Chapter 4 – Risk Assessment and the Precautionary Principle

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4.1 INTRODUCTION

The various governmental agencies – provincial, federal and inter-governmental – described in Chapter 3 are responsible for setting standards, guidelines and policy on matters regarding environmental contamination. At issue in this study is whether or not these standards and guidelines, and the policies used to establish them, adequately account for (or in the past, accounted for) the health of children in Ontario. It is clear from the review in Chapter 2 that some environmental pollutants are affecting children's health and many other pollutants place children at risk. The level of uncertainty as to the extent and severity of these risks is significant. Yet the potential exists for both very large numbers of children to be affected and for the increased incidence of typically rare but very serious or even fatal health effects.

To continue this review, the present chapter begins with an historical look at standard setting approaches. Although there are different approaches to standard setting, the underlying framework for most of them is risk assessment.[1] This chapter focuses on a description and evaluation of risk assessment in order to determine how and to what extent the health concerns outlined in Chapter 2 are addressed. This focus on risk assessment is also necessary to appreciate and evaluate the detailed standard setting explored in subsequent chapters, including the two case studies. The setting of standards for air quality (Chapter 5), toxic substances (Chapter 6), consumer products (Chapter 7), lead (Case Study #1), and pesticides (Case Study #2), have all relied upon and increasingly rely upon the application of risk assessment. As noted in Chapter 1, the choice of focusing on standards for air, toxic substances, consumer products and pesticides was made to scope a large inquiry and to focus on areas most relevant to children's health in terms of known or suspected avenues of increased risk.

An evaluation of the health effects of environmental contaminants and of standard setting approaches also requires an appreciation of key issues surrounding interpretation of scientific evidence. Section 4.3 of this Chapter, the Science Behind the Assessment, explores these issues in depth. The chapter then focuses on recent examples of standard setting that recognize the increased risks to children of environmental contamination.

The review of risk assessment in this chapter takes a close look at the situation in the United States. This review is necessary for two reasons. Much of what is applied in Canada, both in absolute terms in the adoption of specific standards and in methodological terms in the development of risk assessment and risk management disciplines, comes from the United States. This situation is increasingly true due to efforts to achieve harmonization of standards under the terms of international trade agreements. To understand the application of risk assessment in Canada requires an understanding of the U.S. approach. Moreover, the Canadian Pest Management Regulatory Agency (PMRA) has stated that its pesticide re-evaluation process will borrow heavily from the ongoing pesticide re-evaluation process occurring in the United States. Since pesticides and children are of significant concern in both countries and the subject of a detailed case study herein (Case Study #2), the choice was made to focus this review of risk assessment in the United States on the implementation of the *Food Quality Protection Act* of 1996.

Finally, the shortcomings and challenges posed by risk assessment are contrasted to a review of the Precautionary Principle or a precautionary approach to standard setting.

[1] For brevity the term risk assessment is used in this introduction to include risk assessment and the related procedure of risk management. The two terms and their variations are defined further below.

4.1.1 Standards and Standard Setting

For the purposes of this discussion, the term "standard" includes any regulatory limit, including a full ban, on chemical or metal substances emitted to the environment. Since children's exposure to toxic substances occurs via numerous environmental pathways but also via manufactured goods, (such as paint, children's toys, plastic mini-blinds, etc.), this review of standards includes consumer products. Since pesticides are not environmental contaminants in the same sense as most but are toxic substances that are intentionally released into the environment, this review also includes the approval process for the use of pesticides.

The term "standard setting" refers to the various processes by which these regulatory limits or standards are set or the use of pesticides is approved.

The focus is on what can be called "health-referenced" standards, or those standards that are derived through an evaluation or estimation of the human health effects of the contaminant in question. Other types of standards can include "environment-referenced" standards where the evaluation process concerns environmental or ecological effects. Often, of course, a consideration of both health and environmental factors is included in a standard setting exercise. Another category is a "technology-referenced" standard, such as a limit on air or water emissions based on the "best available technology economically achievable," or BATEA. While this latter approach may set standards that are based solely on what is technically and economically achievable, it is generally the case that such standard setting occurs due to a prior understanding or concern about environmental or health imperatives or usually both.

As discussed more fully throughout this Chapter, the derivation of "health-referenced" standards during risk assessment includes both an estimation of exposure and an evaluation of health effects. An alternative approach to health-referenced standards is to eliminate the exposure assessment component and establish standards based on "inherent hazard" or "inherent toxicity." Advocates of this approach see it as a means of fast-tracking inherently toxic contaminants towards their ultimate elimination via regulatory phase-down if necessary but ultimately towards a total phase-out. This approach is discussed further in Section 4.5 below with respect to implementation of a precautionary approach to standard setting.

4.1.2 "Safe" Levels, Safety Factors, Threshold and Non-Threshold Effects

The history of standard setting approaches is one of increasing complexity of techniques mostly preoccupied with the establishment of "safe" or "acceptable" levels of contaminants. In some early cases, evidence of environmental persistence and/or harm in humans or wildlife was used in many industrialized countries as justification for banning outright some chemicals (e.g., the pesticides DDT and mirex and the entire class of chemicals known as PCBs). These early decisions to ban substances were examples of standards that recognized the "inherent toxicity" of the substances in question. More often however, evidence of harm was only suspected, difficult or impossible to prove, and hotly contested by the industries responsible for the contamination. As Section 4.3 below explores in detail, drawing inferences of causality in environmental health matters is extremely difficult. The "cautionary tale" of lead, described in Case Study #2, illustrates all of these aspects of standard setting. Over more than thirty years, lead standards have been constantly revised (up to and including a ban on lead additives in gasoline), as evidence of harm increased and within an adversarial climate of stiff industry opposition to regulation.

Early approaches to standard setting intended to protect human health from environmental exposure to

chemicals took a variety of forms. In many cases, health effects from toxic substances would be more or less understood due to their use and control in occupational settings. These occupational standards would have been derived from animal testing as well as knowledge of health effects among occupationally exposed workers. Somewhat arbitrarily, standards for environmental exposure might have been set at 10 times or 100 times the level considered safe in an occupational setting. This notion of using multipliers or "safety factors" in order to set standards for chemical exposures at levels 10 times, 100 times, etc., lower than the level where health effects are known or detected continues to be a key aspect of ever-more refined standard setting approaches to this day.

The application of safety factors, implying that safe levels of exposure are achievable, has been a key foundation from which risk assessment has grown. Indeed, the practice of setting standards based on a scientific determination of an "acceptable" level of risk developed since the 1970s largely as a substitute for bans or phase-outs of chemicals. However, with greater understanding of the mechanisms of toxicity of certain classes of chemicals, the notion of "inherent toxicity" has arisen, or has perhaps been revived, whereby substances are identified as toxic without the need for scientific determinations of harm. Substances that are considered inherently toxic are those that, by virtue of their molecular structure, are persistent and bioaccumulative and for which risk-based standards cannot establish "safe" levels of exposure. Other inherent characteristics may also justify classification of chemicals as inherently toxic such as very high acute toxicity, ability to cause endocrine disruption, probable human carcinogen, and neurotoxic or developmental neurotoxic effects. These distinctions are central to key aspects of the precautionary approach to standard setting discussed in Section 4.5 below, in Chapter 6 and the Pesticides Case Study.

Standard setting in both occupational and environmental settings also has often included making a distinction between chemicals for which a threshold is or is not apparent. In other words, in the case of chemicals with a threshold, the evaluation (using animal studies or the results of occupational exposure, accidents, etc.) determines the lowest point, or threshold, at which a health effect is detected. These threshold levels are called the Lowest Observed Adverse Effect Level (LOAEL). Lower limits are also calculated where no health effects are discernable. Also called the No Observed Adverse Effect Level (NOAEL), regulatory limits for human exposure to chemicals with threshold effects are often set by applying safety factors (typically between 10 and 1000) to NOAELs derived from animal studies.

Of course, considerable debate has occurred over whether or not health effects in fact do occur below these thresholds. Again, the example of lead is one where the threshold for adverse effects has been progressively lowered (see e.g., Figure 8.2 in the Lead Case Study) from occupationally derived standards steadily downward to a point where there is increasing agreement that, for some health effects, there is probably no safe level of lead in young children.

In the case of non-threshold chemicals, investigations are not able to discern any level or threshold below which certain effects (often called the most sensitive effect or the critical effect) do not occur. Such health effects are often various forms of cancer. The long history of the study of asbestos provides one of the best examples of a chemical for which no threshold is apparent. Regardless of a historical progression towards lower and lower levels of asbestos exposure, occupationally exposed individuals consistently experience excess rates of cancer.[2] For non-threshold effect chemicals, the safety factor applied has often been higher such as 1000 times the lowest dose where cancer has been seen to occur. Or, more typically for carcinogens, the safety factor approach is replaced by the use of mathematical models that assume a linear dose-response relationship. Using these models, a standard is set with the intention of ensuring that there is only a one-in-a-million chance for the cancer to occur across an exposed population often assuming a 70-year or "lifetime" exposure period.

[2] See review in Epstein, S. *The Politics of Cancer, Revisited*. East Ridge Press, 1998, pp. 54-68.

4.2 RISK ASSESSMENT AND RISK MANAGEMENT

4.2.1 Definitions

Since at least the mid-1970s, the still-evolving system by which these standards for threshold and non-threshold chemicals have been set has included *risk assessment* and *risk management.* Terminology and definitions have varied over time and in different countries and experts disagree on how "risk" and related terms should be defined. The Canadian Standards Association (CSA) has developed a series of definitions for a range of terms and these are reproduced in Figure 4.1.

Figure 4.1: Risk Management Definitions According to the Canadian Standards Association[3]

Hazard: a source of potential harm, or a situation with a potential for causing harm, in terms of human injury, damage to health, property, the environment, and other things of value, or some combination of these.

Hazard Identification: the process of recognizing that a hazard exists and defining its characteristics.

Risk: the chance of injury or loss as defined as a measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value.

Risk Analysis: the systematic use of information to identify hazards and to estimate the chance for, and severity of, injury or loss to individuals or populations, property, the environment, or other things of value.

Risk Assessment: the overall process of risk analysis and risk evaluation.

Risk Communication: any two-way communication between stakeholders about the existence, nature, form, severity, or acceptability of risks.

Risk Control Option: an action intended to reduce the frequency and/or severity of injury or loss including a decision not to pursue the activity.

Risk Estimation: the activity of estimating the frequency or probability and consequence of risk scenarios, including a consideration of the uncertainty of the estimates.

Risk Evaluation: the process by which risks are examined in terms of costs and benefits, and evaluated in terms of acceptability or risk considering the needs, issues, and concerns of stakeholders.

Risk Management: the systematic application of management policies, procedures, and practices to the tasks of analyzing, evaluating, controlling, and communicating about risk issues.

Risk Perception: the significance assigned to risks by stakeholders. This perception is derived from the stakeholders' expressed needs, issues, and concerns.

In the United States,[4] a slightly different set of definitions exists. Several of these are provided for

[3] Canadian Standards Association, *Risk Management: Guidelines for Decision-Makers* (CAN/CSA-Q850-97), July, 1997.

[4] Source for the three definitions and four-step framework for EPA risk analysis described in this section: Congressional Research Service (CRS) Report 98-618, *Environmental Risk Analysis: A Review of Public*

comparison to those developed by the CSA and because they underlie the United States Environmental Protection Agency (EPA) approach to be discussed in detail below. They are also the most relevant and useful for a discussion of health-referenced standards.[5]

In the context of the EPA approaches to standard setting, *environmental risk assessment*, can be defined as:

> Any formal or informal scientific procedure used to produce a *quantitative* estimate of environmental risk. For example, risk assessment is often used to estimate the expected rate of illness or death in a human population exposed to a hazardous chemical based on the number of experimental animals affected by various doses of the chemical as measured in laboratory experiments.

Environmental risk analysis is defined more broadly to include:

> Any *quantitative* or *qualitative* scientific descriptions of an environmental hazard, the potential adverse effects of exposure, the risks of these effects, events and conditions that may lead to or modify adverse effects, populations or environments that influence or experience adverse effects, and uncertainties with regard to any of these factors.

There is an underlying four-step process within risk assessment and risk analysis that originated in the United States during the late 1970s. Much has happened since this basic framework was established, as this Chapter discusses in detail, but the four steps remain relevant today. They include:

Hazard identification: determining whether a particular chemical causes a particular health effect.
Dose-response assessment: determining the relationship between magnitude of exposure and probability the health effect will occur.
Exposure assessment: determining the extent of exposure before or after application of regulatory controls.
Risk Characterization: describing the nature and often the magnitude of risk, including attendant uncertainty.

Finally, *risk management* is the policy making step. To complete the set of definitions from the U.S. approach, *risk management* can be defined as:

> The process of deciding what should be done about a hazard, the population exposed, or adverse effects, implementing the decision, and evaluating the results. Decision makers may consider social, political, economic, legal, ethical, and engineering information as well as scientific risk estimates in choosing among available risk management options. Risk management decisions often require value judgements on such questions as "What level of risk is acceptable?" and "What level of expenditure is reasonable?"

Policy Issues. 40 p., Appendix. July 15, 1998. (Hereinafter: CRS Report 98-618.) Part VIII, Appendix, pp.3-4. Available at: www.cnie.org/nle/rsk-11g.html.

[5] Note that there are many areas where risk assessment and risk management are applied including the setting of standards, environmental assessment and planning decisions, remediation of contaminated lands or hazardous waste sites, and many non-environmental settings as well. Approaches and frameworks differ in each of these areas and this study is only concerned with risk assessment and management with respect to the setting of standards. For an overview of a variety of risk assessment and management frameworks, see: Dyck, W, *et.al.*, *Current Directions in Environmental Risk Assessment and Management*, Network for Environmental Risk Assessment and Management (NERAM), February, 1999. Available at: www.neram.ca.

4.2.2 Towards a Consistent Approach

Techniques for evaluating hazards and measuring risks pre-date the environmental and health concerns that became the subject of policy and legislation in the late 60s and early 70s. Early techniques were developed often for engineering and/or insurance purposes (risk of death, chance of floods, etc.) and were subsequently borrowed and adapted to assess environmental risks. Several different agencies within the U.S. government, often regulating the same industries for different purposes, developed their own techniques for assessing risk and devising regulatory standards. Predictably, different conclusions were reached by agencies with different mandates. Such differences were understandable given the level of complexity and inherent uncertainty involved in making risk calculations. Much criticism resulted.[6]

A first step towards coordinating risk assessment procedures was to establish an Interagency Regulatory Liaison Group (IRLG). Five different agencies were ultimately part of the ILRG including the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the Consumer Product Safety Commission (CPSC), the Food and Drug Administration (FDA), and the Food Safety and Quality Service of the Department of Agriculture. The ILRG focused on cancer risks and in 1979 proposed a "cancer policy" to coordinate risk analysis and risk management across their members respective agencies and within the constraints of the statutes each administered. The agreement reached among these agencies included a consistent approach for cancer risk assessment procedures. In particular, the proposed policy included a consistent approach to the choice of "inference options" or "default assumptions" that need to be applied throughout risk assessment in order to compensate for gaps in data and scientific theory and methodology. Although a first step towards addressing the problem of inter-agency differences in risk assessment procedures, as well as getting a grip on the many assumptions inherent in the process, the proposed policy was condemned by many as allowing policy prescriptions to influence scientific judgements.

The ILRG was disbanded in 1981 and the U.S. Congress turned to the National Academy of Sciences to address both the substance of risk assessment procedures and the issue of interagency coordination. The result was a pivotal study that had a far-reaching influence on risk assessment practices. *Risk Assessment in the Federal Government: Managing the Process*[7] reviewed the various agencies practices and found the institutional arrangements to be basically sound. It recommended a framework for cancer risk assessment which has continued to be refined to the present day. Additional key recommendations included the need to separate risk assessment from risk management (along the lines of the definitions noted in Section 4.2.1 above) and to develop risk assessment guidelines for the federal government as a whole.

The report also identified the many gaps in both data and theory that exist in risk assessment. It identified at least 50 "inference choices" that are necessary during cancer risk assessment that cannot be made on a scientific basis. Herein lies the central criticism of risk assessment that has been part of an extensive and vocal critique, mostly championed by environmental organizations at least since the NAS report was published. The list in Figure 4.2 provides some examples of the inference choices or subjective judgements that are necessary during risk assessment. Despite the many inherent and fundamental limitations of risk assessment identified, the NAS report nevertheless concluded that risk assessment

[6] Historical account summarized from: CRS Report 98-618, Part II (available at www.cnie.org/nle/rsk11a.html) and Part VII (available at www.cnie.org/nle/rsk11f.html).

[7] National Academy of Sciences, *Risk Assessment in the Federal Government: Managing the Process*. Washington, D.C., National Academy Press. 1983.

required refinement, (through the development of detailed guidance documents), not replacement.

Figure 4.2 : Some Subjective Judgements in Risk Assessment[8]

What kinds of evidence are needed to demonstrate carcinogenicity?
How important are toxicity studies that show an effect relative to studies that show no effect?
How are benign and malignant tumours in animals counted?
What are the appropriate dose levels for experiments?
How should animal doses be compared to human doses?
How should animal effects be compared to human effects?
Are the effects observed at high doses expected to occur at low doses?
Should different chemical carcinogens be treated differently?
How should carcinogenicity be compared to mutagenicity? To birth defects?

The NAS report contributed to increasing consistency and coordination in risk assessment approaches across the various agencies.[9] It also led to amendments in 1990 to the *Clean Air Act* which established a Risk Assessment and Management Commission, also more recently called the Presidential/Congressional Commission on Risk Assessment and Risk Management. This group ultimately concluded that detailed interagency guidelines were not possible given different departmental mandates. It recommended a general framework instead which was published in 1997.[10]

Among all the agencies, EPA has consistently taken the lead in developing and revising risk assessment guidelines. EPA was the first to propose an interim guideline for its cancer risk assessments in 1977. Using the framework proposed in the 1983 NAS report, EPA finalized its guideline for cancer risk assessment in 1986.[11] This guideline also included early consideration of developmental risks (from chemicals that can cause mutations or damage to human development) and guidance on assessing exposure (to both individual chemicals and chemical mixtures). Subsequently, a revised guideline for developmental risks was published in 1991[12] and for exposure in 1992.[13] During the late 1990s these guidelines have continued to be revised and additional guidance documents have been developed in response to new requirements flowing from the *Food Quality Protection Act* of 1996 (discussed further in Section 4.4 below).

[8] Source: Adapted from Rushefsky, M. *Making Cancer Policy*. Albany, N.Y. State University of New York Press, 1986, p.40, as cited in CRS Report 98-618, Part VII (available at www.cnie.org/nle/rsk11f.html).

[9] For example, the NAS risk assessment framework was adopted by the White House Office of Science and Technology Policy in 1985. Subsequent documents contained similar government-wide guidance including the "Regulatory Impact Analysis Guidance" contained in the 1991-1992 *Regulatory Program of the United States*, the 1994 *Draft Principles for Risk Assessment; Management, and Communication* and the 1996 Office of Management and Budget report, *Economic Analyses of Federal Regulations Under Executive Order 12866*. See more detailed review in CRS Report 98-618, Part II.

[10] The Presidential/Congressional Commission on Risk Assessment and Risk Management. *Framework for Environmental Health Risk Management.* Final Report, Volume 1, 1997, and *Risk Assessment and Risk Management in Regulatory Decision-Making*, Final Report, Volume 2, 1997.

[11] *51 Federal Register* 33992-34054, Sept.24, 1986.

[12] *56 Federal Register* 63798-63826, Dec.5, 1991.

[13] *57 Federal Register* 22888-22938, May 29, 1992.

4.2.3 The "Delaney Paradox"

The continuing acceptance, and indeed frequent insistence by industry, of risk assessment for the setting of environmental standards, faced a fundamental problem in the United States with the so-called "Delaney clause" in the U.S. federal *Food, Drug and Cosmetic Act*.[14] This clause, named after the Congressman who had been its author in 1958, prohibited FDA approval of any food additive found to cause cancer in animals or humans. This clause set up a conflict between the FDA in its approval process for food additives and the EPA, responsible for approving pesticides. A federal appeals court ruling in 1992[15] stated that an EPA finding of cancer-causing pesticide residues in processed foods would be a violation of the Delaney clause. This case forced the U.S. government on the road to choosing between weakening the Delaney clause or banning cancer-causing pesticides. They ultimately chose the former.

The Delaney paradox was resolved in favour of risk assessment. The "zero cancer risk" policy demanded by the Delaney clause was clearly at odds with the commercial interests of pesticide manufacturers and such a policy, if applied more broadly, also was not supported by other corporations wanting to continue releasing carcinogenic chemicals to the environment. It was also dismissed as the product of an earlier time when scientific techniques were considered crude.[16] Advocates of risk assessment pointed to the need to use "good science" that could determine levels of "safe" or so-called *de minimus* or "negligible" risk; levels so low that there would be, according to the risk assessors, no cause for concern. These low levels of risk are the one-in-a-hundred-thousand, or one-in-a-million or one-in-ten-million risk levels that are established using risk assessment techniques for incorporation into environmental standards.

4.2.4 Science or Pseudo-Science?

Although risk assessment is routinely described by its proponents as an objective, fact-based scientific activity, it is not, and probably never will be.[17] While it can provide a generally reliable means of predicting acute effects from high dose exposures, it falls far short in the most important area of environmental concern: chronic effects from long-term, low dose exposure. As for assessing the real-world situation of exposure to and the interactive effects of multiple chemicals in the environment, it fails miserably. There are simply too many uncertainties inherent in the process in terms of 1) basic insufficiency of data; 2) lack of methodologies for key steps in the process; and 3) the difficulty of reproducing or ensuring consistency and equal levels of professionalism and expertise across highly

[14] *Federal Food, Drug, and Cosmetic Act (FFDCA),* 21 U.S.C. 301 (1996).

[15] Les v. Reilly, 968 F.2d 985 (9th Cir. 07/08/1992).

[16] There was an extensive, multi-year debate over the Delaney Clause with environmental advocates often insisting on its retention and industry equally opposed to its rigidity. In *Our Children's Toxic Legacy*, (Yale University Press, 1996, p. 282) John Wargo argues that the Delaney Clause was unreasonable because: 1) it applies only to a small portion of pesticides, those that are carcinogenic and concentrate during food processing, and neglects other health effects; 2) scientific evidence supports the claim that some compounds pose cancer risks that approach zero, but are not definitively zero and forcing these compounds off the market may cause more risky substitutes to be used; 3) uncertainty in cancer studies often is substantial due to reliance on animal studies; 4) the costs of achieving a zero risk pesticide environment are enormous and difficult to justify given the possibilities of reducing other types of more certain health risks at lower costs; and 5) the clause has caused scarce regulatory resources to be disproportionately devoted to manage cancer risks rather than other types of effects such as neurological and reproductive damage.

[17] CRS Report 98-618, Part II. See also: Congressional Research Service Issue Brief for Congress No. 94036: *The Role of Risk Analysis and Risk Management in Environmental Protection*. November 5, 1999. Available at: www.cnie.org/nle/rsk-1/html. (Hereinafter: CRS Issue Brief No. 94036.)

complex analyses.[18] Moreover, the presentation of results and their incorporation into policy decisions, the risk management extension of the exercise, is equally subject to the value judgements and guesswork that are central to the "science" of risk assessment.

Just looking at cancer risk assessment, which is, arguably the most well developed and reliable of any form of risk assessment addressing chronic health effects, several important points can be made that challenge the notion that risk assessment is objective, fact-based and "good science." Recall that the NAS 1983 report identified at least 50 "inference choices" that are necessary during a cancer risk assessment that cannot be made on a scientific basis, many of which directly influence the policy choices made about the chemical under investigation.

The conclusion of the NAS study was, as previously noted, the need to develop better risk assessment guidance documents and to continually improve the database upon which risk assessment depends. The result over time has been a steady increase in the sophistication of risk assessment procedures, particularly with respect to cancer. However, the amount and significance of inference choices has not changed very much. Rather, because of a long-term focus on cancer as the most serious of a variety of possible chronic health effects, a great deal of research has been conducted on whether and at what dose, chemicals contaminants can cause cancer. There also have been a lot of cancer risk assessments conducted and revised in light of new and emerging information as well as increasing agreement about key areas where judgement calls are made (including the many areas noted in Figure 4.2).

The result of all of this work in cancer risk assessment has been a reduction in the range and variability of risk estimates but not necessarily a reduction in cancer risk. On the contrary, cancer risks have very likely increased as this chemical by chemical approach has proceeded and devised one-in-a-million cancer risk estimates for hundreds of different chemicals. The result in terms of cancer risk is 100s-in-a-million and perhaps even thousands-in-a-million. The actual risk level is not one-in-a-million since each chemical is assessed separately and considered in isolation from any other cancer risks that may exist from either similar or dissimilar cancer-causing or potentially cancer-causing chemicals in the environment. Nor has cancer risk assessment been conducted on more than a mere handful of chemicals by comparison to the many tens of thousands of chemicals in commercial use for which almost no toxicological information exists at all (as described and referenced in Chapter 1).

This numbers game is particularly abhorrent to those who criticize the ethics of risk assessment (discussed further below). Another way of describing the risk result of this chemical by chemical assessment and generation of "negligible" risk estimates, is to think in terms of even just ten substances with a one-in-a-million excess cancer risk (two very conservative assumptions). This situation would work out to a risk level of ten in a million or one-in-one-hundred-thousand (10/1000000 = 1/100000). For risk assessments conducted at the one-in-one hundred thousand risk level (and there are many; even at a one-in-ten thousand level), the number gets even worse, i.e., 10/100000 = 1/10000 and 10/10000=1/1000. Risk assessment proponents would rightly point out that these simple calculations incorrectly assume that all exposures are additive. Although each person could be exposed to each and every one of the ten chemicals at the exposure levels assumed, such additive exposure may not be the case. Nevertheless, risk assessment proponents would never advocate that 1/1000 or one-in-a-thousand is an "acceptable" risk of cancer from environmental exposure to contaminants. Taking these calculations further, if the number of carcinogens being released is more than 10, (an entirely reasonable assumption), the risk level continues to increase. If excess deaths due to other mechanisms (non-cancer) from these chemicals are added, the risk number is worse yet. And such calculations still have not accounted for synergistic effects or inter-

[18] See for example, the error in dust exposure calculations in Health Canada's risk assessment for plastic mini-blinds, as discussed in Chapter 8, Section 4.6.4.

generational effects. In other words, no matter how much the individual risk assessment process is refined, it is still counting trees and missing the forest in terms of real risks to people.

The long period of time during which cancer research and risk assessment has occurred also contributed to a situation where carcinogenicity was, and to a considerable extent still is, heavily relied upon as a surrogate measure for any chronic health effects. This situation resulted in the near total exclusion in risk assessments of other less understood and less studied effects such as reproductive, neurological or neurodevelopmental effects, or immunological and endocrine effects. Notably, these other potential effects are particularly relevant to children's health.[19]

Other central criticisms of the scientific shortcomings of risk assessment include the fact that uncertainties and errors can result from:

- *small population generalizations* – i.e., when extrapolations are made from high concentrations of chemical exposures in small populations to predict health effects in large populations exposed to lower concentrations of the same chemical.
- *generalizations from animal studies to human health* – i.e., when extrapolations are derived from animal studies (both high dose, short term exposure and low dose, long term exposure) to predict human health effects.
- *ignoring background sources* – i.e., the tendency to ignore or be unaware of background sources of exposure to chemicals affecting people or ecosystems leading to exceedances of threshold values established through risk assessment.
- *ignoring multiple chemical exposure* – i.e., the inability of risk assessment to accommodate real world situations of multiple chemical exposures of varying dose and duration or to assess the possible cumulative or synergistic effects of such multiple exposures.
- *the "healthy white male" as the norm* – i.e., the tendency to exclude the most sensitive segments of the population from calculations of risk by not including a wide enough margin of safety (and even assuming safe levels are known or knowable).
- *major limitations in animal testing* – i.e., the fact that animal bioassays do not always extend over entire lifetimes, dosing generally begins after weaning, thereby skipping *in utero* and neonatal periods comparable to the first 3-6 years of human life, the complication of the "wasted dose" which is the difference between the lifetime dose and the dose that actually causes disease, and the inappropriate assumption that negative results in animal bioassays indicate safety for humans.

The above list is drawn from analyses published mostly during the early 1990s.[20] Within the above list, it

[19] Note however that considerable work has continued in the development of additional risk assessment guidance documents for these other health effects. However, despite the existance or evolution of guidance for the evaluation of these other effects, they may not necessarily inform the risk assessment process if they are not part of "core testing" requirements. This matter is discussed further in Section 4.3.1 below with respect to concerns about endocrine disrupting effects at vulnerable periods of very low dose exposure and with respect to the use of developmental neurotoxicity tests.

[20] See for example: Benbrook, C.M., *et.al.*, Consumers Union, *Pest Management at the Crossroads*. (Consumers Union of the United States, New York, 1996) Chapters 3 and 4; Chess, C. and D. Wartenberg, The Risk Wars: Assessing Risk Assessment, *New Solutions* 3(2) (1993), pp.16-25; Chociolko,C., The Experts Disagree: A Simple Matter of Facts Versus Values?, *Alternatives* 21(3) (1995); Costanza, R. and L. Cornwell, The 4P Approach to Dealing with Scientific Uncertainty, *Environment* 34(9) (1992); Ginsberg, R., Quantitative Risk Assessment and the Illusion of Safety, *New Solutions* 3(2) (1993), pp. 8-15; Gregory, M., Pesticide Reform in Arizona: Moving Beyond Risk Assessment and Clean-up to Exposure Prevention, *Arizona Toxics Information*, (1991); Gregory, M., Some Unacceptable Risks of Risk Assessment, *Pesticides and You*, Spring (1995), p.14-16; Gutin, J., At Our Peril: The False Promise of Risk Assessment,

is important to note the difference between the first two points and the final four. For the first two, there is no way around the need to make such generalizations and extrapolations. Problems of uncertainty, variability, error, and gaps in data will exist but inferences have to be drawn from the information that such studies can provide (as described further in Section 4.3 below). The final four points however are shortcomings of a different kind. They represent problems of fundamental gaps in information and methodology to assess both real-world exposure and actual risks to sensitive populations or life stages. While refinements in risk assessment continue and have begun to address some of these shortcomings, many fundamental limitations remain. The work within the United States EPA to implement the *Food Quality Protection Act* is particularly illustrative of this ongoing debate (as discussed in Section 4.4 below).

Uncertainty, variability, error and large gaps in basic data and methodology occur in two of the four risk assessment steps described in Section 4.2.1 above. Of the four steps: hazard identification, *dose-response assessment, exposure assessment*, and risk characterization, the second two (in italic) are especially difficult due to a basic lack of both critically important scientific and/or empirical data and assessment methodologies. Even when risk assessors are considering a single chemical at a time, basic scientific and/or empirical data and methodologies are lacking to be able to calculate exposure and a dose-response relationship. Of course, this problem is greatly magnified when considering multiple exposures and the chance of cumulative or synergistic effects.

To illustrate,[21] risk assessors simply do not know exactly (or in some cases even remotely) how much of a pesticide (or a group of pesticides) makes up a child's exposure. They do not know whether the adverse effect levels detected in laboratory experiments on rats or dogs are comparable, or even approach the range of possible adverse effects in a human fetus, infant, child or adolescent. To be able to carry through to the risk characterization step and assign exposure and dose-response numbers for incorporation into a risk management strategy such as setting a standard for exposure or permitting the use of a pesticide, gaps are filled by the "inference choices" noted above. Also called "science policy choices" or "default assumptions," these gaps in critically important scientific and empirical data and methodologies are filled by what is essentially guesswork. It may be the product of "best guesses" or "informed guesses" or "the informed judgement of experts" but it is still guesswork, not science.

Nor is it simply a matter of doing more research or spending more money to fill in these gaps. It is certainly true that more research can and does eliminate data gaps and uncertainty. Improvements in methodology can also reduce the broad range in risk estimates that risk assessments can generate. However, the enormity of the data collection task is formidable. According to one risk assessment expert and advocate, "toxicologists know a great deal about a few chemicals, a little about many, and next to nothing about most."[22] Further, the key methodological gaps are even less easy to fill and proposals for addressing them are controversial as Section 4.4.3 below explores in more detail.

Greenpeace Magazine, 16(2) (1991); Highland, J., *Risk-Benefit Analysis in Regulatory Decision-Making*, Toxic Chemicals Program, Environmental Defense Fund, undated; O'Brien, M., Alternatives to Risk Assessment, New Solutions 3(2) (1993), pp.39-42; Smith, C., K. Kelsey, and D. Christiani, Risk Assessment and Occupational Health: Overview and Recommendations, *New Solutions* 3(2) (1993), pp.26-38; Thornton, J., Getting Burned: Risk Assessment is the Real Threat to the People Who Live Near Toxic Waste Incinerators, and Risking Democracy, *Greenpeace Magazine* 16(2) (1991), p.15 and p.17.

[21] Adapted from example in: Risk Assessment –Part 2, Judge Breyer's Prescription for Risk, *Rachel's Hazardous Waste News*, #394, June 16, 1994. See also: *Rachel's Hazardous Waste News* Part 1, The Emperor's Scientific New Clothes, #393, June 9, 1994; Part 3, Which Problems Shall We Ignore?, #395, June 23, 1994; and The Ethical Hazards of Risk Assessment, #519, November 7, 1996.

[22] Rodricks, J., *Calculated Risks*. Cambridge University Press, New York (1992), p. 192.

Finally, and perhaps most fundamentally, the assigning of individual risk levels for each chemical is essentially a game of odds that cannot address two of the most serious issues of toxic chemical pollution: inherent toxicity and population-wide effects such as may be occurring with endocrine disrupting chemicals. Risk assessment enables risk calculations that allow for "acceptable" levels of one-in-a-million or one-in-ten-thousand risks (of cancer, birth defects, etc.) across a population. However, the odds game becomes useless if further research confirms the suspicion that chemicals such as endocrine disruptors are capable of exerting population-wide effects at current levels of exposure.[23] Nor is it appropriate to make such calculations for chemicals that are persistent and bioaccumulative. Risks will continue to increase for chemicals that do not break down and which accumulate in animal fat, breast milk, etc. Such risks will no doubt affect some people more seriously than others depending on the flow of persistent chemicals through the environment.

4.2.5 Politics, Ethics and Equity

The political and ethical hazards of risk assessment stem directly from the combination of guesswork and science described above. Despite its gaps in basic information and methodologies to implement key steps, risk assessment is enormously complex and the domain of specialized experts. This complexity makes several things possible. Value judgements and questionable assumptions can be concealed. Policy-makers can be manipulated or misled during the political decision-making or risk management phase. An intellectual elite and those wealthy enough to hire them can dominate discussions, the political process and the outcome.

It is not surprising that a methodology that requires the making of frequent "inferences choices," or "science policy choices," or what many consider to be significant and influential value judgements, will raise important issues of ethics and social equity. Commentators frequently note that risk assessment tends to impose risk on those that are often most susceptible to harm, and the least able to confront or resolve the source of harm, including the poor, the elderly, children (including fetuses) and minority groups. Moreover, risks can be imposed on these groups without their consent and under circumstances where those being placed under the highest risk receive little to none of the benefits that result from whatever activity the risk assessment sanctions. As noted above, the political malleability of the process provides the opportunity for those with money and power to influence the outcome.[24]

Two additional ethical issues arise directly from the shaky scientific foundation of risk assessment. First, the vast ignorance about the toxic effects of chemicals leads to each chemical being treated as "innocent until proven guilt." Risk assessment calculations (where these have been done at all) guarantee the granting of a risk level (e.g., the one-in-a-million, also called the "negligible" cancer risk level) or a risk range (between one-in-10,000 and one-in-10-million) for each chemical and often in each medium. Hence risk calculations have customarily been done to establish the one-in-a-million risk level for a chemical in fish, meat, air, drinking water, etc. Although a multi-media approach may be conducted so that a risk assessment accounts for aggregate exposure via different pathways, this may be very difficult, may apply controversial methods or may not occur at all. It is almost certain that aggregating exposure (to ensure lower risk calculations for each individual pathway) did not occur in the past for evaluations of chemicals,

[23] Colborn, T, D. Dumanoski, and J. Peterson Myers, *Our Stolen Future* (Dutton, New York, 1996), see in particular, Chapter 11 (Beyond Cancer) and Chapter 11 (Flying Blind).

[24] See multiple sources *supra* notes 19 and 20, in particular, O'Brien, M. and J. Thornton, *Rachel's Hazardous Waste News*, #519; and se also: Silbergeld, E., The Risks of Risk Assessment, *New Solutions* 3(2) (1993), pp.43-44.

particularly pesticides, that have been in use for a very long time.

This approach of providing a guaranteed risk level for each chemical is exactly that; each chemical is entitled to its one-in-a-million risk level. The human population on the other hand is faced with hundreds if not thousands of these one-in-a-million risk levels (and of course many additional risks remembering that only a relative few chemicals have been assessed). In effect, the chemicals have greater rights than the human population. While each chemical is allotted a one-in-a-million risk level, (or sometimes even higher risk levels), the human population does not have the right to avoid the cumulative risk of real-world exposure circumstances. In addition, some people are more exposed than others. For example, a one-in-a-million risk level may be established for chemicals emitted for particular air emissions or water effluents or leachate from landfills. The risks however can be borne disproportionately by the population living nearby, not the hypothetical population that informed the risk assessment calculation. Even if, as some do, the risk calculations account for the localized circumstances of the exposed population, these are still groups of people disproportionately exposed to toxic chemicals, and this is often the case because they are poor or otherwise disenfranchised from the political decisions flowing from risk calculations.

Similarly, as Chapter 2 and the Pesticides Case Study describe, children are known to be more highly exposed and susceptible to the harmful effects of pesticides than are adults. They are clearly at risk from current exposure levels, and the lion's share of the risk in Canada is probably due to the over 73% of pesticide active ingredients that were not evaluated with children's circumstances in mind. Nevertheless, the fact that the pesticides are approved for use is given as justification by government officials at all levels (federal, provincial and municipal) that the pesticides are safe. Or, if statements by such officials are more accurate and specific, it is stated that risk levels have been calculated and found to be acceptable. Although there is strong evidence to show that children are at risk from current pesticide exposure, risk assessment calculations for approving additional pesticides can proceed regardless and the long overdue re-evaluation of currently approved pesticides continues very slowly within a political and funding backwater.

The second ethical problem with this approach of guaranteeing a risk level to each chemical is that risk assessment has only recently begun to consider health end-points other than cancer. There may in fact be other end-points such as endocrine disruption and neurodevelopmental effects, which may occur at even lower exposure levels or under different circumstances than the cancer risk assessment considered. These other unknown or poorly understood effects have to be assumed to be non-existant. Alternatively, they require the application of default assumptions and there is great uncertainty as to whether these assumptions adequately inform the risk assessment calculations. Further, those chemicals which are unidentified, untested, or otherwise not part of the analysis, (including the real-world situation of complex mixtures of small amounts of chemicals) must also be assumed to be safe as they are simply not part of the risk assessment exercise. Again, the chemicals are given the right to an inherently incomplete risk level calculation; the exposed human population does not have the same right to be exposed to no more than a specific level of risk. Under this ethically slippery construct, it is not surprising that the human population is experiencing a rise in the chronic health effects that toxic environmental contaminants are known or suspected of causing when "one-in-a-million" risk levels are doled out for every chemical that comes along.

The situation is not improved by the fact that the critique of risk assessment, as summarized here, is frequently not accepted by risk assessment practitioners or advocates as valid or worthy of consideration. Instead, it is seen as an unjustified attack on their scientific credentials. This reaction is ironic since what is at issue is the very lack of scientific integrity at key steps within an exercise that otherwise should be, and must be, highly dependent on "good science." A further irony is contained in the position advanced

by industry and the right-wing press,[25] generally in reaction to public concerns about toxic chemicals and insistence on better regulation. These concerns are dismissed as emotional and unscientific. The solution offered is the "objective science" of risk assessment. Like this industry approach, risk assessment practitioners often react to the critique of risk assessment by ignoring it. Instead, their non-self-critical approach is one of essentially pretending that the gaps in data and methodology are insignificant in terms of presenting barriers to continued application of what is, again, seen and described as an objective, fact-based scientific exercise. Such an approach is evident in the document prepared by the Canadian-based Network for Environmental Risk Assessment and Management (NERAM) entitled "*Current Directions in Environmental Risk Assessment and Management.*"[26]

Alternatively, for those risk assessment practitioners and advocates that recognize the scientific limitations of the process, the approach is to accept the level and degree of default assumptions as inevitable and a valid part of the exercise and something that ever more effort at refining techniques will ultimately overcome. In the meantime, they consider the solution to the problem to be a matter of improvements in risk characterization and communication.[27]

Finally, there is a very important distinction to be made between the United States and Canada in terms of the political forces that are brought to bear on risk management decisions due to underlying differences in the legal context in the two countries. This distinction stems from a fundamental difference in the United States whereby property rights are afforded to persons under the U.S. Constitution. Such rights provide persons (and by extension, corporations) in the U.S. with the ability to challenge and constrain environmental regulation (via litigation) in a way that does not exist in the Canadian legal context.[28] Therefore, decisions to harmonize Canadian standards or standard setting approaches with the U.S. may unnecessarily constrain the ability of Canadian regulatory agencies to set protective standards. It should therefore be of serious concern to Canadians if standard setting derived under, and constrained by, a different constitutional context, is borrowed by Canadian regulators who are not similarly constrained. More legal research is needed in this area.

4.2.6 Risk Assessment and Cost-Benefit Analysis

The increasing prevalence of risk assessment and risk management in environmental decision making has been the subject of much debate and controversy. A related trend is the corresponding increase in demands and/or requirements for cost-benefit analysis of environmental decisions. Part of the story of the increasing use of risk assessment and management practices is the fact that risk assessment is often a pre-

[25] See for example: Corcoran, T. The mad voyage beyond zero risk, *Financial Post*, May 8, 1999; and Junk Science, Junk Policy? Managing Risk and Regulation, Fraser Institute Conference, April 29, 1999, Ottawa.

[26] Dyck,W. *et.al.*, NERAM, 1999, *op.cit.*

[27] See for example, Stern, P. and H. Fineberg, (eds) *Understanding Risk: Informing Decisions in a Democratic Society*, Committee on Risk Characterization, Commission on Behavioral and Social Sciences and Education, National Research Council, (1996) 264 p.

[28] See e.g., *Industrial Union Department v. American Petroleum Institute, et.al.,* [1980] U.S.S.Ct. #78-911, 78-1036; 48 LW 5022. In this U.S. Supreme Court case dealing with an occupational benzene standard, brought by the American Petroleum Institute, Mr. Justice Powell, concurring with the majority said, "I conclude that the statute [the *Occupational Health and Safety Act*], requires the agency [the Occupational Health and Safety Agency] to determine that the economic effects of its standard bear a reasonable relationship to the expected benefits . . . It is simply unreasonable to believe that Congress intended to pursue the desirable goal of risk-free work places to the extent that the economic viability of particular industries is threatened . . . [the] regulations would impair the ability of American industries to compete . . . [and] would result in a serious misallocation of resources," p.5038.

requisite when a cost-benefit analysis is done for an environmental matter. Similarly, there is increasing insistence among politicians and industry representatives, particularly in the United States, for the application of *comparative risk analysis,* an approach that evaluates environmental hazards as a group to be able to assign priorities and budget allocations based on relative magnitude of risk. Application of such an approach pre-supposes that a quantitative risk assessment has been conducted for each hazard in the comparison.[29]

A form of comparative risk analysis is apparent in Health Canada's proposed decision-making framework being developed as part of its review of health protection operations. The three-part framework includes: issue identification, risk assessment and risk management. Intended to be comprehensive and consistent across all aspects of Health Canada's mandate, the draft framework focuses on general principles more than the details of risk assessment. The draft framework moves Health Canada towards a "population health approach" to risk assessment and management including a prioritization of risks so that "the most important risks are addressed." The draft speaks of putting risks "in a broad context," and though it is not explicit, there is the danger that, in a time of deregulation and cuts to departments, this will become a way of avoiding assessments and interventions that are thought to be less important. Such prioritization is described in the document as being more accountable for the "wise use of limited resources." Risk prioritization though, often falls into the trap of comparing very different types of risks, natural and human-made, voluntary and involuntary, as if they have the same importance in society. This approach is echoed in the statement that "every choice brings with it some degree of risk and that certain risks are shared by society as a whole."[30] In reality, as discussed above, risks are often unevenly shared in society, and those shouldering much of the burden often have little input into decisions.

Insistence on the evaluation of (readily quantifiable) economic impacts has often served to limit or reduce safety margins for standards derived from evaluation of uncertain (and difficult to quantify) risks. Canadian decisions in the early 1980s on lead in gasoline are a case in point (see Section 8.4.1.2 in the Lead Case Study). As the harmonization of standard setting continues between the U.S. and Canada,[31] the treatment of economic impacts in standard setting becomes increasingly important. Alongside this increased harmonization has been large cuts in staff and resources in both the federal and Ontario governments undermining their ability to create, implement and enforce toxic substance regulation. As discussed for separate departments in Chapter 3 above, between 1994 and 1998, the departments of Fisheries and Oceans, Health, Environment and Natural Resources reduced their scientific personnel by 17%. The departments admitted that these cuts included a reduction in the resources available for the assessment of toxic substances.[32] Deeper cuts have occurred at the provincial level in Ontario. Meanwhile, governments are increasingly contracting out the work of conducting human health risk assessments to private firms that generally see the world through the eyes of their corporate clients. For example, as noted in the Canadian-based Network for Environmental Risk Assessment and Management

[29] For more on this topic see CRS Report 98-618, Parts I, II, III and V, *op.cit.*, and Congressional Research Service, Issue Brief for Congress, *Environmental Risk and Cost-Benefit Analysis: A Review of Proposed Legislative Mandates, 1993-1998*, January 22, 1999. RL30031. Available at: www.cnie.org/nle/rsk-24.html. See also description in Chapter 3 of arrangements reached under NAFTA by the Pest Management Regulatory Agency and the U.S. Environmental Protection Agency.

[30] Health Protection Branch, Health Canada. *Health Canada Decision-Making Framework for Identifying, Assessing and Managing Health Risks, Draft.* (Oct 1, 1999), pp.1,6,18

[31] This increased harmonization is occurring internationally as well and flows from the implementation of international trade agreements, particularly the North American Free Trade Agreement (NAFTA). See information regarding "Trade Negotiation and Agreements" and "Regional and Bilateral Agreements" at www.dfait-maeci.gc.ca/tna-nac/reg-e.asp

[32] Federal Commissioner for the Environment and Sustainable Development. *1999 Annual Report.* s.3.60, 3.61

report addressing the state of risk assessment in Canada: "industry is facing increasing pressure to be competitive in the global marketplace and would prefer a move towards a "risk-based" approach," which would "enable industry and government to set priorities and better focus their resources on high risks that are of greatest concern."[33]

Debate over the use of risk assessment in the context of cost-benefit analysis or in assigning environmental priorities within overall governmental priorities is beyond the scope of this report. Nevertheless this context is important because risk assessment of environmental hazards is considered by its proponents as providing a scientifically sound basis for assisting with broader economic decision making. Such confidence is undermined however, by the fact that central and well-founded criticisms of risk assessment and risk management include evidence of frequently shaky scientific foundations combined with multiple opportunities for value judgements and bias.

4.2.7 Summary

The two disciplines generally known as risk assessment and risk management have developed and been applied for roughly thirty years to the task of regulating toxic substances in the environment. Risk assessment is routinely characterized as the "scientific" stage of the exercise while risk management is considered the policy-making step.

The ever-increasing complexity of risk assessment methodologies has been matched and consistently overcome by the greater complexity of the problems they attempt to address. An underlying four-step process at the heart of risk assessment includes: hazard identification; dose-response assessment; exposure assessment; and risk characterization. The second two of these four steps have consistently suffered from large gaps in data and methodology providing many opportunities for uncertainty, variability and error. Gaps have been filled with "inference choices," or "science policy options," or what critics have accurately labelled as guesswork, not science. For those risk assessment advocates or practitioners who accept this criticism, and many do not, the problem is considered inevitable and insignificant and a key solution is seen as the need to improve techniques of risk characterization and communication.

Important issues of ethics and equity arise since the complexity of risk assessment makes it the domain of specialized experts and those wealthy enough to hire them. The combination of science and guesswork provides numerous opportunities for value judgements and bias to enter risk calculations. Critics charge that risks can be disproportionately assigned to those unable to avoid them (the poor, children, etc.) and who do not share equally in the benefits. Each chemical is treated as "innocent until proven guilty" and chemicals arguably have greater rights than the human population.

When chemicals are assessed one at a time, in isolation from other chemicals, risk levels are assigned regardless of risk levels that already exist or that are yet to be calculated for new chemicals. When risk levels are assigned without accounting for all relevant health effects, or for the cumulative or synergistic effects of chemicals acting in combination, these additional risks have to be ignored and they do not inform the risk calculations. As more and more chemicals continue to have the right to be assigned a risk level (alongside the many thousands of chemicals that have never been adequately assessed), the human population does not have the same right to be exposed to no more than a specified level of risk.

The assigning of individual risk levels for each chemical is also a game of odds that cannot address two of

[33] Dyck, *et.al.*, NERAM, 1999, *op.cit*. p.1.

the most serious issues of toxic chemical pollution: inherent toxicity and population-wide effects such as may be occurring with endocrine disrupting chemicals. Risk assessment enables risk calculations that allow for "acceptable" levels of one-in-a-million or one-in-ten-thousand risks (of cancer, birth defects, etc.) across a population. However, the odds game becomes useless if further research confirms the suspicion that chemicals such as endocrine disruptors are capable of exerting population-wide effects. Nor is it appropriate to make such calculations for chemicals that are persistent and bioaccumulative. Risks will continue to increase for chemicals that do not break down and which accumulate in animal fat, breast milk, etc. These risks will of course be highest for children and other vulnerable populations than for the adult population at large.

The increasing insistence on both cost-benefit analysis and comparative risk analysis as a means of assigning government priorities and budget allocations may perpetuate the inequities that can arise from risk calculations.

4.3 THE SCIENCE BEHIND THE ASSESSMENT – EPIDEMIOLOGY AND CAUSATION

4.3.1 Introduction

Before addressing some specific examples of the application of risk assessment to the special circumstances of children, it is important for this review of risk assessment and the review of children's health effects in Chapter 2 and the two case studies, to address key scientific and methodological issues. Central questions arise as to whether and how causal connections can be shown to exist between exposure to environmental contaminants and health effects in humans.

4.3.2 Sources of Data

Epidemiological studies examine the patterns of occurrence of health problems in different groups of people with the aim of determining causes for such patterns. Epidemiological studies are generally considered an important source of information for evaluating the health risks to humans from exposure to environmental contaminants, particularly for formal risk assessments. The strength of evidence from epidemiologic studies depends upon the quality of information identifying: a) populations at risk;[34] b) an estimate of the level of exposure;[35] and c) a measure of the dose[36] received, and the proportion of the population that exhibits the particular response (i.e., health problem). The degree to which this

[34] Population at risk refers to the group of individuals among whom the particular health problems might be observed, or all people who are susceptible to or could have the disease or health problem (or a representative sample of them (see: Fletcher *et.al.*, *Clinical Epidemiology: The Essentials*. (Williams and Wilkins, Baltimore, 1988). In environmental health studies these would be people who by virtue of their occupation, residence, activities or physiology are exposed to a given environmental chemical.

[35] Exposure refers to "the extent of contact between the toxicant and the surfaces of the human body." See: Roberts, J.R., P.B. Curry, R.F. Willes, M.F. Mitchell, S.Narod and L.C. Neri, Epidemiological evidence of the effects of pesticides on human health in Canada. Monograph II. In: *Strengths and Limitations of the Benefit-Cost Analyses Applied to the Assessment of Industrial Organic Chemicals Including Pesticides*. Associate Committee on Scientific Criteria for Environmental Quality. National Research Council of Canada. NRCC No. 22852 (1985: 1).

[36] Dose refers to "the amount of toxicant in the critical organ or tissue" (Roberts *et.al.*, *op.cit.* 1985: 1).

information is known or characterized depends in large part on the strength of the research design.[37]

4.3.3 Study Design in Epidemiology

Epidemiological studies examining environmental health effects are typically observational. In other words, they observe the effect of various influences that occur by chance (i.e., the so-called "natural experiments"). This observational approach is in contrast to randomized controlled trials (frequently used in drug trials or clinical epidemiology) where, with adequate sample size, blinding of subjects, therapists and researchers, standardized measurement techniques and analysis, the unique effects of a single factor can be studied. Such experimental studies provide the strongest evidence for establishing cause-and-effect relationships, however, when investigating potentially harmful agents epidemiologists do not have this option. For ethical reasons, humans are not subjected to clinical trials of non-therapeutic agents such as pesticides. [However, some pesticide companies have crossed this line in the past and have recently increased the practice of using human "volunteers" to determine NOAELs for their products. This renewed and highly controversial practice is discussed further in Section 4.4.3.2 below.]

Observational studies are the only alternative to experiments but they also vary in their strength and the degree to which they are subject to biases. There are three basic observational study designs including: 1) cohort studies; 2) case-control studies; and 3) ecological studies, in decreasing order of statistical power.[38]

Cohort Studies

Cohort studies examine groups of people who share some attribute, such as, birth year, a particular occupation, or living in a neighbourhood at a certain time. They are also called prospective studies since the direction of research is forward in time. The investigator starts with the defined group or cohort and follows them through time to assess the development of disease or health problems. Researchers compare those who develop disease with those who don't to see which factors vary between the two groups. The cohort study represents the most powerful observational study design having fewer biases and typically with better estimation of exposure. One weakness of cohort studies is that they may need very large sample sizes to adequately detect weak risk associations especially between rare health outcomes, such as cancer, and environmental contaminant exposures. An example of a cohort study is that examining the effects of perinatal exposure to PCBs on neurodevelopment in infants whose mothers ate contaminated fish from Lake Michigan during their pregnancy. The study has followed the developmental characteristics of these children who were exposed to PCBs *in utero* and via breast milk for more than a decade now.[39] Several other examples of cohort or prospective studies evaluating the health effects of lead in children are discussed in Case Study #1.

Case-Control Studies

In case-control (also called retrospective) studies, subjects with (i.e., cases) and without (i.e., controls) a particular health problem are matched to be similar for certain variables such as, age, sex, etc., and are compared for differences in factors such as exposure. In contrast to the cohort study design, this type of study is best suited to, and statistically stronger for, studying rare health effects with a long latency period

[37] Note that b) and c) would correspond to the second two steps of risk assessment noted above, .i.e., exposure assessment and dose-response assessment. The ability of risk assessment to accurately or even adequately deal with these two steps is central to the review of risk assessment in this chapter.

[38] Power refers to the ability of a study to detect an association or a significant difference when one actually exists.

[39] Jacobson, J.L. and S.W. Jacobson, A 4-year follow-up study of children born to consumers of Lake Michigan fish. *J. Great Lakes Res*. 19(1993):776-783.

such as cancer. Because these studies are retrospective, they often rely on the recollection of the subjects for details of past exposure. Accurate estimation of exposure is therefore plagued by the recall bias of subjects which may over- or under-emphasize certain details of their exposure history. They are also vulnerable to selection biases since the comparability of cases and controls rests on the assumption that they have had an equal chance of being exposed to the particular agent. (See Figure 4.3 for clarification of case control studies.) Case-control studies examining environmental causes of breast cancer have compared DDT and DDE levels in breast tissue and exposure histories to assess differences between women with breast cancer and those without.[40]

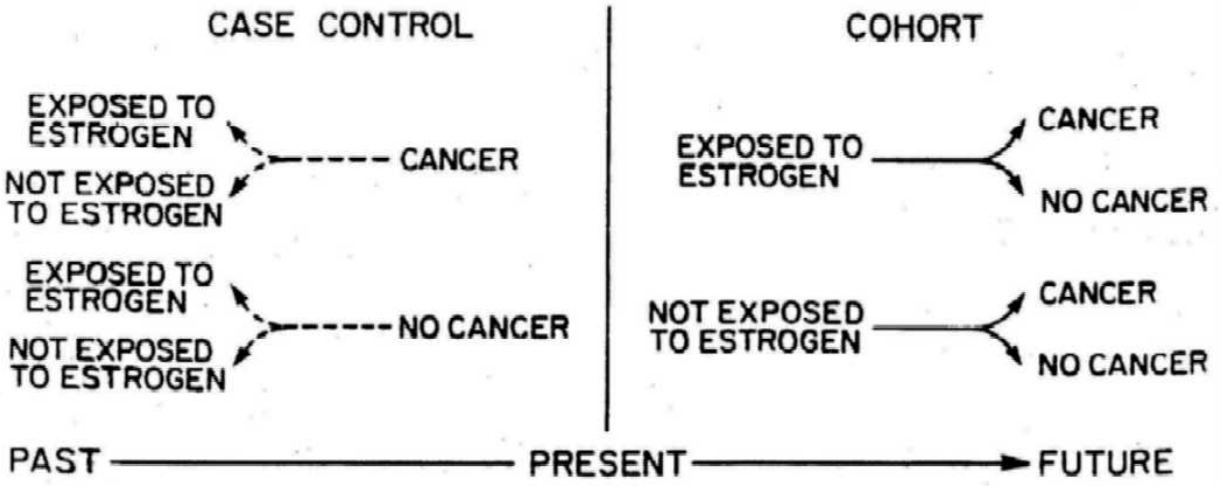

Figure 4.3 A comparison of cohort and case control research: studies of exogenous estrogens as a risk factor for endometrial cancer. (Source: Fletcher, 1988, *op.cit*. p.194).

Ecological Studies

The third type of observational study important in environmental health is the ecological design. Here, the unit of study is the population or community (vs. individuals) and the patterns of health problems and exposures are often tabulated from data (usually cross-sectional) that are already available such as mortality records, cancer registry data, etc. Data are assessed for correlations between disease and various risk factors such as, geographical location, time trends, occupation, social class, etc. (Ecological studies are often characterized as being descriptive as opposed to case-control and cohort studies which are considered analytical.) There have been many epidemiological studies that have shown associations between, for example, difference in breast cancer incidence and differences in diet, or incidence of Alzheimer's disease and levels of aluminum in local drinking water. One ecological epidemiology study has shown an association between possible excess prenatal exposure to pesticides by place of residence and an increase in rates of undescended testes in male infants.[41] Ecological studies represent statistically the weakest epidemiological design. Researchers can calculate those with particular risk factors and the proportions with a particular health outcome, but they cannot prove that the associations are necessarily causal. There is often no control over other factors that may confound or modify or be causing the effects

[40] van't Veer, P., *et.al.*, DDT (dicophane) and postmenopausal breast cancer in Europe: case-control study. *BMJ*, Jul.12, 315(1997)(7100):81-5.

[41] Garcia-Rodriguez,J., M. Garcia-Martin, M. Nogueras-Ocana, *et.al.*, Exposure to pesticides and cryptorchidism: Geographical evidence of a possible association. *Environmental Health Perspectives*, 104(1996):1090-95.

observed. Ecological studies are important however, for initial investigation and generating hypotheses as to possible important associations between environmental factors and health risks. Epidemiologists then rely on inferences from the analytical studies (i.e. cohort and case-control studies) to test hypotheses and to ascertain the statistical confidence in association between exposure and disease incidence.

4.3.4 Inferences of Causality in Environmental Health Studies

A fundamental step in interpreting epidemiological data is evaluating causality of the association between agent and hazard, a process that applies directly to the hazard identification element of risk assessment.[42] It is notably difficult to prove causal relationships in epidemiology. It is often only possible to increase the confidence in a cause and effect relationship observed between two factors. "When experiments are not possible and only observational studies are available, deciding whether something is a cause requires *judgement*, based on all the evidence."[43] Epidemiologists refer to criteria developed by Bradford-Hill in 1965.[44] These criteria for causation include a series of conditions that if met, can increase the confidence that an association is "real" and hence help guide the judgement as to whether a given environmental factor is a cause of disease or adverse health effect. Bradford-Hill's scheme suggests that the important criteria to consider in inferring causality include:

- *Strength of the association* - there should be a significantly higher relative risk of observing the health effect in the exposed versus the unexposed population. In this case, we might assume that such effects are not occurring by chance alone and that the evidence is stronger for a causal relationship between the environmental factor and the health effect. Note that Bradford-Hill stated that one should not too readily dismiss a cause and effect relationship just because the observed association is slight.
- *Consistency* - the association is observed by different people in different circumstances.
- *Specificity of the association* - it may be established that one cause leads to one effect. This criterion is not to be over-emphasized because diseases may have more than one cause.
- *Temporality* - which observed event came first of the associated events. This may be difficult to determine if one is examining cross-sectional data since they do not directly indicate the sequence of events.
- *Biological gradient* - whether there is a dose-response curve if it can be revealed.
- *Plausibility* - consistency with known biology, but Bradford-Hill cautioned that this requirement cannot be demanded because it is dependant on the knowledge of the day and the study may disclose something new. For example, the attention paid to researching the effects of endocrine disruptors on human health has been strengthened by "suggestive evidence of a possible role of man-made chemicals in developmental abnormalities of the reproductive tract."[45]
- *Coherence* - that the cause and effect relationship observed does not seriously conflict with the generally known facts.
- *Reversibility of an experimental/intervention effect* – if possible, it may be shown that

[42] Samet, J.M., R. Schnatter and H. Gibb, Invited commentary: Epidemiology and Risk Assessment. *Am. J. Epid*. 148(1998):929-936.

[43] Fletcher, *et.al.* 1988, *op.cit.*, p.216, emphasis added.

[44] Bradford-Hill, A., The environment and disease: Association or causation? *Proc. Roy. Soc. Med.* 58(1965): 295-300.

[45] Foster, W. Endocrine Disruptors and Development of the Reproductive System in the Fetus and Children: Is there Cause for Concern? *CJPH* 89 *Suppl* 1) (1998): S37-41, S52. S37.

removal of the proposed causal agent is associated with a decreased risk of disease.

- *Analogy* - comparison with another similar drug or disease. For example, the fact that measles causes other de-myelination disorders (subacute sclerosing panencephalitis) has been suggested as evidence for a role of the measles virus in the etiology of multiple sclerosis.[46] Analogy is relatively the weakest argument for causality.

Alongside the above scheme, several additional points regarding inference of causality were raised. First, it is important to remember that hard and fast rules cannot be laid down, and none of the factors individually can answer the question of cause and effect.[47]

Second, with respect to tests for significance, their role is to remind us that the "play of chance" can create certain effects; but that significance tests provide nothing else to the "proof" of the hypothesis. Far too often a conclusion of "no difference" is drawn from a finding of "no significant difference." Decisions in real life must be governed by the seriousness of the consequences - for instance restricting a drug administered to pregnant women on slight evidence, but requiring stronger evidence before forcing lifestyle choices on people.[48]

More recently, it has been suggested that an additional criterion should be added whereby the significance factor is combined with a reporting of the "power" of the statistical test that is used. Reporting the power would assist in preventing "type II" errors: that is to reduce the probability of concluding that there is no effect when that conclusion is in error.[49] To clarify, there are two opposing opportunities for error in making causal inferences from epidemiological studies. Type I errors involve accepting spurious associations as causal. Type II errors involve missing true causal associations. Scientific rigour is more often focused on avoiding Type I errors. This focus ensures that scientific literature is not overly burdened with false claims and that time is not wasted on correcting them. However, this preoccupation with avoiding Type I errors can result in true associations being overlooked.[50]

Further work in understanding the ideas of causation has included examination of the need to replace a paradigm in which the search is for "simple schemes of single causes" with a "scheme of multiple causes", especially in examining ecological causes.[51] While causation analysis needs to be kept arbitrarily simple in order to conduct useful work, a causation analysis is needed that allows for recognition of multiple causes. Two aspects of multiple causation include that one type of exposure or experience can give rise to a myriad of effects or manifestations among those exposed; while a single type of manifestation in different individuals may arise as a result of many diverse exposures or experiences. Such an approach would allow an investigator to begin with either causes or effects. Beginning with a cause might reduce the likelihood of missing the possibility that one cause may give rise to more than one effect. An investigator could begin with one independent variable and search out its effects. This

[46] Fletcher, *et.al.* 1988, *op.cit.*

[47] Bradford-Hill, A. 1965, *op.cit.*

[48] *Ibid.*

[49] Bertell, R., Weight of Evidence versus Proof of Causation, In: *Applying Weight of Evidence: Issues and Practice*, A Report on a Workshop held October 24, 1993. International Joint Commission, June 1994, pp. 27-32.

[50] See for example, with respect to the literature on lead and IQ, a discussion of six flaws in study design or interpretation that have systematically reduced the risk of Type I errors but at the cost of increased risk of Type II errors. In: Needleman, H. and D. Bellinger, The Health Effects of Low Level Lead Exposure, *Annu. Rev. Publ. Health*, 12 (1991): 111-40.

[51] Susser, M., The Logic of Multiple Causes, Chapter 4 in *Causal Thinking in the Health Sciences: Concepts and Strategies in Epidemiology*. (Oxford University Press. 1973), pp. 42-47.

approach is more useful for studying the health of populations, and has application in environmental health studies.[52]

Further refinements have included a pragmatic definition of cause: "a cause is something that makes a difference"[53] and simplification of the Bradford-Hill criteria. Those criteria that are "most useful and least tautologic" in assisting with causal inference are: Strength; Specificity; Consistency; and Predictive Performance.[54] Methodological criteria for judging epidemiologic studies have also been suggested since it may be possible in advance to determine how conclusive a study is likely to be.[55] The "markers" for this purpose include: how certain is it that there has been exposure to a specific toxicant; how accurate is the knowledge of the biologic effects of an exposure on human populations; how specific is the health outcome that is to be measured; and, is there a large exposed population or relatively common adverse health effect to be measured?

From the foregoing discussion, it is important to keep in mind the elements of judgement that make up the "science" of determining causation, regardless of which paradigm is followed. As well, the elements of those judgements are not fixed but evolving as contributing factors become better understood. The implications from these points are further discussed in Section 4.3.7 below with respect to the "Implications for Decision Making and Policy Setting". It is worth remembering that:

> Epidemiologists have come to understand that the data and the assumptions used in sound causal inference and those used in sound decision making are not the same.[56]

4.3.5 Limitations of Epidemiological Studies for Risk Assessment

Direct human evidence is often not available or may be of limited use to risk assessments for a variety of reasons. It is beyond the scope of this report to adequately analyse all the limitations presented when using epidemiological data in risk assessment.[57] However, we can briefly address some of the key issues that limit use of human data for the purposes of assessing environmental health risks. Some methodological or analytical weaknesses of epidemiological studies surround identification of health effects, exposure assessment, and sample size and representativeness.

Accurate identification of health effects is important. For example, different types of cancer represent distinct disease processes and so must be specifically defined. Many health effects of concern (including cancer, respiratory problems and neurological effects) may not appear for long periods following the causal exposure or they may occur as a result of progressive accumulation of damage that doesn't produce

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[52] *Ibid*.

[53] See: Susser, M., *Epidemiology, Health & Society: Selected Papers.* (New York: Oxford University Press, 1987); and Susser, M., What is a cause and how do we know it? A grammar for a pragmatic epidemiology. *Am. J. Epidemiol.* 133(1991): 635-648.

[54] Susser, M., 1991, *op.cit.*

[55] Frank, J.W., B. Gibson, and M. Macpherson, Information Needs in Epidemiology: detecting the health effects of environmental chemical exposures. In: *Information Needs for Risk Management Environment Monograph No. 8,* D.D. Fowle, A.P. Grima and R.E. Munn (eds.) (Toronto: Institute of Environmental Studies, University of Toronto, 1988), pp. 129-44.

[56] Susser, M., 1991, *op.cit.*

[57] For recent critical discussions of the role of epidemiology in risk assessments see sources such as, Samet J.M., *et.al.*. *op.cit.*; and Herz-Picciotto I., Epidemiology and quantitative risk assessment: A bridge from science to policy. *Am.J.Pub.Health* 85(1995): 484-491.

identifiable effects. These types of effects are difficult to associate with a specific exposure with any degree of certainty (because of the time lag) and they are also not easily detected. With "rare" health effects such as cancer, it is also difficult to collect data on a large enough sample. Larger sample size increases the ability (statistical power) to detect real associations between exposure and outcome.

Where those conducting a risk assessment are interested in quantifying dose-response relationships, epidemiological studies are often only able to address the exposure-response relationship, i.e., there is no way of accurately determining what proportion of the amount to which people are exposed actually reaches the body tissues. Even so, risk assessors are also frequently unable to accurately determine the degree of exposure to a contaminant of interest. They can often only infer exposure from job description in occupational studies, or by place of residence or subject recall in exposures of the population at large. In many instances, exposure can only be characterized as a dichotomous variable with subjects designated as either "exposed" or "not exposed." Biological exposure data (for example, measures of contaminants from urine or blood samples) improves accuracy in assigning the dose-response relationship. However, such measurement adds extra expense and logistical problems, especially in large epidemiological studies and is often not an option in retrospective studies.

Another problem of exposure assessment is that there may frequently be multiple exposures from multiple sources. For example, children can be exposed to many different pesticides via contamination of food, drinking water, and home, school and playground surroundings. Children experience exposure to other contaminants as well and via various pathways. Multiple exposures are especially the case for those who are exposed to contaminants in both occupational and environmental settings. For instance, pesticide workers are routinely exposed to several pesticides, and other toxicants such as solvents, emulsifiers as well as "inert" ingredients.[58] This multiple exposure makes it very difficult to attribute observed health effects to exposure to a specific pesticide. A similarly complex picture exists for the children of these workers since they may be additionally exposed to pesticides on their parents' clothing, shoes, etc., or due to living very near to where their parents work. This exposure is in addition to the range of pesticide residues and contamination to which all children are exposed.

Factors other than the exposure of interest may also confound the observations. For example, poor nutrition will enhance the uptake of lead and hence, the lead-based health effects in children. Lastly, the choice of human population samples for epidemiological studies is often opportunistic. As a result there may be inadequate representation of the effects in all population subgroups (the healthy worker effect[59]) especially particularly sensitive ones, such as children or the elderly.

As a consequence of these weaknesses in epidemiological data, risk assessors rely on other types of evidence (such as animal experiments and wildlife studies) which may provide only a prediction of the nature and magnitude of the health effects in humans. However, reliance on wildlife and animal studies alone would also have limitations.[60] It is insufficient for public policy and public protection to focus solely on cancer testing or bio-accumulation. Effects may be produced at extremely low levels, but at extremely sensitive times in the development of embryos. Rather than "the dose is the poison;" the

[58] Roberts, J.R., *et.al.*, 1985, *op.cit.*

[59] In occupational epidemiology if non-exposed workers are the control sample, they are less representative of the general population, since employed people are on the whole, in better health compared to the general population which includes people with a broader range of states of health from poor to good (Roberts, J.R., et al, *op.cit.*, 1985).

[60] Colborn, T.E., A.Davidson, S.N.Green, R.A. Hodge, C.I.Jackson, and R.A.Liroff, Human Health, Chapter 7 in *Great Lakes Great Legacy?* (Washington, Ottawa: The Conservation Foundation and the Institute for Research on Public Policy, 1990).

timing may be the poison. Extremely small amounts of dioxins exposed to the mother at day 15 in a rat's gestation or at day 56 in a human's gestation may irreversibly affect sexual differentiation in the offspring.[61]

4.3.6 Weight of Evidence

The term "weight of evidence" refers to an approach to estimating human health risks from toxic environmental exposures that makes use of all the best available science and data collected by accepted scientific methods.[62] In particular, it considers data from a variety of sources including toxicological (animal) studies, wildlife studies, and epidemiological studies of both acute and chronic exposures in humans. The more extensive the research, and the more consistent the results across different studies and in different species, the stronger is the weighting given to a judgement that a given contaminant may pose a risk to human health. Weight of evidence comes into play when identifying potential human health hazards, especially when appropriate human data are lacking and inferences have to be made about the degree of proof that is provided by existing toxicological data. A "weight of evidence" approach was taken in the 1990 work, *Great Lakes Great Legacy?*[63] It reviewed the available evidence from:

wildlife (replication in laboratories, observation of health effects such as wasting, birth defects, immune suppression and target organ damage in offspring, cancerous tumours);
public health data (cancer incidence, cancer mortality, and reproductive outcomes);
human exposure from tissue analysis (pesticides and pesticide break down products found in human tissues); and
studies of individuals, (such as from eating Great Lakes fish).

Exposure pathways addressed included: ingestion of food, drinking water, inhalation, body contact with water and from other less well understood pathways.

The approach to assessing "weight of evidence," appropriately requires a differentiation between "science" and "policy;" the latter being informed by many disciplines, including science, but also ethics, values, opinion, conflicting interests and perspectives.[64] The next section, Implications for Decision Making and Policy Setting, explores this difference further.

Related to the "weight of evidence" approach is the need to consider[65] newly developing methods for using epidemiologic evidence in decision making and standard setting, such as geographically-based health information and meta-analysis. Meta-analysis is a means to review or re-review a wide range of previously conducted studies and can assist in gathering the most relevant evidence and in analysing the collective implications of a range of studies. It has been particularly useful in the understanding of the health effects of low-level lead exposure in children (see Section 8.3.4.1 in Case Study #1). Geographical information systems are becoming more important as databases are created and the ability to map the

[61] Colborn, T, Listening to the Lakes, *Pesticides and You*, June, 1992: 4-8.

[62] Sixth Biennial Report Under the Great Lakes Water Quality Agreement, International Joint Commission, 1992. Available at: www.ijc.org/comm/6bre.html

[63] Colborn, T.E., *et.al.* 1990, *op.cit.*

[64] Weinberg, J. and J. Thornton, Scientific Inference and the Precautionary Principle. In: *Weight of Evidence: Issues and Practice, A Report on a Workshop held October 24, 1993.* (International Joint Commission, June 1994), pp 20-6; see also Fox, G. Scientific Principles. In: *Weight of Evidence: Issues and Practice, A Report on a Workshop held October 24, 1993.* (International Joint Commission, June 1994), pp 2-5.

[65] Pershegen, G. Environmental epidemiology in public health. *Lancet* 352(1998): 417.

information becomes more widespread.[66]

4.3.7 Implications for Decision Making and Policy Setting

The fact that efforts to determine causation and interpretation of epidemiological and other scientific studies involves considerable judgement has important implications for decision making and policy setting based on those studies. As noted above,[67] "science" is different from "policy." Policy is informed by many disciplines, including science, but also ethics, values, opinion, conflicting interests and perspectives. The foregoing review of the way in which the "science" is conducted illustrates that it is an impossible demand of science to provide the policy answers. Furthermore, the judgements and conclusions based on "science" may be far from certain even in terms of the limited questions that science attempts to answer. Accordingly, decisions must be made, based on all of the best available information. While the results of "science" (epidemiological studies; assessments as to contributors to the questions of "causation", etc.) are important contributors to the decisions, science is incapable of playing the role of the sole determinant of these questions.

Standard setting is primarily a policy-making exercise. Decisions on policy entail a review of the science, together with many other judgements. A "weight of the evidence" approach is appropriate for policy making as to standards, i.e., in the risk management process itself, not solely at the hazard identification stage. An important question in that context is what "burden of proof" to demand; where to place the "burden of proof"; and what elements of "proof" to consider in making standard setting decisions.

There is a history of considering differences in required burdens of proof in legal decision making. Two commonly applied standards are the usual civil "balance of probabilities" (which means "is the contested fact more likely than not?") and the criminal law standard of proof of the contested facts as being "beyond a reasonable doubt." The reasons for the differences vary with the reasons behind the court proceedings that apply these different burdens. In criminal proceedings, the legal system has institutionalized an approach that, ideally, makes it extremely unlikely that an innocent person would be wrongly convicted. It is understood and accepted in that approach that sometimes, "guilty persons" will not be convicted. This is because the value of freedom for innocent persons is strongly protected by our legal system. On the other hand, for civil disputes – that is, disputes between two parties over contracts, tortious claims and other such matters – the value is on expeditious resolution of disputes based on defendable and reasonable evidence. The burden is slightly higher on the party claiming a legal wrong has been committed, but they need not satisfy the decision maker "beyond a reasonable doubt" – it is only necessary to show that their claim is more likely than not "true" based on the evidence.

Because standard setting is intended to protect human health and welfare, ecosystems and other very high values, the "burden of proof" that is required in standard setting should be one that is more likely to be protective of those desired values. Too often, however, a protective approach has not been the case due in part, to a mis-application of the ideas of causation and the statistical significance testing that is applied to epidemiological studies.

In epidemiological studies, statistical tests that estimate the likelihood that the study has produced the correct answer (e.g. a causal link is present) have been set, usually at 95% or 99% "confidence" levels. It is important to remember that these confidence levels are arbitrary cut-off points chosen for convenience

[66] Another new measurement tool for assessing complex data includes the Child Behavior Check List, discussed in Section 8.3.5 of the Lead Case Study.

[67] Weinberg and Thornton, 1993, *op.cit.*

and consistency; they have "no sound logical basis and [remain] unjustified."[68] They indicate the statistical likelihood that an association shown in a study is purely due to chance. Said another way, scientific convention takes the level of less than 5% or less than 1% as a limit in judging whether an effect is to be considered significant or not. The value that the scientific method is protecting in this approach is a value to base hypotheses and further work on studies that meet this extremely rigorous test.[69] These tests do *not* mean that when the confidence level is less than 95% or less than 99% that the association is not present. They just mean that as the confidence level decreases, it becomes more and more possible that the association that was found is an artifact of chance.

However, to base standard setting decisions on the same approach *before* establishing protective measures or refusing to allow additional exposures raises the likelihood that too much exposure is allowed. One noted legal text on evidence discussed the possibility in some circumstances of a third standard of proof. It was described as that of "clear, strong and cogent" evidence.[70] There are also legal evidentiary tools that assist decision makers, such as the establishment of common inferences and presumptions. The "presumption of innocence" is an example. In deciding who should bear the risk from environmental contaminants, the burden should be shifted once there is epidemiological evidence showing an increase in incidence of the harm under study.[71] Normally the legal concepts of duty of care, the failure of which may lead to legal liability, are based on a "balance of probabilities" or "50% plus one" likelihood standard. Standard setting policy decisions should follow a paradigm in which it is *at least* "more likely than not" that the appropriate protective decision has been made – that is, that a standard is set that is protective of children's health. An approach that requires human epidemiological evidence demonstrated at a 95% or 99% confidence interval *before* taking protective action would not meet this requirement.[72] On the other hand, an approach that truly weighs all of the available evidence and arrives at a prudent protective judgement based on all of that "weight of the evidence" would be more likely to meet this standard.

In considering this issue, "precautionary inference" is proposed as a method to make scientific judgements when data are incomplete or inconclusive, and where significant harm may follow from a false negative judgement.[73] This approach would be a reversal of the current scientific and policy framework. For instance, since data are lacking for most chemicals, if a given chemical belongs to a class for which it is plausible to presume that members of that chemical class may be persistent toxic substances, the onus, under this approach, should be reversed. Hence, using a reverse onus approach, specific exceptions could be made upon proof that a particular chemical is not a persistent toxic substance. Similarly, for those engaging in processes that mix chemicals and release the products of those mixtures, the onus should be on them to demonstrate that the processes do not result in the release of persistent toxic substances. These recommendations are specifically directed to the area of environmental

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[68] Cornfield, J., Recent methodological contributions to clinical trials, *Am.J.Epidemiol*. 104(1974):553-58, as discussed in Needleman and Bellinger, 1990, *op.cit.*

[69] The intention, as noted above with respect to drawing causal infererences from epidemiological studies, is to avoid Type I errors (i.e., accepting spurious associations as causal). Notably, one of the six flaws found by Needleman and Bellinger, 1990*, op.cit.*, in the literature on lead and children's IQ, was a tendency to overvalue the status of the P value (or confidence level) as a criterion for inferring causality. The result was an increased tendency to overlook causal connections, i.e., an increase in Type II errors.

[70] Cross, Sir Rupert and C. Tapper, *Cross on Evidence*, 6th edition, (London (UK) Butterworths, 1985).

[71] Harris, O.F., Toxic Tort Litigation and the Causation Element: Is there any hope of reconciliation? *Southwestern Law Journal* I 40(Sept.1986): 909-965.

[72] Jenicek, M., Rules of Evidence: Criminality and Causality. In: *Epidemiology: The Logic of Modern Medicine.* (Montreal: Epimed, 1995), pp 192-4.

[73] Wineberg and Thornton, 1993, *op.cit.*

contamination and health damage. Rather than the traditional epidemiological approach, in which all confounding variables cannot be controlled and the "webs of cause and effect ... are too complex to be fully illuminated by the tools and models currently available...", a precautionary inference approach would rely on "an integrated body of evidence from laboratory experiments, wildlife studies and epidemiological investigations... to consider [not] whether causal relationships have been definitively proven, but whether the body of evidence suggests a plausible hypothesis that harm has occurred."[74]

Herein lies the central difference between standard setting approaches that apply risk assessment versus a precautionary approach. As the next two sections and indeed the rest of this report explores, in both the U.S. and Canada, the application of risk assessment has predominated and contaminants largely have been considered "innocent until proven guilty." Section 4.5 below however, addresses these issues (weight of evidence, burden of proof, and precautionary inference) again with respect to the implications of a precautionary approach to standard setting that is protective of children's health.

In light of the foregoing discussion of science and policy, and for the purposes of introducing more detailed discussion of the application of risk assessment, it is worthwhile asking a central question.

For a given standard or proposed standard, is the best hypothesis, based on all of the evidence, that harm is *not* likely to occur to children? If not, the standard should be improved (made more strict) until the best hypothesis on all of the evidence is that at that standard, harm to children is *not* likely to occur. For areas of uncertainty that make it difficult to assess this question, the approach should be modified by a precautionary approach. In that case, the standard should be made appropriately more rigorous unless and until the uncertainty is resolved to demonstrate on "clear, strong and cogent evidence" that at the permitted exposure level, no harm to children will result. As the discussions in Section 4.4 and subsequent chapters reveal, a precautionary approach has not been followed for the majority of standards affecting children's health.

4.3.8 Summary

The progress of scientific inquiry is an extremely cautious effort of avoiding errors and drawing conclusions only when a high level of certainty can be gleaned from the evidence. As sources of information for assessing human health risks of environmental contaminants, the three types of epidemiological studies have important strengths and key weaknesses. The strength of scientific evidence from epidemiological studies depends on the quality of the underlying information. Unfortunately, for epidemiological studies addressing environmental contaminants, basic information and methodologies are either lacking or fundamentally constrained. These constraints apply to the scientific work necessary to undertake the two risk assessment steps at issue in this chapter, dose-response assessment and exposure assessment.

The weaknesses inherent in individual studies and epidemiological data in general make it very difficult to draw causal inferences. In drawing inferences of causality from epidemiological evidence, investigators must look at a body of evidence as to environmental factors and human health effects. A detailed set of criteria is applied to make inferences as to causality. Even with these criteria, a great deal of judgement must be applied within the "science" of determining causation.

Risk assessors must rely on additional evidence from animal experiments and wildlife studies which can only provide a prediction of the nature and magnitude of health effects in humans. Such predictions are

[74] *Ibid*.

also limited by the many differences between animal and human species and the shortcomings in methodologies to assess effects at sensitive and/or developmental lifestages.

A "weight of evidence" approach to estimating human health effects considers the best available science from the full range of sources. It differentiates between "science" and "policy," the latter including science but also ethics, values, opinions, and conflicting interests and perspectives. The complexity of these inquiries is also assisted by new and developing methods of data evaluation such as meta-analysis and spatial analysis such as via geographical information systems.

Many implications arise when applying judgement and non-scientific values to the process of weighing a body of evidence and setting policy or standards for exposure to contaminants. Key among them is the choice made as to the "burden of proof" demanded. Because standard setting is intended to protect human health and welfare, ecosystems and other very high values, the "burden of proof" that is required in standard setting should be one that is more likely to be protective of those desired values. However, standard setting rarely applies such a protective approach. Instead, protective standards generally are not set until rigorous scientific inquiry has been applied to the available (and always incomplete) information in order to verify proof of harm. The result is delay in setting protective standards and the greater likelihood of too much exposure before protective action is taken.

A more appropriate standard of proof would incorporate the legal concepts of duty of care, based on a "balance of probabilities" or "50% plus one" likelihood standard. Standard setting policy decisions should follow a paradigm in which it is *at least* "more likely than not" that standards have been set that will be protective of children's health. Where data are incomplete or inconclusive, the approach of "precautionary inference" is a more prudent and appropriate means of making scientific judgements particularly since significant harm may flow from incorrectly assuming that no harm is possible from the environmental contamination being regulated. This approach reverses the current scientific and policy framework, recognizes the inherent shortcomings of information and methodologies, and would set protective standards first. Such standards would be made less stringent only when the uncertainty as to the toxicity of the chemical hazard is resolved via "clear, strong and cogent evidence" that, at the permitted exposure level, no harm to children or other sensitive populations will result. Such a "reverse onus" approach would place the scientific burden of proof on those wishing to create environmental contamination while regulatory agencies could apply precautionary inference to the setting of protective standards including a "weight-of-evidence" approach.

4.4 ASSESSMENT OF CHILDREN AT RISK

4.4.1 Introduction

The 1990s saw an explosion of publishing, mostly in the U.S., about the health effects in children of environmental contaminants, particularly pesticides.[75] The highly influential 1993 report of the U.S.

[75] See for example: CALPIRG – California Public Interest Research Group Charitable Trust and PSR – Physicians for Social Responsibility (Greater SF Bay Area and LA Chapters). *Generations at Risk: How Environmental Toxicants May Affect Reproductive Health in California* (November, 1998); Canadian Institute for Child Health. *Proceedings from National Symposium on Environmental Contaminants and the Implications for Child Health*, (May, 1997); Consumers Union. *Do You Know What You're Eating? An Analysis of U.S. Government Data on Pesticide Residues in Foods*. Consumers Union of the United States, Inc. Public Service Projects Department, Technical Division, Groth, E., C.M. Benbrook and K. Lutz, (February, 1999); Consumers Union. Worst First: High Risk Insecticide Uses, Children's Foods and Safer

National Research Council, *Pesticides in the Diets of Infants and Children*, set the stage for the ensuing debate over whether and how pesticides and other contaminants could be regulated to protect children's health. The NRC review of children's health issues with respect to pesticides is summarized in Chapter 2 and Case Study #2 of this report.

The policy conclusions drawn by the NRC significantly influenced subsequent changes to U.S. law and policy concerning pesticides and other environmental contaminants. Legal reforms included the passage in 1996 of the *Food Quality Protection Act* and amendments to the *Safe Drinking Water Quality Act.* Also in 1996, the EPA confirmed policy commitments to consider risks to infants and children during risk assessments throughout its environmental policy-making.[76] This commitment to protecting children's health was made government-wide under President Clinton's April, 1997 Executive Order entitled "Protection of Children from Environmental Health Risks and Safety Risks."[77] In addition to broadening the consideration of children's health issues from pesticides to all environmental contaminants and all government departments, the Executive Order focused primarily on research. It established an inter-departmental Task Force (the Task Force on Environmental Health Risks and Safety Risks to Children) and led to subsequent decisions to establish Centers of Excellence across the country to address the many research needs within the field of children's environmental health.

These and many other legal and policy initiatives are all part of the story of how children's environmental health risks have been addressed in the United States in recent years.[78] Risk assessment has been central to all of these new developments. However, for the purposes of addressing the role of risk assessment and informing an understanding of its application by Canadian regulatory agencies, this review focuses on the recommendations of the NRC report and their subsequent implementation in the *Food Quality Protection Act* of 1996.

4.4.2 The NRC Benchmark

The NRC reviewed in detail the shortcomings in exposure assessment and toxicity testing for pesticides as these relate to the special circumstances of children (in all life stages including prenatal, neonatal, and adolescence). Key gaps were identified in terms of both data and methodologies for assessing exposure to, and metabolism and toxicity of, pesticides during children's developmental stages. For the two key areas of risk assessment uncertainty – exposure assessment, and dose-response assessment – the NRC made several important recommendations.

Alternatives. (Washington: Consumers Union of the United States, September, 1998).; Davies, Katherine. Pesticides and Your Child. AN Overview of Exposures and Risks. Prepared for the Campaign for Pesticide Reduction (CPR!), Ottawa, Ontario. (1998); National Research Council. *Pesticides in the Diets of Infants and Children*. (Washington: National Academy Press, 1993); Repetto, R. and S.S. Baglia. *Pesticides and the Immune System: The Public Health Risks*. (Washington: World Resources Institute, 1996); Schettler, T., G. Solomon, M. Valenti and A. Huddle, Generations at Risk: Reproductive Health and the Environment. (MIT Press: Cambridge, 1999); Wargo, J. 1999, *op.cit.*; etc.

[76] United States Environmental Protection Agency, Office of the Administrator. *Environmental Health Threats to Children*, EPA 175-F-96-001, September, 1996. Available at: www.epa.gov/epapages/epahome/epadocs/child.htm

[77] Executive Order No. 13045, Protection of Children from Environmental Health Risks and Safety Risks, April 27, 1997. Available at: www.epa.gov/children/document/executive.htm

[78] For a detailed overview of numerous EPA programs see: The EPA Children's Environmental Health Yearbook, June, 1998. Available at: www.epa.gov/ocepa111/NNEMS/oeecat/docs/1075.html ; see also the activities of the Tolerance Reassessment Advisory Committee at: www.epa.gov/oppfead1/trac

For dietary exposure calculations, the ability to quantify pesticide exposure from data about pesticide residues on food was found lacking. Inconsistent and weak data collection and analysis of pesticide residues have made interpretation difficult. These shortcomings have been particularly problematic for determining the potential for pesticide residue exposure in the major foods consumed by children. Pesticide residues in water had been largely overlooked.

The NRC recommended standardization and coordination of data collection and analysis, the need to pay special attention to collecting sufficiently large samples of data by children's age sub-categories, and also paying attention to child-specific consumption patterns including water consumption. For non-food sources of pesticides, the NRC noted the many additional routes of exposure (as discussed in Chapter 2 and Case Study #2) and found that these exposures were not considered in setting pesticide tolerances. Hence, the report recommended that risk estimates for individual pesticides consider exposure from all sources as well as the need to estimate intake of multiple pesticides with a common toxic effect. Exposure distributions, in contrast to point estimates, were considered a more relevant means of characterizing exposure and for contributing to evaluations of both acute and chronic toxicity. The report recognized however that the identified shortcomings in data collection as well as methodological problems undermine the ability to conduct these three kinds of exposure estimation (i.e., calculations of: exposure from all sources; exposure to multiple pesticides with common toxic effects; and exposure distributions). Hence additional recommendations were made concerning methods to estimate exposure.

To address shortcomings in the area of dose-response assessment, numerous recommendations were made for new toxicological tests and new pharmacokinetic[79] models to include specific consideration for children's unique biochemical and physiological characteristics. Refinements in animal testing were also recommended to evaluate toxicity to developing organ systems, and to evaluate developmental impacts on the central nervous system, the endocrine and immune systems and the reproductive system. For example, recommendations were made for modified testing for chronic toxicity/carcinogenicity in rats to address *in utero* exposure during the last trimester, exposure during lactation and following weaning, and oral exposure through diet. Similarly, recommendations were made for improved or new testing requirements to assess developmental and functional neurotoxicity and to expand acute and subchronic neurotoxicity testing for all food use pesticides (i.e., to expand beyond an earlier focus on only the organophosphate and carbamate pesticides).

Perhaps most significantly, the NRC report made two recommendations that attempted to address central criticisms of risk assessment – i.e., the large gaps in data and methodology, and for the latter, the problem of not assessing real-world combinations of chemical exposures. To address the "data gap," particularly as it relates to children, the NRC recommended the use of an additional 10-fold margin of safety. While many recommendations, noted above, were made to fill the data gap, this additional margin of safety was intended for situations where information is incomplete. To address real-world combinations of chemicals, the NRC found that exposure estimates and dose-response assessments should not be restricted to the impact of a single pesticide but should be required to assess the cumulative effect of pesticides with a common toxic effect.

[79] Pharmacokinetics is the process of uptake, biotransformation, distribution, metabolism and elimination of drugs and their breakdown products by the body. Toxicokinetics is a variant on this term used to refer to the body's reaction to toxic chemicals.

4.4.3 The Food Quality Protection Act

The NRC report recommendations noted above were adopted almost entirely in the *Food Quality Protection Act* (FQPA).[80] Adopted by Congress with only a single dissenting vote in August of 1996, the new law fully embraced risk assessment as the means to evaluate existing and new pesticides for their impacts on children.[81] It was described as being guided by the principles of "sound science" and "health-based approaches to food safety."[82] The FQPA amended the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA),[83] governing registration, sale and use of pesticide products, and the *Federal Food, Drug, and Cosmetic Act* (FFDCA),[84] under which EPA sets allowable pesticide residue levels for food, also called food tolerances.

Large public interest and environmental groups supported the new law because it required, (or they thought it would require), an additional ten-fold safety factor in risk calculations to provide added protection for children. The pesticides industry supported the new law in exchange for removal of the disliked Delaney Clause and the establishment of a regulatory regime founded on science-based, risk assessment. Those who have consistently criticized risk assessment however opposed the new law as legalizing statistically predictable deaths from toxic residues on foods. They also mourned the loss of the precautionary ethic contained in the Delaney Clause.[85]

To resolve the "Delaney Paradox," the new law replaced the conflict between FIFRA and FFDCA by establishing a new standard of food safety. The new approach would establish legally allowable limits of pesticide residues on food (tolerances) that would ensure a "reasonable certainty of no harm" while recognizing the benefits of using pesticides on food crops. Hence pesticide tolerance levels established under FFDCA were required to ensure that only "safe" residues were left on food. "Safe" levels were to be calculated (as recommended in the NRC report) by taking into account aggregate exposure from all dietary and non-dietary sources and all routes of exposure (including drinking water, household sources but excluding occupational sources). For all tolerance levels established prior to the passage of the FQPA, re-evaluation against this new standard was required.[86] Note that this new set of rules governs the "exposure assessment" step of risk assessment.

For the "dose-response assessment" step of risk assessment, the new law set out a number of requirements for assessing the risk of pesticide residues allowed by a tolerance. The FQPA requires EPA (again, as recommended in the NRC report) to consider:

- the susceptibility of children to exposure and/or to adverse health effects;
- potential effects of *in utero* exposure;

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[80] *Food Quality Protection Act,* Pub. L. No. 104-170, 110 Stat. 1489 (1996).

[81] In the same year, Congress also passed another risk-based law with amendments to the *Safe Drinking Water Quality Act* to explicitly require the assessment of all impacts on children and other sensitive populations for setting drinking water standards.

[82] United States Environmental Protection Agency, *1996 Food Quality Protection Act: Implementation Plan*. Prevention, Pesticides and Toxic Substances, March, 1997(hereinafter: USEPA, FQPA Implementation Plan).

[83] *Federal Insecticide, Fungicide and Rodenticide Act (FIFRA),* 7 U.S.C. s/s 135 (1972).

[84] *Federal Food, Drug, and Cosmetic Act (FFDCA),* 21 U.S.C. 301 (1996).

[85] Stroshane, T., U.S. Food Quality Protection Act: Will the Risk Cup Runneth Over? *Global Pesticide Campaigner*, 9(1) (1999), pp.1,4-8.

[86] USEPA, FQPA Implementation Plan, *op.cit.*

- potential disruptive effects on endocrine systems; and
- cumulative risks due to exposure to the pesticide and to other pesticides that may have a similar toxic effect (i.e., common mechanism of toxicity").[87]

To specifically address the particular susceptibility of children to pesticide exposure, FQPA requires EPA to:

> Use an extra 10-fold safety factor to take into account potential pre- and post-natal developmental toxicity and completeness of the data with respect to exposure and toxicity to infants and children. A different safety factor may be used only if, on the basis of reliable data, such a factor will be safe for infants and children.[88]

In exploring how the risk assessment basis of the FQPA has been implemented, it is worth recalling the 1983 report by the National Research Council. Recall that *Risk Assessment in the Federal Government: Managing the Process* noted that it was necessary to make at least 50 "default assumptions" during cancer risk assessment that are not based on science. Recommendations were made to separate risk assessment from risk management and to develop detailed guidelines for the risk assessment part of the process. Work progressed on a number of guidelines, particularly on cancer risk assessment.

A second influential report by the National Research Council, published in 1994, revisited these issues and found that very little had changed in terms of the amount and necessity of applying "default assumptions" in risk assessments. However, that report, *Science and Judgement in Risk Assessment*,[89] supported the continued use of "default assumptions" thus validating the manner in which risk assessment practice and guidance documents had continued to be developed.[90] The result of both of these influential NRC reports, recommending the development of detailed guidance on risk assessment, has been the generation of an enormous amount of documents. Over the course of many years of iterative drafts, guidance documents have been proposed, consulted upon, revised, and in some cases finalized, for exposure assessment,[91] developmental toxicity,[92] carcinogenicity,[93] reproductive toxicity,[94] neurotoxicity,[95] among others.

Despite the existence of all of these guidelines (in either draft or final form) prior to the passage of the FQPA, they all fall short of providing the additional guidance necessary to implement key aspects of this

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[87] *Ibid.* See also: Congressional Research Service, CRS Issue Brief for Congress, *Pesticide Residue Regulation: Analysis of Food Quality Protection Act Implementation*. RS20043, August 3, 1999. Available at: www.cnie.org/nle/pest-10.html (hereinafter: CRS Issue Brief RS20043, 1999).

[88] USEPA, FQPA Implementation Plan, *op.cit.*

[89] National Research Council. *Science and Judgement in Risk Assessment*. (Washington, D.C., National Academy Press, 1994).

[90] It also recommended the development of systematic and transparent guidelines that would ensure clear communication to the public of the "default assumptions" applied during the risk assessment process. The NRC published further on this matter in 1996 in: Stern, P.C. and H.V. Fineberg (eds.) *Understanding Risk: Informing Decisions in a Democratic Society*; Committee on Risk Characterization, National Research Council, 264 p.

[91] *57 Federal Register* 22888-22938, May 29, 1992.

[92] *56 Federal Register* 63798-63826, Dec. 5, 1991.

[93] *61 Federal Register* 17959-18011, April 23, 1996.

[94] *61 Federal Register* 56273-56322, October 31, 1996.

[95] *63 Federal Register* 26925-26954, May 14, 1998.

new law. For example, it has been necessary to develop two additional guidelines for improving exposure assessment, one for data requirements[96] and another for performing aggregate exposure and risk assessments.[97] Still more guidelines are proposed for first identifying and then assessing chemicals with a common mechanism of toxicity (two different guidelines)[98], another is proposed for screening chemicals (87,000 of them) for their potential as endocrine disruptors.[99] Thereafter, presumably additional guidance will be necessary for both exposure assessment and toxicity testing (dose-response assessment) for endocrine disruptors.

As of February 2000, none of these guidelines is yet finalized and all are hotly debated. Particularly contentious is the treatment of the application of the 10-fold safety factor. Notably, the approach has not been to simply apply the 10-fold safety factor. Rather, it has been either omitted or, in many cases, been only partially applied. Two draft policies[100] on its application are also the subject of debate. Despite the promise of a simpler system, FQPA implementation has been mired in controversy and delay and environmental group critics contend that overall risks from pesticides to children have likely only increased since its passage.[101]

Once again, the two areas where data and methodology are most lacking – exposure assessment and dose-response assessment – call into question the ability of risk assessment to deliver on the FQPA's promise of protecting children using "sound science." This fundamental shortcoming of risk assessment serves the pesticides industry very well since it can insist on more scientific evidence any time a risk assessment results in a conclusion that would require reduction or elimination of a pesticide product. The industry influence is equally pervasive at early stages since the insistence on science-based approaches also occurs at the level of the drafting of guidelines that steer the entire process. The result of this influence is a tendency across all of the proposed guidelines to increasingly limit and constrain the application of the key progressive elements of the FQPA. This situation is discussed further below with respect to the application of the 10-fold safety factor and the requirements for assessing aggregate exposure and the cumulative effects of chemicals with a common mechanism of toxicity.

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[96] United States Environmental Protection Agency, Scientific Advisory Panel (SAP), *Draft – Exposure Data Requirements for Assessing Risks from Pesticide Exposure of Children*, March 8, 1999. Available for review but not for citation or quotation at: www.epa.gov/oscpmont/sap/1999/may/10xdoca3.pdf

[97] United States Environmental Protection Agency, Scientific Advisory Panel (SAP), *Draft – Guidance for Performing Aggregate Exposure and Risk Assessments*, February 1, 1999. Available at: www.epa.gov/oscpmont/sap/1999/february/guidance.pdf

[98] United States Environmental Protection Agency, Office of Pesticide Programs, *Guidance for Identifying Pesticide Chemicals and Other Substances That Have a Common Mechanism of Toxicity*, January 29,1999. Available at www.epa.gov.fedrgster/EPA-PEST/1999/February/Day-05/6055.pdf ; and United States Environmental Protection Agency, Scientific Advisory Panel (SAP), *Preliminary Draft - Proposed Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of Toxicity*, August 29, 1999. Available at www.epa.gov/oscpmont/sap.1999/september/cumdoc.pdf and not for citation or quotation.

[99] *63 Federal Register* 71541-71568, December 28, 1998.

[100] United States Environmental Protection Agency, *Draft – Toxicology Data Requirements for Assessing Risks of Pesticide Exposure to Children's Health*, Report of the Toxicology Working Group of the 10X Task Force, April 28, 1999; and United States Environmental Protection Agency, Office of Pesticide Programs, *Draft – The Office of Pesticide Program's Policy on Determination of the Appropriate FQPA Safety Factor(s) for Use in the Tolerance-Setting Process*, May, 1999. Both available at: http://www.epa.gov/oppfead1/trac/science/index.htm#additional

[101] Letter from Kenneth Cook, president, Environmental Working Group to Vice-President Albert Gore, October 28, 1998. Available at: www.ewg.org as cited in Stroshane, T. 1999, *op.cit.*

As the weighty and bewildering pile of guidance and policy documents continues to be developed, negotiated, and disputed, the EPA's 1997 Implementation Plan for the FQPA, has been relied upon for interim strategies to begin the massive task at hand.

Overall, the new law required EPA to reevaluate 33% of existing residue limits for food-use pesticides by August 3, 1999, 66% by August 3, 2002, and 100% by August 3, 2006. Over 9,000 pesticide tolerances were in line for re-evaluation when the FQPA was passed and tolerances for the riskiest pesticides were to be evaluated first. This requirement proved very difficult since the pesticide industry and the farming community mounted stiff opposition over the prospect of losing some of the riskiest pesticides, particularly the carbamates and organophosphates. Nor did data collection or methodology exist to adequately assess these riskier products according to the new FQPA requirements; hence the need for the additional detailed guidance noted above.

Instead of addressing the riskiest first, EPA met its numeric deadline by re-evaluating over 3,000 tolerances. However, it concluded that the majority of these tolerances posed no significant risks as many were for outdated practices, i.e., the residue limits were on crops no longer treated with the pesticide in question. Hence of the nearly 1000 pesticide uses that were revoked due to this reevaluation, many were for inactive uses. In addition, during 1998, EPA reported registering 27 new pesticides and over 100 new food uses for previously registered pesticides.[102]

4.4.3.1 The 10-Fold Safety Factor

The FQPA was passed in response to the alarm bell sounded by a renowned group of scientists that children faced unacceptable risks from existing pesticide exposure. The surface impression of an additional 10-fold margin of safety to specifically protect children was understandably interpreted as a step forward; protection for children would be increased 10-fold. However, this increased margin of safety has not occurred.

The qualifying started with the FQPA Implementation Plan and the results were soon apparent. In the first year after the law was passed, of 90 reassessed pesticides, the EPA applied the 10-fold safety factor only 9 times. In other cases, a factor of 3 or less was applied.[103] The Implementation Plan justified this approach and it has been a matter of ongoing controversy.

For the purpose of background information to this discussion it is worth noting first that the approach of applying "safety factors" in risk assessment is one of the key areas of "default assumptions." More typically called "uncertainty factors," it is standard practice to apply two 10-fold safety margins (i.e., an overall 100-fold margin) to the No Observed Adverse Affect Level (NOAEL), determined using animal toxicity studies. The animal NOAEL is divided by 10 to account for unknown differences between animals and humans. Hence the NOAEL for humans is assumed to be 10 times lower than for the laboratory test animals. An additional 10-fold safety margin is added to account for unknown differences in sensitivity among people. Hence, the two 10-fold uncertainty factors result in a NOAEL for humans that is 100 times lower than the NOAEL observed in the animal tests. It has also been standard practice in risk assessments to decide, using scientific judgement, whether and if to apply an additional uncertainty factor (typically in the range between 3 and 10) to account for incomplete test data such as incomplete information about risks to children.

[102] United States Environmental Protection Agency, *Pesticide Program Highlights from Fiscal Year 1998*, November , 1998 as cited in Stroshane, T., 1999, *op.cit*.

[103] Stroshane, T.,1999, *op.cit.*

It is this final and additional 10-fold safety factor, above and beyond the routine application of the 100-fold safety factor, that has been the subject of debate under the FQPA. The direction given in the statute is that EPA shall add the additional safety factor to protect infants and children against threshold effects unless EPA determines based on reliable data, that a different margin will be safe. EPA chose right from the start to interpret the FQPA mandate to mean that the application of the additional child-protective 10-fold safety factor would remain a matter of scientific judgement.[104]

Instead of adding the 10-fold safety margin where data are incomplete, EPA interprets this direction to mean that where data are incomplete it will use scientific judgement to decide on adding a safety factor of between 3 and 10 based on *how much* information is incomplete. Hence, incomplete information does not mean the application of a 10-fold safety margin but instead the application of "default assumptions," more guesswork, as to whether data are incomplete *enough*. As well, the EPA states that "where reproductive and developmental data have been found acceptable by EPA, and the data do not indicate potential pre- or post-natal effects of concern, the additional tenfold margin of safety will not be applied."[105]

This approach is apparently consistent with recommendations made in 1996 by the FIFRA Scientific Advisory Panel. However, it could well ignore the potential for adverse effects of endocrine disrupting chemicals that may be hazardous to fetuses, infants, children and adolescents at particularly low levels of exposure during periods described as "windows of vulnerability" (see discussion in Chapter 2, Section 2.3). Assessing the latter using animal testing is rarely required during standard risk assessment procedures.

The result of this exercise of deciding, in the face of incomplete information, how much of a safety factor to apply, depends on how much information the risk assessors are addressing in the first place. An important criticism came from a group of environmental, children's health and public interest organizations writing to the EPA in 1999 concerning the EPA's evaluation of organophosphates, pesticides that are known to adversely affect brain development in young animals through multiple pathways.[106] They noted the recommendations of the 1993 NRC report and the EPA's own Toxicology Work Group that developmental neurotoxicity testing (DNT) should be a "core" or required test for all risk assessments on organophsophates. The EPA only requires neurotoxicity tests on adult animals despite having had a validated Developmental Neurotoxicity Test Guideline (OPPTS 870-6300) since 1991. By not requiring DNT, the result in terms of the application, qualified application, or decision not to apply the 10-fold safety margin for children is clear. If the risk assessors do not look for effects, they will not find them and will therefore conclude that the safety factor is unnecessary.

A recent example of EPA choosing to apply only a 3-fold safety factor to comply with the FQPA child-safety requirement is the preliminary risk assessment for the pesticide chlorpyrifos, one of the organophosphates and widely used in over 800 pesticide products. This risk assessment is discussed further with respect to "Implications for Canada" in section 4.4.3.4 below.

[104] USEPA, FQPA Implementation Plan, *op.cit.*

[105] *Ibid*. p.13.

[106] Letter to Carol Browner, Administrator, United States Environmental Protection Agency from: Learning Disabilities Association of America, Consumers Union; Natural Resources Defense Council; Science and Environmental Health Network; Physicians for Social Responsibility; and U.S. Public Interest Research Group, Re: Developmental Neurotoxicity Testing Data Gaps and the Children's 10X Safety Factor, May 12, 1999.

4.4.3.2 Human Testing of Pesticides

Perhaps the most unexpected and certainly the most perverse result of the new 10-fold safety margin intended to protect children, is the recently renewed[107] and increasing practice, by pesticide companies, to seek and often pay human "volunteers" to test for pesticide NOAEL's. The intention of this renewed testing is to eliminate one of the core 10-fold uncertainty factors by providing data on a NOAEL derived directly from experiments on humans. The result, if these studies are accepted, could well be to *increase* pesticide tolerances directly as a result of the passage of the supposedly child-safety-focused FQPA. Said another way, the FQPA requirement for an additional safety factor has unintentionally created an incentive to test pesticides in humans.[108]

At least twelve unpublished studies conducted by pesticide companies have been submitted to EPA and more are expected. They are systemic toxicity studies to establish a human NOAEL. Most were conducted in England and Scotland, often seeking volunteers from among company employees or offering to pay "volunteers" from the public at large.

The pesticides most commonly being studied in the human experiments are organophosphates and carbamates, the two categories of pesticides that have been the subject of the most heated debate in the U.S. during their reevaluation. The FQPA requirement to address the riskiest first as well as to first aggregate exposure from, and then assess chemicals with, common mechanisms of toxicity led to an initial focus on these two groups of pesticides. Since the 10-fold safety margin would be very likely applied to chemicals known or strongly suspected to negatively affect developing nervous systems, human testing offers a potential way out of lower tolerance levels.[109]

The human testing of pesticides has arisen within a policy vacuum at the EPA. It has been greeted with disgust and outrage and is opposed on moral, ethical and scientific grounds by the public interest, farmworker, religious, environmental, consumer, health and medical communities in the United States.[110] A 1998 report[111] and subsequent evaluations by the above-noted groups have charged that the practice is scientifically dubious and ethically indefensible. When the story hit the headlines in 1998, the EPA responded with concern and referred the matter to its independent Science Advisory Board for advice.

The referral to the Science Advisory Board (SAB) has resulted in a deeply controversial investigation. A Joint Science Advisory Board-Science Advisory Panel (SAB/SAP) Subcommittee on Data from Human

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[107] *Ibid.*; the 1972 study cited therein is: Coulston, F., L. Golberg, and T. Griffin, 1972. Safety Evaluation of DOWCO 179 in Human Volunteers, Institute of Experimental Pathology and Toxicology, Albany Medical College, Albany, New York. MRID No. 95175. HED Doc No. 000179, 03822, 04363.

[108] Staff Background Paper for November 30, 1999 Meeting of SAB/SAP Joint Subcommittee on Data from Human Subjects. Available at: www.epa.gov/oscpmont/sap/1999/november/background-1130.pdf

[109] Indeed, the process of revising down tolerances for these chemicals according to an additional 10-fold safety factor might well conclude that many ought to be banned to ensure avoidance of children's health effects.

[110] See multiple letters to Carol Browner, Administrator, United States Environmental Protection Agency, from the farmworker community (www.cehn.org/cehn/farmltr.html), the religious community (www.cehn.org/cehn/reliltr.html), the consumer and environmental community (www.cehn.org/cehn/consltr.html) and the health and medical community (www.cehn.org/cehn/htletter.html) Re: Human Testing of Pesticides, November 18/19, 1999.

[111] Environmental Working Group, *The English Patients: Human Experiments and Pesticide Policy*, July, 1998. Available at: www.ewg.org

Subjects is advising on policy to ensure that EPA can rely on data meeting the highest ethical and scientific standards.

The standard approach to toxicity testing at EPA has been the use of its authority to specify what tests are required and how they should be performed (via the guidelines discussed above). EPA has never developed guidelines for testing pesticide effects or establishing NOAELs in humans nor have such tests been considered necessary, or to be encouraged.[112] Pesticide companies and their farming supporters argue that human tests are more appropriate and reliable in making accurate estimates of human health risk during a risk assessment exercise.[113] In seeking the SAB/SAP committee's advice, EPA wants a policy that applies the protection of the Common Rule (see below) to this new area of inquiry but that also recognizes the wide range of human research that already exists in less controversial circumstances. EPA notes that general standards of conduct will apply to all research but specific standards of conduct and acceptability are necessary in this new area of research.

The SAB/SAP Committee has not been able to agree on this contentious issue. The rift in the Committee has delayed the setting of a policy by EPA. At issue has been debate over whether this testing, as science, is dubious or ethical. John McCarthy of the American Crop Protection Association states that testing pesticides on humans is no different from testing the toxicity of new drugs. Bioethicists disagree pointing out that pesticides are not therapeutic agents.[114]

The comparison to clinical drug trials is important because it takes this issue directly and appropriately into the field of medical ethics. The history of abuse within medical experimentation is a horrific tale. It runs the gamut from the appalling practices of systematic torture and total control over "patients" by the German Nazi doctors through to the Tuskegee syphilis study[115] and the seminal work of Henry Beecher.[116] The history of abuse has provided detailed understanding of the conditions necessary for ethically justifiable research. The Nuremburg Code was the first attempt to enshrine ethical conduct in medical research; the most recent expression of policy for the protection of human subjects in research is The Common Rule.[117]

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[112] Staff Background Paper for November 30, 1999 Meeting of SAB/SAP Joint Subcommittee on Data from Human Subjects. Available at: Available at: www.epa.gov/oscpmont/sap/1999/november/background-1130.pdf

[113] Stroshane, T. 1999, *op.cit.*

[114] Ibid.; Staff Background Paper, *op.cit.*; and Joint SAB and SAP Open Meeting, November 30, 1999. Data from Testing on Human Subjects Subcommittee, Baskerville Transcription, Vienna, VA. Available at: www.epa.gov/oscpmont/sap/1999/november/jointsab.sap.pdf

[115] The Tuskegee syphilis study was one of the most condemned experiments in US medical history. Although a cure for syphilis was found during the course of this multi-year investigation, the hundreds of poor southern black men infected with the disease and involved in the study were not given treatment so that researchers could learn more about the disease by seeing the study through to its fatal conclusion.

[116] Henry Beecher wrote the seminal work in medical ethics in the 1960s after conducting an exhaustive review of unethical conduct in medical research. He drew distinctions between the most heinous examples of the Nazi doctors and the Tuskegee syphilis study but also found extensive unethical conduct within medical studies reported in the peer-reviewed medical literature.

[117] The Federal Policy for Human Subjects Protections (The Common Rule): From the *Final Report, National Committee on Human Radiation Experiments, 1995*, (as reproduced in Environmental Working Group, 1998, *op.cit.*), sets out the responsibilities and obligations of those conducting research on human subjects to ensure protection of their subjects rights and well-being and to ensure the application of informed consent requirements.

Two mandatory components of such rules have included the notion of informed consent and a responsible investigator. While it is beyond the scope of this report to explore the details of these two components, several important points are relevant. First, there is a crucially important set of conditions to be met for the ethically justified medical research on humans. There are issues of scientific adequacy, therapeutic value, protection of subjects and informed, comprehending and voluntary consent. As a two-way transaction, informed consent is a matter of shared decision-making. Hence, informed consent is considered possible only between adults, not between an adult and a child. The irony here is brutal since the experiments conducted by pesticides companies on humans are being done for the purpose of avoiding safety factors intended to protect children.

A key aspect of the notion of a responsible investigator revolves around the central ethical problem of medical experimentation. Beecher's work addressing the continuum of abuse noted above found that while the Nazis had a systemic and racist contempt for their subjects, the less horrendous forms of abuse in medical research stem from a conflict of goals of the physician-researchers. Beecher found that the central ethical problem of medical experimentation concerned balancing the interests of individual subjects with the goals of both helping future patients and advancing careers. Clearly, a central issue to consider in the applicability of The Common Rule to toxicity testing of pesticides on human subjects is the vested interests of pesticide company investigators. Research results that would enable sustained or increased pesticide sales are comparable to the conditions upon which ethical conduct rules have had to be established within the sphere of medical research.[118] A related issue in these studies is whether the alleviation of poverty motivated the human subjects to participate.

TheSAB/SAP Subcommittee on Data from Human Subjects met in December of 1999 to re-consider these issues after failing to agree on policy proposals at an earlier meeting in August. No policy has yet been proposed by the committee or EPA. Meanwhile, EPA states that it expects to receive more results from pesticides companies conducting human testing for pesticide toxicity. As unpublished reports, the nature of informed consent within these studies is not the subject of independent peer review. Nor is there any independent review on the extent to which The Common Rule is being applied.

4.4.3.3 Aggregate Exposure and Common Mechanisms of Toxicity

In the absence of data and exposure models (and guidelines governing their collection/application) to measure aggregate exposure to pesticides, the EPA came up with the notion of "the risk cup" as an interim approach to assessing aggregate exposure. The logic is based on the concept that the total level of acceptable risk from all sources is contained or aggregated in the Reference Dose (RfD). For a chronic health hazard like cancer, the RfD is the daily exposure level over a seventy year period (an average lifetime) that does not, according to the risk assessment calculations, create appreciable risk. For aggregate exposures, the risk cup is filled up with an assessment of the combined exposure estimates from multiple sources including all dietary and non-dietary sources and drinking water, but excluding occupational exposures. Calculations and default assumptions are applied for areas of exposure where data are incomplete. So long as the RfD has not reached 100%, EPA can consider registering additional uses of the pesticide in question or setting new tolerances.

As with exposure assessment for individual pesticides, the degree of uncertainty and gaps in data are enormous for these "risk cup" calculations. This interim approach continues to be applied as debate

[118] For two reviews of these issues see: Roy, D.J., J.R. Williams and B.M. Dickens, *Bioethics in Canada,* Chapter 13: When Treatments are Uncertain: The Ethics of Research with Human Beings, Prentice-Hall, 1994; and Pence, G.E., *Classic Cases in Medical Ethics*, Chapter 9: The Tuskegee Syphilis Study, McGraw-Hill Inc. 1990.

surrounds two proposed guidelines concerning the assessment of aggregate exposure.[119] In both proposed guidelines, critics charged that the EPA's risk assessment methodology refinements focus almost exclusively on ways to reduce exposure estimates despite repeated criticisms pointing to evidence that such exposure estimates should be raised.[120]

In particular, the well documented problem of organophosphates posing an unacceptable risk to children at current levels of exposure is cited by environmental group critics of these efforts at refining risk assessment techniques. Action is justified now, they say, without waiting for further complex risk assessment refinements. EPA has been repeatedly criticized as delaying such action to reduce organophosphate exposure. Instead, environmental groups and their hired experts have carefully documented the apparent one-way effort to refine exposure assessments by focusing almost exclusively on measures that will tend to reduce the final risk estimates. This effort within EPA appears to be in response to industry criticism that actual or "real" use of these pesticides is not informing risk calculations. The critics counter that the exposure averaging techniques being proposed also ignore real world circumstances. The actual circumstances of exposure, they charge, serve to increase exposure in a manner that EPA is factoring out. Further, critics charge that EPA is:

> "…removing more and more of the default assumptions that were built into previous risk assessments, and which presumably were intended to ensure that risk assessments erred on the side of overstating rather than understating true pesticide toxicity and exposures. In many cases, these health-protective defaults are being replaced by new assumptions with no validation using real world data that can assure the risk estimate will not understate the true risk."[121]

The groups are concerned that, due to pressure from registrants, these older, default assumptions are being replaced with new assumptions that claim to better approximate true exposure or toxicity. However, EPA readily admits that the data gaps remain enormous. Environmental groups charge that these proposed "refinements" in calculating and assessing exposure are a systematic attempt to eliminate the more "conservative" default assumptions with less conservative assumptions. They also note that the historically more conservative assumptions were claimed by EPA as being more than adequate to protect all Americans from pesticide risks. This claim is clearly not the case as evidenced by the NRC's 1993 report, numerous other authoritative reports, and the decision by Congress to pass the FQPA.

The reevaluation of organophosphates is equally controversial in the area of assessing common mechanisms of toxicity. The proposed guideline[122] is extremely rough and posted to the internet for

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[119] United States Environmental Protection Agency, Office of Pesticide Programs, *Draft - Guidance forPerforming Aggregate Exposure and Risk Assessments.* February 1, 1999. Available at: http://www.epa.gov/fedrgstr/EPA-PEST/1999/November/Day-10/6043.pdf (note that this version is dated November, 1999 and is revised from the February 1, 1999 draft reviewed for this report and by the environmental organizations noted below); and United States Environmental Protection Agency, Office of Pesticide Programs, *Draft – Choosing a Percentile of Acute Dietary Exposure as a Threshold of Regulatory Concern*. Final document posted to 65 *Federal Register,* 15330 –15333, March 22, 2000. Likewise, the research for this report reviewed the April 7, 1999 draft of this document.

[120] Environmental Working Group, Comments on the Office of Pesticide Programs Proposed Science Policy for "Choosing a Percentile of Acute Dietary Exposure as a Threshold of Regulatory Concern," June 7, 1999; and Natural Resources Defence Council, Comments in response to Public Docket #OPP-00591, Data for Refining Anticipated Residue Estimates Used in Dietary Risk Assessments for Organophosphate Pesticides, June 9, 1999. Both (and several related documents) available at www.ecologic-ipm.com/whatsnew.html

[121] Natural Resources Defense Council, June 9, 1999, *op.cit*. Section III.

[122] United States Environmental Protection Agency, Scientific Advisory Panel (SAP), *Preliminary Draft - Proposed Guidance on Cumulative Risk Assessment of Pesticide Chemicals That Have a Common Mechanism of*

discussion purposes and not for citation or quoting. Although it is slightly unfair to comment on it in this context, it is worth noting that it is clearly on the same continuum. Since it has been the subject of consultation, analyses and responses to it have been prepared by the same environmental groups that have been part of thorough-going critiques of this entire process of refining risk assessment techniques. The most notable impression of this document is, like its companions discussed above, an obvious pre-occupation throughout with exclusionary criteria and/or techniques for narrowing the scope of what is cumulatively assessed.

4.4.3.4 Implications for Canada

The Canadian Pest Management Regulatory Agency (PMRA) has stated that its re-evaluation of pesticides[123] used in Canada will make use of the U.S. EPA pesticide reviews "to the extent possible" and it will "implement approaches (increased safety factors for sensitive populations, aggregate exposure and cumulative risk assessment) taken by the EPA for tolerance reassessment under the FQPA *where necessary and appropriate* (emphasis added).[124] There is no legislative requirement in Canada to include the new approaches contained in the FQPA. However, additional arrangements to harmonize approaches and standards have been established (as described in Chapter 3) and these flow from commitments made under international trade agreements to move towards harmonization of pesticide standards between the two countries. The PMRA also made clear its commitment to risk assessment in the January, 2000 "draft guide to risk assessment and risk management in the PMRA." The draft states: "there is a broad international consensus among regulatory agencies that the acceptability of a chemical should be predicated on the degree of risk rather than simply the hazard (or inherent toxicity) of a chemical." [125] While this rather self-serving view may serve to maintain the *status quo,* it is not particularly accurate, at least not in terms of trends discussed in Section 4.5 below, or when the views of commentators outside of "regulatory agencies" are taken into account. Unfortunately such a view serves to pre-empt the progress embodied in various international agreements to which Canada is a signatory (also discussed in Section 4.5 below).

There are benefits and pitfalls from hitching the Canadian wagon to the FQPA star. On the one hand or perhaps on the surface, the FQPA includes some important and progressive advances over previous U.S. approaches and the existing Canadian regulation of pesticides. However, the reality of FQPA implementation is another matter. The decision to put total faith in the "sound science" of risk assessment underlies much of the problems that have arisen and the concerns that remain. Within the bewildering array of documents that have been drafted, and as yet rarely finalized, to guide the risk assessment process in the application of new requirements flowing from the FQPA, the central limitations of risk assessment are not overcome. Rather, the problems of gaps in data and methodologies for both exposure assessment and dose-response assessment are magnified most particularly in the area of aggregating exposure and assessing cumulative effects. Nor has the additional, supposedly child-focused and much heralded, 10-fold safety factor been applied at key steps along the risk assessment path. Rather, it has

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Toxicity, August 29, 1999. Available at www.epa.gov/oscpmont/sap.1999/september/cumdoc.pdf and not for citation or quotation.

[123] The long overdue task of pesticide re-evaluation by the PMRA needs to address 73% of pesticide active ingredients registered for use in Canada including potentially hundreds if not thousands of pesticide products and formulants (see Chapter 9, the Pesticides Case Study).

[124] Pest Management Regulatory Agency, *Re-evaluation Document: Re-evaluation of Organophosphate Pesticides*. REV99-01, June 29, 1999, pp. 1, 4.

[125] Pest Management Regulatory Agency. *Risk Assessment and Risk Management in the Pest Management Regulatory Agency (Draft)*. (Jan 17, 2000), p.6.

been treated as an add-on at the end of the traditional process where often it has been either circumscribed or omitted altogether. Finally, the unexpected renewal and increasing practice by pesticide companies testing their products on human "volunteers" to avoid and perhaps weaken pesticide regulation is a perverse and sad result of a law intended to increase regulation for the sake of protecting children from known risks.

A recent example illustrates many of these points. Dursban or chlorpyrifos is one of the most widely used of the organophosphate pesticides and has been the subject of a re-registration application in the U.S. during 1999. The Reregistration Eligibility Decision (RED) Document[126] for chlorpyrifos clearly reveals an exposure problem for U.S. children. However, without a final decision as to methodology, an aggregate exposure assessment was not conducted and the risk assessment is not informed by aggregate exposure calculations despite the fact that this chemical is the active ingredient in over 800 commonly used products. Nor has the risk assessment been informed by as-yet unknown or uncalculated cumulative risks of this pesticide with others having a common mechanism of toxicity. Despite the above gaps in information the risk assessors chose to apply only a 3-fold additional safety factor within the FQPA requirement. The situation could be worse since chlorpyrifos was the subject of one of the first of the human dosing experiments to determine a human NOAEL.[127] However, as part of this re-registration review process and likely due to a great deal of public pressure, and the child-specific health risks of this chemical, the EPA decided to eliminate the results of the human testing results of chlorpyrifos from its re-registration decision on this chemical.[128]

The Canadian PMRA apparently continues to rely on this 1972 human study[129] as the basis for its Tolerable Daily Intake (TDI) for chlorpyrifos. Notably, in light of the EPA re-registration review, twelve prominent scientists have recently called for tight restrictions on agricultural use of chlorpyrifos and for a full ban on all applications in the residential setting, schools or childcare facilities because of concerns about neurological effects in children.[130]

The expensive and time-consuming nature of a chemical-by-chemical approach to regulation embodied in risk assessment is only slightly improved in the FQPA requirement to assess the "worst first" and to assess groups of chemicals with common toxic effects. The outcome so far has been much the same as in past however with only a handful of chemicals having been assessed and only the most egregious

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[126] United States Environmental Protection Agency Office of Prevention, Pesticides and Toxic Substances, internal memorandum and attached reports re: Chlorpyrifos: Health Effects Division Preliminary Risk Assessment for the Reregistration Eligibility Decision (RED) Document. October 18, 1999. 66 p. Available at: www.epa.gov/oppsrrd1/op/chlorpyrifos/hedassessment.pdf

[127] Coulston, F. *et.al.*, 1972, *op.cit.*

[128] United States Environmental Protection Agency, Office of Pesticide Programs, Memorandum regarding *Chlorpyrifos – Replacement of Human Study Used in Risk Assessments*, Report of the Hazard Identification Assessment Review Committee, June 2, 1999. Available at: http://www.epa.gov/oppsrrd1/op/chlorpyrifos.htm

[129] D.L. Grant and Associates, Ltd., *Chlorpyrifos: Review of the basis of the human health assessments conducted by PMRA and identification of uncertainties in the assessments*. Report prepared for Pollution Probe, Toronto, Ontario. December 13, 1999.

[130] Of these twelve scientists, two are former EPA officials. Dr. Philip Landrigan, director of the Center for Children's Health and the Environment at Mount Sinai School of Medicine in New York, was a senior advisor on children's health to EPA in 1997 and 1998. Dr. Lynn Goldman, adjunct professor at Johns Hopkins University School of Hygiene and Public Health, was assistant administrator for the EPA's Office of Prevention, Pesticides and Toxic Substances from 1993 to January of 1999. See: Environment News Service, Americscan: April 13, 2000 at www.ens.lycos.com/ens/apr2000/2000L-04-13-09.html

examples having been the subject of use restrictions. For example, in August of 1999, EPA took regulatory action to reduce residue limits for two organophosphates, methyl parathion and azinphos methyl.[131] However, now-illegal residues remain on the bulk of the apple crop sold throughout the winter of 1999-2000 according to recent test results by the Environmental Working Group. They found unsafe residues of methyl parathion in 2 of 25 bags tested and residues of aziphos-methyl in 14 of 25 bags tested. The tests also revealed residues of endosulfan, recommended for a ban by the Washington State Department of Ecology.[132] Despite having stated that Canada will follow the FQPA lead, no regulatory action on azinphos methyl use in Canada has been announced (methyl parathion is not registered for use in Canada) although a report is apparently in preparation.[133] Nor has any Canadian action been taken on restricting the use of chlorpyrifos, or Dusrban. In contrast, recent media reports indicate that the U.S. EPA will be announcing use restrictions for this pesticide to reduce exposure to children.

Actual reductions in pesticide use and exposure under the FQPA have been limited by the insistence on the "sound science" of risk assessment. Implicit in this approach is the standard of proof demanded by scientific inquiry. The lack of data and methodologies to provide this standard of proof undermine the notion that risk assessment is "sound science" or that it can deliver child-protective standards quickly or perhaps at all. Rather, the science necessary to deliver protective standards tends to demand that exposure to pesticides reaches measurable (according to rigorous scientific standards) and often excessive levels and that health impacts of such exposures have been both detected and verified by defensible scientific inquiry. The situation is reminiscent of the early days of the cautionary tale of lead, documented in Case Study #1, when scientifically defensible proof of both exposure and harm was uncertain but deeply troubling; comparable to the situation with many pesticides in common use today. The regulatory reforms provided by the FQPA offer very limited and mostly inadequate solutions to this problem.

4.5 THE PRECAUTIONARY PRINCIPLE

4.5.1 Introduction

Sections 4.2, 4.3 and 4.4 above describe the nature, scope and the limits of risk assessment. These sections provide considerable commentary on the scientific limits, (such as attempting to generalize animal studies to human health ignoring background sources, ignoring multiple chemical exposure, among many others), the gaps and deficiencies in data and methodologies and those limits pertaining to epidemiological and causation issues.

Two responses have emerged to respond to these criticisms of risk assessment. Predominantly, as discussed in Sections 4.2 and 4.4 above, the response has been to find risk assessment basically sound and in need of ever more complex refinement. To a certain extent, this refinement has included incorporation of the weight-of-evidence approach discussed in Section 4.3.6.

The other response is to provide a new "overlay" on risk assessment that instills in effect a new approach. This new approach incorporates the precautionary principle.

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[131] EPA Press Release, *EPA Acts to Reduce Children's Exposure to Two Older, Widely Used Pesticides*, August, 2, 1999; available at: www.ecologic-ipm/epapr080299.html).

[132] See: Environmental Working Group, *A Few Bad Apples… Pesticides in Your Produce; Why Supermarkets should "Test and Tell,"* March, 2000. Available at: www.ewg.org/pub/home/reports/fewbadapples/foreword.html

[133] Personal communication with Adrian Carter, Pest Management Regulatory Agency, May, 2000.

Simply put, the precautionary principle provides a policy framework to make decisions to protect human health and the environment in the face of scientific uncertainty. As summarized by one commentator, the principle has a "dual trigger," namely, "If there is a potential for harm from an activity and if there is uncertainty about the magnitude of impacts or causality, then anticipatory action should be taken to avoid harm."[134]

Although simply put, the definition of the principle, the legal basis, the scope of its application, its core elements and how to implement it, have been but a few issues raised by the concept and which are now being debated both within the context of international law and domestic legislation.

One of the key issues raised by the precautionary principle is how the principle relates to risk assessment. While the precautionary approach is not usually viewed as an alternative to risk assessment, it is at times regarded as a threat to the "sound science" and the rigour that is supposedly inherent within risk assessment. This section provides some context on the precautionary principle in terms of its origins, definition and application. It also builds and relies upon the discussions of "weight of evidence", "burden of proof" and "precautionary inference" contained in the review of "The Science Behind the Assessment" in Section 4.2 above. The components of the precautionary approach are reviewed again here in terms of their relevance to children's health. The present status of the precautionary principle in Canada is then discussed.

4.5.2 Evolution of Principle

Although the articulation of the precautionary principle as a distinct, recognizable principle is fairly recent in origin, the key motivation and thinking behind the term is anything but new. Its basis is rooted in public health thinking of attempting to anticipate harm in the face of uncertainty,[135] or colloquially put, "an ounce of prevention is worth a pound of cure." The legal and policy footing of the term can be traced through its recognition in a number of international treaties and conventions commencing in the early 1980s, followed by some modest efforts to incorporate the concept domestically.

4.5.2.1 Precautionary Principle and International Law

One of the on-going debates is whether the precautionary principle has emerged into a customary rule or norm of international law.[136] A customary norm or rule creates an obligation upon all states to follow the rule. While most seem to agree that the principle is an international custom, it is unclear whether the principle has evolved into a binding rule. Evidence or indicators that the principle has emerged as an international custom is derived from the fact that a large number of treaties and conventions incorporate the principle, it is found in state practice to some extent, and it exists within commentary from the international court of justice, among other indicators. The list of international treaties, conventions, agreements and statements where the concept is mentioned is impressive, including the *Protocol on*

[134] Raffensperger, C. and J. Tickner (eds.), *Protecting Public Health and the Environment: Implementing the Precautionary Principle* (Washington, D.C.: Island Press, 1999), Introduction, p. 1.

[135] *Ibid*., pp. 4-7.

[136] For a more detailed discussion on this topic, see: Castrilli, J.F., *The Precautionary Principle and Canadian Environmental Law: From Principle to Practice*. A Report Prepared for Pollution Probe, 1999, p. 6; and McIntyre O. and T. Mosedale, The Precautionary Principle as a Norm of Customary International Law. *Journal of International Law*, 9(1997) p.221.

Substances that Deplete the Ozone Layer (1987); *Bamako Convention on Hazardous Wastes within Africa* (1991); the *Rio Declaration on Environment and Development* (1992); and the *Framework Convention on Climate Change*, (1992), to name but a few.[137] Moreover, many earlier international agreements have been interpreted as applying or implicitly recognizing the precautionary principle. The clearest example perhaps is the discussion by the International Joint Commission (and one of its advisory bodies, the Science Advisory Board) in its interpretation of the *Great Lakes Water Quality Agreement*.[138]

Certainly most treaties and conventions in the past decade have incorporated the precautionary principle in some fashion.[139] This trend is continuing. In January of 2000, the principle was incorporated into the *Cartagena Protocol on Biosafety to the Convention on Biological Diversity.*[140] At the 4th International Negotiating Conference for the proposed Legally Binding Treaty on Persistent Organic Pollutants held in Bonn, Germany in March of 2000, the use of the precautionary principle received, and is anticipated to continue to receive, extensive debate as to how to implement the principle within that regime.

4.5.2.2 Approaches in Other Countries

The Maastricht Treaty, which formed the European Union, commits the environmental policy of the community to the precautionary principle. A number of countries, including the Netherlands, U.K, and Sweden have been studying how to implement the principle while Hungary and Brazil have already adopted it.[141] In February of 2000, the European Commission issued a Communiqué formally recognizing the principle and providing guidance as to how to further it.[142]

According to one commentator, the United States has yet to adopt the precautionary principle as an "explicit basis" for environmental decision-making. However, there is an emerging debate on the topic, especially since the U.S. did sign the *Rio Declaration on Environment and Development* (which obliges countries to adopt the principle) and there is some articulation of the concept in a few national environmental laws. As well, the principle is recognized in the 1996 statement of guiding principles for sustainable development by the U.S. President's Council on Sustainable Development.[143] However, the concept of pollution prevention, a component of the precautionary principle (described in the next

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[137] For a review of treaties and conventions that have incorporated the precautionary principle see: Raffensperger and Tickner, 1999, *op.cit*., Appendix B, Uses of the Precautionary Principle in International Treaties and Agreements in U.S. Legislation. This is a summary review with more extensive treatment in: Hickey, J. and V. Walter, Refining the Precautionary Principle in International Environmental Law, *Virginia Environmental Law Journal*, 14(1995) pp. 423 –436, as cited in Appendix B of Raffensperger and Tickner, 1999, *op.cit*.

[138] See: International Joint Commission, *Sixth Biennial Report on Great Lakes Water Quality* (Ottawa/Washington, 1992); International Joint Commission, *Seventh Biennial Report on Great Lakes Water Quality* (Ottawa/Washington, 1994); International Joint Commission, *1993-95 Priorities and Progress Under the Great Lakes Water Quality Agreement* (IJC, 1995).

[139] *Ibid*.

[140] The Protocol can be found at: www.biodiv.org/biosafe/BIOSAFETY-PROTOCOL.htm. For commentary on this issue, see: Swenarchuk, M., The Cartagena Biosafety Protocol: Opportunities and Limitations. Canadian Environmental Law Association, February, 2000. Available at: www.web.net/cela/Trad&Env/biosafe.htm

[141] Tickner, J., *Precautionary Principle: Current Status and Implementation*. Lowell Center for Sustainable Protection, March, 2000, p. 1.

[142] *Ibid.*

[143] *Ibid*., pp. 1 and 2.

section), is a part of the policy mainstream in the U.S. Approximately 25 states now have toxic use or pollution prevention laws now in place, although they vary greatly in scope and effect.

The Canadian position with respect to the precautionary principle is discussed below.

4.5.3 What is the Precautionary Principle?

While a strong argument can be made that the precautionary principle is becoming enshrined in both international law, and perhaps less so, national law, there are enormous debates that remain as to both the definition and the implication of the principle.

4.5.3.1 Definitions

Clearly, there is no consensus on how to define the "precautionary principle." The definition is important is since it either expands or constrains the scope of the concept. A comparison of two definitions illustrates the point. The *Rio Declaration on Environment and Development*[144] states the definition as follows:

> In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

While this definition speaks to "serious or irreversible damage" and "cost-effective" measures, other definitions do not have such qualifications. For example, the *Wingspread Statement on the Precautionary Principle*[145] states:

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

As noted , even though Canada seems to be tending to accept the Rio Definition, certainly the concept will continue to evolve as the policy debate matures. Indeed, one can expect a continuous rigorous debate on the definition for a number of reasons. Foremost, the definition will determine the scope of application of the concept. Second, the definitions that have evolved also implicitly or explicitly refer to a number of elements or components that seek to implement the principle. These components are discussed in the next section.

4.5.3.2 Components of the Precautionary Approach and their Relevance to Children's Health

As the debate as to the definition of the principle continues, the literature on the topic is rich in outlining the key components or policy implication emanating from the principle. While no attempt will be made to outline the full range of possible components or policy implications, those most germane to the present discussion pertain to: onus of proof; the weight of evidence approach; prevention-based tools and

[144] June 14, *International Legal Material* 31(1992) p.849.

[145] The Wingspread Statement is reproduced in: Raffensperger and Tickner, *op.cit*., Appendix A.

standards; and public participation.[146] These components are discussed generally, but some effort is also made to relate these components to implications for risk assessment referred to in section 4.2 and 4.3, as well as some commentary on the implications for children's health.

Burden/ Onus of Proof

One of the common noted elements of the precautionary principle is that, where there is a threat of harm, the onus should be on those threatening such harm to establish the activity will not cause harm to the environment or human health. As discussed in detail in Section 4.3.7, standard setting is primarily a policy-making exercise and decisions on policy entail a review of the science, together with many other judgements. While there is increasing agreement and application by regulatory agencies of the need to apply a "weight of evidence" approach in standard setting, disagreement remains concerning the "burden of proof." In particular, the questions (discussed in more detail in Section 4.3.7) include: what "burden of proof" should be demanded; where should the "burden of proof" be placed; and what elements of "proof" should be considered in making standard setting decisions.

If environmental standards are to protect human health and welfare, ecosystems and other very high values, the "burden of proof" that will be protective of those desired values cannot rely strictly upon the statistical significance testing that is applied to epidemiological studies. To base standard setting decisions on scientifically derived inferences of causation *before* establishing protective measures or refusing to allow additional exposures will result in potentially hazardous exposure to contaminants. The Lead Case Study provides the cautionary tale of the perils of this rigid approach.

The legal concepts of duty of care based on a "balance of probabilities" or "50% plus one" likelihood standard are valid here and can reasonably be applied. Standard setting approaches that would truly weigh all of the available evidence and arrives at a prudent protective judgement based on all of that "weight of the evidence" would be the most likely to create standards that are protective of children's health.

Again, as is explored in more detail in Section 4.3.7 above, "precautionary inference" is a preferred method for making scientific judgements when data are incomplete or inconclusive, and where significant harm may follow from a false negative judgement, i.e., in matters typical of environmental contamination and health damage. The risk assessment approach of contaminants largely being considered "innocent until proven guilty" is reversed and the burden of proof is on demonstrating lack of harm. Standards would be set at rigorous levels of safety and not lowered unless and until the ever-present uncertainty is resolved to demonstrate on "clear, strong and cogent evidence" that at the permitted exposure level, no harm to children will result.

Weight of Evidence Approach

Although, as noted above, regulatory agencies are increasingly applying a weight-of-evidence approach, another question implicit within the precautionary principle is the determination of how much evidence is required that harm may occur before precautionary action will be taken. Is it necessary that there will be absolute proof of harm or only a mere suspicion?

One commentator summarized the preferred approach this way:

> Decision –making about associations or likelihood of harm under the Precautionary Principle

[146] The criteria identified are derived from a review of the literature, and in particular, see: Castrilli, J.,F., 1999, *op.cit*., pp.11-13; and Raffensperger and Tickner, 1999, *op.cit*., A Map Toward Precautionary Decision Making, pp. 166-177. Other components identified include use of the "polluter pays" principle, evaluating alternative activities, technologies and chemicals, ongoing monitoring, investigation and information dissemination, strong enforcement, among others.

> should be based on a "weight-of-evidence" approach, rather than on some quantitative probability of harm (as is the case with risk assessment approaches). The weight-of-evidence approach to decision-making takes into account the cumulative weight of information from numerous sources that address the question of injury or the likelihood of injury to living organisms."[footnotes omitted][147]

As discussed in detail in Section 4.3.6 above, a wide array of evidence is at issue when identifying potential human health hazards, especially when appropriate human data are lacking and inferences have to be made about the degree of proof that is provided by existing toxicological data.

Prevention-Based Tools and Standards

Another element of the precautionary principle calls for the use of prevention-based tools and standards aimed at avoiding or preventing harm from some activity. In other words, rather than focusing on the proof of harm, a focus would be on designing products and activities such that the threat of harm would be avoided. Examples of such measures in this context would include recognition of inherent toxicity as the basis for phasing out of dangerous substances, the establishing of pollution prevention standards, the development and encouragement of clean technologies; methodologies to promote alternatives, to name but a few.[148] It is important that principles of Just Transition be applied so that workers affected by the phase-down and phase-out of toxic chemicals are able to at the very least obtain alternative training and employment. Ideally, the expertise of these affected workers can assist with the process of workplace transition and transformation.

Public Participation

One of the implementing mechanism for the precautionary principle relates to greater public participation in environmental decision-making. This mechanism is important since the implementation of the principle requires "the need to balance value judgements before decision-makers when health and environmental risks of activities are being evaluated."[149]

4.5.4 Precautionary Approach in Canada

Canada's initiatives to embrace the precautionary approach has been described as "hesitant hugs." Although Canada has perhaps accepted the approach in principle in various legislative enactments, it has yet to provide any specific roadmap with respect to its practical implementation.[150]

Federally, both the *Oceans Act* and the new *Canadian Environmental Protection Act* formally commit to the precautionary approach. In the *Oceans Act*, the precautionary principle is recognized in the preamble and is required to be considered when the Minister of Fisheries and Oceans develops a national oceans management strategy.[151]

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[147] Tickner, J., A Map Toward Precautionary Decision Making, Raffensperger and Tickner, *op.cit.,* p. 169.

[148] Castrilli, J.,F., 1999, *op.cit*., pp. 11; and Raffensperger and Tickner, 1999, *op.cit*. p.171.

[149] Castrilli, J.,F., 1999, *op.cit*., pp. 13; and Raffensperger and Tickner, 1999, *op.cit*. p.175-6.

[150] VanderZwaag, D., The Precautionary Principle in Environmental Law and Policy: Elusive Rhetoric and Embraces , *Journal of Environmental Law and Practice* 8(355)(1999), p. 369. See also: Moffet, J., Legislative Options for Implementing the Precautionary Principle *Journal of Environmental Law and Policy* 7(1997), p. 157.

[151] *Oceans Act*, S.C. 1996, c. 31, Preamble and section 30.

In the *Canadian Environmental Protection Act* (CEPA), which was recently revamped and passed into law in 1999,[152] as with the *Oceans Act*, the precautionary principle is mentioned in the preamble. It also outlined those administered duties committed to by government, namely:

> In the administration of this Act, the Government of Canada shall .. exercise its powers in a manner that protects the environment and human health, applies the precautionary principle that, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation, and promotes and reinforces pollution prevention approaches…"[153]

Hence, while the Act embraces in a general way the precautionary principle, using the language from the Rio Declaration, the general view is that the Act falls short of implementing the principle in a meaningful way.[154] Some of the highlights of the law in this regard (as well as some of the limits), include:

- *Virtual Elimination*: Part 5 of CEPA contains a number of provision that recognize the inherent toxicity of substances. For those substances designated to be persistent, bioaccumulative and toxic, the goal is "virtual elimination." Despite this goal, the law is drafted is such a way that there is no actual requirement to achieve virtual elimination, but instead requires the setting of interim targets taking into account social, economic and technical matters.

- *Weight of Evidence*: When the government is conducting and interpreting the results of toxicity assessments pursuant to the Act, the Ministers of the Environment and Health "shall apply the weight of evidence approach and the precautionary principle."[155]

- *Pollution prevention plans*: Under Part 4 of CEPA, the government is empowered to require pollution prevention plans for those substances found to be toxic under the Act and placed on the Toxic Substances List. These provisions, however, are completely discretionary on the part of the Minister of the Environment and these powers are only for substances found to be toxic under the Act..

Because the Act is only to be proclaimed in the spring of 2000, the interpretation and application of these provisions remains to be seen.

The federal and provincial governments have also recognized the precautionary principle, at least in principle, in the *Canada-Wide Accord on Environmental Harmonization* which was concluded on January 29, 1998. The intent of the Accord is to avoid overlap and duplication between federal and provincial governments in areas of shared jurisdiction. However, the Accord has been seriously criticized by non-governmental groups as a mechanism to devolve federal environmental roles and responsibilties to the provinces.[156] It is too early to tell whether this devolution of responsibility will mean that Canada's

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[152] *Canadian Environmental Protection Act*, 1st Sess. 36th Parl. 1997-98-99.

[153] *Ibid*., section 2(1)(a).

[154] VanderZwaag, D., 1999, *op.cit*. p. 371.

[155] *Canadian Environmental Protection Act*, 1st Sess. 36th Parl. 1997-98-99, section 76.1.

[156] For example, see: Canadian Environmental Law Association and the Canadian Institute for Environmental Law and Policy, *Brief to House of Commons Standing Committee on Environment and Sustainable Development Regarding the Canadian Council of Ministers of the Environment (CCME) Environmental "Harmonization" Initiative*, CELA Brief No. 332; CIELAP Brief No. 97/4 (October 1997).

international commitments to the Precautionary Principle will be implemented. However, if the progress so far on Canada-Wide Standards is any indication, the prospects are bleak (see Chapter 5 for further discussion).

In addition to acknowledging the need for pollution prevention, the Accord adopts the Rio Declaration of the precautionary principle as it states under a section entitled "Principles":

> Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (precautionary principle);

There is no mention in the Accord of implementation measures for this principle ensuring that, so far at least, the commitments remain primarily rhetorical.

According to one commentator,[157] only two provinces, namely Nova Scotia and New Brunswick, have legislation that acknowledges the precautionary principle.[158] Neither of these statutes though provide implementing mechanisms.

4.5.5 Summary

The precautionary principle is now recognized as a legitimate public policy principle, although it has yet to be fully implemented. Its acceptance as an international law norm suggests that it is just a matter of time before domestic law will more routinely and effectively reflect this principle.

While the precautionary principle will probably not replace risk assessment, it will certainly promote risk assessment in a different light. Rather than being the core of standard setting exercises, risk assessment would be just another tool along side other important tools. The components of the precautionary principle, if implemented, would profoundly recast how environmental standard setting takes place. These components are essentially direct responses to the limits of risk assessment identified in sections 4.2 and 4.3 above. The onus of proof, weight of evidence and pollution prevention are a number of the key elements that ensure that real progress can be made towards more protective standards. It should be noted however, that these elements are anything but radical. By and large, some of these components are slowly drifting into the lexicon of decision-makers while other are already firmly entrenched (such as pollution prevention) although there is an enormously long way to go yet.

While Canada has made some modest gains in furthering the precautionary approach through recognizing it in such statutes as the *Canadian Environmental Protection Act* and the *Oceans Act*, its implementation is anything but certain.

4.6 CONCLUSIONS

This Chapter provides a foundation for answering the question as to whether environmental standard setting, via the predominant approaches of risk assessment and risk management, is or can be, *intentionally* protective of children. It is clear from this historical review that risk assessment approaches

[157] VanderZwaag, D. 1999, *op.cit*., p. 372.

[158] See: *Environment Act*. Statutes of Nova Scotia 1994-95, c. 1, s. 2(b)(ii); *Clean Air Act*, Statutes of New Brunswick 1997, C-5.2, 2(b).

to standard setting have evolved over time and continue to do so. These changes have attempted to resolve gaps in data and methodology including better accounting for children's health effects. However, the ever-increasing complexity of risk assessment methodologies has been matched and consistently overcome by the greater complexity of the problems they attempt to address, including accounting for the special exposure circumstances and vulnerabilities of children.

Advances in risk assessment guidance and methodologies continue to be undermined by central problems that have been with risk assessment from the start. Even when risk assessment approaches have been modified to specifically account for children's health, as is being attempted under the *Food Quality Protection Act* in the United States, the outcome in terms of actual reduction in risk has so far been minimal as well as highly acrimonious, controversial and slow. Moreover, the application of additional child-specific safety factors has been mainly an exercise in minimal afterthought rather than application of precautionary measures at each step where uncertainty exists throughout the process. Methodologies to overcome key barriers (aggregate exposure, cumulative effects) are barely developed, controversial, and have yet to be employed to any significant extent.

These problems frequently stem from the incorrect assertion that risk assessment is an objective science-based activity. Although risk assessment is routinely characterized as the "scientific" stage of the exercise (while risk management is considered the policy-making step), two of the four key steps in risk assessment suffer from large gaps in data and methodology providing many opportunities for uncertainty, variability and error. When gaps have to be filled with "science policy options," or informed guesswork, the risk assessment exercise can no longer claim to be objective and scientific. This Chapter's review of the "science behind the assessment" explores the many reasons for the high degree of difficulty and scientific uncertainty in drawing inferences of causation in environmental health matters. A key issue for standard setting is a mis-application of the standard of proof demanded by scientific inquiry. While there are important reasons for maintaining this standard, not the least of which is ensuring the integrity of scientific inquiry, problems arise when the scientific standard of proof is applied to the only-partially scientific process of setting standards to limit exposure to contaminants.

The insistence on risk assessment to provide objective science-based standards has resulted in a demanding, time and resource intensive chemical-by-chemical approach. With so many chemicals to assess, so many gaps and uncertainties in data and a lack of methodologies to both assess exposure and health effects, it is distinctly unfair and illogical to insist on scientific standards of proof (of exposure and harm) before taking preventative action. Such an approach is doomed to failure in terms of being truly protective of children. Given these fundamental constraints, it is debatable whether individual techniques can be added to make risk assessment *intentionally* protective of children. Although standard setting agencies can and do increasingly apply a weight-of-evidence approach, the political forces brought to bear on the risk management side of the exercise can be formidable and can serve to remove any safety margins or precautionary influence on the final choices as to standards.

The assigning of individual risk levels for each chemical is also a game of odds that cannot address two of the most serious issues of toxic chemical pollution: inherent toxicity and population-wide effects such as may be occurring with endocrine disrupting chemicals. Risk assessment enables risk calculations that allow for "acceptable" levels of one-in-a-million or one-in-ten-thousand risks (of cancer, birth defects, etc.) across a population. However, the odds game becomes useless if further research confirms the suspicion that chemicals such as endocrine disruptors are capable of exerting population-wide effects. Nor is it appropriate to make such calculations for chemicals that are persistent and bioaccumulative. Risks will continue to increase for chemicals that do not break down and which accumulate in animal fat, breast milk, etc. These risks will of course be highest for children and other vulnerable populations than for the adult population at large.

Important issues of ethics and equity arise during risk assessment and risk management. Within the domain of specialized experts and those wealthy enough to hire them, the combination of science and guesswork provides numerous opportunities for value judgements and bias to enter risk calculations. Again, the chemical by chemical supposedly scientific process is a central part of the problem. Each chemical is treated as "innocent until proven guilty." By applying the high standard of proof demanded within scientific inquiry, chemicals essentially have greater rights than the human population. Assessed one at a time, in isolation from other chemicals, risk levels are assigned to new chemicals regardless of risk levels that already exist or that are yet to be calculated for new chemicals. Such assessments also underestimate risk since they rarely account for all relevant health effects or for the cumulative or synergistic effects of chemicals acting in combination. As more and more chemicals continue to have the right to be assigned a risk level (alongside the many thousands of chemicals that have never been adequately assessed), the human population does not have the same right to be exposed to no more than a specified level of risk.

Many implications arise when applying judgement and non-scientific values to the process of weighing a body of evidence and setting policy or standards for exposure to contaminants. Key among them is the choice made as to the "burden of proof" demanded. Because standard setting is intended to protect human health and welfare, ecosystems and other very high values, the "burden of proof" that is required in standard setting should be one that is more likely to be protective of those desired values. However, standard setting rarely applies such a protective approach. Instead, protective standards generally are not set until rigorous scientific inquiry has been applied to the available (and always incomplete) information in order to verify proof of harm. The result is delay in setting protective standards and the greater likelihood of too much exposure before protective action is taken.

A more appropriate standard of proof would incorporate the legal concepts of duty of care, based on a "balance of probabilities" or "50% plus one" likelihood standard. Standard setting policy decisions should follow a paradigm in which it is *at least* "more likely than not" that standards have been set that will be protective of children's health. Where data are incomplete or inconclusive, the approach of "precautionary inference" is a more prudent and appropriate means of making scientific judgements particularly since significant harm may flow from incorrectly assuming that no harm is possible from the environmental contamination being regulated. This approach reverses the current scientific and policy framework, recognizes the inherent shortcomings of information and methodologies, and would set protective standards first. Such standards would be made less stringent only when the uncertainty as to the toxicity of the chemical hazard is resolved via "clear, strong and cogent evidence" that, at the permitted exposure level, no harm to children will result. Such a "reverse onus" approach would place the scientific burden of proof on those wishing to create environmental contamination while regulatory agencies could apply precautionary inference to the setting of protective standards.

In contrast to risk assessment, the precautionary principle provides a policy framework to make decisions to protect human health and the environment in the face of scientific uncertainty. While the precautionary approach is not usually viewed as an alternative to risk assessment, it is at times regarded as a threat to the "sound science" and the rigour that is supposedly inherent within risk assessment. The components of the precautionary principle, if implemented, would profoundly recast how environmental standard setting takes place. These components are essentially direct responses to the limits of risk assessment. The onus of proof, weight of evidence and pollution prevention are a number of the key elements that ensure that real progress can be made towards more protective standards.

4.7 RECOMMENDATIONS

4.7.1 Risk Assessment

1. The use of "comparative risk assessment" and "cost-benefit analysis" in environmental standard setting should be monitored and evaluated for effectiveness in environmental and health protection versus their narrower ability and purpose of cutting costs.

2. All regulatory agencies in the federal and provincial government need to explicitly acknowledge the scientific uncertainties and limitations of risk assessment for deriving environmental standards.

3. The harmonization (either NAFTA-imposed or as cost-saving measures) of Canadian pesticide standards with those being developed in the U.S. should be undertaken as a preliminary step towards, or at least should not undermine Canada's ability to move towards, more precautionary standards. Such standards should include more rigorous and stepwise application of child-protective safety factors during both exposure assessment and dose-response assessment, as well as assessments of aggregate exposure, cumulative and synergistic effects, and the ability to implement a full ban on persistent organic pollutants. Child-protective safety factors and a weight-of-evidence approach should continue through to the risk management stage of setting new or revised standards for pesticides and all environmental pollutants.

4. Further research is necessary regarding whether and how commitments made under international trade agreements constrain Canada's ability to set protective standards. In addition, given the influence on Canada of standard setting in the United States, further research is required to determine the degree to which final standards established in the United States are set at numbers influenced by the possibility of legal challenge, including on a constitutional basis, so as to be able to recognize when a resulting standard is weaker than it should be within the Canadian legal context.

5. The Canadian Pest Management Regulatory Agency, as part of a government-wide approach, should immediately implement a policy of refusing to accept from pesticide companies new or existing toxicity test data derived from experiments on human "volunteers."

4.7.2 Precautionary Principle

6. Although the federal government has committed to the precautionary principle in the *Canadian Environmental Protection Act*, the *Oceans Act*, and in other policy pronouncements, there is little evidence that the principle has been operationalized. It is therefore recommended that the federal government develop a national implementation strategy to further the precautionary principle that includes:

   (a) Change in the burden of proof: a process that ensures that those parties creating a threat of harm, such as those that produce a new substance that is being assessed or that introduce new products, have the onus to establish that such substances or products are safe, rather than having government establish that they pose a risk of harm;

   (b) Weight of evidence: a protocol that allows decisions at each step in a risk based decision-making process (i.e., during all stages of both risk assessment and risk management) to be based on the weight of evidence approach rather than waiting for an extremely high standard of proof;

(c) Pollution Prevention: a commitment to operationalize pollution prevention through the development of a regime for bans and phase-outs of inherently toxic substances as well as pollution prevention standards for industrial sectors;

(d) Just Transition: a commitment to ensure the application of the principles of Just Transition for workers affected by toxic substance phase-down and phase-out;

(e) Public Participation: in recognition of the political and ethical implications of environmental and risk-based decisions, a commitment to make these decision-making regimes more transparent and open to the involvement of the public.

7. At this time, there is little evidence in provincial law or policy that Ontario is committed to the precautionary principle. It is recommended that the province of Ontario development a regulatory commitment to the precautionary principle together with a strategy to operationalize the principle similar to that described in Recommendation 5 above.

8. Both Ontario and Canada should adopt a definition of the precautionary principle that is more expansive than the definition found in the *Rio Declaration,* and preferably one similar to that found in the *Wingspread Statement on the Precautionary Principle*, which states:

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically.

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