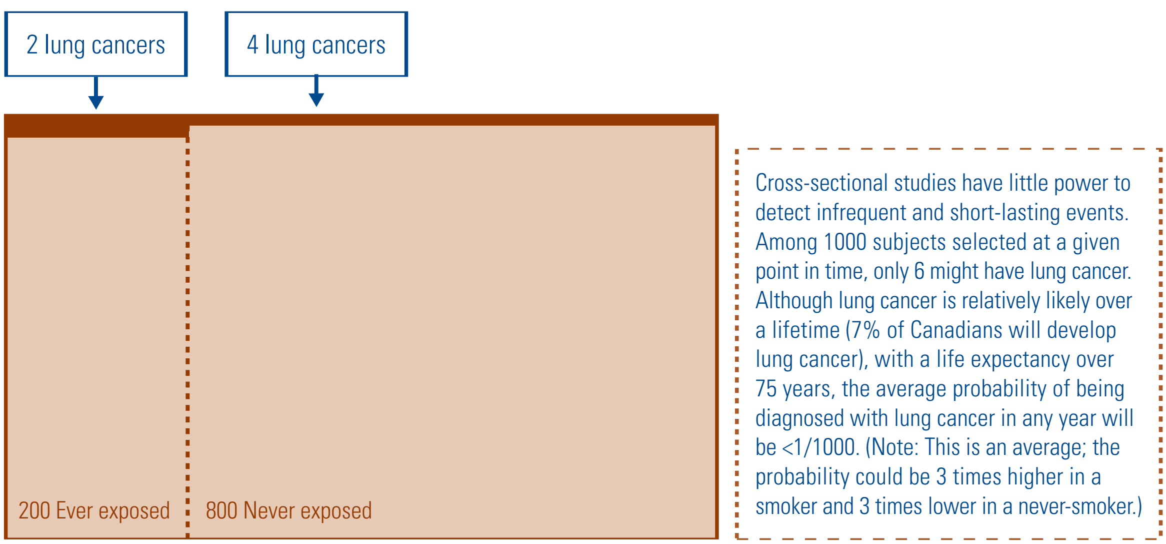
Cross-sectional studies are most useful for public health planning purposes. However, they may be used to examine cause-effect relationships between relatively frequent diseases and relatively frequent exposures. They usually are best suited for diseases of slow onset or long duration: e.g., asthma, allergies, diabetes, osteoarthritis, and depressive disorders. Cross-sectional studies rely a lot on individual recall or self-reporting, which makes them less reliable than other designs. However, self-reporting may be documented by contacting hospitals or physicians attended by the subjects or by having medical tests applied to the subjects for the study. When past exposures of interest are relatively simple and objective/neutral, such as past places of residence, cross-sectional studies can be very valuable. Cross-sectional studies may also be very useful to assess and describe the health status of a population, particularly when a surveillance program involving periodic cross-sectional surveys over time is planned. (Note: Cross-sectional studies that are repeated over time on the same subjects are called “panel studies.”)

Thus, in Table 6.4, the proportion of lung cancer cases is 1.0% (2/200) among exposed subjects and 0.5% (4/800) among the unexposed, for a prevalence ratio of 2.0 with a 95% confidence interval of 0.18-14.0. The prevalence ratio is very far from statistical significance, even though 1000 subjects were sampled, more than the 780 in the case-control study. This demonstrates why cross-sectional studies have less statistical power than cohort or case-control studies. Indeed, cross-sectional studies will be useless if less than 10% of the population is exposed or if less than 10% has the health outcome of interest. Still, for relatively prevalent conditions such as asthma and prevalent exposures such as parental smoking or use of wood furnaces, cross-sectional studies can be most useful.

Table 6.4
Cross-sectional Study of 1000 Subjects

	Cross-sectional Study Group		Total	Prevalence
	Exposed	Unexposed		
Cases	2	4	6	0.6%
Controls	198	796	992	99.4%
Total	200	800	1000	100.0%
Prevalence	1.0%	0.5%		
Odds ratio (OR)	Point estimate 2.0		95% confidence interval 0.182-14.026	

Figure 6.4
Cross-sectional Study of 1000 ZTL Present or Past Employees



6.2.2.4 Ecological Study

In an ecological study, the question asked is: do geographical populations with a higher occurrence of a specific exposure tend also to be those with a higher occurrence of disease/health outcomes or mortality?

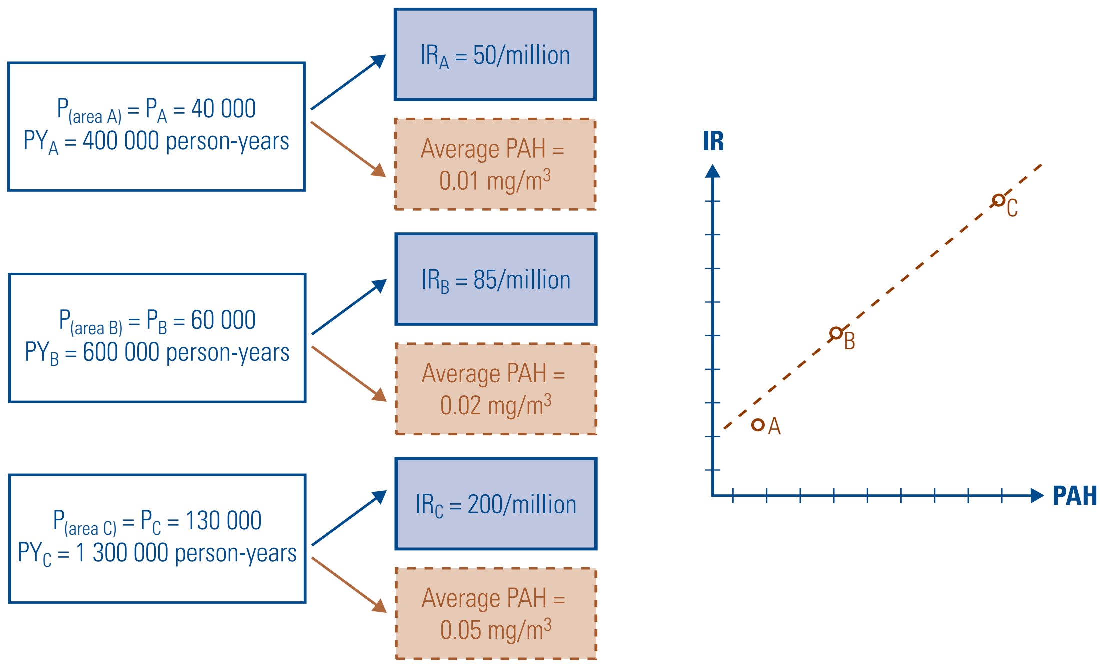
Ecological studies are also called aggregate-level or correlation studies, and the units of observation and analysis are *populations or groups* of people rather than *individuals*. This contrasts with the three study designs discussed above. In ecological studies, data on *aggregate measures* (averages or rates) of exposure and of disease/health outcomes are obtained for each "ecological unit of analysis" (i.e., geographically and chronologically defined populations), and the relationship between the summary exposure and outcome measures is analysed across ecological units. Thus, we look for space-time trends.

Ecological studies are usually based on routinely collected data or on readily available data collected independently by various geopolitical authorities and agencies, usually for purposes related to health determinants and health indicators; they have large statistical power due to the size of the populations and of the aggregate data. Ecological studies are often used as a first, preliminary step in investigating a suspected exposure-outcome relationship. Ecological studies can also be of value in environmental epidemiology when exposure to a health determinant is spread relatively evenly within a community or affects a large proportion of individuals in that community. Results from ecological studies should always be considered as preliminary or exploratory and should be confirmed by cohort, case-control, or cross-sectional studies.

The main drawback of ecological studies is that within each ecological unit of analysis, one does not know if the individuals who develop a disease/health outcome are actually those who were exposed or most exposed. One can only draw conclusions from population "averages" or proportions/rates; one assumes that exposures were *uniformly* distributed within each area/population. In reality, this is rarely the case; exposures are most often heterogeneously distributed in populations, and overall means can be misleading. In the hypothetical example in Figure 6.5, the *average (mean)* PAH concentrations in outdoor air are compatible with the following heterogeneous exposure distributions:

- Due to different urbanization patterns around PAH-emitting foundries, 10% of population "P_A" might live 100 m from a steel foundry and be exposed to 0.1 mg/m^3, while 90% might live quite far away and thus be exposed to no PAHs at all.
- On the other hand, 50% of population "P_B" might live 300 m from a foundry and be exposed to 0.04 mg/m^3, while 50% might live far away and be exposed to no PAHs at all.
- Finally, 100% of population "P_C" might live about 500 m away from a foundry and be exposed to 0.05 mg/m^3 if the whole population lived in the midst of a number of steel foundries.

Figure 6.5
Ecological Study of Three Areas with Steel Foundries



Note 1: "IR" = lung cancer incidence rates.
Note 2: The outcome measure is known for whole populations (e.g., $P_A \rightarrow P_A$), but *not separately for exposed* (e.g., $PA_1 \rightarrow IR_{A1}$) *vs. unexposed* (e.g., $P_{A0} \rightarrow IR_{A0}$) groups.

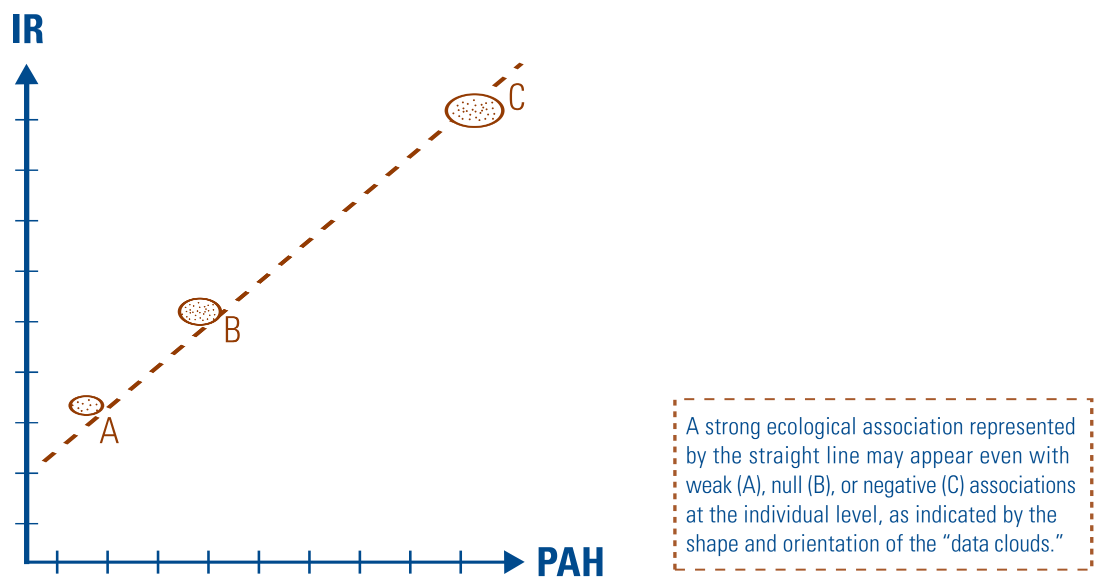
Likewise, average exposure is known for whole populations, not for cases vs. non-cases separately.

This is the main limitation of ecological studies. As in the graph, exposure and disease averages, rates, or proportions can be "correlated," but we do not know if exposed individuals count more cases than unexposed individuals do, nor if cases are actually more exposed than non-cases.

Hence, the most exposed individuals may be in the area with the lowest average exposure levels ("A"). Such heterogeneity makes "ecological" ("aggregate" or "average") exposure comparisons speculative, because one does not know if the cases are actually those people most exposed or not. The situation is even more complicated due to the presence of "confounders," such as tobacco smoking-induced exposure to PAHs. Thus, the effect of ambient PAH levels in outdoor air would be overestimated in our example if the proportion of smokers were larger in population "C" than in population "A" or "B."

These drawbacks seriously limit the inferences or generalizations about individuals that might be derived from ecological studies. When the relationship between aggregate variables does not represent the relationship between the corresponding variables in individuals, it is said to result from an *ecological bias*, and reasoning as if this were true has been termed ecological fallacy. The graph in Figure 6.6 illustrates an example of a possible *ecological fallacy*; it shows how a strong ecological association across three populations might appear even when individual-level associations are weak within each area. Although the ecological association differs from the individual-level association, one does not know where the truth lies; in certain circumstances, there may be too many sources of variability at the individual level to distinguish the forest (effect of interest) from the trees (individual susceptibilities and other "noises"). Sometimes only the ecological level may detect and suggest effects difficult to see at the individual level.

Figure 6.6
Ecological Fallacy of Equating Individual and Aggregate



6.2.2.5 Comparative Advantages of the Main Epidemiological Study Designs

For ease of comparison, Table 6.5 lists the advantages and disadvantages of each of the five epidemiological study designs described above.

Table 6.5
Comparative Advantages of Main Epidemiological Study Designs

Study Design	Advantages	Disadvantages
Intervention studies (randomized trials)	Groups are likely more comparable due to randomization Subjects, staff, data collectors, analysts, and investigators can be blinded for greater objectivity Many health endpoints possible Exposure (dose) well controlled	Impractical and unethical for studying pollutants Inefficient for rare health effects Very expensive
Cohort studies	Efficient for rare exposures Simple logic, easy to explain Absolute risks or rates estimated Many health endpoints considered Exposure is well characterized Reduces and assesses losses to follow-up (e.g., out-migration)	Expensive Inefficient for rare health effects Some selection bias Confounding bias, controllable Only one exposure assessable Prospective studies are expensive Longer time for health outcomes of long latency to appear Blinding is reduced
Case-control studies	Short duration, therefore faster results Less expensive (usually) Efficient for rare health effects or diseases with long latency Many exposures considered	Only risk/incidence ratios estimated Exposure information imprecise mostly with long-latency diseases Some selection bias Confounding bias, controllable Recall bias (frequent) Single health endpoint assessed Losses to follow-up unknown
Cross-sectional studies	Short duration, usually inexpensive Efficient for health states/chronic diseases for which medical care is not immediately sought Representative sample of a target population makes results more easily generalized Can consider many exposures and many health effects simultaneously Health/exposure picture of a population at one point in time	Possible confusion between cause and effect due to simultaneity of determining disease and exposure Low statistical power Inappropriate when both exposure and outcome <8% prevalence Recall bias (often) Low information quality (self-report) Overrepresentation of long-duration disease among cases Confounding is hard to control
Ecological (aggregate) studies	Short and inexpensive Statistically efficient and thus efficient for small effects Natural and efficient for localized point source exposures Useful to screen or generate hypotheses about group attributes Use of available routine data	Possible confusion of ecological relations with individual effects (ecological fallacy) Selection and confounding bias are very difficult to control Limited to available routine data Pollution effects often confounded with socioeconomic effects

6.3 Data Sources for Epidemiological Health Impact Assessment

6.3.1 Population Data

Population data by sex, age groups, and time periods are essential to estimate and to standardize disease/health outcome rates over time and across populations. Standardization makes rates comparable between different populations and time periods by correcting for age and gender differences. Moreover, data should be considered for specific age groups, such as children, adults, and elderly populations; specific time periods (e.g., before vs. after shutdown of an industry); and for each gender separately (e.g., male rates may reflect more occupational risk factors, while female rates may reflect environmental risk factors). Population data are available by census subdivisions and may be obtained (for a fee) from Statistics Canada, which conducts census surveys every five years. Population data categorized by enumeration area, the smallest geographic unit for which such information is available, may also be required to perform finer analyses and to reduce the ecological fallacy problem. Population data by enumeration area may be useful to help determine whether a health hazard affects predominantly a particular neighbourhood (enumeration area) within a town (census area). Such data are often available from provincial/territorial and local health authorities.

It should be noted that Statistics Canada *never* grants access to individual census data. It even "censors" or "suppresses" non-nominal statistics stratified by age, gender, and area when the number of individuals in a cell is less than four. Thus, users often cannot say if a "0" in a cell means that zero, one, two, or three individuals have that characteristic. This privacy requirement has a slight scientific toll; it hampers the precision of statistics and studies of small populations.

6.3.2 Disease/Health Outcome Data

6.3.2.1 Mortality

Canada has had a computerized database containing information on causes of death, by census subdivision area, since 1950. This mortality database includes the name, sex, age, address, and cause of death of the decedent. These data may be obtained either directly from each provincial/territorial vital statistics department or, for all provinces/territories and Canada as a whole, from Statistics Canada (for a fee). Information included in mortality databases can be used to reliably estimate rates for any cause of death (e.g., cancer, non-cancer diseases, accidents, and poisoning). However, the mortality data suffer from a number of limitations, notably changes in the International Classification of Diseases (ICD) system over time, errors in the reported cause of death (particularly for the elderly), errors in coded place of residence, and the lack of information on residence duration and on main lifetime occupation.

6.3.2.2 Cancer

A computerized database containing information on cancer incidence has been in place in Canada since 1969. It includes the name, age, address, cancer site, and histology for every newly diagnosed cancer patient. These data may be obtained either from the respective cancer registries for each province/territory or, for all provinces/territories and Canada as a whole, from Statistics Canada (again, for a fee). Cancer information from cancer registries is more precise than that obtained from mortality databases, as it includes histological diagnosis of the tumour. Moreover, place of residence and, where available, occupation at the time of diagnosis are more likely to have occurred well before the onset of the disease than would similar data indicated on a death certificate. As with the mortality database, the cancer database also lacks information on residence duration.

Canada is one of the few countries in the world with a national cancer reporting system, which is based on centralizing data from the provincial/territorial cancer registries. The Canadian Cancer Registry is used extensively to identify excess cancer risks in certain populations.

6.3.2.3 Morbidity (Disease/Injury) Databases

Information collected for administrative purposes, such as hospital separation and physician billing forms, may be of some value for disease/health outcome measures. However, in general, the information records cannot be used to estimate disease rates, but rather frequencies of events, since they are not – as opposed to the mortality and cancer registry databases – based on individual subjects. Thus, for instance, if 100 hospital admissions for hypertension are recorded in a given hospital in a given year, one cannot infer that they involve 100 individual cases, as they could be 50 people admitted twice or 10 persons admitted 10 times, or any other combination. In addition, such databases suffer from a number of biases due, in particular, to differences in physicians' admitting and practice patterns.

6.3.2.4 Special Databases and Data Access

Specific databases may exist in some, but not all, provinces/territories that may be of importance for disease/health risk assessment. One example is the Nova Scotia Atlee Perinatal Database, which contains data on birth outcomes, including congenital malformations, for every pregnancy of over three months' duration. Insurance company databases, workers' compensation board databases, and similar data sources are also used in epidemiological studies.

Finally, individual medical files in hospitals, clinics, and private practices as well as individual employee records may be accessed directly, albeit under strict conditions and controls. It must be emphasized that in Canada, privacy and access to nominal data (i.e., data records with personal identifiers such as name, address, social insurance number, etc.) are protected at multiple levels by numerous laws, access-to-information boards, ethics panels' peer reviews, and usually also by the patient's physician.

6.4 Health Impact Assessment: Suggested Approach

6.4.1 Context

Environmental and occupational epidemiological studies are often retrospective in nature, investigating suspected health effects of past exposures. However, the objective of HIA is usually to determine whether *present* or *new* environmental conditions resulting from a proposed development project will influence future health outcomes. Epidemiological studies in this context must be essentially prospective. Since disease/health outcomes may be multiple, indirect, or unexpected, such studies must take a more exploratory perspective than that of classic hypothesis-testing epidemiological studies. This “look-out” approach implies broader and more systematic data collection systems.

To document any health effect potentially related to an environmental impact or exposure, *baseline* data are needed to compare the population health status at a future point in time relative to its health status *prior to* the environmental modification. An alternative to the establishment of a baseline is the establishment of a *reference* population (i.e., identification of a comparable population not affected by the project). Baseline/reference information may also be obtained on the environmental and spatial relationships between the development project and the population, as well as on any known or suspected health effects related to occupational exposures associated with the development project. It must also be emphasized that in addition to public buy-in, long-term input and involvement of health professionals are essential to the successful implementation of HIA.

Thus, HIA entails both retrospective and prospective epidemiological studies. The importance of follow-up monitoring cannot be overstated. During and after the implementation of a new project, stakeholders should ensure that actual exposures and diseases/health outcomes do not exceed those anticipated and acceptable. Thus, HIAs rely heavily on exposure monitoring and on health surveillance (follow-up) to control potential side-effects of a project. Exposure monitoring can entail ambient measurements/sampling schemes such as installing air monitoring stations or analyses of regular drinking water and recreational water or of country food, where relevant. It may also entail biological monitoring (e.g., analyses of urine, blood, hair, sputum samples) if the suspected exposures and disease/health outcomes so warrant.

Health surveillance, if warranted, should involve all health authorities that can provide or gather data on the target population. For instance, provincial/territorial and federal health authorities could agree to produce periodic reports specific to the target population, while local physicians/hospitals/clinics could look out for increased incidence of certain signs or symptoms of diseases/health outcomes for a specified time period.

6.4.1.1 Health

Baseline data on mortality from all causes of death and on cancer incidence may be obtained from the databases mentioned above to determine if the rates for any diseases in a given environment of interest are statistically significantly increased over expected or baseline national or provincial/territorial rates. However, it is often not obvious what the background or baseline incidence of certain diseases in a specific population may be; in such cases, it is useful to examine in greater depth whether disease/health outcome incidence rates in the town or area of interest significantly exceed those of neighbouring areas.

For example, Health Canada is currently investigating the health impact of environmental exposures in Sydney, Cape Breton County, Nova Scotia, a town that has been the site of heavy industrial pollution from a steel foundry and coke ovens. In 1999, Health Canada completed a mortality study of all deaths occurring between 1951 and 1994. In order to determine whether risks of death from specific diseases were significantly increased in Sydney only or showed a statistically significant risk gradient between Sydney (higher exposure, expected higher risk) and neighbouring areas, standardized mortality ratios (SMRs), measures of relative death rates, were compared for Sydney, Cape Breton County (the county in which Sydney is located), and Cape Breton County excluding Sydney. Examples of the results are shown in Table 6.6.

Table 6.6
Standardized Mortality Ratios (SMRs) by Geographic Area, 1951-1994
(Canadian Population Rates Used as Reference) (Band *et al.*, 1999)

Cancer Site	Gender	Cape Breton County[1]	Cape Breton County Excluding Sydney[1]	Sydney[1]
Stomach	Male	1.48*	1.56**	1.28*
Colon	Male	1.10	0.88	1.69*
Pneumoconiosis[2]	Male	16.8	16.9**	1.66
Breast	Female	1.09*	1.03	1.25**
Cervix	Female	1.82*	1.83*	1.79*

[1] * = SMR statistically significantly higher in the given area than in Canada; ** = SMR statistically significantly higher in the given area than in the rest of Cape Breton County.

[2] Chronic inflammation of the lungs, produced by the inhalation of mineral dust (e.g., black lung).

For certain diseases, such as cervical cancers, although the SMRs are significantly increased in all geographic areas, there is no geographic gradient of risk within Cape Breton County. For other diseases, such as stomach cancer in males, the SMRs are also significantly increased in both areas within Cape Breton County, but the risk in Cape Breton County excluding Sydney is significantly greater than in Sydney, possibly as a result of coal mining. For colon cancer in males and breast cancer in females, the SMRs are significantly increased in Sydney only.

In addition to providing baseline data, this approach helps to determine the disease conditions that may prevail in the geographic area of interest. However, to correctly attribute death or cancer incidence rates to the population under study, it is crucial to ensure that address information actually corresponds to the town of residence of the subjects. There is a tendency for people living at the periphery of a town to use the town's name instead of the name of their locality as their mailing address. This can be reflected on the death certificate or cancer registration form. Such address misclassification may lead to an overestimate of the rates in the population under study. In the study referred to above, all death certificates of Cape Breton County were verified for a one-year period. Of the 365 certificates indicating Sydney, only 305 were correctly attributed to Sydney after address and postal code verification. Thus, the number of deaths in Sydney, based on the information contained on the death certificate, was overestimated by close to 20% (60/305), leading to spurious overestimation of disease rates. A number of means were used to estimate the average percentage of address misclassification occurring over the 44-year period of the study, and the SMRs corrected accordingly. It is imperative that this problem of residence misclassification be very carefully addressed whenever disease/health outcome rates are calculated at the subcensus division level.

6.4.1.2 Occupation

For HIA involving an industrial project, a literature review of health studies should be carried out to verify whether specific diseases/health outcomes have been reported to be significantly associated with the industry under consideration. This information could alert decision-makers to potential health hazards to the workers; provide clues to the type of diseases/health outcomes that might possibly be expected in the general population as a result of the new development project; and lead to specific prevention and surveillance measures.

Where appropriate, information on mortality from all causes of death and on cancer incidence could also be obtained, using the databases indicated above, to investigate whether workers in specific industries have significantly increased health risks.

Case Example

Pulp and paper is a primary industry in British Columbia, which produces almost one third of the annual Canadian pulp and paper tonnage. Wood is converted to pulp most commonly by chemical processes. In chemical pulping, lignin is solubilized by chemicals under two conditions – alkaline, also referred to as the kraft or sulphate process; and acidic, also called the sulphite process – the latter being the most common. In a first study (Band *et al.*, 1997), the causes of death in a cohort of 30 157 workers in 14 pulp and paper mills in British Columbia were investigated. Of these, 20 373 (68%) worked in the kraft process only, 5249 (17%) worked in the sulphite process only, and 4535 (15%) worked in both processes. Cancers significantly associated with work duration and time from first employment of 15 years or more were as follows:

- *total cohort*: cancers of the pleura, kidney, and brain;
- *workers in kraft mills only*: cancer of the kidney;
- *workers in sulphite mills only*: Hodgkin’s disease; and
- *workers ever employed in both kraft and sulphite mills*: cancer of the esophagus.

In a second study (Band *et al.*, 2001), the cancer incidence pattern of this cohort was investigated. Cancers significantly associated with work duration and time from first employment were as follows:

- *total cohort*: cancer of the stomach;
- *workers in kraft mills only*: no significant excess of cancers;
- *workers in sulphite mills only*: cancer of the pleura; and
- *workers ever employed in both kraft and sulphite mills*: cancers of the stomach and prostate.

Although the results of these two studies differ, most of the discrepancies can be explained. Before attempting to do so, it must first be recalled that:

- mortality data in Canada are available from 1950 onward, but only since 1969 for cancer incidence; and
- information based on pathology reports (cancer incidence) is more accurate than information based on death certificates (cancer mortality).

An in-depth look at the two sets of data, cancer mortality and cancer incidence, will serve to identify reasons for the observed discrepancies. For certain cancer sites, discrepancies were more apparent than real. For example, the relative risks for cancers of the pleura and of the brain were of the same order of magnitude in both studies, but were not statistically significant in the cancer incidence study due to smaller numbers as a result of the shorter period of observation. This is a frequent phenomenon, because cancer registries are much more recent than mortality registries. In other situations, due to their longer time series, mortality data pointed to cancer risks that cancer incidence information could not have revealed due to the more recent availability and shorter coverage period of the latter. For instance, a subanalysis by time periods showed that the increased mortality from Hodgkin's disease was confined to the period 1950-1968, so that the lack of excess risk in the cancer incidence data for the period 1969-1992 really concurred with the mortality findings for that later time period.

Finally, for certain cancer sites where pathological confirmation is essential for precision, different results between cancer mortality and incidence suggest that caution must be exercised in interpreting cancer data based on mortality alone. The main discrepancies in these studies concerned the increased risks of kidney and esophageal cancers, which were observed only in the mortality study. For these cancer sites, a review of all death certificates of individuals who died between 1969 and 1992 was carried out, and the diagnoses listed on the death certificates were compared with those indicated on the pathology reports obtained from the British Columbia Cancer Registry.

The analysis revealed that there were 46 cases of death from kidney cancer for which pathology reports were available in the incidence study; of these, 7 (15%) were not primary renal cell carcinoma. Consequently, IRs for the 39 actual primary renal tumours did not reveal an increased risk, and this result prevailed over that of the mortality study, because cancer registry data based on pathological reports are more accurate than death certificate data. Likewise, for esophageal cancer, of the 31 cases for which pathology reports were available, 9 (29%) were in fact adenocarcinomas of the stomach. Thus, the statistically significant excess of esophageal cancers in the mortality study was due to a (common) misdiagnosis artifact on death certificates; this was corrected, and a proportion of the so-called esophageal cancer deaths were reattributed to stomach cancer based on the more precise information from the cancer registry.

The characteristics of mortality and cancer incidence databases (registries) need to be taken into consideration before interpreting results of occupational and environmental studies investigating cancer risks.

6.4.1.3 Environment

As part of an HIA, an overview is needed of the environmental conditions of the new project with respect to how they might influence the health status of the surrounding population. For example, environmental conditions that should be documented include the type of industrial contaminants and their estimated environmental levels; the areas most likely to be affected by airborne, soil, or water pollution; and the distance between human receptors and the health hazard. Main exposure pathways should also be identified in the environmental overview.

6.4.2 Prospective Data

Once baseline data on population health status, occupational health risk, and environmental conditions have been acquired, prospective studies must be considered. A cohort study represents the most accurate epidemiological study design (if losses to follow-up are minimal) for documenting an association between an exposure and a disease/health outcome. In a prospective cohort study, a population may be stratified into various levels of exposure and then followed over time to determine health outcomes. However, in the context of an HIA, prospective cohort studies suffer from two significant shortcomings:

1) They are costly and usually last a long time, since the potential health outcomes may be relatively rare and/or occur after a prolonged latent interval.

2) In view of the relatively low levels of environmental exposures, cohort studies may fail to document a health risk in an exposed population, especially if the population under study is small.

For these reasons, in the context of an HIA, a cohort study should not be the first option considered; rather, a two-phased approach consisting of monitoring and identification of risk factors is suggested.

6.4.2.1 Phase 1: Monitoring

The first phase in gathering prospective data involves collecting monitoring data on health status and on occupational and environmental risk factors and then integrating these data.

Health

Monitoring the same baseline health parameters within the population every 5-10 years might alert the investigator to any unusual deviation from the baseline status, which would then require specific investigation. This periodic monitoring should pay particular attention to diseases/health outcomes significantly elevated in neighbouring areas around the development project. It should be noted that diseases/health outcomes that were significantly elevated during the original baseline assessment may no longer be significant, due to random fluctuation, short follow-up, or insufficient numbers.

Occupation

Establishing the basis that would allow for the long-term monitoring of workers and facilitate identification of occupational health hazards in an industrial development project cannot be overemphasized. Firstly, occupational levels of exposures are generally higher than environmental levels; thus, a specific disease/health outcome pattern observed among workers could serve as a “sentinel event” for population surveillance purposes. Secondly, diseases related to occupational exposures are generally identified from retrospective cohort studies where exposure information over time is frequently incomplete or lacking, and from which exposure estimates are difficult to establish.

At the outset of a development project, a monitoring system should be set up to provide the responsible authorities with the exposure profile associated with all distinct tasks and exposures of each worker – most appropriately, exposures to substances listed in the Workplace Hazardous Material Information System (WHMIS). This would enable investigators to develop job-exposure matrices prospectively, thereby greatly reducing the time and cost of any future evaluation of disease/health outcomes potentially related to occupational exposures. (For more information on occupational health, see Chapter 7 of this volume.)

Environment

Depending on industrial emission patterns, samples of air, soil, water, and local country foods should be collected in various locations and the concentrations of the main pollutants determined. These data, in addition to providing reliable information for population health risk assessment, would help to document the relative levels of exposure associated with specific geographic areas.

Data Integration

For environmental epidemiological investigations, the use of spatial databases, referred to as geographic information systems, greatly facilitates the integration and analyses of disparate data having definable spatial locations. Spatial analysis also helps to interpret the interrelationships between population health and environmental factors. Mapping the distribution of mortality and of disease/health outcome incidence within a community/region onto maps that display the distribution of industrial emissions (into air, water, soil) is a useful tool for understanding environment-health linkages. The community/region can be characterized into areas of relatively high, moderate, and low exposures. Map overlays of health outcomes with environmental exposure patterns may help to detect disease/health outcome clusters associated with high-exposure areas. A similar approach consisting of mapping mortality, cancer incidence, and morbidity patterns over time in relation to environmental exposure could be used as an HIA procedure on a prospective basis.

6.4.2.2 Phase 2: Risk Factor Identification

This phase involves designing analytical epidemiological studies to explain the underlying causes of any specific disease/health outcome found to be significantly increased over baseline levels during the monitoring phase of the HIA process. By definition, this phase needs to be considered only if the above conditions exist. Furthermore, in view of the long latency of many diseases to which environmental and occupational factors may contribute, these studies are unlikely to be envisioned until several decades have elapsed from the time the development project has been implemented.

Exceptions may occur, however, particularly if the waste emissions contain teratogens (i.e., substances that cause birth defects). Since disease risks are multifactorial (i.e., having many contributing causes), the aim of epidemiological studies at this stage is to determine the contribution of environmental and/or occupational factors relative to other risk factors such as lifestyle or genetic factors. The epidemiological methods that are most appropriate will depend on the conditions encountered. Among the possibilities to be considered are the following:

- *for health outcomes affecting the general population*: case-control studies with detailed residential information; and
- *for health outcomes in an occupational setting*: a cohort study of workers that includes exposure assessment.

In both cases, the data acquired as baseline and during the monitoring phases of the HIA should provide much of the required background information.

6.5 Conclusion

This chapter's discussion of the main types of epidemiological studies and a suggested epidemiological HIA approach, emphasizing prospective data collection for monitoring purposes, provides a solid basis for HIA. Transparency must prevail throughout this process, as well as communication with the public. The population must be informed on a continuing basis of the rationale for the methods used, of the types of data collected, and of the results and their interpretation. However, health authorities and collaborative stakeholders should be advised and the results should be definite before making them public, so as to avoid confusion and to develop credibility and mutual confidence. This will ensure a level of understanding and of trust on the part of the population without which an HIA would be compromised.

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7 CONSIDERATIONS RELATING TO WORKER HEALTH PROTECTION

7.1 Occupational Health Risks and Health Impact Assessment

As summarized in Chapter 6, much of what we know about the adverse effects of environmental factors on humans is derived from our workplace experience. When a new material or substance is introduced into commerce, workers are the ones most likely to be exposed to high levels, day in and day out, over a working lifetime. In effect, as summarized by the report of the Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario (Dupre *et al*., 1984): "The asbestos story demonstrates that the process of hazard identification can unravel slowly and that regulatory responses can lag behind the knowledge that slowly accumulates, while a mounting toll of disease and death is borne by workers who are thereby cast in the role of human guinea pigs."

In the past, workers have unintentionally played the role of the "mining canary," with their negative health outcomes serving as a warning for the rest of society. It behooves us to give prominent consideration to these individuals, who not only are responsible for societal productivity, but are most at risk by virtue of the dose-response relationship that is fundamental to toxicology. As another example, vinyl chloride monomer, used in making vinyl (specifically, polyvinyl chloride), became recognized as a human carcinogen because of the number of cases of a unique type of liver cancer occurring among workers in an aspect of that industry.

We also need to consider the potential for hazardous substances in the workplace to be brought home, for example, on clothing. Such was the case with asbestos workers, thereby affecting the health of their families.

Despite our knowledge of such potential hazards/risks, in EIAs, the effect of a development project on worker health is typically regarded in only a positive context – i.e., as a provider of jobs and all of the related benefits (including health-related). Conversely, the Westray mine tragedy in Nova Scotia, killing 26 workers on May 9, 1992, underscored the fact that workers, particularly in economically deprived regions, are prepared to put their own lives and health at risk in order to provide for their families.

In 1997, a U.S. Presidential/Congressional Committee on risk assessment and management published its findings, which, among other factors, "highlighted the discrepancy between extensively regulated outdoor air pollution and indoor air pollution, which receives little attention and remains largely unregulated...." (Omenn, 1997). Although *workplace* air quality is typically subject to regulation, the standards applied may be out of date, or enforcement may be non-systematic and regulatory priority assigned on the basis of complaints and/or demonstrable ill effects – i.e., after the fact. Increasingly, there is an expectation at all levels that such likelihoods be eliminated in a proactive manner. Accordingly, occupational health risks need to be anticipated before the start of a project and mitigated in the design stage; and post-project assessments – i.e., monitoring of actual exposures to risk factors and worker health status itself – need to be incorporated into the EIA/environmental impact studies.

Box 7.1
Operating Tenets of the Mansville Corporation

Based on the Mansville Corporation's extensive litigation experience resulting from worker asbestos exposures, the Corporation's chairman has indicated that its current operating tenets include the following:

- Activities in safety and health are going to be judged in the context of tomorrow's laws, not today's.
- The ultimate test of professional success is not whether you keep your company out of court, but the degree of trust between the companies that you work for or consult with, and the employees that you are there to protect.

Source: Occupational Hazards, November 1992

It is important to recall that according to WHO (1967), "health" is to be considered not only in the negative (as in "absence of disease"), but also as "a state of complete physical, mental, and social well-being," not just of the general public but also including those select individuals known as workers. The "casualty" statistics cited for workers are higher in countries where occupational health and safety statutory and regulatory infrastructure is not in place. In other words, in nations that are developing or "in transition," a proper consideration of potential impacts on workers (which, in that instance, can also include children, for example) as an integral part of the EIA becomes even more compelling. This attitude and the requirements of governments and stakeholders are changing in this respect.

Box 7.2
Occupational Health Statistics from the National Institute for Occupational Safety and Health and Vietnam

Recent statistics from the U.S. National Institute for Occupational Safety and Health (NIOSH) National Occupational Research Agenda indicate that "Each day, an average of 137 individuals die from work-related diseases and an additional 16 die from injuries on the job" (NIOSH, 1996).

In Vietnam, occupational health is considered an integral part of EIA. Statistics from the Viet Nam National Environmental Action Plan indicate the following estimated percentages of workforces suffering from employment-related illnesses: construction – 55%; chemical – 61%; and metallurgy – 66% (Viet Nam Ministry of Science, Technology and Environment, 1995).

The Voisey's Bay Environmental Assessment Panel (1999) report was one of the first to consider environment and health rather holistically. In addition to assessing the numbers and types of jobs that would be created, air and water quality were considered in the outdoor/environmental context: "The main effect of the Voisey's Bay project on air quality would be dust raised by the open pit operation and by haulage trucks along the roads. This dust would get into streams and lakes and would affect water quality. Other air emissions would come from fuel combustion, either to generate power or to operate vehicles. The Panel has recommended that VBNC (Voisey's Bay Nickel Company) develop a plan to control dust, and to reduce the amount of fuel used by conserving energy" (Voisey's Bay Environmental Assessment Panel, 1999). There was also consideration given to Aboriginal traditions such as harvesting; country foods were to be served on site when available.

The proponent of the Voisey's Bay project had provided information on a proposed occupational health and safety plan. Despite recommendations made by an expert speaking on behalf of the Innu Nation, the Panel was "not convinced...that workers would be subject to unacceptable health risks." The Panel acknowledged that many of the advances in protecting worker health and safety in the mining industry can be credited to the unions involved and acknowledged the expressed concern that there may not be the necessary experience or organizational support on site to address such issues, if the workforce were not unionized. The Panel further noted that many of the issues that had been raised were the responsibility of provincial authorities and believed "a detailed investigation of occupational health and safety issues" to be "beyond the scope of this environmental review."

Box 7.3
Rabbit Lake Uranium Mining

As described in a November 1993 report of the Rabbit Lake Uranium Mining Environmental Assessment Panel, "the Panel's consideration of health and safety issues included both community health and worker health and safety" (CEAA, 1993). Following a hazardous spill at Rabbit Lake in 1989, Cameco (the proponent) implemented a number of measures to promote the health and safety of employees at the Rabbit Lake operation, including:

- appointment of an environmental and workers' safety committee;
- full-time personnel in the safety department conducting training, monitoring, etc.;
- new employees receiving basic training immediately upon arrival on site;
- an occupational health and safety committee for each of two shifts; and
- an Atomic Energy Control Board (AECB)-approved Code of Practice for radiation protection.

Similarly, at the provincial/territorial level, and at the scale of changes occurring within a factory, it is now incumbent upon the owner/employer to carry out a variety of risk assessments. In Ontario, amendments to workplace legislation in 2000 introduced a "pre-start health and safety review," which requires that "before workers can operate machinery, equipment or a process in complex and hazardous situations, an employer must first have a report prepared stating what measures need to be taken to be sure that equipment is safe" (Ontario Ministry of Labour, 2001). One of the criteria that invokes the need for such a review is if the "process uses or produces a substance that may result in the exposure of a worker in excess of any occupational exposure limit set out in regulations...." Such a circumstance requires that the review be conducted by "appropriately qualified or expert persons."

In British Columbia, the Occupational Health and Safety Regulation under the *Workers Compensation Act* stipulates that "...all work must be carried out without undue risk of injury or occupational disease to any person" (section 2.2) (Government of British Columbia, 2004).

Specifically, risk assessments are mandated, for example, for:

- accidental release, fire, or other emergency due to hazardous substances (section 5.99); and
- toxic process gases (section 6.118).

Certain other jurisdictions have been more progressive than those in Canada. The United Kingdom has considerable experience and has published guidance on chemical/occupational risk assessment as a result of its *Control of Substances Hazardous to Health Regulations*, which first appeared in the 1980s.

Box 7.4
United Kingdom Risk Assessment Model – Control of Substances Hazardous to Health

1) What substances and what health effects.

2) Exposure estimate; how and how much.

3) Estimate compared with some standard.

4) Tiered; simple to complex, as required.

5) Done by a competent person.

6) All but simplest recorded; employees informed.

7.2 Facets of, and Professional Disciplines in, Occupational Health

When conducting an HIA, it is important to attribute considerable weight to the potential impacts of a development project on workers, including both positive (by improving socioeconomic status) and negative impacts. Occupational health can be a rather expansive concept and can involve diverse workplace parties, including a "joint health and safety committee," off-site therapists, including occupational therapists and physiotherapists, as well as various other clinical specialists, in the case of a need for after-the-fact therapeutic intervention. However, the focus in HIA is the prevention of negative health outcomes in populations, rather than the treatment of affected workers.

The International Commission on Occupational Health uses the term "occupational health professional" to encompass occupational health physicians and nurses, occupational hygienists (hygiene being defined as the science dealing with the preservation of health), ergonomists, and safety specialists. This chapter considers primarily the occupational health discipline that has evolved to proactively address potential toxic hazards (among others) "in, or arising from, the workplace," and whose practice is being increasingly applied to broader human environmental health issues by adaptation of the tools and techniques that had been developed for the industrial workplace. (That is not to say that nursing or medicine is a discipline without proactive attributes, or that there are not practitioners who are very interested in prevention. The reality, however, is that clinicians are largely occupied with the diagnosis and treatment of pathologies that have arisen from adverse exposures or with conducting baseline/routine assessments of individuals to be able to detect early changes; the latter may be protective of the population in question, even if it is too late for the individual.)

7.3 Occupational/Environmental Hygiene

Industrial hygiene, as it is still known in some (U.S.) circles, originated as a professional discipline in the early part of this century. In the United States, the first national conference on industrial disease was held in 1910, and the first governmental hygiene agencies were established just before World War I.

Box 7.5
1884 *Ontario Act for the Protection of Persons Employed in Factories*

In Canada, the 1884 *Ontario Act for the Protection of Persons Employed in Factories* stated (in part):

"Every factory shall be ventilated in such a manner as to render harmless, so far as reasonably practicable, all gases, vapours, dust or other impurities generated in the course of the manufacturing process or handicraft carried on therein that may be injurious to health."

Amendments in 1932 to the *Factory, Shop and Office Buildings Act* required employers to report any cases of industrial diseases directly to the Director of Industrial Hygiene.

However, as part of the natural evolution in this area, and with an increasing proportion of workers in service sector industries, the discipline became known as occupational hygiene. Indoor air quality in an office or commercial building became as much an issue in the 1980s as had welding fume exposure in the manufacturing sector in the previous decade. Carbon dioxide was utilized as a surrogate of human occupancy to permit a facile appraisal of the adequacy of ventilation from the standpoint of the primary purpose of most buildings. Meanwhile, urea formaldehyde foam insulation in some 80 000 houses across Canada and a crescendo of concern about asbestos exposures among school children due to thermal and acoustic insulating materials that had been applied decades earlier led to a demand for quantitative appraisals of risk based (in many cases) on an evaluation of the extent of exposure. More recently, mouldy school portables have led to the expenditure of millions of dollars per year in remediation by individual school boards. This spread to the non-occupational arena extended the name of the profession (at least for some) to "environmental hygiene." However, we will refer to it by its most universally accepted term – occupational hygiene.

Box 7.6
Canadian Registration Board of Occupational Hygienists

The Canadian Registration Board of Occupational Hygienists accredits (registers) two types of occupational hygiene practitioners: Registered Occupational Hygienist and Registered Occupational Hygiene Technologist. Registered Occupational Hygienists are qualified professionals with a university degree in science and a minimum of five years of professional experience. Registered Occupational Hygiene Technologists are qualified technologists who have a minimum of five years of related experience. Ongoing competency maintenance and development are demonstrated through a formal cyclic reregistration process.

It is imperative that an accredited occupational hygienist (in the Canadian context, a Registered Occupational Hygienist) be involved in any HIA relating to a substantive project with a job-related element. Other individuals may perform adequately as well, but in the absence of demonstrable professional accreditation may well not conform to "due diligence" expectations, should there be unanticipated problems in the future. Additional information in this respect is provided in Appendix B (Guidelines on the Selection of an Occupational Hygiene Specialist).

The occupational hygienist is placed in the following context by the Canadian Registration Board of Occupational Hygienists (see list of Internet sources):

- "Occupational Hygiene involves the identification of existing and potential human health hazards in, or arising from, the workplace; the evaluation or assessment of the extent of risk posed by the hazards; and the development of effective strategies to eliminate or control the risks.
- "Occupational Hygiene draws upon, yet integrates, background disciplines such as biology, chemistry, physics, medicine, engineering, toxicology, etc. In part, it can be regarded as that aspect of the risk assessment field which focuses on the interface between workplace-derived hazards and human health consequences. The management of these risks (by means of control programs) is similarly an integral part of the discipline.
- "Occupational Hygiene is a unique, broad, and multi-faceted discipline. To illustrate the nature of occupational hygiene practice, the following examples of typical functions are provided."

Within the definition of occupational hygiene, practitioners of this discipline may typically:

- review projects, designs, and purchases to anticipate hazards;
- critically evaluate environments, processes, materiel inventories, and worker demographics to recognize potential health risks to persons or communities;
- assess human exposures to hazards through a combination of qualitative and quantitative methods to determine health risks and regulatory compliance;
- recommend effective control measures to mitigate risks via engineering, administrative, or personal protective methods;
- communicate risks and control methods to affected parties, including workers, unions, management, clients, and/or communities;
- provide education and training about risks and control measures;
- conduct research and development of occupational hygiene methods and tools;
- provide academic education and training in occupational hygiene;
- develop, implement, and audit occupational hygiene and related programs;
- manage, supervise, or advise occupational hygiene personnel;
- coordinate occupational hygiene programs with related risk management efforts, including safety, environment, and medicine;
- interface with regulators, communities, and professional associations;
- advise on the development of government laws and programs related to occupational hygiene; and
- provide expert advice in legal and regulatory matters relating to occupational hygiene.

Occupational hygiene is generally defined as the art and science dedicated to the anticipation, recognition, evaluation, communication, and control of environmental stressors in, or arising from, the workplace that may result in injury, illness, or impairment or affect the well-being of workers and members of the community. These stressors are normally divided into the following categories: biological, chemical, physical, ergonomic, and psychosocial.

The occupational hygiene practitioner has comprehensive knowledge of workplace chemical factors and physical factors such as noise and heat stress. In terms of chemical factors, occupational hygiene practitioners also have knowledge of safety concepts (e.g., flammability, water reactivity, etc.). They are familiar with biological factors and ergonomics (especially in the case of specific environments such as office buildings), but in many cases would work in conjunction with (or defer to) practitioners with specific expertise in these areas, as well as in health physics, occupational psychology, safety, etc. Thus, their knowledge in these areas would normally be more limited.

The occupational hygiene practitioner is concerned with the broader (extra-workplace) environment – e.g., with respect to workplace discharges to the natural environment. As well, the practitioner has an appreciation of the differential impacts of toxicants on workers and the general population (e.g., the greater susceptibility of children to lead).

As noted above, it should be recognized that there may be other jurisdictional/regulatory requirements that overlap with, or even supersede, the HIA.

Box 7.7
Definition of Occupational Hygiene

Occupational hygiene involves the anticipation, recognition, evaluation, communication, and control of hazards in, or arising from, the workplace (see http://www.crboh.ca for the web site of the Canadian Registration Board of Occupational Hygienists).

7.4 Occupational Disease and Its Prevention: Occupational Exposure Limits (OELs) as a Tool

We know that there are many negative health outcomes that have occurred in workers (and, in some cases, their families) as a result of excessive workplace exposures (and/or improper workplace programs and/or facilities, such that workplace contaminants are brought home).

In occupational hygiene, the environmental factors resulting in these negative health outcomes tend to be categorized into one or more of the following:

- biological (e.g., mould in building ventilation, animal dander, hepatitis virus);
- chemical (e.g., welding fumes, solvent vapours, flour);
- ergonomic (e.g., work station and tool design);
- physical (e.g., noise, vibration, cold stress, radiation); and
- psychosocial (e.g., poor labour relations, shift scheduling, "stress").

Here, we deal only with the chemical factors, and mainly in terms of quantitative exposure criteria. We want to reduce health risks to an "acceptable" level. Risk, in turn, can be described as Hazard × Exposure × Susceptibility.

Chemicals vary in their hazardous properties (e.g., toxic potential) and in the health effects that they can cause. These include some "contact"-type conditions, such as dermatitis or corrosive damage. However, by and large within the occupational context, we are concerned with airborne contaminants that are inhaled into the lungs. They can cause lung disease directly and/or be absorbed into body fluids (e.g., blood) from the lungs and travel elsewhere in the body to cause other adverse health effects. We consider potential consequences ranging from irritation to fatality, in either the short or long term.

The prevention of such adverse consequences is based on maintaining personnel exposures to airborne contaminants well below the levels recognized as having the potential to cause disease. This requires the ability to *anticipate* hazards that might occur, to *recognize* existing hazard potential, to *evaluate* the degree of exposure of personnel (for comparison with accepted standards), and to conceive and implement *control* measures where warranted. In order for these to be effective, we have to *communicate* effectively the risks to the stakeholders.

The best recognized (and most universally accepted) occupational exposure limits (OELs) are the Threshold Limit Values (TLV®s). These are established by the American Conference of Governmental Industrial Hygienists (ACGIH) (http://www.acgih.org), a private group of professionals from academia and government. Although OELs are sometimes compared with highway speed limits, their application and interpretation are considerably more complex. Anyone using the TLV®s (or derivatives) in a real-world situation is cautioned to read thoroughly the most recent policy statement in the TLV® booklet published by the ACGIH at the beginning of every year. As well, when applying the TLV®s to particular substances, one is well advised to read the appropriate section in the documentation (ACGIH, 1991; now in its 6th edition, but amended by supplements annually).

The OELs are not "ideal" or "target" workplace levels, but rather the current maximum acceptable levels of airborne contaminants. In the case of OELs adopted by regulation, they are legal maxima. Even in situations where exposures are below the OELs, the former should be reduced to the lowest practical levels (where circumstances permit) on a matter of principle. The TLV®s (and related regulatory OELs) are subject to change, for a variety of reasons. For example, for many years the TLV® for formaldehyde was 1 ppm as a time-weighted average (TWA). In 1992, this was changed to a "ceiling" of 0.3 ppm, largely to reduce the incidence of sensory irritation.

In the case of workplaces that fall under federal jurisdiction in Canada (i.e., under Part II of the Canada Labour Code; this pertains to all federal employees, as well as those involved in interprovincial activities such as banking, telecommunications, trucking, etc.), the TLV®s actually are the regulatory OELs (see section 10.19(1) of the *Canadian Occupational Safety and Health Regulations*).

Box 7.8
Time-weighted Average

A TWA is simply the "average" exposure over the working day. The TWA numerical limits that are listed assume that there is an 8-hour exposure. If worker exposure occurs over a longer period and/or there is not a 16-hour period between exposures, then adjustments may have to be made to these values from a legal standpoint and/or to conform to fundamental toxicological principles.

In addition to the TWA, there may be specific "short-term" exposure limits (STEL) and "ceiling" (C) limits. The intent may be to limit irritative effects, acute systemic health effects, and/or the ability of peak exposures to overwhelm the body's defence mechanisms. The ACGIH also has "generic" excursion limit rules: worker exposures may exceed 3 times the TWA for no more than 30 minutes in any work day and may not exceed 5 times the TWA at any time (effectively a "default" ceiling).

Use of the individual OELs generally assumes that exposure is occurring only by the airborne route and to only one substance. Where there is extensive skin contact (particularly for those substances that have a "skin" notation), keeping airborne levels below the OEL may not be sufficiently protective. With the typical concurrent exposure to multiple toxicants, the consideration of (and mathematical adjustment for) additive or synergistic relationships between the contaminants is also subject to interpretation and (professional) judgment. For further consideration of these points, see, for example, 1) Risk assessment: totally exposed. *OHS Canada* 12(4): 56-57 (1996); 2) Skin: the final frontier. *OHS Canada* 13(3): 38-40 (1997); and 3) Quicksilver, slow death – mercury poisoning. *OHS Canada* 14(2): 54-60 (1998). Also, visit the web site: http://www.ohscanada.com/

It may be helpful to consider several exposure criteria intended to protect members of the general public and workers from chronic and acute health effects, as the case may be. These are outlined in Box 7.9.

Box 7.9
Exposure Criteria for Chronic and Acute Health Effects

Chronic community environmental health criteria:

- air emission limits (e.g., point of impingement, PoI); Reg. 346, Ontario – drafts, 2002
- ambient air quality criteria (AAQC); Ontario – drafts, 2003
- criteria: drinking water, recreational water, irrigation water, soil, air, etc.
- tolerable daily intake (TDI) or reference dose (RfD)

Acute community (spill/discharge):
American Industrial Hygiene Association's 2000 emergency response planning guidelines (ERPG)

- ERPG-1: 1 hour, mild, transient health effects
- ERPG-2: 1 hour, no serious or irreversible or escape-impairing effects
- ERPG-3: 1 hour, no life-threatening health effects

Acute/chronic workplace:

- occupational exposure limits (OELs)
- airborne, but may also be skin notation

Acute workplace airborne only – escape (originally, 30 minutes maximum):

- immediately dangerous to life or health (IDLH)

Table 7.1
Exposure Criteria for Ammonia, Benzene, and Chlorine

Criterion	Concentrations in air (ppm)		
	Ammonia	Benzene	Chlorine
AAQC	0.1 (24 h)		0.003 (24 h)
PoI	5→4→0.4		0.1→0.01
ERPG-1	25	50	1
ERPG-2	150	150	3
ERPG-3	750	1000	20
TLV® - TWA	25	0.5	0.5
TLV® - STEL/C	35	2.5	1
IDLH	300	500	10

In the field of environmental/health protection, it is customary (e.g., as mandated by various regulations and departmental policies) to dichotomize toxicants into "threshold" and "non-threshold" types. The latter category includes genotoxic carcinogens and mutagens, which are regarded by some authorities as presenting some element of increased risk (e.g., in accordance with a "linear" dose-response model), no matter how low the dose. The alternative is to invoke the concept and principle of a physiologically based threshold and/or *de minimis* risk.

The TLV®s designate by "A" codes those substances that have been categorized as to workplace carcinogenicity. These are numbered 1-5, from "Confirmed Human Carcinogen" to "Not Suspected as a Human Carcinogen." Under Canada's WHMIS legislation, a material is a workplace carcinogen if so deemed by the ACGIH and/or the International Agency for Research on Cancer (IARC) (http://www.iarc.fr).

7.5 Occupational Hygiene Applied to Health Impact Assessment

7.5.1 Prospective

In order to apply the principles of occupational hygiene (i.e., workplace risk assessment) to HIA, there are various items that should be "assembled," including:

- a clearly articulated and written statement of goals and an identification of the standard(s) that will be assigned for the purpose of evaluation. In other words, will the goal be the preservation of worker health (as per the WHO definition) or simply compliance with statutory requirements?;
- the layout of the plant, identifying the location of the various processes and other factors of significance to hygiene considerations (e.g., locations of operable windows, doors, etc.); and names of the processes and equipment as they are intended to be used in the plant;
- a description/schematic of process flow and a chemicals inventory, by process;
- documentation of previous hygiene work that may have been conducted at predecessor/sister plants: air sampling data, government reports, etc.; specifications for the local exhaust ventilation system and other control methodologies;
- a record of summarized health/disease data (e.g., incidence of back injury in Department X); Joint Health and Safety Committee minutes or other documentation of concerns/complaints/symptoms, as above; and
- a review of the scientific and professional literature, both text-based and web-based, for reports of detrimental effects associated with the materials and processes in question.

There will be a need to understand the intended facility as well as possible (in terms of both structure and function) and to use professional judgment, based on the available information, as to the likelihood of adverse health effects occurring.

The process of anticipating impacts parallels that for ecosystem or broader environmental HIA. However, we are dealing with a more clearly defined and more highly exposed population, operating in an environment that is inherently more controllable than the outdoor one. Where the type of facility in question has already been established and is operating elsewhere, the “borrowing” of exposure data from these other facilities (which may be possible as a professional courtesy, even between representatives of companies that are commercial competitors on a different level) can be very effective in anticipating and preventing contamination problems.

Mathematical and/or physical modelling may be useful, particularly in cases where there are adequate data. Mathematical models are simply equations that attempt to describe (and predict) real-world events. Models are often used to evaluate “worst-case” scenarios for their potential to have a significant impact. Although useful in this context, it should be recognized that (since we tend to err on the side of safety) models can overpredict actual exposures, especially in the absence of good input data. In the context of accepted or generally used workplace models, there are three general types:

1) “box” (mixed-space);
2) “multicompartment” (e.g., two-zone); and
3) “eddy diffusivity” (also known as the “hemisphere diffusion model” or “uniform diffusion model”).

Conceptually, what we are trying to accomplish is to predict what the airborne concentration (e.g., milligrams of contaminant per cubic metre of air - mg/m^3) should be at various times and distances, as it disperses away from the emission source. These models largely differ in how they pattern the movement of the contaminant; each has its own fundamental assumptions. Shown in Table 7.2 are their respective predictions for one hypothetical non-particulate scenario, under “steady-state” conditions (i.e., once a stable airborne concentration has been reached), and illustrating, in the case of each model, the effect of choosing several values for one of the key input parameters. (Note: It is common to find “equilibrium” used synonymously with “steady state,” although the latter is typically more correct in these applications.)

Table 7.2
Steady-state Model Predictions for Example Scenario (from Keil, 2000)

Model	Assumed Mixing Parameter	Distance from Source (m)	Concentration (mg/m^3)
Mixed-space	m = 1.0	entire space	5
	m = 0.5		10
	m = 0.2		25
Two-zone	ß (m^3/min) = 22	0-1	9.5
	ß (m^3/min) = 11		13.8
	ß (m^3/min) = 6		22.4
		rest of room	5
Eddy diffusion	D (m^2/min) = 0.1	0.05-1.05	483
	D (m^2/min) = 0.3		161
	D (m^2/min) = 0.6		81

Clearly, even in an *idealized* situation, a wide range of outcomes can result, depending on the model and the specific input parameters chosen.

The general equation for the mixed-space model (the one that has perhaps been in use the longest) is:

$$C = \frac{G - Ge^{-(Qm + k)\,t/V}}{Qm + k}$$

where:

C = the predicted airborne contaminant concentration;

G = the generation rate in mg/min (calculated with additional assumptions, as specified);

Q = the air exchange rate (m^3/min);

m = the mixing factor (ideally 1; typically 0.1-0.3);

k = non-ventilatory losses (e.g., surface deposition) – typically assumed as zero;

V = the volume of the space; and

t = time.

Simplified versions apply if steady state has been achieved. However, this model underestimates the exposures that are close to source (e.g., the worker operating a process). For this application, we have the eddy diffusivity model, expressed (in simplified form) as:

$$C = \frac{G}{4\pi Dr}\left[1 - \sqrt{1 - e^{\frac{-r^2}{\pi Dt}}}\right]$$

where common variables have the same meanings as above, and:

D = diffusivity, i.e., describes the turbulent movement of a contaminant in m^2/min (there is limited information in the literature; diffusivity should be site determined; clearly not feasible *a priori*); and

r = distance from the source, in metres.

If steady-state conditions apply, then the term under the square root in the equation above can be disregarded.

There are a number of limitations/assumptions inherent in this model:

- The contaminant is emitted continuously without significant momentum.
- There is a steady-state emission rate during the time period.
- There is random air movement (no directional movement of work room air).
- Eddy diffusivity is constant throughout the space.
- There is no surface deposition.
- The model applies strictly to vapours and gases; however, particulate matter of respirable size may behave similarly.

This discussion has focused on *deterministic* (i.e., single-value) predictions. Increasingly, there is an attempt in risk assessment to use *probabilistic* determinations, which provide a range of likely outcomes from Monte Carlo analysis, based on even further (typically assumed) input characteristics, such as the probability distribution functions of the various variables that feed into the model. For further information, see Keil (2000).

As well, there are many desirable design characteristics presented in standard reference materials, such as in *Industrial Ventilation – Handbook of Recommended Practice* (ACGIH, 1998).

7.5.2 Actual (Post-project Appraisal)

The evaluation of worker exposures (as may be undertaken as part of a post-project assessment) has a well-established set of approaches and technical methodologies. Mandating such work is “in accordance with accepted occupational hygiene practice” (wording commonly found in regulatory text). The reference section (section 7.7) of this chapter cites several texts and specific guides (e.g., “official methods”) available on the Internet and provides access to rosters of accredited occupational hygiene personnel.

Worker exposures are typically evaluated under “representative” or “worst-case” conditions with respect to the processes under consideration. Similarly, the workers designated to wear the sampling devices that will indicate their exposure may be selected from the overall worker population randomly and/or by the use of judgment; on a process- or department-specific basis; or from what are termed “homogeneous exposure groups” (which themselves could be a topic of considerable discussion).

Many of these above considerations depend on the specific goal(s) of the exercise. This is an area where an approach mandated by a need to “audit” exposures, to determine how they compare with the corresponding OELs, may well be inconsistent with the collection of data that would be appropriate to use in an epidemiological investigation.

As has been described in the various recent texts on modelling in occupational hygiene, a judgmental/experiential form of modelling (often non-systematic and unrecorded) has typically been used in air sampling/monitoring campaigns directed by professional occupational hygienists. To make the exercise more effective, exposures of workers at various tasks are often not determined empirically, because such factors as fundamental physicochemical principles, the assessment of control system effectiveness, etc., would indicate that such exposures should be insignificant (i.e., well below the existing OELs).

Therefore, in such a circumstance, only those situations that are in doubt or of concern are assessed empirically. Although this effectively serves the purpose of the audit function (assuming, of course, that there are no errors in the exclusion of various workers from the sampling exercise), it does not provide a *representative* illustration of worker exposures. Rather, such a data set illustrates only the upper end of the exposure range. Thus, if there were an attempt to correlate such data with health/disease outcomes (i.e., an epidemiological investigation), it would likely lead to an *underestimation* of disease risk (i.e., the disease appears to occur only in what are apparently highly exposed workers, whereas these same workers may be exposed at (most) other times to considerably lower exposures). Conversely, the failure to design *a priori* a sampling protocol that would correctly allocate all of the workers in the plant into appropriate/representative exposure groups may lead to an artifactual negative outcome in an epidemiological investigation because there may well turn out to be no *apparent* association between exposure and disease, although this could simply be due to exposure *misclassification*.

Accordingly, the standard questions that must be answered before any sampling campaign is undertaken are all-important:

- Why? (Compliance audit? Epidemiological investigation? Both?)
- What? (Are input/output materials and/or degradation products to be assessed?)
- When? How often? (Are there diurnal, seasonal, or product-related fluctuations in likely outcomes?)
- How many? Who? (Which workers are to be assessed, as per the above discussion?)
- How? (With respect to relative specificity, sensitivity, stability, etc., as well as the health effects of concern, which would be the most appropriate methodology?)

7.5.3 Biological Monitoring

Another approach to the assessment of worker exposure involves “biological monitoring,” rather than the sampling and analysis of breathing-zone air. In this case, an appropriate bodily fluid or tissue (exhaled breath, urine, blood, etc.) is analysed and the result compared with, for example, the ACGIH biological exposure indices (BEIs).

There are several advantages to biological monitoring. For example, it evaluates not just airborne contaminant exposure, but also the extent to which the body has assimilated the contaminant(s) from all of the possible routes of exposure (inhalation, skin absorption, and ingestion). It also typically provides an indication of exposure over a longer period of time (e.g., days to weeks), rather than on a particular day. Conversely, the approach may be invasive (e.g., in the case of blood sample collection), and there is often an attitude of unacceptability in principle, as the detection of overexposure by this means is “after the fact” (i.e., the overexposures have already occurred).

7.6 Pitfalls of Occupational Hygiene in Health Impact Assessment

The pitfalls of occupational hygiene are associated with uncertainty, as in all HIAs. There is a need to use reliable data to carry out a reasonable assessment of risk. Particularly in the prospective mode, as may be mandated by modelling exercises, these data will typically be unavailable. Accordingly, we need to rely on professional judgment, both in the case of prospective appraisal and to ensure that the determination of post-project exposures is assessed in accordance with accepted practices. We therefore may well face a resource-limited impediment; although there is accreditation of the professional occupational hygienist by the Canadian Registration Board of Occupational Hygienists, there are only a few hundred registered occupational hygienists in Canada.

7.7 References and Suggested Readings / Information Sources

Texts

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Magazines

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Occupational Health and Safety Canada (1998). Quicksilver, slow death – mercury poisoning. *OHS Canada* 14(2): 54-60.

Internet Sources

American Board of Industrial Hygiene: http://www.abih.org

American Conference of Governmental Industrial Hygienists: http://www.acgih.org

American Industrial Hygiene Association: http://www.aiha.org

Canadian Centre for Occupational Health and Safety jointly with the European Union: http://www.eu-ccohs.org (Also contains links to Canadian governmental occupational health and safety departments and provincial Workers' Compensation Boards in Canada. *OSH Legislation – Who Does What in Canada*)

Canadian Registration Board of Occupational Hygienists: http://www.crboh.ca (This site has many links to other relevant organizations – e.g., the other hygiene associations in Canada)

Integrated Risk Information System (IRIS): http://www.epa.gov/iriswebp/iris/index.html (Prepared and maintained by the U.S. Environmental Protection Agency; electronic database containing information on human health effects that may result from exposure to various chemicals in the environment. The information in IRIS is intended for those without extensive training in toxicology, but with some knowledge of health sciences.)

International Agency for Research on Cancer: http://www.iarc.fr

International Labour Organization: http://www.ilo.org

Occupational Health and Safety Canada: http://www.ohscanada.com/

Organisation for Economic Co-operation and Development:
http://www.oecd.org/env/riskassessment

U.S. National Institute for Occupational Safety and Health (NIOSH):
http://www.cdc.gov/niosh/homepage.html

World Bank – Health Aspects of Environmental Assessment:
http://lnweb18.worldbank.org/ESSD/envext.nsf/41ByDocName/Environment

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Official Methods

Occupational Safety and Health Administration (OSHA): http://www.osha-slc.gov/dts/sltc/methods/index.html

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U.S. National Institute for Occupational Safety and Health (NIOSH):
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8 FOOD ISSUES IN ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Introduction

8.1.1 Regulatory Context

Between 1990 and 1995, Health Canada was active in the National Contaminated Sites Remediation Program, a program devised as a joint federal/provincial/territorial effort to encourage the assessment and remediation of "orphaned" contaminated sites in Canada. However, Treasury Board ceased to fund Health Canada's involvement in this program in 1995, after which the Department terminated the program's activities.

In 1994-95, Health Canada commissioned the preparation of a guidance document on risk assessment of contaminated sites. That document, entitled Human Health Risk Assessment of Chemicals from Contaminated Sites: Risk Assessment Guidance Manual (Health Canada, 1995), was completed in draft form. However, with the termination of Health Canada's participation in the National Contaminated Sites Remediation Program, the document was never completed, approved, or published as a departmental report. This document is currently under review to be updated and will be published shortly.

In June 2003, Treasury Board approved funding for a new Federal Contaminated Sites Accelerated Action Program. This program is designed to ensure that federal departments identify, assess, manage, and/or remediate contaminated sites under their custodianship. Under this program, Health Canada is designated, along with Environment Canada and Fisheries and Oceans Canada, as an Expert Support Department. In that role, Health Canada is required to provide detailed guidance for the assessment of human health risks posed by federal contaminated sites in Canada. To that end, guidance on screening-level risk assessment has already been developed and is available from Health Canada as the following reports:

- Health Canada (2003a). *Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Screening-level Risk Assessment (SLRA)*. Version 1.1, dated October 3, 2003.

- Health Canada (2003b). *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs)*. Version 1.0, dated October 3, 2003.
- Health Canada (2003c). *Federal Contaminated Site Risk Assessment in Canada, Part III: Guidance on Peer Review of Human Health Risk Assessments*. Version 1.0.

The contaminated sites group within Health Canada is continuing to develop and finalize additional guidance documents. These include separate guidance on complex site-specific human health risk assessment of chemical contamination, radiological contamination, and microbiological contamination.

All available documents may be obtained by contacting the contaminated sites group at cs-sc@hc-sc.gc.ca. Also, other documentation relevant to human health risk assessment of contaminated sites that can be obtained from Health Canada is listed at the Health Canada contaminated sites web site (http://www.hc-sc.gc.ca/hecs-sesc/ehas/contaminated_sites.htm).

However, the Department is still required to develop and finalize guidance on complex site-specific risk assessment.

8.1.2 Background

As an integral part of EAs, risk assessments of contaminant levels in foods must be undertaken from a human health perspective. This is particularly important since human health is to be included not only in assessments of contaminated sites but also in EIAs as legislated in the *Canadian Environmental Assessment Act* (CEAA).

Under the CEAA, EAs are undertaken for both development and remediation projects. In the case of the former, country foods – i.e., foods that are harvested by hunting, trapping, or fishing; and produce such as that grown in vegetable gardens and orchards or collected from naturally occurring sources (e.g., wild berries) – that are not contaminated can potentially become contaminated. This may occur as a result of the construction materials used, the activities involved in undertaking the development project, and soil contamination that might occur as a result of deposition from stack emissions relating to the operation of the new project. These country foods are consumed by residents in the area of the project. It is also possible that foods normally consumed by local residents have been contaminated due to the presence of contaminants found at a site that requires remediation. As for CEAA projects, the risk assessment of contaminated sites should quantify the dose corresponding to this pathway. Even though the removal of the source(s) of contamination is part of site remediation, all precautions must be taken to avoid increased food contamination during various stages of a site clean-up, wherever possible.

In general, it has been the practice in EAs to develop models to estimate levels of contaminants in country foods harvested in the study area. Although this modelling approach is considered acceptable, it does result in an uncertain degree of conservatism due to the variety of methodologies, calculations, and assumptions involved.

Included in the EA process, when necessary, are reviews of the risk assessments conducted by various stakeholders. Due to the variety of risk assessment methodologies used, it is necessary, during this review process, to assess them as a means to understanding and evaluating the results and conclusions offered.

A "standardized" procedure within an EIA in regard to potential contaminants in country foods is imperative for risk assessment and sound management decision-making. Although a review of all aspects of the assessment will still be required, this standardized approach would eliminate the need for an in-depth assessment and critique of the risk assessment methodology used for any given site. In this regard, it is anticipated that this approach would reduce evaluation time and facilitate an understanding of the results and conclusions offered in EA documents. Also, it is anticipated that a more standardized approach will lead to more reliable comparability between sites or projects and a better consensus in regard to the human health issues involved and, ultimately, the feasibility of the proposed project.

8.1.3 Overview

The underlying premise suggested in this chapter is the use of data on contaminant levels actually measured in country foods under study in EIAs (guidance on appropriate sampling strategies to collect such data is provided by Health Canada (2004)). This proposal would serve to advance the human health risk assessment of food issues in EAs from a screening-level risk assessment to a site-specific risk assessment. A site-specific risk assessment is a more detailed and complex study employing actual sampling data. This proposed in-depth risk assessment should result in a greater level of confidence in the exposures and risks quantified and in achieving the protection of the health and well-being of residents in the study area, in the context of consumption of country foods.

The risk assessment methodology described in this chapter has been designed to serve as a general outline. Relevant data requirements and the subsequent risk assessment of contaminant levels found in country foods are discussed. It is possible that the information presented in this chapter could be of assistance to contractors responsible for conducting assessments of food and human health issues for a proposed development project or the risk assessment and/or the remediation/risk management of a contaminated site.

It is acknowledged that, due to the variability in the scope of development/ remediation projects, there will exist unique issues for each EIA. In this regard, each assessment will require designing and conducting a study specific to the project under review. Therefore, it is recommended that consideration be given to obtaining the services of a trained risk assessor with suitable experience to undertake the risk assessment portion of the EA in regard to food contaminants and human health issues. Areas of expertise would include, but not necessarily be limited to:

- experience in undertaking EAs;
- the identification of potential contaminants (naturally present and those due to human activities);
- identification of foods of concern at a given site;
- planning and organizing analytical studies of contaminant levels in foods;
- significant experience in human health risk assessment of contaminant levels in foods; and
- knowledge and understanding of relevant current toxicological information.

Guidance on appropriate sampling strategies to collect such data is provided by Health Canada (2004).

8.2 Potential Contaminants, Available Foods, and Exposure Pathways

8.2.1 Identification of Potential Contaminants

For the identification of potential contaminants at any given site, it is necessary to consider a variety of factors specific to the proposed development/remediation project, as well as environmental issues relevant to the area of the study. Such factors include:

- the nature of the project to be undertaken;
- the release of contaminants from stack emissions;
- materials and chemicals present;

- excavation and construction issues;
- transportation of goods and materials;
- potential flooding;
- rerouting of waterways;
- landscape changes; and
- waste management.

All or any of these activities can potentially result in the contamination of foods in the area of the project. Of course, contamination of foods can also result from the release of contaminants naturally present at a particular site. In general, most contaminants present at a remediation site will be identified before undertaking the project.

Box 8.1
Examples of Potential Contaminants in Food

Examples of potential contaminants in food by group are provided below. This short list is by no means exhaustive, but is provided as an aid or a starting point for assessment purposes.

- *Metals*: Where possible, information on the speciation of metals is useful. For instance, the Joint FAO/WHO Expert Committee on Food Additives and Contaminants (JECFA) Toxicological Reference Value (TRV) (provisional tolerable daily intake, or PTDI) established for arsenic is for the inorganic form. Also, the TRV established for methylmercury (organic form) is lower than the TRV established for inorganic mercury. See section 8.3 for more detailed information on JECFA and TRVs.
- *Polycyclic aromatic hydrocarbons (PAHs)*: Individual PAHs reported; information on PAH mixtures is available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=51959
- *Pesticides*
- *Persistent organic pollutants (POPs)*: Information regarding POPs is available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=51746
- *Polychlorinated biphenyls (PCBs)*: Individual congeners reported; for information concerning PCB congeners, see page 36 of the pdf document found at the following Internet site: http://www.epa.gov/toxteam/pcbid/
- *Dioxins and furans*: Individual polychlorinated dibenzo-*para*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) reported; information on dioxins and related compounds is available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55264

Taking into consideration the many variables unique to the development/remediation project, potential organic and inorganic contaminants should be identified. Some investigative work may be necessary (as mentioned above, in regard to remediation (contaminated) sites, information on the identification of the contaminants is typically available). For instance, research should be conducted into the availability of the results of studies, if any, that have been undertaken on naturally occurring contaminants in the area of the project. Where such studies do not exist, soil and water analysis for the levels of metals and organic chemicals would be required. Knowledge of environmental concerns pertaining to similar sites, discussions with local residents, and information on contaminants typically of concern in similar development projects are of assistance in planning analytical studies of the soil and water.

A comprehensive list of potential contaminants to be taken into consideration should be provided in the EA report on the development/remediation project.

Analysing for individual PAHs, individual PCDDs and PCDFs, and/or individual PCB congeners, when required, is very important. (There are 209 possible PCB "congeners"; see the List of Acronyms (section 8.12) for more information. Levels of PCBs of concern should be reported.) Reporting total PAHs, total dioxins/furans, or total PCBs will not be acceptable for risk assessment purposes; it is necessary to analyse the levels of the individual components of such mixtures and to provide acceptable reporting criteria. Table 8.1, which lists contaminants typically associated with industrial operations, may also be of assistance.

Table 8.1
Contaminants Commonly Associated with Various Industrial Operations

Industrial Operation	Potential Contaminants
Agricultural operations	Pesticides, metals (as components of pesticides)
Battery recycling, disposal	Metals, pH changes
Coal gasification	PAHs, petroleum hydrocarbons (PHCs)
Dry cleaning	Tetrachloroethylene (PCE) and degradation products (trichloroethylene, 1,1-dichloroethylene, *cis*- and *trans*-1,2-dichloroethylene, vinyl chloride)
Electrical equipment/transformers	PCBs, PHCs (mineral oils)
Electroplating	Metals, pH changes
Machine shops, metal fabrication	Metals, volatile organic compounds (VOCs), degreasing solvents (trichloroethylene, or TCE), and degradation products (1,1-dichloroethylene, *cis*- and *trans*-1,2-dichloroethylene, vinyl chloride)
Mining, smelting, ore processing	Metals, pH changes
Petroleum production, distribution, processing, storage	PHCs, benzene, toluene, ethylbenzene, xylenes (BTEX), PAHs, lead, methyl tertiary butyl ether (MTBE)
Road salt storage	Sodium adsorption ratio, electrical conductivity, chloride, sodium
Wood preservation	Pentachlorophenol, PAHs, PHCs, arsenic, chromium, copper

Note: The above table is not intended to be exhaustive of all industrial operations or contaminants.

8.2.2 Identification of Foods Available in the Area

Studies of all country foods available for gathering and consumption by local residents in the study area are necessary for evaluation purposes. In this regard, it would be helpful to conduct surveys of the local population to determine those foods that are actually consumed. Country foods may include backyard garden vegetables or other produce that grows naturally in the area of the project site. Additionally, wild animals (e.g., deer) harvested for consumption, small-scale chicken farms, sport or subsistence fish, and seafood harvested in the area or down-gradient of the site may be of interest.

It is important to emphasize the significance of determining actual food consumption by the local residents for use as a basis for designing sampling studies. Taking into consideration cost and time constraints, it is vital to exclude from the study those foods that may be available but are not consumed. However, documentation is required to confirm that they are not consumed. A comprehensive list of all country foods that can be consumed is to be included in the EA report.

Mention should be made of foods that are harvested (e.g., by commercial fisheries) from the area of the project site and are intended for the retail market. Such foods fall under the mandate of the Health Products and Foods Branch (HPFB) of Health Canada and may or may not be subject to evaluation in the EA report. In any case, since officers in HPFB are often requested to undertake reviews of food issues in EAs, they will then be alerted to potential issues involving retail foods in the project area.

8.2.3 Determination of Exposure Pathways for Potential Contaminants in Foods

Exposure pathway refers to the route of contaminant transport from source to receptor. In the case of development/remediation projects, examples of potential sources are discussed in section 8.2.1 concerning potential contaminants. The term receptor refers to the human population residing in the project area that may be exposed to potential contaminants from the consumption of country foods. Where no communities exist near the project site, receptors can be humans who frequent the area to gather country foods.

Based on the information collected on the identification of potential contaminants and of foods available in the area (sections 8.2.1 and 8.2.2 above), the feasibility of pathways of potential contaminants into foods can be determined. Air, soil, and water sources must be considered in the case of country foods. As mentioned previously, factors related to the project under study, such as flooding (contamination of fish with methylmercury is a potential concern where there is flooding or changes in water flow), changes to existing water flow, alterations to landscape, processing, aerial deposition from stack emissions, or the results of other development/ remediation project activities, must be taken into consideration in order to identify direct and indirect contaminant pathways into foods.

8.2.4 Contaminants of Potential Concern (COPCs)

Contaminants of potential concern (COPCs) can subsequently be identified. This can be achieved based on the full list of potential contaminants initially identified, the country foods consumed by residents in the area of the project, the measured contributions of the contaminants in country foods consumed, and, lastly, the identified feasible pathways that can result in the introduction of contaminants into these foods. Identification of COPCs must be discussed and justified in the environmental HIA document.

Based on the background data collected and the potential pathways identified for COPCs, it may be possible, at this time, to estimate the potential impact of project activities on contamination of country foods before the project begins. It is also possible that models to estimate contaminant levels in foods after the project proceeds can now be designed for the EA report. Periodic monitoring studies, discussed later in this chapter, can be used to verify the predictions of the models developed. This combination of the use of models and monitoring could also be useful in designing more accurate models for future projects.

At this point in the assessment, the basic needs of a screening-level risk assessment may have been met. The risk assessor can now determine whether further risk assessment or monitoring is required. In this regard, if any one (or more) of the following criteria is identified, then no further assessment is necessary:

- No potential contaminants have been identified.
- No exposure pathways of contaminants into foods appear to exist (and/or no feasible exposure pathways have been identified after the project commences).
- No country foods are harvested from the site area.
- There are no receptors identified at any stage of the project.

A discussion of the justification for discontinuing the human health risk assessment of contaminants in foods and/or further monitoring studies of the levels of contaminants in foods must be included in the environmental HIA.

8.3 Hazard Assessment – Toxicology

For assessment purposes, it is necessary to identify toxicological reference values (TRVs), established by appropriate agencies, for the contaminants of potential concern in an EIA. These values will be used to determine the human health risk issues associated with the levels of these contaminants found in foods collected from the project area. Sources of the TRVs established for the contaminants of concern must be cited.

As mentioned, preference should be given to those TRVs typically approved (by toxicologists) and employed for human health risk assessments by Health Canada. For instance, these TRVs would be preferable for risk assessments in project EAs undertaken for Canadians within or outside of Canada. As discussed above, many of the TRVs established by the Joint FAO/WHO Expert Committee on Food Additives

Box 8.2
Sources of Information on Toxicological Reference Values

TRVs specific to food-borne contaminants and approved by Health Canada are preferable for the assessment of human health risks posed by contaminants in country foods. See the document *Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values* (TRVs) (Health Canada, 2003b).

JECFA has established TRVs for various contaminants specifically in foods. These TRVs are internationally recognized, are generally adopted by Health Canada, and can be found for individual contaminants at: http://www.inchem.org/pages/jecfa.html. Other sources of information include:

- Health Canada TRVs (Health Canada, 2003b);
- the U.S. EPA's Integrated Risk Information System (IRIS) (http://www.epa.gov/iris/);
- the Oak Ridge National Laboratory Risk Assessment Information System (ORNL RAIS) (http://risk.lsd.ornl.gov/tox/tox_values.shtml); and
- the Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/).

The Contaminated Sites Section of the Environmental Health Assessment Services, Healthy Environments and Consumer Safety Branch, Health Canada, can be contacted for assistance in determining the most appropriate TRVs to be applied in risk assessments within the context of EAs (http://www.hc-sc.gc.ca/hecs-sesc/ehas/index.htm). Information may also be available from the Chemical Health Hazard Assessment Division of the Health Products and Foods Branch (HPFB), Health Canada (contact information is available at: http://www.hc-sc.gc.ca/food-aliment/cs-ipc/chha-edpcs/e_chemical_health_hazard.html).

and Contaminants (JECFA) are used in human health risk assessments by the HPFB of Health Canada.

TRVs for COPCs should be confirmed for each study at the time of assessment. These values do change from time to time as new toxicological information becomes available.

8.4 Food Consumption Information

In order to estimate exposures to COPCs found in foods, consumption information is required. Reliable survey information concerning the amount of each type of food consumed by residents in the area of the development project is preferable and would be the most accurate source. Unfortunately, the results of such local surveys are not usually available. Other well-documented sources for food consumption figures would then be required. For the purposes of EIAs, appropriate references must be documented for specific food intake levels used to calculate exposure estimates. The consumption information should be representative of the food intake of Canadians and is also required for any unique local consumption of the various tissues of fish and wild game (as appropriate).

For statistics on country food intakes, data and information from remote and/or subsistence communities are preferable, as available national data on food intakes will underrepresent the significance of country foods as a part of the diet of the typical (mostly urban) Canadian. Reports on country food consumption patterns in numerous regions and First Nations and Inuit communities in Canada are listed in Appendix E of this volume of the Handbook.

Canadian national food intake levels are available from the 1972 Nutrition Canada Survey and are presented in summary form by Richardson *et al*. (1997). Although these data are somewhat dated, Canadian intake figures for children can be found in this survey. More recent surveys, conducted jointly by Health Canada and each of the 10 provincial governments from the late 1990s until the present, are also sources of food consumption data. This consumption information must be obtained from provincial authorities (see the Table of Provincial Contacts Regarding Food Issues, Appendix C of this volume of the Handbook).

In those cases where Canadian consumption figures are not available, data from surveys undertaken by the U.S. Food and Drug Administration's Continuing Survey of Food Intakes by Individuals can be used (information on such surveys is available at: http://www.cfsan.fda.gov/~dms/acryrob2/tsld005.htm). The U.S. EPA documents entitled *Exposure Factors Handbook Volume II: Food Ingestion Factors* (available at:

http://www.epa.gov/ncea/pdfs/efh/front.pdf) and *Child-specific Exposure Factors Handbook* (available at: http://www.epa.gov/ncea/pdfs/efh/cover2.pdf) may also be helpful. In addition, the results of other international studies may be used to estimate food intake levels, where the intake figures provided are representative of Canadian food intakes.

Statistics Canada has undertaken Cycle 2.2 of the Nutrition Focus Survey in 2004 as part of the Canadian Community Health Services Survey. This nutrition survey involved a 24-hour dietary recall, and it is anticipated that the survey results will be available in 2005. Consumption figures based on this study should be available from Statistics Canada at that time. Further information on this survey is available at: http://www.statcan.ca/english/concepts/health/cchsinfo.htm

Eaters-only statistics for the foods of interest are typically used to estimate levels of exposure to contaminants (e.g., see Richardson *et al*., 1997). It is suggested that these figures be employed in EIAs as a conservative measure.

8.5 Monitoring and Background Data

Before the development/remediation project proceeds, an initial monitoring study should be conducted to collect background data. (The concept of monitoring studies in this chapter refers to measuring levels of potential contaminants in the country foods under study.) Levels of the COPCs should be measured in the country foods that are consumed by the local population. These data may already be available from studies done in the area. This possibility should be determined before conducting analyses of these foods. Background data must be reliable and sufficiently recent to be representative of contaminant levels present in the country foods.

If it is not possible to obtain preconstruction background levels of contaminants, other options may be considered. For instance, in regard to fish, levels of COPCs can be measured in fish caught upstream from the proposed development/remediation project. (The fish samples collected must be far enough upstream so as not to have been contaminated as a result of the development/remediation project.) Alternatively, levels of COPCs can be measured in fish or in other foods under study that are harvested from an equivalent (uncontaminated) location not subject to a development/remediation project. (To ensure that samples representative of the foods consumed are collected, it is advisable to obtain the services of a statistician before beginning the sampling.) Published papers – e.g., regarding total-diet studies – providing levels of the contaminants of concern can be used for comparison purposes as well.

Periodic monitoring of the levels of COPCs in the foods under study would then be undertaken upon commencement of the remediation project or, for development projects, of operation of the new facility. Comparison of the results of these monitoring studies with the background levels mentioned above can be used to confirm modelling predictions and exposure estimates, to determine the need for future human health risk assessments, and/or to determine the need for additional or extended monitoring. In those cases where no significant increases are identified in the contaminant levels found, no adverse human health effects would be indicated as a result of project activities. Where it is suspected that increases in the levels of contaminants in the country foods are sufficiently significant, health risk assessments, based on the new results obtained, can be conducted to determine the potential impact on human health. In some cases, it may be necessary to issue food consumption advisories based on the results of such assessments. For example, provinces often issue fish consumption advisories indicating safe amounts of various species of edible fish found in specific lakes.

Depending on the nature of the project, follow-up monitoring may be considered after the project has been completed to ensure that there is no negative effect on the health and well-being of the local community residents. Any need for additional risk assessments can be determined based on the results of these monitoring studies and comparison with previous monitoring data relating to the project area.

Monitoring studies must be undertaken in such a manner that the food samples analysed are representative of those country foods consumed by the local population. For example, monitoring studies of the levels of contaminants in fish may include collecting samples of certain species of fish caught in specific locations, based on the potential exposure pathways identified. Representative samples from each location would consist of at least four to six individual fish of a species or one or more composites of each species of fish. Each composite sample would consist of three or more fish. It is advisable to obtain the services of a statistician to ensure that samples that are representative of the country foods consumed have been collected for analysis.

It is also important that the correct tissues of fish or other animals be analysed. For example, the meat, liver, and/or kidney of wild game animals such as caribou may be consumed locally. Another example may be that whole fish and/or individual tissues of a fish species may be consumed. In some communities, fish livers are considered to be a delicacy and are preferentially consumed. The accumulation of many contaminants in the liver often exceeds that observed in fish filets.

Furthermore, in regard to contaminants in various tissues, if, for instance, sufficient levels of PCBs are present in fish, a positive result will be obtained for this contaminant mixture if the whole fish is analysed. This can occur because PCBs are typically found in the fat just under the skin of fish. If the skin is discarded and only the filet of the fish is typically consumed, the elevated PCB levels found from analysing the whole fish will result in estimating intakes of this contaminant mixture that are not representative of actual intakes. Likewise, methylmercury is typically found in the meat of fish. If only the filet is consumed, analysing the whole fish will result in diluting the actual levels of methylmercury intake. Analysing tissues of fish and wild game that are not consumed can result in the underestimation or overestimation of contaminant exposures.

Another important point in regard to monitoring and contaminant levels in foods is that a short-term elevated exposure to a contaminant(s) from the consumption of certain country foods can be identified. Although such a situation is not desirable, a short-term exposure to elevated levels of contaminants does not necessarily represent a chronic risk to human health. The TRV for a specific contaminant is generally based on a lifetime exposure to that contaminant. Therefore, a short-term increase in exposure will not necessarily affect the lifetime average daily intake of the contaminant.

In any case, monitoring will allow responsible authorities to be alerted to these potential short-term elevated exposures. Monitoring efforts can also result in initiating mitigative measures to avoid potentially higher exposures to contaminants, which would be the desired risk management preference.

8.6 Analytical Data

For the purposes of a human health risk assessment in regard to contaminants in foods, analytical methodologies are required that are capable of measuring contaminants at levels consistent with known toxicity and risks. In most cases, methodologies exist that can measure levels of contaminants in certain foods, with detection limits expressed in parts per billion (ppb) or micrograms per kilogram (µg/kg). (For example, the detection limit currently required for high molecular weight PAHs is in the range of 1 ppb, and the detection limit typically required for lead is approximately 20 ppb. These detection limits are achievable in many foods for these contaminants. Note that 1 ppb is equivalent to 1 nanogram/gram (ng/g) or 1 µg/kg.) Although the detection limits are typically measured in units of ppb, contaminant levels in foods may be reported in parts per million (ppm) or micrograms per gram (µg/g). (The detection limits may also be reported in ppm (µg/g) – e.g., a detection limit of 20 ng/g (or 20 ppb) is equivalent to 0.02 µg/g (or 0.02 ppm).)

This requirement for detection limits is generally necessary to ensure that estimated intakes are quantifiable to levels less than or equal to the TRVs established for specific contaminants. Therefore, a suitable certified laboratory capable of providing these desired analytical results must be chosen to undertake the analysis of the levels of COPCs in country foods.

In order to verify the reliability of the analytical results, the standard analytical methodology must be identified (e.g., American Society for Testing and Materials, U.S. EPA, etc.). Results of the contaminant analysis must include the detection limit for each contaminant measured in each type of country food. Proof of the accuracy of the analytical results, as well as the results of some duplicate analyses for each contaminant, must be provided.

Analytical laboratories will require guidance as to the required detection limit for each contaminant. It is the responsibility of the risk assessor to provide instructions to the laboratory in regard to the detection limits necessary for human health risk assessment.

8.7 Human Health Risk Assessment: Contaminant Levels in Foods

It is recommended that a separate chapter or section in an EA report be devoted to the human health risk assessment of contaminant levels in country foods. This may require some duplication in the report. Nevertheless, the assessment of food issues in an EA will be clearly stated and easier to review for the various stakeholders involved. It is the responsibility of the risk assessor to ensure that the level of detail is sufficient to justify and support the conclusions and recommendations with regard to country food risks or absence thereof.

8.7.1 Risk Characterization: Calculations and Presentation

Based on the levels of contaminants found in the country foods, estimates of exposure to COPCs can be calculated. These exposure estimates can then be compared with TRVs established for these contaminants. In addition, recommended maximum weekly intakes (RMWIs) can be determined for each of the country foods consumed. RMWIs are particularly useful where food consumption data are not available. Furthermore, RMWIs can be used to develop consumption advisories, when such recommendations are deemed necessary.

Tables providing estimated contaminant intakes must be presented in the EA report. Units of measurement, food consumption figures, body weights and other required receptor characteristics, and TRVs employed in these calculations must be clearly indicated in these tables. Suitable references for any assumptions must also be cited in the EA report.

Examples of formulas typically used to estimate exposure to contaminants from the consumption of foods and formulas used for risk characterization are presented below. (Typical units of measurement used for these calculations are provided. Some units of measurement may vary, depending on the TRV established for the COPC.)

$$\text{Dose} = C_f \times IR_f / BW$$

where:

Dose = contaminant intake from the consumption of a food (µg/kg body weight per day);

C_f = mean of the levels of the contaminant of potential concern found in the food (µg/g);

IR_f = rate of consumption of the food (g/day);

BW = body weight (kg) (suitable body weights for males and females of various age groups can be found in Richardson *et al.* (1997)).

$$ER = \text{Dose} / TRV$$

where:

ER = exposure ratio (also termed the Hazard Index; see Health Canada, 2003a);

Dose = contaminant intake from the consumption of a food (µg/kg body weight per day);

TRV = toxicological reference value (µg/kg body weight per day).

$$RMWI = \left[\frac{TRV \times BW}{C_f}\right] \times 7$$

where:

RMWI = recommended maximum weekly intake of the food (g/week);

BW = body weight (kg);

C_f = mean of the levels of the contaminant of potential concern found in the food (µg/g);

TRV = toxicological reference value (µg/kg body weight per day);

7 = days/week.

Two hypothetical case studies are presented below to illustrate calculations using the formulas outlined above. The first case study involves the risk assessment for a hypothetical development project, and the second one concerns a hypothetical site remediation project. For each of these case studies, the analytical laboratory has adequately described the methodology employed, and the limits of detection have been provided. As well, satisfactory information has been presented on the accuracy of the results, and sufficient quality assurance/quality control exercises (such as acceptable duplicate analysis of samples) have been carried out.

8.7.1.1 Case Study #1: Development Project

A project is proposed to build a dam. Flooding and flow changes in existing waterways are necessary for this project. It has been established that somewhat elevated mercury levels are present in soil in the area of this proposed dam. In addition, in previous analytical studies, elevated levels of mercury have been found in predatory fish caught in two lakes close to this site. (Mercury found in fish is in the form of methylmercury, which bioaccumulates in fish meat; levels of this contaminant are typically found to be more elevated in larger and older predatory fish.) These two lakes, however, are not connected to the waterways associated with the proposed dam.

It has been determined that mercury loading can possibly occur in a nearby lake due to the construction of this dam. Therefore, there exists a potential exposure pathway for methylmercury to contaminate fish inhabiting this lake. Pike is known to be caught in this lake, and sport fishing by local residents does occur. Information obtained from the local community indicates that only the meat of these pike is consumed.

An EA is required for this proposed development project. Some of the details required for the risk assessment of the food issues from a human health perspective are discussed below.

Before the construction of the dam, results of analyses of composite samples of the filet of pike harvested from four areas of this lake indicate that the levels of mercury are, in general, low. (The age and the size of the pike harvested for this study are representative of those fish consumed. Analysing samples of filets of more of the larger and older pike than those normally consumed would result in intake estimates of methylmercury that are much higher than the actual intake of this contaminant; filets from small fish would underestimate mercury intake.) The background levels of mercury in the filets of these pike ranged from below the detection limit to 0.03 µg/g (0.03 ppm), and the mean mercury level was 0.01 µg/g. (The detection limit provided is 2 ppb (or ng/g) or 0.002 µg/g (or ppm).)

The project commences, and an advisory is issued to avoid fishing in this lake for the next five years. A follow-up monitoring study is conducted. Two composites of the filet of pike harvested from each of the same four locations in the lake as those for the study of the background data (total of eight composites) are analysed for levels of mercury. Each composite sample consists of three to five fish. The results of the analysis for each of the background and follow-up studies are presented in Table 8.2.

Table 8.2
Total Mercury Found in the Filet of Pike Caught in Lake X[1]

Sample	Site A (B*)	Site A (F*)	Site B (B*)	Site B (F*)	Site C (B*)	Site C (F*)	Site D B*	Site D (F*)	All Sites (B*)	All Sites (F*)
Composite 1 MeHg level found (µg/g)	<0.002	0.32	0.01	0.28	0.03	0.56	0.01	0.28	Composite 1 Mean 0.01	Composite 1 Mean 0.36
Composite 2 MeHg level found (µg/g)	0.02	0.48	0.02	0.52	<0.002	0.40	0.02	0.36	Composite 1 Mean 0.02	Composite 2 Mean 0.44
Mean of the levels of MeHg found (µg/g)	0.01	0.40	0.02	0.40	0.02	0.48	0.02	0.32	Composites 1 and 2 Mean 0.01	Composites 1 and 2 Mean 0.40

[1] B = results of the background study; F = results of the follow-up study; MeHg = methylmercury.

When compared with the background levels, it is evident from the results provided in this table that contamination of the filet of pike with methylmercury has occurred due to the construction of the dam.

Assumptions for Contaminant Intake Calculation

Consumption of 40 g/day of the filet of pike is assumed. This consumption figure is the best estimate of an eaters-only figure used by the HPFB of Health Canada.

JECFA has established a TRV for methylmercury of 0.47 µg/kg body weight per day. In addition, more recently, a TRV (or provisional tolerable daily intake (PTDI)) of 0.2 µg/kg body weight per day has been established by HPFB toxicologists, which is specific for young children and women of child-bearing age. Therefore, consideration must be given in this risk assessment to each of these sectors of the population. This risk assessment is undertaken in order, beginning with the most sensitive sector of the population.

Intake by Young Children

A body weight of 14.4 kg for young children is used to calculate estimated methylmercury intakes. This body weight is employed by HPFB for risk assessment purposes for children 1-4 years of age.

It is assumed that the total mercury found in the fish is in the form of methylmercury.

Dose

$$\text{Dose} = C_f \times IR_f / BW$$

Background (before construction):

$$\begin{aligned}\text{Dose} &= 0.01 \times 40 / 14.4 \\ &= 0.028\ \mu g/kg \text{ body weight per day}\end{aligned}$$

After the construction of the dam:

$$\begin{aligned}\text{Dose} &= 0.40 \times 40 / 14.4 \\ &= 1.11\ \mu g/kg \text{ body weight per day}\end{aligned}$$

(Note: A consumption rate of 40 g/day of the filet of fish is considered to be high for 1- to 4-year-old children.)

Exposure Ratio

Where the TRV for methylmercury (established by HPFB) = 0.2 µg/kg body weight per day for young children:

$$ER = \text{Dose} / TRV$$

Background (before construction):

$$\begin{aligned}ER &= 0.028 / 0.2 \\ &= 14.0\%\end{aligned}$$

After construction of the dam:

$$ER = 1.11 / 0.2$$
$$= 555\%$$

Recommended Maximum Weekly Intake

$$RMWI = \left[\frac{TRV \times BW}{C_f}\right] \times 7$$

Background (before construction):

$$RMWI = \left[\frac{0.2 \times 14.4}{0.01}\right] \times 7$$

$$RMWI = \sim 2015 \text{ g/week}$$

After construction of the dam:

$$RMWI = \left[\frac{0.2 \times 14.4}{0.40}\right] \times 7$$

$$RMWI = \sim 50 \text{ g/week}$$

In this case, where the consumption of 40 g/day of fish meat is considered high for young children, the RMWI of 50 g/week provides a better demonstration of the potential health issues relating to the intake of methylmercury.

Based on the background data, the levels of methylmercury found in the pike harvested from this lake are low and would not pose a health risk to consumers (including young children, the RMWI for whom is estimated to be approximately 2015 g/week, or about 65 ounces per week).

Based on the monitoring data provided after building the dam, it is evident that, for young children, exposure to methylmercury from this one source (i.e., from the consumption of the filet of pike caught in this lake after construction of the dam) is very high. Taking into consideration that the RMWI of pike for young children is estimated to be approximately only 50 g (or about 1.5 ounces per week), it would be prudent for children to avoid consumption of pike harvested from this lake.

Tables D.1 and D.4 in Appendix D provide examples of the presentation of intake estimate calculations for children.

Intake by Women of Child-bearing Age

A body weight of 53.8 kg for women of child-bearing age is used to calculate estimated methylmercury intakes. This body weight is employed by the HPFB for risk assessment purposes with regard to adult females.

Again, it is assumed that the total mercury found in the filet of pike is in the form of methylmercury.

Dose

$$\text{Dose} = C_f \times IR_f / BW$$

Background (before construction):

$$\text{Dose} = 0.01 \times 40 / 53.8$$
$$= 0.007\ \mu g/kg \text{ body weight per day}$$

After the construction of the dam:

$$\text{Dose} = 0.40 \times 40 / 53.8$$
$$= 0.3\ \mu g/kg \text{ body weight per day}$$

Exposure Ratio

Where the TRV for methylmercury (established by HPFB) = 0.2 µg/kg body weight per day for women of child-bearing age.

$$ER = \text{Dose} / TRV$$

Background (before construction):

$$ER = 0.007 / 0.2$$
$$= 3.5\%$$

After construction of the dam:

$$ER = 0.3 / 0.2$$
$$= 150\%$$

Recommended Maximum Weekly Intake

$$\text{RMWI} = \left[\frac{\text{TRV} \times \text{BW}}{C_f}\right] \times 7$$

Background (before construction):

$$\text{RMWI} = \left[\frac{0.2 \times 53.8}{0.01}\right] \times 7$$

$$= \sim 7530 \text{ g/week}$$

After construction of the dam:

$$\text{RMWI} = \left[\frac{0.2 \times 53.8}{0.40}\right] \times 7$$

$$= \sim 185 \text{ g/week}$$

Based on the background data, the levels of methylmercury found in the pike harvested from this lake are low and would not pose a health risk to women of child-bearing age consuming the meat of these fish.

Based on the monitoring data provided after building the dam, consideration should be given for women of child-bearing age to limit consumption of the filet of pike harvested from this lake to 150 g/week (or approximately 5 ounces per week). Tables D.2 and D.5 in Appendix D provide examples of the presentation of intake estimate calculations for women of child-bearing age.

Intake by Adults Other than Women of Child-bearing Age

An adult body weight of 60 kg is used to estimate methylmercury intakes. This body weight, which is lower than the average Canadian adult body weight, is used for risk assessment purposes by the HPFB. Using this lower figure creates a built-in safety factor. An adult body weight of 70.7 kg (Richardson *et al*., 1997) would also be acceptable.

As for the other sectors of the population, it is assumed that the total mercury found in the fish is in the form of methylmercury.

Dose

$$\text{Dose} = C_f \times IR_f / BW$$

Background (before construction):

$$\begin{aligned}\text{Dose} &= 0.01 \times 40 / 60 \\ &= 0.007\ \mu\text{g/kg body weight per day}\end{aligned}$$

After the construction of the dam:

$$\begin{aligned}\text{Dose} &= 0.40 \times 40 / 60 \\ &= 0.27\ \mu\text{g/kg body weight per day}\end{aligned}$$

Exposure Ratio

Where the TRV for methylmercury (established by JECFA) = 0.47 µg/kg body weight per day. The HPFB uses this TRV for undertaking human health risk assessments for adults other than women of child-bearing age.

$$ER = \text{Dose} / TRV$$

Background (before construction):

$$\begin{aligned}ER &= 0.007 / 0.47 \\ &= 1.5\%\end{aligned}$$

After construction of the dam:

$$\begin{aligned}ER &= 0.27 / 0.47 \\ &= 57.4\%\end{aligned}$$

Recommended Maximum Weekly Intake

$$RMWI = \left[\frac{TRV \times BW}{C_f}\right] \times 7$$

Background (before construction):

$$\text{RMWI} = \left[\frac{0.47 \times 60}{0.01}\right] \times 7$$
$$= \sim 19\,740 \text{ g/week}$$

After construction of the dam:

$$\text{RMWI} = \left[\frac{0.47 \times 60}{0.40}\right] \times 7$$
$$= \sim 490 \text{ g/week}$$

Based on the background data, the levels of methylmercury found in the pike harvested from this lake are low and would not pose a health risk to consumers.

The monitoring data provided after building the dam indicate that the estimated intake of methylmercury from the consumption of the meat of pike caught in this lake would not exceed the TRV established for this contaminant. Nevertheless, there is potential for a significant increase in exposure to methylmercury when compared with the intake estimates for this contaminant based on the results of the monitoring done before the construction of the dam.

A recommendation could be provided to resume fishing in this lake, but to limit consumption of the filet of pike by adults other than women of child-bearing age to approximately 400 g/week (approximately 13 ounces per week). Tables D.3 and D.6 in Appendix D provide examples of the presentation of intake estimate calculations for adults other than women of child-bearing age.

Further periodic monitoring of the levels of mercury in the filet of pike harvested from this lake would be advisable. The mercury levels found in these fish will vary over time. Mercury levels in fish in impounded lakes can remain elevated for three to four decades. Eventually, however, mercury contamination in fish will decline. It is advised that periodic monitoring (e.g., annual monitoring) of the meat of pike in this lake be conducted until mercury levels return to pre-project levels, or at least decline to levels presenting no risk to human health.

8.7.1.2 Case Study #2: Contaminated Site Remediation Project

Remediation measures are required for a gold mine that has been abandoned. Arsenic levels in soil in the area of the mine are elevated, as is typical for the surrounding areas of gold mine sites. Due to mine tailings remaining at the site and a high annual rainfall in the area, additional arsenic contamination of the soils has been determined.

Ranchers residing near the site of the abandoned gold mine raise free-range chickens. This results in a potential pathway of arsenic from the feed (from local vegetation) to chickens raised and consumed by the local population. Some of the chickens are also sold at the retail level (this information should be included in the EA document).

An EA is required for this proposed remediation project. Some of the details needed for the risk assessment of the food issues from a human health perspective are discussed below.

The meat of five individual chickens collected from each of four farms in the area of the gold mine is analysed for total arsenic levels (i.e., a total of 20 chickens analysed). The results of this study are presented in Table 8.3.

Table 8.3
Total Arsenic Found (ng/g) in Meat of Chickens

Sample	Farm A	Farm B	Farm C	Farm D	Farms A, B, and C	All Farms
#1 Arsenic level found	31.6	29.6	31.9	14.8	Mean of #1 samples 31.0	Mean of #1 samples 27.0
#2 Arsenic level found	40.1	42.3	30.1	23.2	Mean of #2 samples 37.5	Mean of #2 samples 33.9
#3 Arsenic level found	26.6	28.7	40.6	22.9	Mean of #3 samples 32.0	Mean of #3 samples 29.7
#4 Arsenic level found	31.8	29.2	26.8	26.3	Mean of #4 samples 29.3	Mean of #4 samples 28.5
#5 Arsenic level found	30.4	31.5	35.4	19.4	Mean of #5 samples 32.4	Mean of #5 samples 29.2
Mean level of arsenic found	32.1	32.3	33.0	21.3	Mean of all samples 32.4	Mean of all samples 29.7

The mean arsenic level found in the meat samples of chickens from farm D is lower than the mean levels found for chicken samples from the other three farms. It was discovered that the chickens raised on this farm were supplemented with retail feed. Therefore, the results for farm D were discarded for risk assessment purposes.

In a total-diet study conducted by Health Canada (Dabeka *et al*., 1993), the mean arsenic level of 24.3 ng/g was reported for meat and poultry. Samples of meat and poultry were collected at the retail level from six cities across Canada. The reported mean arsenic level of 32.4 ng/g in chickens gathered from farms A, B, and C is approximately 25% higher than the mean level reported in the total-diet study. Table D.7 in Appendix D provides a sample of intake estimate calculations.

Assumptions for Contaminant Intake Calculation

Information on the speciation of arsenic (i.e., identification of the form of arsenic present) is not available. Therefore, it is assumed, in a worst-case scenario, that the total arsenic found in the meat of chickens in this study is in the form of inorganic arsenic.

An adult body weight of 60 kg, used in risk assessments by the HPFB, is assumed.

An eaters-only mean consumption figure of 125.85 g/day of chicken meat was used to estimate arsenic intake from the consumption of these chickens. This consumption figure is reported in the joint Health Canada/Nova Scotia survey conducted during the fall of 1996 to the spring of 1997. (This food consumption study is discussed in section 8.4, and a provincial contact list is provided in Appendix C.)

Intake by Adults

Dose

$$\begin{aligned} \text{Dose} &= C_f \times IR_f / BW \\ &= 0.032 \times 125.85 / 60 \\ &= 0.067 \ \mu g/kg \text{ body weight per day} \end{aligned}$$

Exposure Ratio

Where the TRV or PTWI for inorganic arsenic established by JECFA is 15 µg/kg body weight per week (2 µg/kg body weight per day).

$$\begin{aligned} ER &= \text{Dose} / TRV \\ &= 0.067 / 2 \\ &= 3.4\% \end{aligned}$$

Recommended Maximum Weekly Intake

$$RMWI = \left[\frac{TRV \times BW}{C_f} \right]$$

(In this example, there is no need to multiply by 7, since the arsenic TRV used is 15 μg/kg body weight per week.)

$$\text{RMWI} = \left[\frac{15 \times 60}{0.032}\right]$$

$$= \sim 28\,000 \text{ g/week}$$

The levels of arsenic found in the meat of the chickens gathered from farms in the area of the mine are low and would not pose a hazard to consumers. In addition, a substantial proportion of the arsenic present in foods, such as chicken meat, is in the less toxic organic form (Lawrence *et al*., 1986).

It is expected that, over time, remediation of the gold mine site will reduce any further soil contamination by arsenic in this area, since the mine tailings are being removed. Therefore, it is anticipated that the pathway for additional contamination of chicken meat, due to the mine tailings, will no longer be viable. It is important that fugitive dust mitigation measures be used during remediation.

Monitoring of the arsenic levels in the meat of chickens harvested from these farms can be considered after completion of the project. Although no risk to human health would be anticipated, the information resulting from this monitoring may be desirable for the local residents, should they have any further concerns.

8.7.2 Conclusions and Recommendations

Based on the estimated exposure to the contaminants of concern, comments and conclusions must be offered in regard to the contaminants in country foods and the potential impacts on the health of the local communities. Mitigation procedures to reduce or eliminate the potential contamination of foods available in the study area can be suggested. Recommendations could include acceptable changes to the proposed development/remediation project to facilitate these goals. In addition, and as discussed previously, food consumption advisories, or possibly changes in the preparation of foods before consumption, can be suggested.

Arguments in favour of or in opposition to certain project activities should be presented. Based on these discussions, the feasibility of the project, as proposed, can be determined. Options could then be investigated that could satisfy project needs in such a manner that the development/remediation project can be undertaken without any unnecessary or deleterious impact on the health of local residents.

8.8 Review Requirements for the Draft Environmental Assessment: Critical Timing

In order to ensure efficient and effective use of this risk assessment portion of the EA, it would be necessary to allot sufficient time for the review required by the various stakeholders involved. Therefore, a final proposed draft copy of the risk assessment report should be presented to stakeholders for coordination of the review process as soon as possible. After the review by all stakeholders has been completed and comments have been considered for the final EA report, the responsible decision-maker(s) will then be able to consider this report, without the need, it is hoped, for further evaluation of its contents.

8.9 Risk Assessment and Risk Management

The focus of a risk assessment of the levels of contaminants found in foods, within the context of the evaluation of a proposed development/remediation project, is to estimate potential risk to the local human population from consumption of the country foods harvested from the area. In short, the purpose of this exercise is to protect human health. This objective can be achieved by reducing exposure to potential contaminants to levels as low as reasonably achievable.

It is important to emphasize that it does not necessarily follow that the project will not go forward if it is estimated, at first glance, that there is potential for a somewhat more elevated exposure to certain contaminants as a result of project activities. Measured food contaminant levels that are above typical or background levels do not necessarily mean that a health risk exists. Furthermore, estimated potential risks to the health of local residents can be further evaluated by undertaking a more in-depth review of the assumptions used and through the collection of more site-specific and/or community-specific data as input for a refined risk assessment. Built-in safety factors, such as the consumption figures used and the exposure pathways identified, can be reexamined to determine their validity. This further evaluation can provide the relative level of potential risk in order to determine if there are, indeed, reasons for concern from a human health perspective.

Risk management tools are available in those cases where a potential human health hazard has been determined. For example, some recommendations may be to avoid fishing in specific lakes for a certain amount of time, depending on follow-up monitoring studies. Perhaps precautions can be taken in regard to growing vegetables or other produce during certain periods of the project operations. Risk management actions can serve to greatly reduce or, in some cases, eliminate potential risk to human health. For instance, in those cases where it is determined that potential elevated exposure to certain contaminants could occur, consumption advisories for specific foods are an option, as previously mentioned. All reasonable measures to ensure the protection of human health must be undertaken, taking into consideration that the degree of potential risk to human health must be balanced by the nutritional benefits, as well as the benefits of the project to the community.

Risk management issues, of course, are beyond the scope of the EIA. Nevertheless, risk managers can consider the results and the recommendations provided in these assessments to formulate risk management measures, if necessary.

8.9.1 Uncertainty in Risk Assessment

The results of a risk assessment cannot be considered absolute. A degree (often a large degree) of uncertainty is inherent in any estimation of risk, and this uncertainty must be accepted. There is uncertainty in the quantity and quality of the information available to make the exposure estimate, and also in the assumptions used in the derivation of the safe or tolerable dose (such as species and low-dose extrapolations). Listed below are some of the factors that can contribute to uncertainty in risk assessment (Abbot *et al.*, 1999):

- quantity and quality of the toxicity data available;
- use of animal bioassays vs. human epidemiological studies;
- need for dose-response extrapolation to the low-dose range;
- determination of a threshold dose-response extrapolation;
- lack of information on the target dose;
- basis for determining uncertainty factors;
- variability in the contaminant levels in food;
- variability of individual diets over lifetime;
- availability of data on individual dietary exposure; and
- use of 24-hour recall data to make projections about lifelong intakes.

Although the risk assessment process has its limitations, it provides a framework for a structured and logical approach to determine risks associated with exposure to contaminants from the consumption of foods. The review of a risk assessment should consider whether the evidence provided adequately supports the conclusions that are reached in light of the uncertainties involved. It is vital that all assumptions employed in a risk assessment be clearly indicated and documented in order to demonstrate how the potential risk due to the exposure to contaminants was estimated. Limitations can be minimized by careful consideration of the data available and the use of practical and reasonable assumptions in the risk assessment.

8.10 Concluding Remarks

The role of risk assessment and of HIA within an EIA is still evolving. As well, there is growing interest in integrated impact assessment within local, national, and international communities. This includes the integration of health into EIAs and SIAs. The risk assessment protocol for food issues described in this chapter is one tool that can be used to plan an integrated impact assessment.

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8.12 List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	benzene, toluene, ethylbenzene, xylenes
BW	body weight
COPCs	contaminants of potential concern
HPFB	Health Products and Foods Branch (Health Canada)
IRIS	Integrated Risk Information System (U.S. EPA)
JECFA	Joint FAO/WHO Expert Committee on Food Additives and Contaminants
MTBE	methyl tertiary butyl ether
ng/g	nanograms per gram

ORNL RAIS	Oak Ridge National Laboratory Risk Assessment Information System
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDDs	polychlorodibenzo-*para*-dioxins
PCDFs	polychlorodibenzofurans
PCE	tetrachloroethylene (or perchloroethylene)
PHCs	petroleum hydrocarbons
POPs	persistent organic pollutants
PTWI	provisional tolerable weekly intake
RMWI	recommended maximum weekly intake
SLRA	screening-level risk assessment
TRVs	toxicological reference values

Notes:

A

Appendix A: Values That Affect Environmental Dialogue: A List of Definitions

Aesthetic: Values having to do with beauty.

Ecological: Values of nature independent of human use or enjoyment; for example, the value of the existence of a plant, an animal, a species, or an ecosystem for its own sake, even if it is of no use or benefit to people.

Economic: Values having to do with the generation of material wealth.

Educational: Values having to do with the passing on of knowledge and of skill in the use of knowledge.

Environmental: Values having to do with features of the environment that are useful or enjoyable to humans or that support human life; for example, the value of clean air and water, of quiet, of wildlife that people enjoy, of protection from dangerous solar radiation, etc.

Health/Safety: Values having to do with human physical well-being and safety.

Legal: Values having to do with laws, rules, and orders enforceable in a court; for example, the value of acting within the law, of being law-abiding, or of deciding on the basis of legal principles.

Moral: Values having to do with right and wrong, good and evil, and such virtues as justice and fairness.

Personal: Values of a private or idiosyncratic character, such as sentimental attachments, individual tastes, personal preferences, etc.

Political: Values having to do with legitimately authorized actions, procedures, and decisions of governments and government agencies, and with efforts to influence governments and government agencies; for example, the value of a government or government agency's acting within its mandate and jurisdiction, following proper procedures, acting in a fair and democratic manner, etc., or the value of a lobby group's acting in an effective and appropriate manner.

Recreational: Values having to do with pastimes whose goals are relaxation, amusement, refreshment, etc.

Religious/Spiritual: Values having to do with what is thought, understood, or perceived to be sacred.

Scientific: Values having to do with gaining knowledge through systematic observation and/or experimentation; for example, the value of a forest or stream as a site for biological research.

Social: Values having to do with human relationships such as families, friendships, communities, cultures, and ways of life.

Subsistence: Values having to do with provision of the necessaries of life outside of a cash economy.

B

Appendix B: Guidelines on the Selection of an Occupational Hygiene Specialist

[This appendix was prepared as a consensus document by a committee of Ontario-based personnel involved with occupational hygiene.]

These guidelines describe personnel accreditation standards that exist in the occupational hygiene field, to assist the employer with the effective selection of appropriate specialist personnel. They may be useful in considerations both for staff positions and in the case of project-specific third-party contractors (consultants). It is recognized that, as generic guidelines, they are more likely to be generally applied to the latter, and that is their primary intent. In the case of a staff position, the employer may have more need and leisure to consider the nature of individual candidates and the likely ramifications of requiring specific qualifications, or not.

The occupational hygiene capabilities of industry (as well as commercial or institutional workplaces) and the quality of work undertaken within the realm of occupational hygiene are key to the prevention of diseases, disabilities, and discomforts of workplace origin. The failure to achieve this is tied to substantial potential liabilities.

This appendix is intended to provide workplace parties with background and guidance in selecting occupational hygiene assistance.

1) The Need

Employers are expected to address diverse hazards under occupational health and safety (OH&S) legislation. *The Occupational Health and Safety Act* (in this case, Ontario is cited, but similar wording is found in other statutes) requires that an employer "acquaint a worker ... with *any hazard* in the work," and specifically with respect to biological, chemical, and physical agents. The Regulation respecting control (for example) requires that employers take "all measures reasonably necessary in the circumstances to protect workers from exposure," and specifically to maintain exposures within the prescribed limits.

Clearly, fulfilling these responsibilities carries with it specialized administrative, professional, and technical abilities that are not all within the skill set of the typical employer or workplace. Some of the professional specialties that are necessary in order to have healthy and safe workplaces are defined in provincial statutes – for instance, architects, engineers, and doctors. Others are clearly established by licensing provisions (e.g., electricians). However, the various specialists who function in the OH&S field and are integral to a comprehensive and effective health and safety program – namely, in safety, ergonomics, and hygiene – are not defined.

In selecting an individual to perform a role in occupational hygiene, the employer is bound by "due diligence" considerations and "general duty" provisions. In the case of someone who is also appointed to a supervisory position, the onus rests with the employer that this be a "competent person."

What are the consequences if the employer selects someone who does not have the knowledge and skill sets necessary to provide occupational hygiene services for the matter at hand, and the work is done in a manner that places one or more workers at risk? Not only may the worker(s) experience adverse consequences, but the employer faces a liability under OH&S legislation. Conversely, less qualified hygienists may compensate for their uncertainty in making a judgment call by inflating the safety factors inherent in their recommendation(s), thereby resulting in unnecessary cost to the employer.

Accordingly, it is in everyone's best interests if those performing occupational hygiene functions are before-the-fact demonstrably qualified, based on a review by a recognized Board (see below). Occupational hygiene service providers should also be members of a professional association that maintains standards of competence and provides for the accountability of its members – e.g., sanctions in the case of disregard for the code of ethical conduct.

2) Meeting the Need

To determine if occupational hygiene expertise is required, consider questions such as:

- Is your potential need based on a regulatory order? If so, did it advise or specify what type of consultant you should seek?
- Do you require assistance with some aspect of the work environment as it relates to worker health?

- Are you interested in determining the likelihood that a particular job or work area will lead to a health problem?
- Do you have workers who are experiencing vague or specific health effects or who have particular concerns regarding the healthiness of their work environment?
- Do you wish to determine the concentration of a specific airborne contaminant under certain work conditions?

An affirmative answer to any of the above questions would suggest a need for someone with expertise in occupational hygiene. This could be a hygienist or technologist, and either accredited by a recognized hygiene board or not. When should it be a hygienist? A distinction could be made on the basis of the need for "professional judgment," depth of knowledge, problem-solving ability, integrative and communication skills, and holistic programs involving multidisciplinary considerations. Collection and computation of data are commonly considered to be technical functions, whereas interpretation and recommendations on their basis are considered to be professional functions.

Depending on the complexity of the situation, there may be a need to draw upon specific expertise in disciplines such as ergonomics, health physics, or microbiology. This may be provided by hygiene practitioners with specialized skills, or the hygienist may recommend the involvement of personnel dedicated to that particular field. Similarly, the hygienist may advise involving a physician, nurse, epidemiologist, or engineer, in their area of expertise.

3) Accredited Occupational Hygiene Specialists

Accreditation is a recognition of an individual's knowledge, skills, and ability in a wide range of occupational hygiene activities. Any one accredited individual is not necessarily the most knowledgeable or capable candidate for a particular position or project. Other important criteria in selecting a suitable candidate are not dispensed with by accreditation: knowledge of a specific industry, process, or work site; professional referrals from colleagues; a formal statement of qualifications; and written proposals to perform designated work in a specified manner.

By selecting an accredited occupational hygienist, assuming that you have verified that other characteristics of the individual are acceptable, you are protecting yourself, the company, the workers, and society at large. You have accepted the decision of a professional association that has prequalified someone who has demonstrated the requisite characteristics to be designated as an accredited occupational hygienist. However, you still have to satisfy yourself that this individual has the capabilities to meet your particular needs with respect to timelines, corporate and worker interface, comprehensiveness of project and product, integrity by reputation, etc. – just as you would for any consultant or contract employee.

There are two generally recognized North American hygiene accreditations – those offered by the Canadian Registration Board of Occupational Hygienists (CRBOH), which offers services in both official languages, and the American Board of Industrial Hygiene (ABIH). Information/rosters for each of these can be found on their respective web sites: http://www.crboh.ca and http://www.abih.org

4) Unaccredited Occupational Hygiene Personnel

Anyone may call himself/herself an "occupational hygienist"; there is no legal protection of the use of the term. Consultant directories, as published by the Occupational Hygiene Association of Ontario (OHAO – Tel.: (905) 567-7196) and the American Industrial Hygiene Association (AIHA – Tel.: (703) 849-8888), include some of those who offer services in occupational hygiene; these may or may not be accredited individuals. Unaccredited personnel may be quite competent; one may, in fact, find an unaccredited specialist who is more qualified by experience with respect to your specific needs than is a typical accredited specialist. Just as with accredited hygienists, a formal reference may be useful. Errors and omissions insurance may also be considered a positive attribute. However, if one chooses to use the services of unaccredited personnel, the onus is on one to determine the suitability of their hygiene-specific credentials and capabilities.

Accordingly, occupational hygiene projects in which accreditation is thought to be particularly compelling are listed below.

Does the occupational hygiene work involve, or is it being initiated as a result of:

- the laying of charges?
- a Ministry order (or other deficiency, noted)?
- a prescribed assessment?
- a health-based formal work refusal?
- other questions of compliance, or matters that may end up in litigation?
- testimony as an expert?
- a facility audit (or project, design, process, or purchase review) requiring anticipation and/or recognition of health hazards, and/or leading to:

  - identification of critical/likely contaminants and significant exposure scenarios (i.e., risk assessment)?
  - exposure to new, developmental, or poorly characterized environments and/or contaminants (e.g., those without regulatory exposure limits)?
  - concurrent exposure to multiple contaminants, or involving multiple media?
  - (potential) exposure to major contaminants with irreversible effects; these substances include carcinogens, mutagens, reproductive toxicants, and sensitizers?
  - exposure that shows significant (e.g., more than 10-fold) temporal and/or spatial variability?
- a situation in which health effects are occurring or symptoms are being reported?
- an evaluation pursuant to a workers' compensation claim?
- development of a control program for:
  - hearing conservation?
  - respiratory protection or other personal protective equipment?
  - designated substances?
- a multiprofessional team (physician, engineer, etc.) undertaking development of an occupational hygiene training program?
- auditing an existing occupational hygiene program?

If so, it would be particularly advantageous to engage the services of an accredited occupational hygienist to maximize the protection of all concerned. Selecting an accredited individual provides the employer with a measure of assurance based on the recognized Board's certification and maintenance protocols.

Notes:

C

Appendix C: Table of Provincial Contacts Regarding Food Issues

Province	Name	Telephone/Fax	E-mail
Nova Scotia (1990)	Dr. David MacLean	Tel.: (604) 291-5461	dmaclean@sfu.ca
	Pantelis Andreou (data)	Tel.: (902) 494-1563	pantelis.andreou@dal.ca
Quebec (fall 1990)	Lise Bertrand	Tel.: (514) 528-2400 ext. 3469 / Fax: (514) 528-2463	lbertran@santepub-mtl.qc.ca
Saskatchewan (spring 1993; winter 1994)	Alison Stephen	Tel.: (613) 569-4361 ext. 331 / Fax (613) 569-3278	astephen@hsf.ca
	Bruce Reeder	Tel.: (306) 966-7934 / Fax (306) 966-7920	reeder@sask.usask.ca
Alberta (1994)	Barbara Hansen	Tel.: (780) 415-2753 / Fax (780) 427-7683	barb.hansen@health.gov.ab.ca
	Larry Svenson (data)	Tel.: (780) 422-4767 / Fax (780) 427-1470	larry.svenson@gov.ab.ca
Prince Edward Island (1995)	Lamont Sweet	Tel.: (902) 368-4978 / Fax (902) 368-4969	lasweet@gov.pe.ca
	Deborah MacLellan	Tel.: (902) 566-0521 / Fax (902) 628-4367	maclellan@upei.ca
	Linda Van Til	Tel.: (902) 368-4964 / Fax (902) 368-4969	lvtil@gov.pe.ca
	Jennifer Taylor	Tel.: (902) 566-0475 / Fax (902) 566-0777	jtaylor@upei.ca
Newfoundland (1996)	Barbara Roebothan	Tel.: (709) 737-8550 / Fax (709) 737-2422	broeboth@mun.ca
	Alison Edwards (data)	Tel.: (709) 777-6218 / Fax (709) 777-7382	aedwards@mun.ca
New Brunswick (fall 1996 - spring 1997)	Gisele McCaie-Burke	Tel.: (506) 453-2280 / Fax (506) 453-8702	gisele.mccaie-burke@gnb.ca
Ontario (fall 1996 - spring 1998)	Rena Mendelson	Tel.: (416) 979-5000 ext. 7522 / Fax (416) 979-5336	mendelso@ryerson.ca
	Valerie Tarasuk	Tel.: (416) 978-0618 / Fax (416) 978-5882	valerie.tarasuk@utoronto.ca
	Teodoro Honrado (sample)	Tel.: (416) 327-7720 / Fax (416) 327-7617	Teodoro.Honrado@moh.gov.on.ca
Manitoba (fall 1998 - spring 1999)	Paul Fieldhouse	Tel.: (204) 786-7350	PFieldhous@gov.mb.ca
British Columbia (1999)	Lisa Forster-Coull	Tel.: (250) 952-1124 / Fax (250) 952-1570	Lisa.ForsterCoull@gems8.gov.bc.ca
Quebec Youth (spring 1999)	Claudette Lavallée (overall)	Tel.: (514) 873-4749 ext. 6117 / Fax (514) 864-9919	claudette.lavallee@stat.gouv.qc.ca
	Lise Bertrand (nutritionist)	Tel.: (514) 528-2400 ext. 3469 / Fax (514) 528-2463	lbertran@santepub-mtl.qc.ca
	Paul Berthiaume (statistician)	Tel.: (514) 691-2410 ext. 3214 / Fax (514) 643-4129	paul.berthiaume@stat.gouv.qc.ca

Notes:

D

Appendix D: Mercury Levels in Filet of Pike and Arsenic Levels in the Meat of Chicken

Table D.1
Background Mercury Levels in Filet of Pike – Lake X

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Children (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.2 µg/kg bw per day)	RMWI (g/week)
A	0.01	0.03	13.9	2016
B	0.02	0.06	27.8	1008
C	0.02	0.06	27.8	1008
D	0.02	0.06	27.8	1008
All sites	0.01	0.03	13.9	2016

Notes:

- Body weight (bw) of a 1- to 4-year-old child = 14.4 kg – used by HPFB for risk evaluation.
- Eaters-only consumption figure for the filet of fish used is 40 g/day. This rate of daily consumption of fish is considered to be high for children.
- PTDI = Provisional tolerable daily intake established by HPFB for MeHg = 0.2 µg/kg bw per day. This temporary PTDI was established for children and women of child-bearing age.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.2
Background Mercury Levels in Filet of Pike - Lake X

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Women of Child-bearing Age (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.2 µg/kg bw per day)	RMWI (g/week)
A	0.01	0.01	3.7	7532
B	0.02	0.01	7.4	3766
C	0.02	0.01	7.4	3766
D	0.02	0.01	7.4	3766
All sites	0.01	0.01	3.7	7532

Notes:

- Female adult body weight (bw) = 53.8 kg – used by HPFB for risk evaluation.
- Eaters-only consumption figure for the filet of fish used is 40 g/day.
- PTDI = Provisional tolerable daily intake established by HPFB for MeHg = 0.2 µg/kg bw per day. This temporary PTDI was established for children and women of child-bearing age.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.3
Background Mercury Levels in Filet of Pike - Lake X

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Adults (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.47 µg/kg bw per day)	RMWI (g/week)
A	0.01	0.01	1.4	19 740
B	0.02	0.01	2.8	9 870
C	0.02	0.01	2.8	9 870
D	0.02	0.01	2.8	9 870
All sites	0.01	0.01	1.4	19 740

Notes:

- Adult body weight (bw) = 60 kg for adults other than women of child-bearing age.
- Eaters-only consumption figure for the filet of fish used is 40 g/day.
- PTDI = Provisional tolerable daily intake established by JECFA for MeHg = 0.47 µg/kg bw per day.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.4
Mercury Levels in Filet of Pike - Lake X After the Project Commences

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Children (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.2 µg/kg bw per day)	RMWI (g/week)
A	0.40	1.11	555.6	50
B	0.40	1.11	555.6	50
C	0.48	1.33	666.7	42
D	0.32	0.89	444.4	63
All sites	0.40	1.11	555.6	50

Notes:

- Body weight (bw) of a 1- to 4-year-old child = 14.4 kg – used by HPFB for risk evaluation.
- Eaters-only consumption figure for the filet of fish used is 40 g/day. This rate of daily consumption of fish is considered to be high for children.
- PTDI = Provisional tolerable daily intake established by HPFB for MeHg = 0.2 µg/kg bw per day. This temporary PTDI was established for children and women of child-bearing age.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.5
Mercury Levels in Filet of Pike - Lake X After the Project Commences

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Women of Child-bearing Age (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.2 µg/kg bw per day)	RMWI (g/week)
A	0.40	0.30	148.7	188
B	0.40	0.30	148.7	188
C	0.48	0.36	178.4	157
D	0.32	0.24	119.0	235
All sites	0.40	0.30	148.7	188

Notes:

- Female adult body weight (bw) = 53.8 kg – used by HPFB for risk evaluation.
- Eaters-only consumption figure for the filet of fish used is 40 g/day.
- PTDI = Provisional tolerable daily intake established by HPFB for MeHg = 0.2 µg/kg bw per day. This temporary PTDI was established for children and women of child-bearing age.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.6
Mercury Levels in Filet of Pike - Lake X After the Project Commences

Site	Mean Level of Mercury (µg/g)	Mercury Intake – Adults (µg/kg bw per day)	ER (% PTDI) (PTDI = 0.47 µg/kg bw per day)	RMWI (g/week)
A	0.40	0.27	56.7	494
B	0.40	0.27	56.7	494
C	0.48	0.32	68.1	411
D	0.32	0.21	45.4	617
All sites	0.40	0.27	56.7	494

Notes:

- Adult body weight (bw) = 60 kg for adults other than women of child-bearing age.
- Eaters-only consumption figure for the filet of fish used is 40 g/day.
- PTDI = Provisional tolerable daily intake established by JECFA for MeHg = 0.47 µg/kg bw per day.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

Table D.7:
Arsenic Levels in the Meat of Chicken

Farm	Mean Level of Arsenic (µg/g)	Arsenic Intake (µg/kg bw per day)	ER (% PTDI) (PTDI = 2.0 µg/kg bw per day)	RMWI (g/week)
A	0.032	0.07	3.4	28 125
B	0.032	0.07	3.4	28 125
C	0.033	0.07	3.5	27 273
D	0.021	0.04	2.2	42 857
All Farms	0.030	0.06	3.0	31 034
Farms A, B, and C	0.032	0.07	3.4	30 000

Notes:

- Adult body weight (bw) = 60 kg.
- Nova Scotia survey consumption figure for chicken meat used is 125.85 g/day.
- PTDI = Provisional tolerable daily intake = 2.0 µg/kg bw per day – used for ER.
- PTWI = Provisional tolerable weekly intake = 15.0 µg/kg bw per week – used to estimate RMWI.
- ER = Exposure ratio or % PTDI.
- RMWI = Recommended maximum weekly intake in g/week.

E

Appendix E: References Pertaining to the First Nations and Inuit

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F

Appendix F: Glossary (Volumes 1-4)

Abiotic: 1) Having no life; lifeless; 2) independent of the vital processes of a living organism.

Actinomycetes: Any one of a group of bacteria found in soil that are structurally similar to certain fungi. Antibiotics such as streptomycin and chloramphenicol are derived from some actinomycetes.

Acute (toxicity): Toxicity manifested within a relatively short time interval after toxicant exposure (i.e., as short as a few minutes to as long as several days). Such toxicity is usually caused by a single exposure to the toxicant.

Adenocarcinoma: A cancer that originates in the epithelium (a thin layer or layers of cells forming a tissue that covers surfaces of the body and lines hollow organs) of a gland or duct.

Adenosine triphosphate (ATP): A compound found in the cells of organisms and consisting of adenosine and three phosphate groups. The removal of phosphate releases large amounts of energy for use in biological reactions or processes such as muscle contraction and the metabolism of sugars.

***Alternaria*:** Any one of a genus of fungi that cause fruit and vegetable blight, mould, or rot.

Alveolitis: Inflammation of the alveoli (the small air sacs of the lungs, where exchange of gases (oxygen, carbon dioxide) occurs.

Anadromous species: Species that travel up rivers from the sea to spawn (e.g., of salmon and shad).

Anaerobic bacteria: 1) Bacteria that can live without free oxygen or bacteria that cannot live in the presence of oxygen; 2) bacteria living, growing, or residing where there is no free oxygen. Some anaerobic bacteria get their oxygen from the matter released during fermentation, which takes place in the absence of free oxygen.

Anuria: The absence of urine; the inability to urinate.

Aplastic anemia: A severe anemia caused by failure of the bone marrow to produce various blood elements, such as red blood cells, as a result of exposure to, for example, certain antibiotic drugs, poisons, or ionizing radiation (e.g., large doses of X-rays), or for unknown reasons.

Audiometry: The testing of the sense of hearing.

Auxin hormone: Any hormone of a group synthesized in the protoplasm of the young, active parts of plants, which regulates plant growth and development.

Baseline status: Refers to the conditions prior to the construction and/or preparation of the development/remediation project.

Benefit transfer technique: An economic tool that uses estimates from existing research to valuate the potential health benefits and detriments of development project scenarios under consideration. The main advantage of benefit transfer is that the process is less expensive and time consuming than primary valuation techniques. The benefit transfer technique consists of five steps: 1) describe the project case; 2) identify relevant studies; 3) review relevant studies for quality and applicability; 4) transfer the benefit estimates; and 5) address uncertainty.

Bioaccumulation: Occurs when a substance is assimilated into an organism through eating another organism (plant or animal). Depending on the substance, it may be passed through the body fairly quickly or it may accumulate (concentrate) in certain tissues or organs. Small animals bioaccumulate toxic substances, for example, by feeding on smaller organisms, and as they in turn are eaten by larger animals, they pass the absorbed contaminants along to the next higher level in the food web.

Bioaerosol: A suspension of airborne particles, large molecules, or volatile compounds that are living or were released from a living organism; also defined as a suspension of non-viable microbial cells with which endotoxins can be associated. Individual aerosol particles range from submicroscopic (<0.1 µm) to greater than 100 µm in diameter.

Biological monitoring: A tool used to assess environmental or occupational exposures and involving the analysis of appropriate bodily fluids (e.g., blood, urine, exhaled breath) or tissues and comparing the results with guideline values such as maximum acceptable concentrations (MACs) or biological exposure indices (BEIs).

Biomagnification: The increase in the concentration of toxic chemicals with each new link in the food chain. For example, a pesticide sprayed on vegetation can concentrate in the fat of animals and fish that eat vegetation and then is further concentrated in the fat of meat and fish eaters, resulting in an overall biomagnification of the chemical.

Boundaries: Spatial boundaries are set on the basis of the geographical limits of project impacts. Temporal boundaries deal with the timing and the life span of the impacts arising from the project. Jurisdictional boundaries refer to the legal requirements to which the project must adhere.

Calcination: The act or operation of calcining – i.e., burning or incinerating (something) to ashes or powder.

Canadian Environmental Assessment Agency: Federal government organization that administers the *Canadian Environmental Assessment Act* and reports directly to the Minister of the Environment.

Carboxyhemoglobin: The compound formed in the blood when inhaled carbon monoxide combines with hemoglobin, thereby restricting the amount of oxygen that the blood can carry; the resulting condition is known as carboxyhemoglobinemia.

Case-control study: (Syn: case-referent study, case comparison study) A type of observational analytical study. Enrolment in the study is based on the presence (“case”) or absence (“control”) of a disease of interest. Histories of previous exposures to some suspected risk factor(s) are then compared between cases and controls, controlling for potential “confounders.” Causal factors should occur more frequently among cases than among controls.

Central agency: Component of government playing a key role in the successful formulation and implementation of government policies and programs by overseeing interdepartmental mechanisms of information-sharing, consultation, and coordination. In the case of the Canadian federal government, the Privy Council Office, Treasury Board, and the Department of Finance are its central agencies.

Chronic (toxicity): The adverse effects manifested after a long period of uptake of small quantities of a toxicant. The most serious manifestation of chronic toxicity is carcinogenesis, but other types of chronic toxicity are also known (e.g., reproductive and neural effects).

Clastogenic: Causing chromosome breaks and aberrations.

Cohort: A well-defined group of people who have had a common experience or exposure and who are then followed up after entry in the cohort (e.g., date of hire, date of birth, date of moving into a neighbourhood) for the incidence of new diseases or events, as in a cohort or prospective study. A group of people born during a particular period or year is called a birth cohort.

Cohort study: (Syn: follow-up, longitudinal, or incidence study) A type of observational analytical study. Enrolment in the study is based on membership in a "cohort" and on exposure characteristics. Disease, death, or other outcome rates are ascertained over the follow-up period and are compared between different exposure subsets of the cohort.

Confounding: The undesired mixing of effects of extraneous risk factors with the main effect of the targeted risk factor(s). The influence of cofactors (e.g., smoking) biases (distorts) the observed main effect of interest (e.g., dusts and lung cancer). Confounding is usually controlled for by multivariate analysis and other statistical adjustment techniques.

Conjunctival congestion: Congestion of the conjunctiva, the mucous membrane that covers the front of the eyeball and the inner surface of the eyelids.

Cost-benefit analysis (benefit-cost analysis): The principal analytical framework used to evaluate public expenditure decisions. It attempts to evaluate a project before it is undertaken to help stakeholders (in the case of environmental assessment) and decision-makers determine in what form and at what scale it should be undertaken, and indeed whether it should be undertaken at all. Cost-benefit analysis involves the following steps: 1) identification of the project or projects to be analysed; 2) enumeration of all project impacts, both favourable and unfavourable, present and future, on all members of the public (e.g., a community) if a particular project is adopted; 3) valuation of these impacts in monetary terms (favourable impacts are registered as benefits, and unfavourable impacts as costs); and 4) calculation of the project's net benefits (total benefits minus total costs).

Country foods: Foods that are harvested by hunting, trapping, or fishing; and produce such as that grown in vegetable gardens and orchards or collected from naturally occurring sources (e.g., wild berries).

Creatinine: A constituent of urine produced by the breakdown of creatine (a compound found chiefly in the muscles of vertebrate animals, which is involved with supplying energy for voluntary muscle contraction); also found in blood, muscle, plants, soil, etc.

Cross-sectional study: (Syn: prevalence study) An observational study in which the presence of exposure and the presence of disease (or other health-related variables) are ascertained simultaneously at the time of the study. Participants are sampled irrespective of their disease or exposure status. While being less expensive than others, such studies have little statistical power, i.e., few cases and few people exposed. They are best used to describe prevalence of diseases or exposures in a population.

Cryptosporidiosis: A gastrointestinal infection caused by the enteric protozoan *Cryptosporidium*, usually through waterborne transmission and resulting in symptoms of gastroenteritis. The most common sources of this protozoan include domestic animals (e.g., cattle, sheep), contaminated recreational waters, drinking water treatment systems, and well and spring water.

Decibel (dB): A unit for measuring the relative intensity of sounds, equal to 1/10 of a bel. The decibel scale used for this measurement is logarithmic, with every 3-dB increase indicating a doubling of noise intensity. The term dBA is the dB sound pressure level filtered through an A filtering network to approximate human hearing response at low frequencies. The decibel is also used to describe levels of sound power and is the logarithm of sound power level. A two-fold increase in the power output of a source will result in a 3-dB increase in power level and correspondingly a 3-dB increase in sound power level at any distance from the source. Sound power level will be reduced 6 dB for every doubling of distance from a source.

Decision-makers: Persons (e.g., cabinet ministers, senior officials, regulatory authorities, etc.) who help determine if a project should be permitted to proceed.

Determinants of health: Interacting factors that influence the health status of individuals and populations and that determine health differentials and inequalities. These factors are many and varied and include biology and genetic endowment, income and social status, social support networks, education, employment and working conditions, physical environment, personal health practices and coping skills, healthy child development, and health services. These determinants of health are interlinked, and differentials in their distribution lead to health disparities in a given population.

Distributional analysis: An economic analytical technique that evaluates the distribution of project impacts across segments of the economy. For example, an economic impact analysis might examine the impacts of a project on the revenues and profits of particular industries or on employment in those industries. Economic impact analysis can help to identify the segments of the economy within the local region that stand to gain or lose from a project's development and can also help to predict the likely distribution of impacts between geographic regions.

Dose: In the context of this volume, dose refers to the contaminant intake from the consumption of a food and is measured in units of µg/kg body weight per day. It is the product of the mean of the levels of the contaminant of potential concern found in the food (C_f in µg/g) and the rate of consumption of the food (IR_f, in g/day), divided by body weight (BW, in kg); i.e., Dose = $C_f \times IR_f$ / BW.

Dyspnea: Difficult or laboured breathing.

Ecological bias and fallacy: The relationship observed between variables at an aggregate level in an ecological study does not necessarily represent the relationship that exists at an individual level. This phenomenon is said to result from an ecological bias. Inferring that the relationships at the individual level are the same as those observed at an aggregate level is called the "ecological fallacy" (an error of inference due to failure to distinguish between different levels of organization). One must be extremely careful in making inferences or generalizations about individuals based on ecological studies.

Ecological risk: The toxicological risk to an ecosystem.

Ecological study: (Syn: aggregate study, correlational study) A type of observational study in which the units of observation are populations or groups of people rather than individuals. The question asked is: Do geographical populations with a higher occurrence of a specific exposure tend also to be those with a higher occurrence of health outcomes or mortality? In ecological studies, data on aggregate measures (averages or rates) of exposure and of health outcomes are obtained for each "ecological unit of analysis" (i.e., geographically and chronologically defined populations), and the relationship between the summary exposure and outcome measures is analysed across ecological units. Ecological studies are often a preliminary step in investigating a suspected exposure-outcome relationship, particularly in the investigation of environmental health impacts, and the results from these studies should be confirmed by cohort, case-control, or cross-sectional studies.

Ecosystem: A biological community of interacting organisms and their physical environment.

Endocarditis: Inflammation of the endocardium (i.e., the smooth membrane that lines the cavities of the heart).

Endospore: 1) The inner coat or wall of a spore of certain plants; endosporium; 2) a spore formed within a cell of certain bacteria.

Endotoxin: A toxic substance that remains inside the organism (e.g., bacteria) that produces it. Endotoxins are cell wall components of Gram-negative bacteria and are inherently toxic and can lead to various problems, but this occurs mainly when they are present in very high concentrations or when the microorganisms that produce them are viable.

Enterobacteria: Intestinal bacteria, especially those belonging to a large family of rod-shaped coliform bacteria that includes the genera *Escherichia* (e.g., *E. coli*) and *Klebsiella*.

Enterotoxin: An intestinal toxin produced by certain bacteria that causes symptoms of food poisoning.

Environment: Refers to the components of the Earth and includes: 1) land, water, and air, including all layers of the atmosphere; 2) all organic and inorganic matter and living organisms; 3) the social, economic, recreational, cultural, spiritual, and aesthetic conditions and factors that influence the life of humans and communities; and 4) a part or combination of those things referred to in 1) and 3) and the interrelationships between two or more of them.

Environmental assessment: A comprehensive and systematic process designed to identify, analyse, and evaluate the environmental effects of a project in a public and participatory manner. Environmental assessment involves the use of technical experts, research and analysis, issue identification, specification of information requirements, data gathering and interpretation, impact prediction, development of mitigation proposals, external consultations, and report preparation and review. In this Handbook, the term "environmental assessment" is used synonymously with "environmental impact assessment," "impact assessment," etc.

The International Association for Impact Assessment defines environmental impact assessment as the process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made.

Environmental assessment practitioner: Someone who is involved in the environmental assessment process (i.e., government employee, knowledgeable person in the environmental assessment field, etc.).

Environmental audit: An internal evaluation by a company or government agency, to verify its compliance with legal requirements as well as its own internal policies and standards. It is carried out by either outside consultants or employees of the company or facility from outside the work unit being audited. Audits can identify compliance problems, weaknesses in management systems, or areas of risk. The findings are documented in a written report.

Environmental effect: Any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the *Species at Risk Act*; and including any effect of any such changes on health and socioeconomic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by Aboriginal persons, or on any structure, site, or thing that is of historical, archaeological, paleontological, or architectural significance.

Environmental epidemiology: The application of epidemiology to suspected environmental health problems. It seeks to determine whether a link exists between diseases or health outcomes and environmental factors. Environmental epidemiological studies are used to assess the health status of populations exposed to suspected environmental sources of pollution and to identify potential health problems; to identify more vulnerable subgroups within environmentally exposed populations; to assess the health risks or effects of environmental exposures; and to assess the contribution of environmental factors to suspected environmental diseases, deaths, or other health conditions.

Epidemiology: The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.

Equity assessment: An economic technique that examines the distribution of project impacts on different segments of society – i.e., across a range of demographic variables, such as income group, race or ethnicity, age, gender, and others. Equity assessments are often designed to provide information on how a project is likely to affect groups that are significantly disadvantaged (e.g., low-income households) or particularly vulnerable to adverse impacts (e.g., children or the elderly).

Erysipeloid: 1) An infectious disease, resembling erysipelas (an acute infectious disease that causes fever and chills and a rapid spreading, deep-red inflammation of the skin, caused by streptococcus), but not attended with fever, contracted by people who handle animals infected with erysipelas; 2) an acute or chronic bacterial disease of hogs, and less commonly of turkeys and sheep, characterized by enteritis, red patches on the skin, and arthritis.

Eutrophication: The accumulation of nutrients in lakes and other bodies of water, causing rapid growth of algae, which deplete the water of oxygen.

Experimental study: A study in which the investigator specifies (ideally by random allocation) the exposure category for each individual (clinical trial) or community (community trial), then follows the individuals or community to detect the effects of the exposure. Only therapeutic and preventive experimental studies can ethically be conducted on human individuals or communities. Hence, epidemiological studies conducted under health impact assessments rely on "observational" and not on experimental epidemiological studies.

Exposure ratio (ER): Also termed the Hazard Index, it is the ratio of the dose (i.e., contaminant intake from food consumption, in µg/kg body weight per day) and the toxicological reference value (TRV, also in µg/kg body weight per day) for a specific contaminant; i.e., ER = Dose/TRV.

Fetotoxic: Toxic to the fetus or embryo.

Fluorosis (dental): A disease condition characterized by a mottled tooth enamel and caused by the ingestion of excessive amounts of fluorine in drinking water. Fluorosis negatively affects tooth development, particularly in children less than six years of age, and, on a longer-term basis, leads to osteoporosis.

Genotoxic: Toxic to the genetic material (i.e., genes, made up of DNA) in an organism's cells.

Genotoxic carcinogens: Cancer-causing agents that are toxic to the genetic material (i.e., genes made up of DNA) in an organism's cells.

Giardiasis: An infection caused by the protozoan parasite *Giardia lamblia* and characterized by a form of gastroenteritis known as beaver fever. This enteric pathogen is the most commonly implicated agent in waterborne disease outbreaks in North America and other parts of the world. A waterborne outbreak often occurs as a result of human or animal fecal contamination of a water supply. Natural hosts include beaver, muskrat, and deer.

Government departments/ministries or agencies: The federal, provincial, and/or territorial government institutions partaking or providing guidance in the environmental assessment.

Health: Defined by the World Health Organization as a complete state of physical, mental, and social well-being and not merely the absence of disease or infirmity. Consistent with this definition, health has been defined in this Handbook in terms of its physical and sociocultural dimensions. "Health and well-being" is synonymous with this definition of "health" and has been used to emphasize the inclusion of physical health and sociocultural well-being. The Aboriginal definition of health is "obtaining and maintaining a balance of all aspects of the self – mental, emotional, spiritual, and physical – with and through the help and involvement of the family and the community."

Health impact assessment: A combination of procedures, methods, and tools by which a policy, program, or project may be judged as to its potential effects on the health of a population and the distribution of those effects within the population (see: http://www.who.int/hia).

Health professional: A person who has formal education and/or experience in how the environment and other factors can affect human health and well-being. This includes professionals in the medical field (i.e., doctors, nurses, epidemiologists, toxicologists, etc.), professors and experts in the social science field, and the occupational health and safety experts in government and industry.

Health promotion: The process of enabling people to increase control over and improve their health; and the combination of educational and environmental supports for actions and conditions of living conducive for health. "Environmental," in this context, usually refers to the social, political, economic, organizational, policy, and regulatory circumstances bearing on health and not the physical environment or the provision of medical services.

Helminthes: Parasitic worms.

Hepatitis: 1) Inflammation of the liver; 2) a contagious viral disease characterized by inflammation of the liver, fever, and usually jaundice. Infectious hepatitis is known as hepatitis A, and serum hepatitis as hepatitis B.

Hepatotoxic: Toxic to the liver.

Histological diagnosis: Medical diagnosis based on the analysis of the microscopic structure of the tissues and cells of animals and plants.

Immunosuppression: Suppression of the immune system. Immunosuppression may result from certain diseases such as AIDS or lymphoma or from certain drugs such as some of those used to treat cancer. Immunosuppression may also be deliberately induced with drugs, as in preparation for bone marrow or other organ transplantation to prevent the rejection of the transplant.

Incidence rate ratio: A measure of effect, the incidence rate ratio is the incidence rate of the health outcome in the exposed group relative to the incidence rate in the unexposed group. The incidence rate ratio is usually the preferred measure of effect because it accounts for duration of exposure and follow-up time for each member of the cohort(s).

Indigenous health impact assessment: The health impact assessment methods and approaches identified by indigenous communities in Canada. Indigenous health impact assessment is based on three concepts: 1) indigenous communities rely heavily on naturalized knowledge systems; 2) health impact assessment is very closely linked to environmental impact assessment; and 3) health impact assessment as a process depends on measurement and evaluation of health indicators, and indigenous communities themselves must develop their own specific community health indicators.

Leachate: Any substance that has undergone leaching – i.e., the dissolving out of soluble parts from, for example, ashes, ores, or other matter – by running water or other liquid through slowly; a substance subjected to the action of percolated water. The contaminated water or leachate in landfill sites is a complex, highly variable mixture, consisting of various organic and inorganic compounds and microorganisms. It is generated by precipitation or by other moisture that enters the landfill from the breakdown of organic matter or from ground water. It is generally characterized by a strong odour and dark brown colour and contains high levels of pollutants.

Life Indicators Wheel: An important part of the indigenous environmental assessment process, the Life Indicators Wheel holds that community health depends on some balance of the corporal and spiritual “opposites” and of the intellectual/visceral. Community life indicators (i.e., values, morale, responsibility, spirituality, economics, environment, politics, and religion) are represented on the perimeter of the wheel. The health of the community is the balance point in the centre of the wheel, and community health indicators are developed from one-on-one links across the centre (i.e., environment-morale, economics-values, politics-responsibility, and religion-spirituality). The Life Indicators Wheel and community health indicators reflect and support the values of cultural sustainability of traditional First Nations societies.

Lipopolysaccharide: A compound formed by a lipid (a type of fatty substance; includes fatty acids, oils, waxes, and steroids) and a polysaccharide (a complex sugar); e.g., bacterial lipopolysaccharides.

Meta-analysis or Bayesian approaches: Statistical methods used in the benefit transfer process to derive values from the study case and apply them to the project case, and which combine estimates from several studies of similar effects; the resulting estimates may be more accurate and reliable than point estimates or valuation functions. Meta-analysis can be used to integrate the results when many relevant studies are available; the Bayesian approach includes data on the project case as well as data from existing studies.

Methemoglobin: A compound that can be formed from nitrates and nitrites and that restricts or prevents transportation of oxygen by the blood, resulting in a condition known as methemoglobinemia. Ingesting water containing more than 10 mg/L of nitrates can, in the long term, promote methemoglobin formation.

Mitigation: The elimination, reduction, or control of a project’s adverse environmental effects, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation, or any other means.

Mucocutaneous irritation: Irritation of the mucous membranes of the skin (e.g., the lining of the nose, throat, and other cavities of the body that are open to the air; tissue containing glands that secrete mucus; mucosa).

Multifactorial: Having many contributing causes, as in, for example, the context of disease risks.

Multiple myeloma: A very painful cancer usually affecting a number of bones, originating in bone marrow, and causing lesions of the bone and of certain soft tissues such as the kidneys.

Myeloma: A malignant tumour of the bone marrow.

Myocarditis: Inflammation of the myocardium, the muscular part of the wall of the heart.

Naturalized knowledge systems: This term is used in various contexts and generally refers to traditional indigenous or Aboriginal knowledge. A key element of indigenous health impact assessment, naturalized knowledge systems are bodies of ideas, values, and concepts that social systems use to function within their environment. This process is dynamic and cumulative – i.e., it adapts itself to new technological and socioeconomic conditions as they emerge. Naturalized knowledge systems are based on the principles of respect, equity, and empowerment. They focus on the understanding of the importance of the environmental knowledge of First Nations communities and the complexity of traditional approaches to environmental systems. Naturalized knowledge systems link the observation and appreciation of the physical world with the philosophy and attitudes created and supported by the close interaction among the environment, health, and lifestyle.

Neoplastic: Having to do with a neoplasm – i.e., a new, abnormal growth of tissue, such as a tumour.

Nephrotoxic: Toxic to the kidneys.

Net efficiency criterion: Decision-making within the context of benefit-cost analysis depends on the net efficiency criterion – i.e., in any choice situation, one selects the alternative that produces the greatest net benefit. In some cases, of course, the net benefits of all alternatives evaluated may be negative – i.e., their costs outweigh their benefits; in such cases, the best alternative is to do nothing, which produces a net benefit of $0.

Neuroendocrinological system: The physiological system having to do with the nervous system and the endocrine glands (i.e., the glands that secrete hormones directly into the blood).

Neurotoxic: Being or caused by a neurotoxin; toxic to the nervous system.

Observational study: A class of epidemiological studies that are "observational" in nature, and where nature is allowed to take its course. Changes or differences in one characteristic are studied in relation to changes or differences in others, without the intervention of the investigator. There are four types of observational studies: 1) cohort; 2) case-control; 3) cross-sectional; and 4) ecological. Each study design has its own economic and scientific advantages and disadvantages.

Occupational hygiene: Generally defined as the art and science dedicated to the anticipation, recognition, evaluation, communication, and control of environmental hazards or stressors in, or arising from, the workplace that may result in injury, illness, or impaired well-being of workers and/or members of the community. These hazards or stressors can be biological, chemical, physical, ergonomic, or psychosocial. Occupational hygiene also deals with the assessment of the extent of risk posed by the hazards and the development of effective strategies to eliminate or control the risks (risk management).

Occupational hygienist: An occupational health professional with expertise in the anticipation, recognition, evaluation, communication, and control of environmental hazards in, or arising from, the workplace that may cause injury, illness, or impaired well-being of workers and/or members of the community. These hazards can be biological, chemical, physical, ergonomic, or psychosocial. The International Commission on Occupational Health uses the term "occupational health professional" to encompass occupational health physicians and nurses, occupational hygienists, ergonomists, and safety specialists (see: http://www.crboh.ca).

Odds ratio: The standard measure of effect used in case-control studies. The odds ratio is a measure of association that quantifies the relationship between an exposure and health outcome in a comparative study; also known as the cross-product ratio. In incidence case-control studies, the odds ratio approximates the incidence rate ratio.

Oocyst: A thick-walled structure in which sporozoan zygotes develop.

Opportunity cost: Represents the value of goods and services that society loses by forgoing allocation of a resource to its best alternative use. While market prices generally reflect opportunity costs, adjustments may be necessary in certain instances – e.g., when the size of a project is so substantial that it may actually influence the market price of a resource.

Organoleptic: Using various sense organs to determine flavour, texture, or other quality.

Osteoporosis: A disease in which the bone spaces or Haversian canals become enlarged and the bones become weak and brittle. It occurs especially in elderly people, causing bones to break easily and heal slowly.

Osteosclerosis: An abnormal hardening and increased density of bone, especially at the ends or outer surface, often caused by an infection or a tumour.

Paresthesia: An abnormal sensation of prickling, tingling, or itching of the skin.

PCB congeners: Each polychlorinated biphenyl (PCB) molecule consists of two six-carbon rings with one chemical bond joining a carbon from each ring. Chlorine can attach to any of the other 10 carbons. There are 209 possible arrangements called “congeners”; congeners with the same number of chlorines are called isomers. PCB molecules with the two rings in the same plane (i.e., the two rings are not twisted) are termed “coplanar.” Coplanar molecules have dioxin-like properties. There are currently 13 PCB congeners listed by the World Health Organization with interim toxic equivalent factors for human intake of dioxin-like PCBs. The potential toxicity of various PCB mixtures present in the environment varies, depending on the composition of the PCB mixture.

Pericarditis: Inflammation of the pericardium, the membranous sac enclosing the heart.

Perinatal: Of or having to do with the period of a child’s life including the five months preceding birth and the first month after birth.

Prevalence ratio: The prevalence of a specific health outcome in an exposed group relative to its prevalence in an unexposed group; i.e., a comparison of two groups in terms of prevalence of the specific health outcome.

Product life cycle analysis: Analysis taking a “cradle to grave” approach to thinking about products, processes, and services. It recognizes that all product life cycle stages (extracting and processing raw materials, manufacturing, transportation and distribution, use/reuse, recycling, and waste management) have environmental and economic impacts.

Project: Any proposed physical undertaking or activity required to undergo an environmental assessment. Most environmental assessment legislation defines the types of development projects subject to environmental requirements.

Proponent: An individual, organization, or company that proposes a development project.

Psychosocial (risk): Of or involving the influence of social factors or human interactive behaviour.

Public: Local residents, environmental groups, Aboriginal people, local businesses, and other citizens. Does not include proponents or government departments (see definition of stakeholder).

Putrescible: Likely to putrefy or rot.

Pyrolysis: Chemical decomposition produced by exposure to high temperatures.

Randomized controlled trial: The ideal experimental epidemiological study design, in which individuals are randomly assigned to different preventive or therapeutic interventions and are then followed prospectively to assess any differences in outcomes between the intervention ("test") groups and the control group(s). Such randomization tends to make study groups comparable in every respect that can affect the outcome. Most often, randomized controlled trial studies are conducted "blind" – i.e., participants do not know which treatment/exposure they are receiving. Ideally, randomized controlled trials are "double blind": neither the participants nor the observers (including caregivers) know which treatment/exposure is given to whom until the end of the trial.

Receptor: Refers to the human population residing in the development/remediation project area that may be exposed to potential contaminants from the consumption of country foods. In those cases where no communities exist near the project site, receptors can be humans who frequent the area to gather country foods.

Recommended maximum weekly intake (RMWI): In the context of food consumption, it is the product of the toxicological reference value (TRV, in µg/kg body weight per day) for a specific contaminant and body weight (BW, in kg), divided by the mean of the levels of the contaminant of potential concern found in the food (C_f, in µg/g); multiplied by 7 (i.e., days in a week); that is: RMWI (in g/week) = $(TRV \times BW/C_f) \times 7$.

Regional public health authorities: Provincial/territorial or regional government bodies with responsibility to address public health concerns (e.g., Medical Officers of Health).

Relative risk: (Syn: risk ratio) A ratio of the risk of some health-related event such as disease or death among the exposed group to the risk among the unexposed group. This measure is usually used in cohort studies, and sometimes in cross-sectional studies. It is sometimes used as a synonym for "odds ratio" or "incidence rate ratio" if the disease is "rare" (i.e., incidence rate <10%).

Revealed preference methods: Economic valuation methods that are based on observed behaviours that can "reveal" the values of non-market goods based on prices and preferences for related market goods or services. Revealed preference methods include wage-risk studies, cost-of-illness studies, and averting-behaviour studies.

Risk assessment: The qualitative or quantitative estimation of the likelihood of adverse effects that may result from exposure to specified health hazards or from the absence of beneficial influences. Risk assessment attempts to calculate or estimate the risk to a given target system following exposure to a particular substance, taking into account the inherent characteristics of the substance of concern as well as the characteristics of the specific target system. The process includes four steps: 1) hazard identification, 2) dose-response assessment, 3) exposure assessment, and 4) risk characterization (see: http://www.who.int/health_topics/risk_assessment).

Risk management: A decision-making process involving considerations of political, social, economic, and technical factors with relevant risk assessment information relating to a hazard so as to develop, analyse, and compare regulatory and non-regulatory options and to select and implement the optimal decisions and actions for safety from that hazard. Essentially, risk management is the combination of three steps: 1) risk evaluation; 2) emission and exposure control; and 3) risk monitoring.

Septicemia: Blood poisoning, especially in which microorganisms and their toxins enter the bloodstream.

Silviculture: The cultivation of woods or forests; the growing and tending of trees as a branch of forestry.

Social impact assessment: The process of analysing, monitoring, and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions. Its primary purpose is to bring about a more sustainable and equitable biophysical and human environment. Social impact assessment is a project planning and decision-making tool that describes the social context within which development projects are undertaken; assesses, in advance, the social impacts of a policy, program, or project on affected communities; and proposes mitigation measures to avoid, reduce, or compensate for the impacts. Social impact assessment also identifies those groups at risk or at benefit and, when possible, the extent of the impacts (see: http://www.iaia.org).

Social learning theory: Supports the ideas that people self-regulate their environments and actions and, though people are acted upon by their environments, that they also help create their surroundings.

Sociosanitary: Of or having to do with social health and well-being; favourable to social or public health. Issues such as public water supplies, sewage systems, air pollution, and radiation controls – as in the construction of dams, pipelines, incinerators, and the like – are examples of sociosanitary issues.

Spatial (scale): Of or concerning space; a geographical analytical scale for the assessment of health impacts. The zone of influence in a spatial scale varies depending on the nature of the exposure to a risk factor. For example, the zone affected by the effluent produced by a smokestack is different from the area affected by noise. When studies are based on official maps and related attributes, sometimes massive but poorly detailed scales (e.g., 1:500 000) are used, which provide a means of "overlooking" certain fragile areas or historical sites and also serve to reduce impact study costs. The Inter-American Development Bank now stipulates minimum scales (e.g., 1:50 000) for these studies in order to avoid such problems.

Sporulation: The formation of or conversion into spores or sporules (small spores), e.g., as in certain protozoa.

Stakeholder: Any individual, organization, or company that has an interest, financial or otherwise, in a project. Types of stakeholders commonly associated with environmental assessments include the proponent, government departments, local residents, environmental groups, Aboriginal people, local businesses, and others (see definition of public).

Stated preference methods: Economic methods used in valuating health effects and that typically employ survey techniques and ask respondents to state what they would pay for the anticipated reduction in adverse health effects (or what they would pay to avoid unfavourable health effects). These methods can be used to directly valuate the development project of concern and to assess the values for specific effects. Stated preference methods include contingent valuation, conjoint analysis, and risk-risk trade-offs.

Strategic environmental assessment: The systematic and comprehensive process of assessing the environmental effects or implications of a proposed strategic decision or action, policy, plan, program, and its alternatives. At the same time, strategic environmental assessment is the process of integrating the concept of sustainability into strategic decision-making. A good-quality strategic environmental assessment process informs planners, decision-makers, and affected public on the sustainability of strategic decisions, facilitates the search for the best alternative, and ensures a democratic decision-making process. This enhances the credibility of decisions and leads to more cost- and time-effective environmental assessment at the project level. For this purpose, a good-quality strategic environmental assessment process is integrated, sustainability-led, focused, accountable, participative, and iterative (see: http://www.iaia.org).

Stressor: Any stimulus that produces stress or strain.

Surveillance system: A systematic, ongoing process whose components are data collection, expert analysis and interpretation, and response (communication of information for action).

Sustainable development: Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Temporal (scale): Of or concerning time. In the context of health impact assessment, "temporal" refers to an analytical scale relating to the time scale for the assessment of health impacts. For example, on a temporal scale, toxicity can be variously described as acute, chronic, or even transgenerational. Therefore, it is important to specify desirable spatial and temporal scales for every significant risk. Scale determination is crucial and can exert a considerable influence on the perceived importance of a pollution problem.

Teratogen: A substance (e.g., a drug or other agent) that causes birth defects or malformations of the embryo or fetus.

Teratogenicity: The quality of being teratogenic, i.e., the tendency to cause malformations of the embryo or fetus or birth defects.

Tetany: A condition characterized by muscle spasm or prolonged contraction of a muscle.

Threshold limit values: The most universally accepted occupational exposure limits, established by the American Conference of Governmental Industrial Hygienists.

Occupational exposure limits are not “ideal” or “target” workplace levels, but rather the current maximum acceptable (airborne) levels of contaminants. In the case of occupational exposure limits adopted by regulation, they are legal maxima. Even in situations where exposures are below the occupational exposure limits, the former should be reduced to the lowest practical levels on a matter of principle.

Time-weighted average: A time-weighted average is the “average” exposure over the working day. The time-weighted average numerical limits that are listed assume that there is an 8-hour exposure. If worker exposure occurs over a longer period and/or there is not a 16-hour period between exposures, then adjustments may have to be made to these values from a legal standpoint and/or to conform to fundamental toxicological principles.

Toxicity: The ability of a substance to produce deleterious or adverse effects in the exposed organism.

Toxicological reference values: Reference values indicating the toxicity of specific contaminants and used for risk assessment purposes. Toxicological reference values are established by appropriate agencies and are used to determine the human health risks associated with exposure to contaminants in the development/remediation project area. For example, toxicological reference values specific to food-borne contaminants and approved by Health Canada are preferable for the assessment of human health risks posed by contaminants in country foods.

Toxicological risk analysis: The determination of the probabilities and magnitude of potential toxic effects due to exposure to xenobiotics or to ionizing radiation.

Transboundary environmental impacts: Typically refers to a local source of pollution that causes environmental impacts across political perimeters.

Transgenerational (toxicity): Toxicological effects occurring in the offspring of the exposed organism.

Trihalomethanes: A class of chemical organic compounds that are chlorination by-products formed when organic matter naturally present in surface water reacts with the chlorine added during the disinfection process (chlorine treatment of drinking water).

Uremia: An abnormal condition resulting from the accumulation in the blood of waste products that should normally be eliminated in the urine. Nephritis (inflammation of the kidneys) is a frequent cause of uremia.

Valuation of health effects: An assessment of the monetary value of the health effects of a development project. If a project is expected to have a favourable effect on human health, the benefit should be valuated by gauging individuals' willingness to pay for the anticipated reduction in adverse effects. Similarly, if a project is expected to have unfavourable health effects, then individuals' willingness to pay to avoid these effects should be added to the project's cost. By valuating health effects in this manner, economic analysis can integrate such impacts into a benefit-cost framework.

Zoonosis: Any of various infectious diseases that can be transmitted under normal conditions from animals to humans (e.g., tuberculosis, rabies).

Notes: