

CHILD HEALTH AND THE ENVIRONMENT—A PRIMER

canadian partnership for



children's
health & environment

ABOUT CPCHE

The **Canadian Partnership for Children’s Health and Environment (CPCHE)** is a multi-sectoral collaboration of organizations (formed in 2001) that is working to protect children’s health from environmental exposures and toxic chemicals by moving children’s environmental health issues into the minds of decision-makers, service provider organizations, individual practitioners, parents and the public. CPCHE’s members include:

- Canadian Association of Physicians for the Environment
- Canadian Child Care Federation
- Canadian Environmental Law Association
- Canadian Institute of Child Health
- Environmental Health Clinic — Sunnybrook & Women’s College Hospital
- Learning Disabilities Association of Canada
- Ontario College of Family Physicians
- Ontario Public Health Association
- Pollution Probe
- South Riverdale Community Health Centre
- Toronto Public Health

With a shared vision of working together to create a healthy environment for children, CPCHE is committed to: raising the level of **literacy** about prenatal and children’s environmental health across Canada; supporting CPCHE partners to **inform and advance** a children’s environmental health **policy agenda** in Canada; advocating for and undertaking **children’s environmental health and policy research** that will help society to better understand prenatal and child health and protect children from toxic exposures; and ensuring that the **coordinated work** of CPCHE, its partners and its expanding network have the capacity to, and are effective, in improving the quality of children’s environmental health in Canada.

It is our societal responsibility to work together to create a healthy environment for children. We invite you to take precautionary action and make decisions now that will protect children’s health and development now and in the future.

To learn more about CPCHE, find out more about the issues and to receive copies of our *Childproofing Brochure*, please go to our website at www.healthyenvironmentforkids.ca.

*The Canadian Partnership for Children’s Health and Environment (CPCHE) would like to acknowledge and thank the **Laidlaw Foundation** and the **Ontario Trillium Foundation** for their ongoing and generous support of CPCHE’s overall work and mandate.*



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CPCHE PARTNERS

Canadian Association of Physicians for the Environment (CAPE) is a group of physicians, allied health care practitioners and citizens committed to a healthy and sustainable environment. As an organization composed mostly of physicians, CAPE brings its health expertise to environmental issues, and is an important voice for environmental health in Canada. CAPE addresses issues of environmental degradation by educating health care professionals and the public and advocating for stronger environmental policy. Children's environmental health is CAPE's priority issue, and it informs all the education and advocacy that CAPE does in working for a healthier environment. www.cape.ca

Canadian Child Care Federation (CCCF) is a national, non-profit, membership-based organization committed to excellence in early learning and child care for Canadian families. Since 1987, it has developed bilingual resources and training materials that support quality early childhood education learning and care. It continues to create networks with others working to support children's healthy development. CCCF has 11,000 members working in a variety of child care settings including child care centres, family day homes, pre-schools, nursery schools and after-school programs. Members also teach at Canadian colleges and universities. www.cccf-fcsge.ca

Canadian Environmental Law Association (CELA) is a non-profit public interest organization, founded in 1970. It is an environmental law clinic — within Legal Aid Ontario — dedicated to providing legal services to low income people and disadvantaged communities, as well as advancing the cause for strong environmental protection through advocacy, education and law reform. Priority areas of activity include: pollution and health, with a particular focus on children; international trade and global governance issues; environmental assessment; and water sustainability. www.cela.ca

Canadian Institute of Child Health (CICH) has worked to improve the health of Canada's children since 1977 through its research and policy recommendations, community development and resources. Through its voluntary Board of Directors and Advisory Council, CICH represents diverse sectors and professionals working with children, helping CICH to focus on the whole child by looking at the broad determinants of physical and mental health, including social, economic and environmental factors. A major focus is on healthy child development and on healthy and safe environments. CICH has been a leader in identifying environmental links to child health and has worked in partnership with its membership, government, other NGOs and corporations to organize and lead national and international initiatives to inform and train professionals working with children and the general public about this issue. www.cich.ca

Environmental Health Clinic began in 1996 as the clinical component of a joint clinical and research program at Sunnybrook & Women's College Health Sciences Centre and the University of Toronto. It is one of only two academically-affiliated, government-funded, provincially-mandated clinics in Canada, the other being in Nova Scotia. The EHC wishes to help prevent adverse health effects of exposure to environmental pollutants, particularly in the most vulnerable citizens, fetuses, children, women and some workers. The purposes of the EHC are to educate patients, the public, and health professionals about environmental health issues, and to provide comprehensive, multidisciplinary assessments and health care advice to people with Environmental Sensitivities/Intolerances, Chronic Fatigue Syndrome/ Myalgic Encephalomyelitis, Fibromyalgia, and other environment-linked conditions.

www.sc.ca/programs/wcacc/clinicsandservices/environmentalhealth

Learning Disabilities Association of Canada (LDAC) is a non-profit, volunteer based organization and the national voice for persons with learning disabilities (LD) and those who support them. Through public awareness about the nature and the impact of learning disabilities, advocacy efforts, research, resource development and collaborative efforts, LDAC is dedicated to levelling the playing field to enable individuals with LD to function as citizens with equitable opportunities to develop to their chosen potential. www.ldac-taac.ca

Ontario College of Family Physicians (OCFP) is the Ontario Chapter of the College of Family Physicians of Canada (CFPC). The OCFP is a provincial, voluntary, not-for-profit organization whose mandate includes undergraduate and post-graduate education, the continuing professional development of family physicians, and the maintenance of high standards of medical care and education in family practice. The OCFP is the voice of family medicine in Ontario and represents more than 6,800 family physicians who provide patient care for remote, rural, suburban, urban and inner city communities throughout Ontario. The building and maintenance of high standards of practice, the continuing professional development of our members and improved access to high quality family medicine services for all residents of Ontario are at the heart of our organization.

www.ocfp.on.ca

Ontario Public Health Association (OPHA), founded in 1949, is a voluntary, charitable, non-profit organization whose membership includes individuals and Constituent Associations from multiple sectors and disciplines sharing a common interest in improving the health of the people of Ontario. The OPHA mission is to provide leadership on issues affecting the public's health and to strengthen the impact of people who are active in public and community health across Ontario. OPHA areas of focus include both environmental health and child health. The OPHA volunteer Environmental Health Workgroup is very active on children's environmental health issues from a public health perspective. Policy papers, resolutions, letters and staff reports related to environmental health issues can be accessed on-line.

www.opha.on.ca

Pollution Probe is a Canadian non-profit environmental organization that works in partnership with all sectors of society to protect health by promoting clean air and clean water. Since its founding at the University of Toronto in 1969, the organization has become national in scope. In the 1990s, Pollution Probe focused its program work on issues related to climate change, energy, air quality, water pollution and human health, including a major program to remove human sources of mercury from the environment. Pollution Probe's scope has also expanded to new concerns, including the unique risks that environmental contaminants pose to children and the development of innovative tools for promoting responsible environmental behaviour.
www.pollutionprobe.org

South Riverdale Community Health Centre (SRCHC) is a community-controlled organization that believes health is a state of physical, mental and social well being. It holds that the health centre's role is to provide quality primary care while engaging in clinical, social, economic, political, cultural and educational initiatives that promote health. It adopts the World Health Organization's definition of health — health is a state of complete physical, mental and social well-being and not merely an absence of disease or infirmity. Health is a fundamental human right. It is central to social, economic and personal development.
www.srchc.com

Toronto Public Health (TPH) is the largest public health unit in Canada, serving the country's most diverse urban population. With programs mandated under Ontario's *Health Protection and Promotion Act*, TPH works to improve the health of the city's entire population while reducing health inequalities. This mission is achieved through evidence-based practice in health assessment, illness and injury prevention, advocacy, health promotion, and health protection. TPH has played a leading role on many environmental health issues, including pesticide use, smog and air quality, and children's health and the environment.
www.toronto.ca/health

AUGUST 2005

The Canadian Partnership for Children's Health and Environment (CPCHE) is proud to present *Child Health and the Environment — A Primer* to the Canadian public.

This educational resource marks a turning point for CPCHE members. Launched in 2001, CPCHE is a partnership of dedicated health, environmental and child care professionals, working across traditional boundaries, who recognized the benefit of working together to create a healthy environment for children. Partnership is never easy, especially in an area in which the issues are so complex and the science is still emerging.

This Primer and our *Childproofing* campaign represent CPCHE's first effort to gather, reflect upon and present information with the public in mind — in particular parents and caregivers, decision-makers, health practitioners and others who are concerned about the impact that the environment has on our children's health.

The commitment and patience of each of the partners has been tremendous and is celebrated as we launch the Primer and the *Childproofing* brochures. In particular, CPCHE recognizes the exceptional work by Kathy Cooper of the Canadian Environmental Law Association, who has worked tirelessly to author this publication. The CPCHE partnership is now looking to inspire and engage a broader audience to work on these issues, so that together we can protect and enhance children's health.

We invite you to join us! Please log on to www.healthyenvironmentforkids.ca to learn more about how you can get involved or stay connected with these issues.



Tonya Surman
Partnership Director
CPCHE



Ken Ogilvie
Executive Director
Pollution Probe

AUGUST 2005

This Primer is ultimately a snapshot in time. New information about children's environmental health surfaces on a daily basis. More often than not, it confirms rather than refutes the information summarized here.

Over the course of two years, steady improvements to this Primer came from the combined input of over forty expert reviewers. Within CPCHE and beyond, we drew upon knowledge from many disciplines — public health, law, family medicine, pediatric medicine, social justice and social anthropology, early learning and child care, toxicology including its many specialized branches, chemistry, epidemiology, and more. This Primer crosses all these disciplines and it was an honour and a privilege to pull it all together.

To add to the acknowledgements that follow, some personal reflections. I note the leadership and determination of Barbara McElgunn, from the Learning Disabilities Association of Canada. Twenty years ago I began working with Barbara to prevent lead poisoning in children. Already a veteran in this work, she has continued tirelessly ever since to seek to protect children's brains from chemicals in the environment.

For over seven years, my work on this topic has almost always been done in partnership with the ever-delightful and brilliant Loren Vanderlinden of Toronto Public Health. My other constant

partner has been Tonya Surman, a woman of boundless energy and both practical and visionary leadership for CPCHE. Loren and Tonya also kept it all real by producing four beautiful baby boys during CPCHE's first five years.

Special thanks must go to Paul Muldoon, Executive Director of the Canadian Environmental Law Association for giving me the space and time that this Primer needed for research, writing and collaboration with CPCHE partners. Likewise, the leadership of Ken Ogilvie, Executive Director of Pollution Probe, was instrumental. We stretched the boundaries of Pollution Probe's Primer series with this one and applied a winning formula that comes with Pollution Probe's formidable Primer experience.

Last but not least, I celebrate Mark Surman's visionary ideas for building community on-line and the unflappable Jason Diceman for making the CPCHE portal website a reality. This Primer is a foundation for the educational work that will continue at the CPCHE website.



Kathleen Cooper
Senior Researcher
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Pollution Probe and CPCHE are solely responsible for the contents of this publication.

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Note that a much more comprehensive list of references for the scientific research summarized in this Primer is contained in a companion report prepared by Toronto Public Health, of which much of this Primer is a shorter, popularized version. *Environmental Threats to Children: Understanding the Risks, Enabling Prevention* will be available on-line in September 2005 at www.toronto.ca.

Photos throughout the Primer were graciously provided by Mark Surman, Tatiana Morita, Toronto Public Health and Health Canada. The illustrations were reproduced by Anna Dong.

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Photo Credit: Mark Surman



Chapter One: Introduction

Children’s environmental health is a large and rapidly growing field. This Primer aims to provide a solid introduction to a vast and complex topic. It will enable the reader to understand the basis for concern about environmental impacts on children’s health, and will make it easier to pursue further readings and research into this vitally important issue.

Among health care practitioners, people who work with children, environmentalists and parents, there is growing concern about the effect that exposures to toxic chemicals or other hazards in indoor and outdoor environments can have on prenatal and child health. Understanding this field requires wading through much complexity and scientific uncertainty. Yet this journey is an important one because the stakes are high — the health of children and future generations. Given what is at risk, there are good reasons to take precautionary action in the face of uncertainty. This Primer explains many of the risks to children posed by environmental exposures. It extends the metaphor of “childproofing,” something every parent understands, and focuses on prevention.

“Why worry about children’s environmental health? Key health outcomes with epidemiological evidence of links to environmental hazards include asthma, cancer, neuro-behavioural and developmental effects, low birth weight and birth defects. Childhood environmental exposures set the conditions for adult health status.”

Source: Raphael, R. 2000. Director General, Safe Environments Programme, Healthy Environments, Consumer Safety Branch, Health Canada. Remarks to *Children — The Environment and Their Health*. A Public Forum sponsored by the Canadian Association of Physicians for the Environment and Pollution Probe, 8 November 2000.

The health of all children living in Canada is at risk from environmental hazards. The degree of risk varies across different hazards, age groups and individual circumstances. Children living in poverty are particularly vulnerable. Scientific evidence exists of associations between environmental hazards and asthma and other respiratory ailments, cancer, impacts on the developing fetal brain, a child’s behaviour and ability to learn, low birth weight and birth defects. Evidence is emerging for other serious health effects.

Hundreds of toxic exposures, such as air pollutants or pesticides, and physical hazards, such as radiation, are either known to contribute, or are suspected of contributing, to these health outcomes. However, very few exposures have been fully evaluated for their effects on prenatal and child development. Full scientific certainty about the effects of most environmental exposures is not possible since it would require carefully controlled scientific experiments on children. Ethically, such experiments would never be allowed.

That being said, unintentional “experiments” on children are happening daily as they are exposed to substances in the places they live, learn and play. For example, it was as a result of experience, rather than prior scientific evaluation, that we learned about the way lead can damage children’s brains. After years of exposing children to lead from gasoline and paint, it became possible for scientists to clearly observe and document the negative effects of this element on fetal and early childhood brain development.

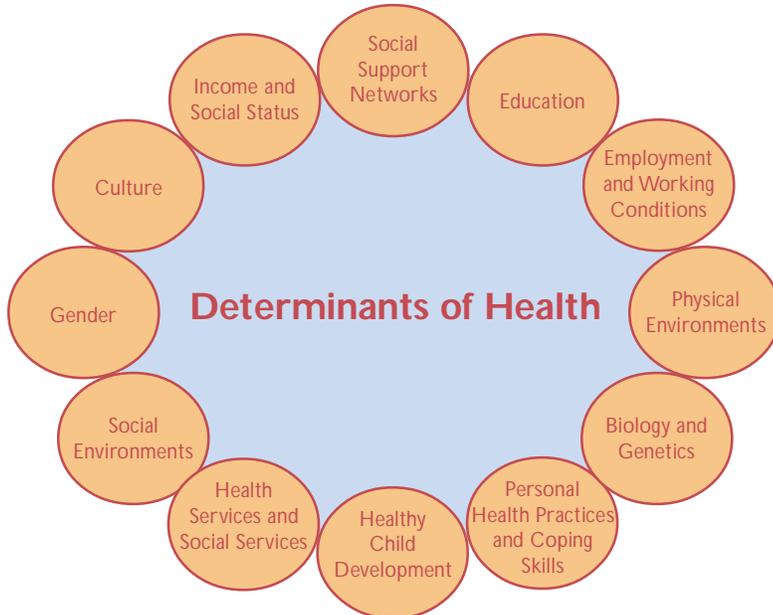
The same is true for our understanding of the impact of air pollution on children’s health. Strong evidence exists to show that air pollution contributes to lung damage, including triggering asthma attacks in sensitive individuals. Suggestive evidence also links air pollution with the onset of asthma in previously non-asthmatic people. This evidence comes from measuring these effects in children exposed to air pollution as part of everyday living.

What Makes Children Healthy?

The World Health Organization describes the multiple factors or determinants that contribute to human health. Among these, the physical environment, including both natural and built environments, plays a crucial role in healthy child development.

In thinking about the determinants of health, it is important to note that, unlike determinants that can't be changed, such as an individual's genetic make-up, environmental exposures are *preventable*. However, such exposures are often beyond an individual's control. For this reason, limiting or preventing environmental exposures must be a collective responsibility. Children are especially dependent upon the adults in their lives and in society to take on this responsibility on their behalf.

Figure 1: Determinants of Health



Source: World Health Organization, undated.

“We are conducting a vast toxicological experiment in which our children and our children’s children are the experimental subjects.”

Source: Dr. Herbert Needleman, Professor of Psychiatry and Pediatrics, University of Pittsburgh. Quoted by Dr. Philip Landrigan, Mount Sinai School of Medicine, keynote address to Children’s Environmental Health II: A Global Forum for Action (Washington, DC: September 2001). This conference was co-sponsored by the Washington-based Children’s Environmental Health Network (www.cehn.org) and the Canadian Institute of Child Health (www.cich.ca).

“Children’s environmental health is increasingly recognized as a global public health issue of great importance. International, national, and other bodies have identified asthma, air pollution (indoor and outdoor), lead, pesticides, water contaminants (chemical and microbial), climate change, hormonally active agents, and environmental tobacco smoke as important children’s environmental health issues.”

Source: Wigle, D. 2003. *Child Health and the Environment*. Oxford: Oxford University Press; www.mclaughlincentre.ca/programs/child.shtml.

Compared to many countries in the world, most children living in Canada are blessed with access to medical care. Overall rates of serious illness and death among children in Canada are generally quite low. However, in Canada, as in other industrialized countries, some health conditions are affecting large, and increasing, numbers of children. Patterns of disease among children have changed dramatically in the last 100 to 200 years. In Canada and other parts of the developed world, infant mortality has dropped steadily. In these countries, improvements in sanitation and public health, and particularly immunization against the historically common infectious diseases of early childhood (e.g., whooping cough, diphtheria, polio), have contributed to a doubling of life expectancy. Nevertheless, chronic diseases and other debilitating or limiting conditions, including several suspected or known to be associated with environmental exposures, are on the rise among children.



Photo Credit: Comstock

Stages of “Childhood”

The life stages of interest in the field of children’s environmental health extend from before conception until the end of adolescence. This period is made up of a series of developmental stages, each of which includes age-specific factors for susceptibility to environmental exposures. The following descriptions note some of the differences (explored in more detail in Chapter Two) across these stages:

Pre-conception: Parents’ germ cells (sperm and egg) vulnerable to occupational or other exposures to reproductive toxicants.

Pregnancy: Entire course of pregnancy (embryo and fetus) is highly sensitive to toxic exposures. Period of rapid cell growth. In females, lifetime supply of ova (eggs) for future reproduction created during fetal development, *in utero*. Environmental exposures may cause permanent cell damage, birth defects, later functional deficits in the brain, later development of cancer. Many environmental contaminants able to cross the placenta and reach the fetus.

Early Infancy (birth to six months): Immature systems for metabolizing and/or excreting toxicants. Breast milk enables optimum development of immune, digestive and nervous systems, among many other benefits. Frequent hand-to-mouth behaviour. During neonatal period (birth to four weeks old), highly permeable gastrointestinal tract (exposures via breast milk or formula) and highly permeable skin (exposures via dermal contact).

Late Infancy and Toddlers (seven months to two years): At six months, maturity reached in blood–brain barrier and most of liver and biliary metabolism and excretion capacity. Kidney excretion capacity not mature until 16 months. Lungs and brain still immature and developing. Continued hand-to-mouth behaviour; expanded play and exploration via crawling and toddling and extensive contact with floors, carpets and the ground outdoors; tendency for consumption of limited range of foods.

Early Childhood (two to six years): Continued immaturity and development of brain and lungs; continued hand-to-mouth behaviour and frequent contact with floors/ground that lessens over time; in many cases consumption of limited range of foods continues. Typically high levels of activity, and therefore faster respiration, often outdoors. Behaviour becoming more important than physiological factors in determining contaminant exposure and uptake.

Childhood (seven to 12 years): Continued brain and lung development; hand-to-mouth behaviour reduced and less time spent on the floor/ground; increased range of preferred foods. Onset of puberty and additional sensitivity to hormonally active agents. High levels of activity, especially outdoors, persist with heightened exposure through faster breathing and tendency in this age for mouth-breathing. Significant amount of time spent in school and engaged in recreational activities.

Adolescence and Reproductive Years (12 to 18 years and beyond): Continued brain and lung development. Sexual development continues as complex interactions occur between nervous and endocrine systems. Decrease in parental control of environments and behaviours. Working teens potentially subject to occupational exposures. Many teens experiment with smoking, alcohol and drugs.

Source: Adapted from WHO-EEA, 2002 and Wigle, D., 2003.

Health Canada states that in Canada:

- Twelve per cent, or one million children, have asthma — this is four times more children than were affected 20 years ago.
- According to data gathered for Canada's *National Longitudinal Survey on Children and Youth*, 26 per cent of children between the ages of six and 11 have one or more learning or behavioural problems. Known risk factors explain less than one quarter of these conditions.
- Birth defects are the leading cause of infant death, followed by immaturity (as a result of pre-term birth) and Sudden Infant Death Syndrome (SIDS).
- Low birth weight and birth defects are major causes of long-term disability and result in an annual 30,000 hospitalizations and 1,500 deaths.
- Cancer is very rare among children, yet is the leading cause of disease-related death of children over one year in age. The National Cancer Institute of Canada points out that several cancers are rising among young adults.

These chronic conditions are caused by multiple factors. It is a slow and incremental process to determine if environmental exposures play a role in their occurrence.

This Primer is concerned with describing how much is known about the contribution of environmental factors to these and other health conditions.

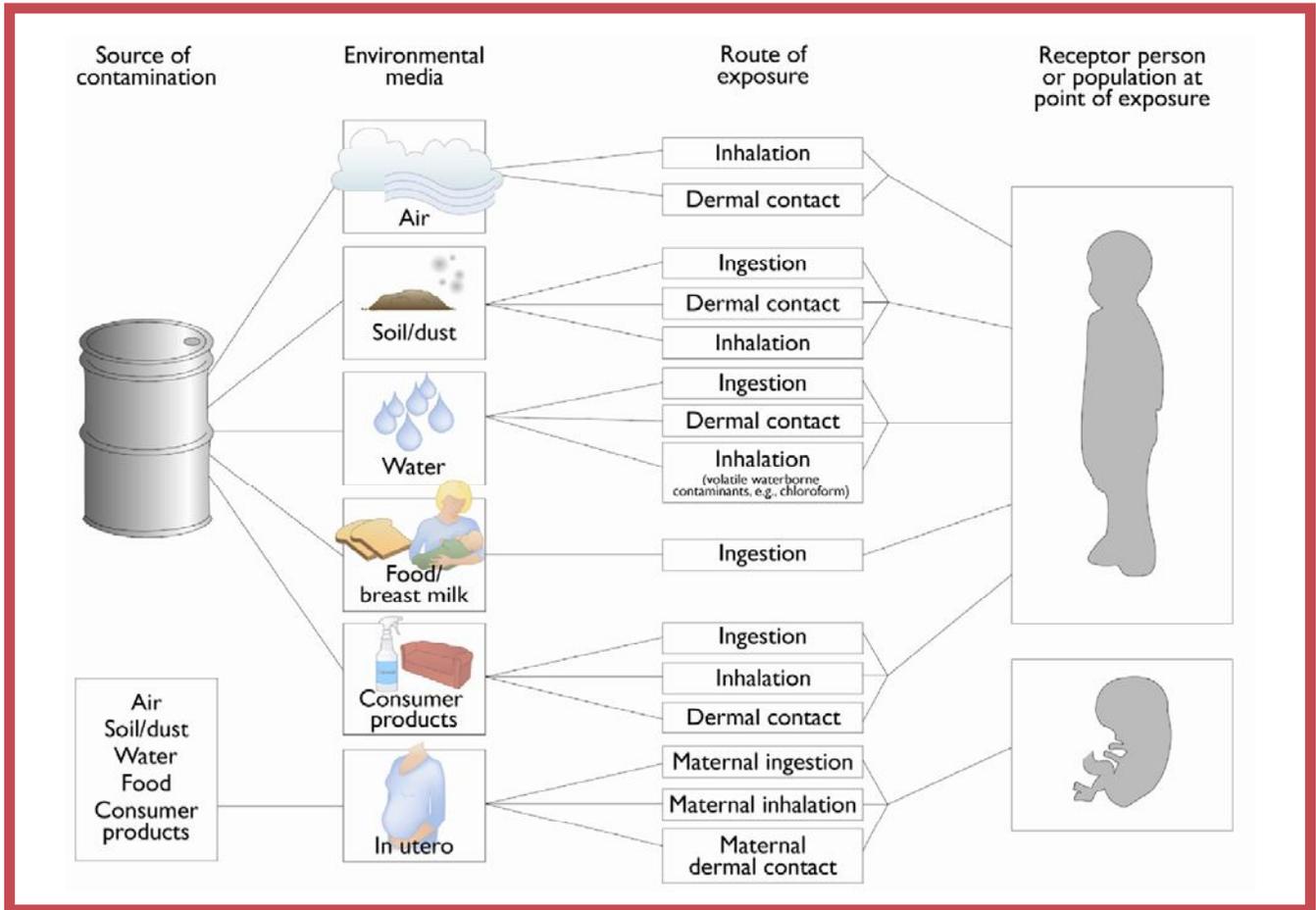
Environmental control measures are often delayed and/or opposed until solid proof of harm is obtained. This delay in applying control measures or finding alternatives also occurs because the environmental exposures are often associated with activities, such as automobile dependence, that are part of entrenched patterns in society and thus difficult to change. Some progress has occurred in terms of revising regulatory approaches to take children's health into account. But the fact remains that widespread exposure to thousands of potentially hazardous substances continues.

Exposures of Concern

Sources of environmental contaminants include industrial and motor vehicle emissions, accidents during the manufacturing, use or disposal of hazardous substances, waste disposal, and the use of consumer products, including the use of pesticides. Potential environmental threats can be chemical in nature (e.g., pesticides), biological (e.g., moulds or infectious agents) and physical (e.g., ionizing radiation) and can come from natural and human activity-related sources. Exposure is not restricted to the outdoor environment. Indoor exposures, particularly due to the use of consumer products, are of increasing concern.

Substances can travel through many environmental pathways and change in composition along the way. Exposure media include air, water, food (including breast milk),

Figure 2: Major Pathways of Human Exposure to Environmental Contaminants



Source: Adapted from Health Canada, 1998.

A Chemical World

Vast numbers of chemicals are a fact of modern life. The Chemical Abstract Service (CAS) based in Columbus, Ohio, assigns a CAS number to every chemical. All scientists benefit from this system of centralized record-keeping that uniquely identifies chemical substances. More than 25 million unique CAS numbers have been assigned and 54 million chemical sequences. These numbers increase regularly. Some chemicals occur naturally while many are synthesized in laboratories. Chemicals can be found in our homes, our clothing, our food and food packaging, our computers, our hospitals, most of our workplaces — in virtually all aspects of modern life. Knowledge about harmful effects of chemicals is very limited, but in some cases is deeply troubling. There are probably large numbers of chemicals that are harmless. Some chemicals, such as chlorine, can create both serious health hazards (as in chlorinated pesticides or other chlorine-containing persistent organic pollutants) and important health benefits (when used to treat drinking water). It is a major challenge of our times to effectively confront the possible effects of so many chemicals resulting from human activity.

and soil or dust. While most contaminants occur at low concentrations, this is not always the case. Children tend to be more exposed than adults.

Over 23,000 chemicals and substances are in commercial use in Canada and hundreds of new substances are generated every year. The list of substances in commerce in the United States is closer to 80,000, of which over 3,000 are in high production use (produced in quantities of over one million tonnes per year). As well, more than 500 pesticide “active ingredients” are approved for use in Canada and are incorporated into thousands of end-use pesticide products.

Scientific understanding is incomplete about the exact nature and effects of low-level environmental exposures. Strong evidence only exists about the circumstances of exposure and any health effects for a relatively small number of substances. Full understanding about most substances is rare.



Photo Credit: Tatiana Morita

Instead, scientists and regulatory agencies talk about the strength of evidence or the various lines of evidence that exist. Testing for drug safety illustrates some key issues and important differences. Before pharmaceutical drugs can be sold, their safety must be carefully evaluated. Drugs are tested in many ways, including clinical trials on human subjects. Requirements for the ethical conduct of such experiments on humans have evolved over time. Key among these requirements is informed consent of (usually adult) test subjects and careful monitoring for adverse effects; if adverse effects are observed, the experiment must be terminated. Where such drug testing is conducted on children, consent must be obtained from their parents. This kind of controlled testing for drug safety, though not without problems, leads to increased knowledge of the drug being evaluated.

Of course, drugs can and do pose risks, but they are developed, tested and used for therapeutic benefits in humans. In contrast, environmental contaminants do not have therapeutic benefits. Nor is it appropriate to test them in controlled experiments on people. Uncertainty about effects of contaminants in people is inevitable since toxicity has to be estimated via tests on animals (and other lines of scientific evidence). Recent advances in regulatory approaches apply a greater degree of pre-market evaluation of chemicals. Pesticides, in particular, historically have been more rigorously evaluated compared to most industrial chemicals. However, it remains the case that the majority of chemicals, including contaminants that are created and released as by-products of combustion or industrial processes, have not been thoroughly or, in many cases, even minimally evaluated for their potential toxicity.

Types of Studies Used to Evaluate Environmental Risks

Human studies can include situations of occupational exposures or accidents, or epidemiological evidence of health effects in a specific population.

Epidemiology is the study of the occurrence and causes of health effects in human populations. These studies often compare two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. Investigators try to determine if the factor in question is associated with the health effect.

Animal studies can include laboratory experiments where it is possible to study specific effects at varying exposure levels. These *in vivo* (or “in the animal”) studies look at effects in laboratory animals. Additional laboratory testing can be done *in vitro* (literally “in glass”). These experiments can look at specific reactions between chemical substances and specific animal tissues or cell cultures.

Wildlife studies can include animal data gathered from studies of wildlife experiencing chemical exposures typical of general environmental levels or specific contaminated environments.

When scientists or regulatory agencies gather scientific evidence of harm about environmental contaminants, the overall “weight” or strength of the evidence is assessed. Risks are described with qualifying language that notes the relative strength of the evidence. For example, chemicals may be described as known carcinogens (cancer-causing substances), suspected carcinogens or possible carcinogens. The result is that we rarely obtain conclusive evidence of harm until that harm can be measured in exposed individuals. By then, widespread environmental contamination may have occurred.

Determining whether a particular substance is known or suspected of contributing to a particular health effect in humans comes from evaluating a wide range of results from these diverse investigations. It is extremely rare that investigations include, or are even capable of considering, the combined effect of multiple chemical exposures.

Health risks from low-level exposures are often inferred from effects observed at relatively high-level exposures in humans (e.g., certain parental occupational exposures or therapeutic use of ionizing radiation, as in medical X-rays), laboratory animals or wildlife. In the absence of adequate, or any, data on directly observed health risks at low exposure levels, uncertainties arise because of incomplete knowledge about extrapolating risks from high to low doses and from animals to humans.

Within this large arena of incomplete information, environmental risks are defined according to the equation: risk = hazard x exposure. Hence, risk arises from both the inherent hazard to health (or to the environment) and the likelihood (or extent) of exposure. In a world awash with so many chemicals, it is important to remember that exposure does not necessarily mean that known or suspected health effects will follow.

Table 1 presents a selected list of exposures of concern to prenatal and child health. The table is organized according to several categories of physical or chemical exposures and also by several media/settings of exposure. Some duplication occurs across these categories. For example, lead exposure is noted with metals, but it can also occur in soil and house dust, in drinking water, food or consumer products. Fortunately, very minimal exposure occurs in Canada to some of the most toxic substances noted in Table 1, such as the organochlorine pesticides. The choice to include items on this list was made on the basis of information about known or suspected health impacts *with sufficient exposure*. Recognizing that information about exposure is often lacking or incomplete, Table 1 provides an indication of the current state of knowledge about the range of exposures that may be capable of inducing specific impacts on prenatal and/or child health.

Table 1: Selected Exposures of Concern to Prenatal and/or Child Health

Chemical Categories or Exposure Media/ Settings	Specific Substances, Groups of Substances or Mixtures		
	well-established human and animal data of harm to prenatal and/or child health <i>with sufficient exposure</i>	strong data from animal studies/weight of evidence; reasonably high likelihood of risk to prenatal and/or child health <i>with sufficient exposure</i>	limited evidence, insufficient to be sure of associations
Metals	Lead, mercury, arsenic and hexavalent chromium; found in pure metallic form or in specific chemical compounds, e.g., methylmercury, nickel carbonyl, chromium copper arsenate	Nickel, cadmium, manganese	
Polychlorinated biphenyls (PCBs), Dioxins and Related Compounds (including organochlorine pesticides, polybrominated diphenyl ethers (PBDEs) and other industrial chemicals)	PCBs, dioxins, furans, organochlorine pesticides (e.g., DDT, dieldrin, aldrin, endrin, heptachlor, chlordane, mirex, hexachlorobenzene, toxaphene, pentachlorobenzene, chlordecone and hexachlorocyclohexane)	PBDEs (specifically octabromodiphenyl ether (octaBDE), pentabromodiphenyl ether (pentaBDE) and hexabromobiphenyl), hexachlorobutadiene and polychlorinated naphthalenes	
Pesticides		Additional organochlorines (e.g., endosulfan), organophosphates (e.g., azinphos methyl, diazinon, chlorpyrifos, malathion, methyl parathion, dimethoate), carbamates (e.g., carbaryl, aldicarb, propoxur), amides (e.g., DEET), chlorophenoxy herbicides (2,4-D, mecoprop, MCPA, dicamba) and triazines (e.g., atrazine)	

Table 1 *continued*: Selected Exposures of Concern to Prenatal and/or Child Health

Chemical Categories or Exposure Media/ Settings	Specific Substances, Groups of Substances or Mixtures		
	well-established human and animal data of harm to prenatal and/or child health <i>with sufficient exposure</i>	strong data from animal studies/weight of evidence; reasonably high likelihood of risk to prenatal and/or child health <i>with sufficient exposure</i>	limited evidence, insufficient to be sure of associations
Radiation	Ionizing radiation (includes radioactive fallout from atomic tests and medical X-rays, nuclear reactor emissions and radon) and ultraviolet radiation (UV) from sunlight		Electromagnetic fields (EMF) and radio-frequency radiation (cell phones)
Outdoor Air	Particulate matter (coarse, fine and ultra-fine particles), nitrogen oxides, sulphur dioxide, carbon monoxide, ground-level ozone and a range of volatile organic compounds (VOCs), polyaromatic hydrocarbons (PAHs) and additional hazardous air pollutants		
Indoor Air	Biological agents, including dust mites, cockroaches and pet dander allergens; gases and vapours, including carbon monoxide, nitrogen dioxide, formaldehyde and particulate matter, including toxicants in environmental tobacco smoke (ETS), particulate matter from other combustion processes, asbestos	Additional volatile organic compounds (VOCs) (including the organic solvents chloroform, benzene, ethylbenzene, trichloroethylene, tetrachloroethylene, toluene, xylenes), radon and pesticides	

Table 1 *continued*: Selected Exposures of Concern to Prenatal and/or Child Health

Chemical Categories or Exposure Media/ Settings	Specific Substances, Groups of Substances or Mixtures		
	well-established human and animal data of harm to prenatal and/or child health <i>with sufficient exposure</i>	strong data from animal studies/weight of evidence; reasonably high likelihood of risk to prenatal and/or child health <i>with sufficient exposure</i>	limited evidence, insufficient to be sure of associations
Soil, house dust	Metals	Soil and dust containing pesticides, PBDEs and other substances deposited and accumulated in dust and carpets, and on furnishings and other surfaces from airborne contaminants or the breakdown of consumer products	
Drinking Water	Metals — lead and arsenic, biological pathogens (e.g., <i>E. coli</i> , <i>Cryptosporidium</i>), nitrates and nitrites in specific exposure circumstances	Disinfection by-products (DBPs), including four trihalomethanes (THMs) — chloroform, bromoform, chlorodibromomethane and bromodichloromethane	Pharmaceuticals
Chemical Contaminants in Foods or Originating in Consumer Products	Metals — lead, mercury and arsenic	Phthalates (specifically diethylphthalate (DEP), di- <i>n</i> -butyl phthalate and di(2-ethylhexyl)phthalate (DEHP), bisphenol A, nonylphenol ethoxylates (NPEs), specifically nonylphenol, short-chained chlorinated hydrocarbons (SCCPs), PBDEs (see PCBs, Dioxins and Related Compounds above) and pesticide residues	Phthalates and perfluorochemicals (PFCs), specifically perfluorooctanoic acid (PFOA)

*“Sustainable development meets the needs of the present without compromising the ability of **future generations** to meet their own needs.”*

Source: Bruntland, G. (Ed.). 1987. *Our Common Future: The World Commission on Environment and Development*. Oxford: Oxford University Press.

*“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.”*

Source: *Rio Declaration on Environment and Development*. 1992. United Nations Conference on Environment and Development, Rio de Janeiro, 3–14 June 1992.

We have much to learn from past experience. While the science continues to be debated, waiting until there is proof of harm from suspect environmental exposures can result in undue exposure and harm to children. The regulatory lesson from the case of lead and other well-studied toxic substances is the need to act sooner when early evidence suggests a problem. Taking precautionary action, despite scientific uncertainty, is an approach that seeks to prevent harm in the first place, rather than scientifically documenting it in one generation of children and then, if possible, belatedly preventing harm in the next.

Advocates for changing traditional approaches to assessing and addressing environmental hazards call for such a precautionary approach. This approach speaks directly to the reality of forever having incomplete information. It denotes a duty, on all members of society, to prevent harm, when it is within our power to do so, even when the evidence is uncertain or unattainable. Prevention of harmful environmental exposures is all the more essential when such exposures can permanently alter or damage a child’s development. Protecting children from harm is at the core of sustainable development — to protect future generations — and is the basic foundation of social justice — to protect the most vulnerable members of society.



Photo Credit: Mark Surman



Chapter Two: Why Focus on Children?

Children are Different

Children are not “little adults.” They are growing and developing in ways that can make them more vulnerable than adults to toxic substances. The world in which today’s children are conceived, develop *in utero* and are born is vastly different from that experienced by their grandparents or great grandparents. A major difference is our modern use of chemicals. Over the past five decades, drawing from both natural and synthetic sources, modern technology has created tens of thousands of chemical substances. Many are ultimately released to the environment and can be detected at low levels in air, water, food and soil, as well as in our bodies.

Human development is fascinating and complex. Scientists are able to explain some, but certainly not all, of the many details about how the stages of development are orchestrated — to get from a single egg and sperm to a healthy full-term infant with all organs and systems functioning, including a highly complex brain.

Starting with the parents' genetic blueprints and using building blocks from the natural world provided through a mother's body, development includes a constant flow of sending and receiving millions of chemical messages. This flow and interaction of the chemical building blocks of life, when derived from good food, clean air and clean water, is what sustains good health throughout everyone's life. However, there are profound differences between sustaining good health among adults and the process of creating and developing a healthy baby and growing child.

Concerns about the effects of exposures to toxic substances are often about the interference of these substances with the chemical interactions that occur during human development. Additional concerns arise about the impact of hazardous substances on immature or more delicate structures or systems in a fetus' or child's body.

Greater Exposure than Adults

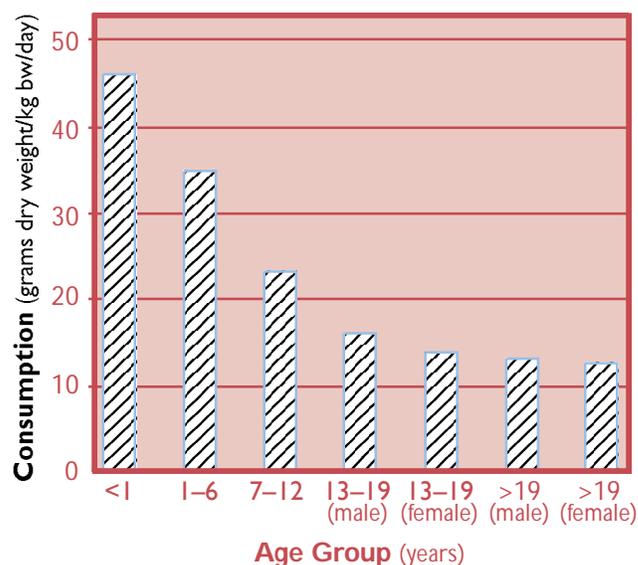
Four differences between adults and children can contribute to children being more highly exposed to substances in the environment.

The first difference is one of proportions. Kilogram for kilogram of body weight, a child will eat more food (see Figure 3), drink more water, and breathe more air than will an adult. To illustrate, both might eat a banana and drink a glass of water. The same level of contamination in the banana and the water will deliver a proportionally higher amount to the body of a

20 kilogram child than to a 60 kilogram adult. Similarly, compared to an adult, the surface area in a child's lungs is larger in proportion to the rest of the child's body. Proportional to body mass, a child's brain is larger and receives about double the blood flow per unit weight compared to an adult.

Physiology and behaviour constitute the second and third differences between adults and children that contribute to varying exposures. The baseline rate of breathing is faster in a child than in an adult, and it speeds up more often because children tend to be more active, especially outdoors and often during peak air pollution times, such as travelling to and from school during the morning and evening rush hours.

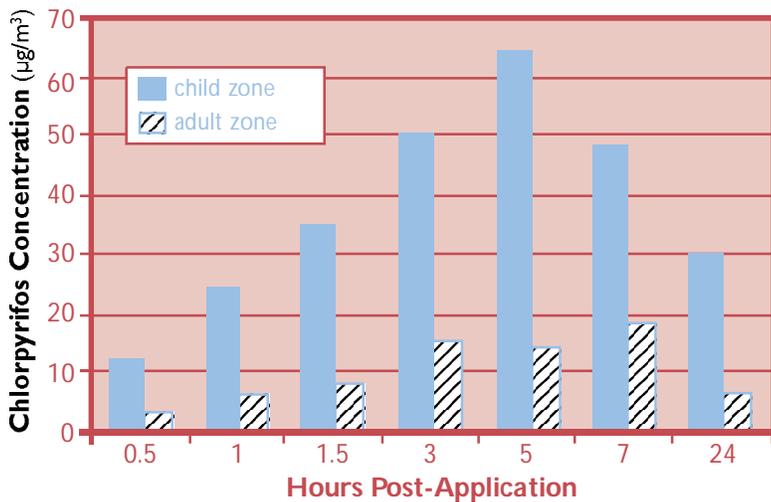
Figure 3: Average Food Consumption by Age



Source: Adapted from Plunkett. 1992.

Figure 4: Pesticide Air Concentrations in Child and Adult Breathing Zones in a Ventilated Room.

The concentration of a pesticide is much higher in the breathing zone of a child than of an adult, even 24 hours after the pesticide is applied. Children also play at ground level and can absorb pesticides by dermal (skin) contact with contaminated objects or materials. Thus, children may have a greater exposure to pesticides applied around the house than adults do.



Source: Adapted from Fenske. 1990.

Children inhale air closer to the ground and floor compared to adults. Studies have shown that certain contaminants in air pollution (e.g., dense vapours) and dust particles settle in a vertical gradient, meaning that they are higher in concentration and therefore more available within a child’s breathing zone (see Figure 4). Playing at ground level also raises dust that may be inhaled or ingested through hand-to-mouth activity. As well, the metabolic need for oxygen is greater in the child because of growth, leading to higher basal (resting) respiratory requirements.

The Body Protects Itself

The human body develops various mechanisms to protect itself. The immune system develops a complex array of cells and antibodies to combat infections and cancer growth. Through vaccines, modern medicine has provided various kinds of proactive immunity (before infection occurs). In partnership with the immune system, the human body has a range of filtering, detoxification and/or excretion mechanisms. Four sites are particularly important: lungs, gastrointestinal (GI) tract, liver and kidneys.

The lungs and the rest of the respiratory system provide an elaborate air filtering system. The GI tract digests and selectively absorbs food components, leaving wastes to be eliminated by the colon. The liver filters everything absorbed into the bloodstream through the gut, detoxifies many contaminants (excreting wastes back into the bowel via the bile duct) and provides a steady and consistent flow of certain nutrients into the bloodstream (e.g., glucose). The kidneys provide a blood filtration system, removing wastes to be eliminated in urine.

...continued on next page

The Body Protects Itself (continued)

The lymphatic system, a key player in the immune system, roughly mirrors the bloodstream throughout the body. It works alongside these other filtering and detoxifying systems. This notion of “filtering” at these four sites in the body is an oversimplification. It is important to note that these “filters” cannot always detoxify or prevent absorption of toxic substances.

Another aspect of the body’s protective apparatus includes cellular barriers between the blood stream and other tissues and organs. Key among them is the blood-brain barrier that functions rather like a semi-permeable membrane that reduces to some degree the access to the brain of certain toxicants in the bloodstream.

All of these systems and barriers are under development in the womb, and are still developing during infancy and, in some cases, throughout childhood.

Infants, babies and toddlers are particularly unique in their behaviour. Adults rarely crawl around with their hands in routine contact with floors, carpets or the ground outdoors. Children are often much more exploratory than adults, and for babies and small children this exploration often includes putting their hands and objects in their mouths. Youngsters regularly play with toys, drop them, either unintentionally or just to see what happens (gravity!), and then pick them up and put them back in their mouths. All of these behavioural differences can increase children’s exposures.

Children have strong food preferences. Often they will want to eat a limited range of the same kinds of foods, sometimes for days or even weeks at a time. Children also tend to consume much more milk than adults. Even when such foods are nutritious, any contaminants in them may deliver higher exposures than would occur with a more varied diet. Two other exposure differences related to food intake are the nourishment received by babies in the womb through the placenta and during breastfeeding (explained in more detail in Chapter Four).

Finally, children have a longer lifetime ahead of them than do adults. They simply have more time for exposures to occur and health problems to manifest. A child’s exposure to persistent substances (those that don’t break down and often accumulate in body fat or bone) lead to build-up in their bodies for a longer period of time. Hence, exposures during childhood may not result in health effects until adulthood. If children are exposed to chemicals or radiation that have latent (delayed) effects, such as with most carcinogens, there will be more opportunity in children than in adults for these exposures to lead to negative effects later in life. An example of both of these situations is sunburns during childhood, which are known to increase the risk of skin cancer in adulthood. In addition to latent effects, some early exposures can cause permanent and irreversible damage, such as the effects of lead on brain development, or lifelong effects on lung function from early exposures to air pollution.

More Vulnerable than Adults

The exposure differences described above are an important aspect of greater vulnerability. Additional vulnerabilities have to do with differences in physiology and metabolism.

Physiology refers to the functions of a living organism and its component parts, including the physical and chemical processes involved. There are key physiological differences between adults and children that can make children more vulnerable to hazardous substances. For example, a child's digestive system will often absorb foods and associated contaminants more efficiently than that of an adult. While this can be due to



Photo Credit: Mark Surman

Results of Biomonitoring

We all carry agricultural and industrial chemicals (or their breakdown products) in our bodies; sometimes called our “body burden” of chemicals. Biomonitoring is the direct measurement of this burden of substances in human tissues, such as blood or urine. The US and Germany have national biomonitoring programs to measure contaminants in the child and adult populations. Canada has no such program, but plans are in place to begin limited population-based biomonitoring of some metals in 2006. Canadian body burdens are likely similar to the following levels recently found in Americans:

- Of those tested, 100 per cent had pesticide residues in their bodies and 93 per cent had detectable levels of chlorpyrifos, a widely used organophosphate pesticide, found to be neurotoxic in animal studies, especially when administered prenatally or soon after birth. This finding resulted in regulatory action to restrict chlorpyrifos uses, and subsequent biomonitoring reveals reduced exposure.
- Phthalates, chemicals found in many cosmetics (nail polish and shampoos), soft plastic toys and tubing, were present in most people. Children had higher urinary levels of some phthalate breakdown products compared to adults.
- PCBs are still commonly found in human tissue. Even though their production was discontinued in the 1970s, large quantities await disposal.
- Six per cent of women of child-bearing age have levels of mercury in their blood at or above the level of concern for fetal brain development.
- Although continuing a multi-year downward trend, a significant proportion of children had elevated blood-lead levels.

The US will report on the next round of biomonitoring in 2005. All of the reports are available at www.cdc.gov/exposurereport.

Thalidomide

Developed in 1953, the drug thalidomide was marketed as a non-toxic sedative and treatment for morning sickness. Tests on mice had shown no birth defects, but abnormalities had been demonstrated in tests on rabbits. Canadian, German and UK regulators overlooked the rabbit evidence and approved thalidomide, whereas a Canadian doctor working for the US Food and Drug Administration ruled against the drug on the basis of the rabbit evidence. The US was thus spared the tragedy of thalidomide, which caused thousands of miscarriages, stillbirths and physical malformations, particularly those in which arms and legs were stunted or missing. Worldwide, 15,000 babies were born with missing limbs.

While dose mattered, the specific timing of exposure influenced the outcome. The overall window of vulnerability was found to be between days 35 to 50 of the pregnancy. Thalidomide dramatically demonstrated the sensitivity of developmental stages and the need for more thorough pre-market toxicity testing.

When effects are less dramatic or obvious, such as learning or behavioural impacts from lead exposure during fetal brain development, they can be more difficult to isolate and verify scientifically.

immaturity of these systems, in children older than six months it is more a matter of young healthy systems that work very efficiently to absorb nutrients necessary for ongoing growth and development.

In infancy, skin is more permeable than in later life, allowing the passage of substances through the skin into the bloodstream. Additionally, a child's airways and lungs develop from the early years through adolescence, during which time exposure to toxic substances can overburden the respiratory system. These exposures can cause temporary symptoms, or can actually affect the physical development of lung tissue, such that the lungs are more susceptible to pollutants later in life.

Metabolism is the combined package of all the life-sustaining chemical processes occurring in any living organism. Children tend to have a faster metabolism than do adults. They need to take in more oxygen per unit of body weight per minute to support their growth and activity needs, which are driven by their higher metabolic rates.



Photo Credit: Mark Surman

Windows of Vulnerability

As described above, four major reasons have been identified that contribute to the greater exposure and vulnerability of children to toxic substances as compared to adults: proportionality, behaviour, physiology and metabolism. Each of these is made more serious by the vulnerability of children's rapidly growing and developing organs and systems.

For example, none of the immune system, digestive system, lungs, liver or kidneys are fully developed at birth. Until age six months, an infant's liver does not have the same ability as an adult's to metabolize and excrete toxicants; for certain liver enzymes the capacity is not on par with an adult's until up to age 18 months. One exception to this rule is the fact that in early childhood the activity of some enzymes of the liver temporarily exceeds the adult capacity. The ability of infant kidneys to excrete certain toxicants is not comparable to an adult until about age 16 months.

There is an old saying that "the dose makes the poison." While this is often true, the field of children's environmental health requires the expansion of this notion to include the additional aspect of timing. Due to increased sensitivity in early life stages, "safe" doses for adults, or even older children, can present risks during certain periods of fetal development or other sensitive stages of childhood. These sensitive stages are called "windows of vulnerability."

There is a large amount of evidence to support the theory of windows of vulnerability during prenatal development, in infants up to at least six months of age, in young children up to two or three years of age in the case of effects of lead on the developing brain, and in all children up to adolescence with regard to health risks from ionizing radiation, lead and air pollutants. Vulnerability during later stages of childhood is not as well studied or understood as during earlier stages. While many developmental stages related to detoxification are

Methylmercury Poisoning

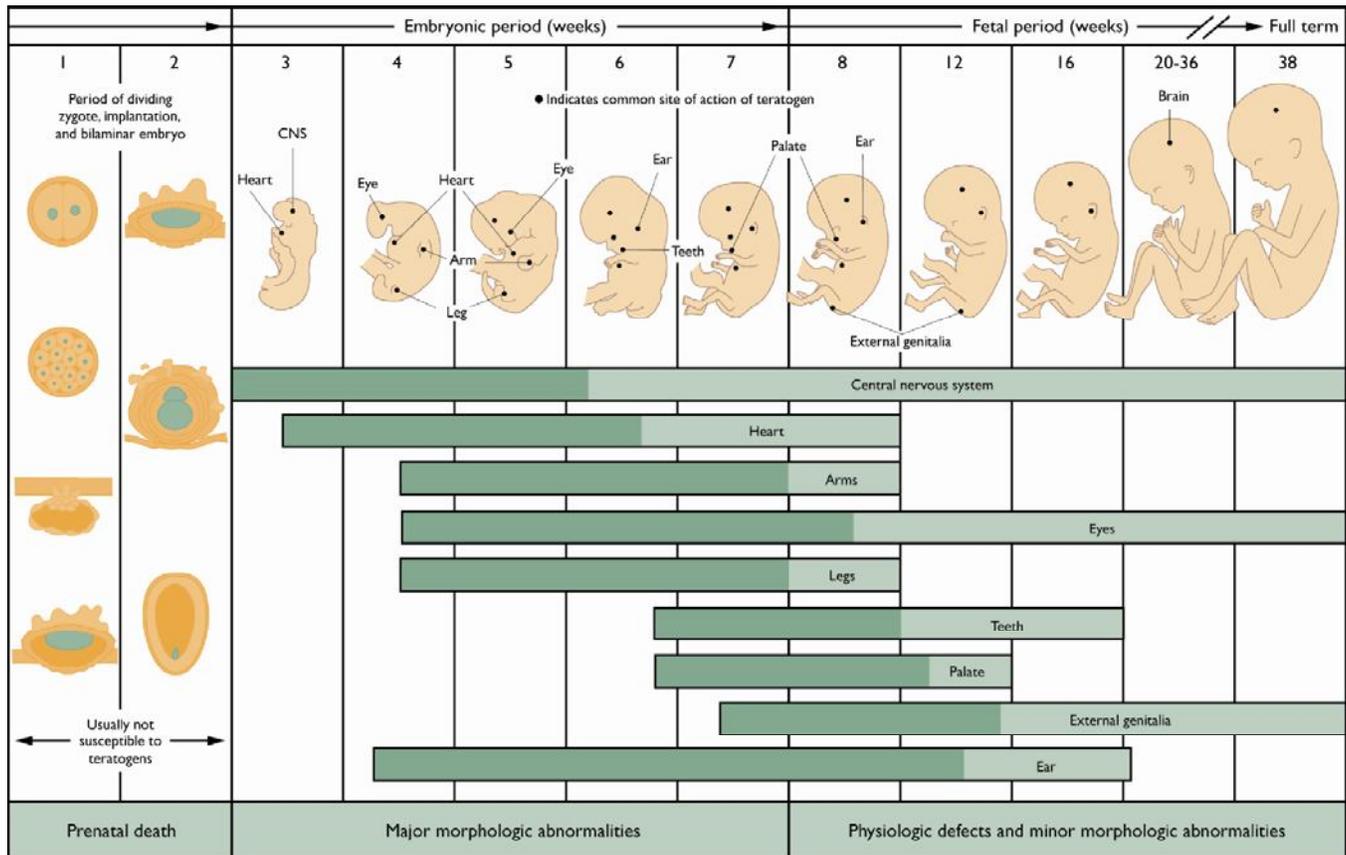
In Minimata, Japan, in the 1950s, a mysterious "disease" among local people was ultimately identified as methylmercury poisoning. Mercury-contaminated wastes dumped by a local chemical plant into Minimata Bay resulted in the formation and accumulation of methylmercury in the local aquatic food chain.

It is estimated that several thousand local residents who ate fish and shellfish from the bay became seriously ill. Hundreds died, a number of whom were unborn children. Children born to mothers who had eaten contaminated food also suffered ill effects. Often appearing normal at birth, they later developed signs and symptoms of nervous system poisoning, such as mental retardation, cerebral palsy, and delayed crawling and walking.

Importantly, the maternal methylmercury doses were sufficient to cause severe effects in their offspring, but the women themselves generally experienced only mild sensory deficits (e.g., "pins and needles" sensations in the arms and legs) or no adverse health effects.

The Minimata poisoning episode provided some of the first evidence of the greater vulnerability of the developing brain.

Figure 5: Critical Windows of Vulnerability (Prenatal). Dark green denotes highly sensitive periods; light green indicates stages that are less sensitive to teratogens.



Reprinted from *The Developing Human: Clinically Oriented Embryology*, Moore and Persaud, page 98, Copyright (1973), with permission from Elsevier.

complete by age six months, there are many physiological and developmental changes that continue until the end of adolescence.

Prenatal development in the womb includes many different windows of vulnerability, as

illustrated in Figure 5. As development progresses, cells differentiate, becoming more specialized to form individual organs and tissues. The eyes and the brain undergo prominent early development, followed by the palate and the genitals. The reproductive system,

the immune system and various biochemical systems develop and mature throughout pregnancy and well after birth. Development of the brain and nervous system, though rapid during pregnancy, is ongoing, continuing throughout adolescence.

The fact that different organs and systems in the body develop at different times and at different rates means that there are different periods of vulnerability for each.

Brain development is a good example since development occurs throughout many stages, from prenatal to adolescence. During the early stages of pregnancy the embryo's developing brain and nervous system are vulnerable to teratogens (substances capable of causing birth defects). Birth defects, also called congenital anomalies, result in structural effects that cause physical changes in the structure of an organ, tissue or system, affecting how something is built. Such defects in the nervous system can include neural tube defects, such as *spina bifida* (a structural deformity in the spine resulting from incomplete enclosure of the spinal cord by the spinal canal and vertebrae) or anencephaly (where some or most of the brain and overlying skull is missing). These kinds of birth defects can only occur from exposure to a teratogen during the window of time when the brain and spinal cord are in the early stages of development.

Continuing into late pregnancy, with the major structural components built, the developing brain is vulnerable to toxic exposures that can

affect how the brain will later function. Such exposures are often called neurotoxins, or more accurately, developmental neurotoxins. In contrast to the structural effects that can result from early prenatal exposure to toxicants, a functional effect alters how an organ, tissue or system works. The third trimester of pregnancy marks a significant window of vulnerability for effects on later brain functioning. It is a time when millions upon millions of brain cells and neurochemical messaging systems are created and their placement and future function in the brain established. Exposure to lead, mercury and PCBs during this stage of pregnancy results in effects that impact mainly on brain function (such as learning ability) and, though less well understood, on behaviour. Many other substances are suspected of impacting upon the many vulnerable aspects of third trimester brain development.

Effects of toxicants during the later stages of pregnancy or early childhood can be less obvious than the major structural abnormalities that may follow exposures during early pregnancy. As a result, the effects of these exposures can be more difficult to isolate and understand. The level of exposure is a key factor in trying to discern these more subtle effects. Scientific understanding and assessment of such effects is often a complicated exercise of trying to determine whether the low exposure levels experienced by the general population are capable of causing effects observed at higher levels of exposure in humans or, more often, in experimental animals.

Some Children are at Greater Risk than Others

Greater risks from environmental exposures can exist for some children. Risk factors include living in poverty, poor nutrition, exposure to environmental tobacco smoke (ETS), parents' occupational circumstances and genetic variability.

Poverty

Poverty is well established as a major determinant of health and is also associated with greater likelihood and opportunities for environmental exposures. Poverty can also contribute to greater susceptibility to harmful effects of such exposures, compounding health and income disparities. Data in Canada are limited, but are similar to more extensive information in the United States, which shows that environmental health risks from industrial facilities, hazardous waste disposal facilities and major roadways are more likely to affect low-income areas, minorities or Aboriginal communities (including reserves).

More than one million children in Canada, or nearly one in six, live in poverty. Children from Aboriginal communities, visible minorities and newcomers to Canada, although a relatively small proportion of the Canadian population, are over-represented in these statistics. Their exposure to toxic substances can be higher than that experienced by other children.

Where neighbourhoods (including schools, playgrounds and homes) are close to high traffic roadways, children are more highly exposed to air pollutants, contributing to respiratory and other health effects, and traffic noise, which may hamper their ability to learn.

There are significant risks associated with older, poorly maintained housing. These can include lead paint hazards and a greater likelihood of pesticide use to control insects and rodents in rental housing, especially where the rate of tenant turnover is high. Excessive moisture and indoor dampness can also be a problem in poorly maintained buildings. These can contribute to increased exposure to respiratory allergens, such as dust mites and mould growth, and can also encourage cockroach and rodent problems.

Nutrition

A well-nourished mother is more able to carry a pregnancy to term successfully. The organs and systems in the body of a well-nourished child can function well and provide some protection from toxic substances and other health threats. Specific vitamins and minerals can help prevent or offset the impact of some substances.

Good nutrition can be difficult to obtain under circumstances of poverty. Poor nutrition is a risk factor for greater uptake of contaminants. A diet low in calcium and iron, for example, will result in more efficient absorption of lead. Poor diet can compromise a child's immune system and the ability to detoxify and excrete pesticides. Some pesticides may have larger effects on the immune systems of children who lack iron.



Photo Credit: Health Canada. www.hc-sc.gc.ca/english/media/photos

Environmental Tobacco Smoke (ETS)

Cigarette smoking in the home is a significant risk factor for children, including while in the womb. ETS is associated with effects on the respiratory system, including the development of asthma and as a trigger in those who already have the disease. ETS is also associated with impacts on brain development and contains over 40 known carcinogens. When other risk factors, such as poverty, are present, the risks of ETS will be compounded.

Parental Occupation

Parents who work with toxic substances can contribute to “carry-home” exposures that can affect their children.

Children who live on farms can experience higher indoor and outdoor exposure to pesticides. If proper precautions are not taken, farm workers can bring home pesticides on their skin, hair, clothing, shoes and equipment.

Aboriginal Children

Children in Aboriginal communities often experience multiple risk factors that can contribute to greater exposures. They often experience poverty and related risk factors, such as low quality and poorly maintained housing, and polluted and inadequate water supply, water treatment and sewage disposal. In remote areas, they are generally exposed to much lower levels of outdoor air pollution compared to urban dwellers. An exception would be persons living in some valley towns with widespread winter-season use of wood-burning stoves or diesel generators for heat.

Traditional food supplies, particularly fish, but also game and marine mammals, can be much more contaminated with persistent toxic substances, such as organochlorine pesticides, PCBs and certain metals, compared to store-bought food sources. The Inuit living in northern regions of Canada have unparalleled exposure to persistent contaminants, as verified by measurements in fish, marine mammals and Inuit breast milk.

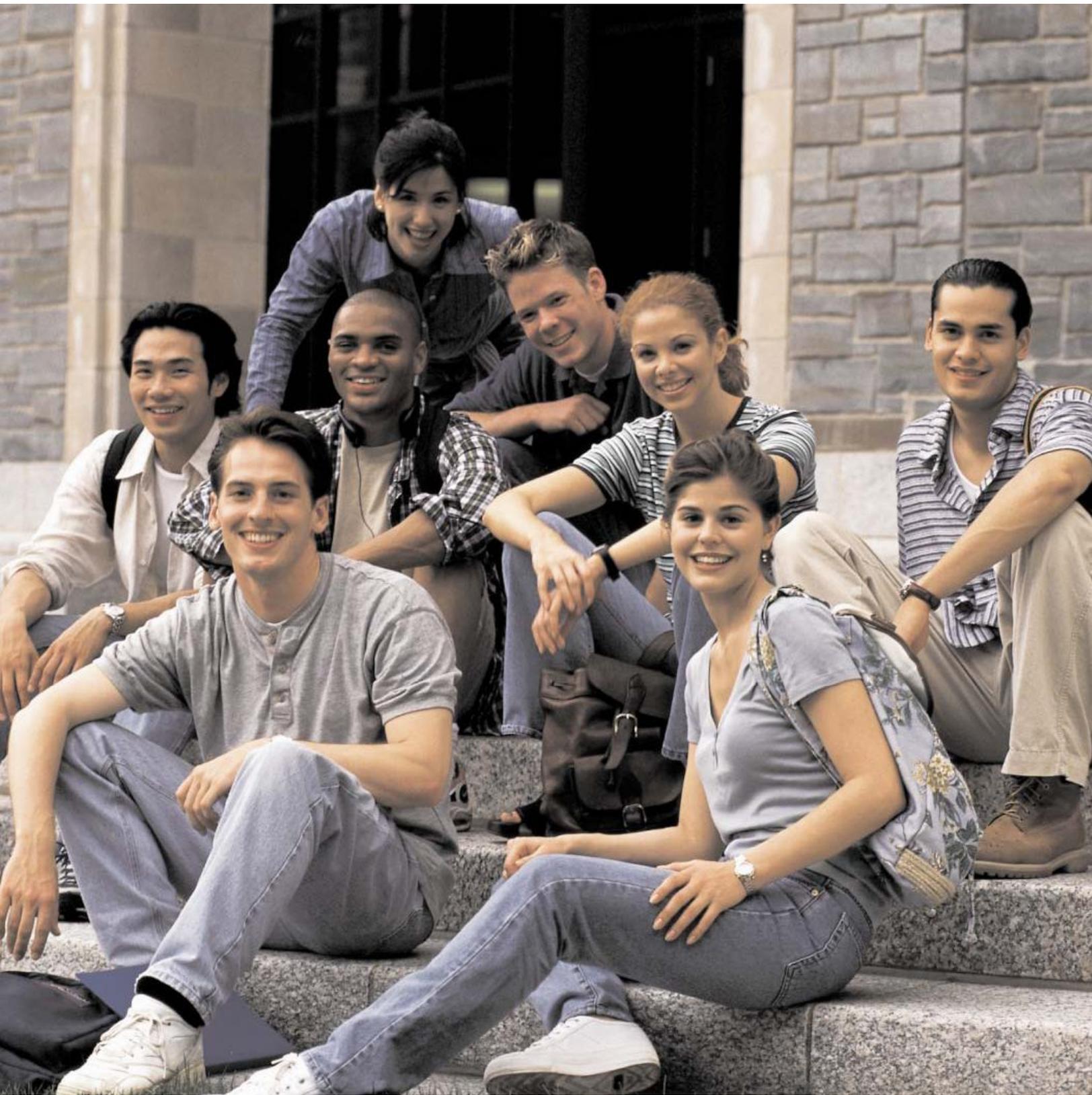
Additional risk factors can include poor nutrition and high rates of infectious and chronic disease. There are high rates of illness and death among infants, and a range of social problems in many Aboriginal communities. These combined factors can make Aboriginal children vulnerable to exposure to and effects from toxic substances.

In addition, some parents work with substances, such as organic solvents, in many different occupations, including in laboratories, dry cleaners, or work that involves use of paint removers, thinners, floor and tile cleaning, etc. Organic solvents can affect germ cells (paternal preconceptional exposures) or the developing fetus (maternal prenatal exposures). In animal studies, solvents have been associated with spontaneous abortion and birth defects. Studies conducted at Toronto's Hospital for Sick Children Motherisk program revealed similar findings; mothers occupationally exposed to solvents had a higher risk of spontaneous abortions. These researchers also found associations between maternal solvent exposure and birth defects, as well as a range of impacts on nervous system function, including visual, cognitive and motor functions, language and behaviour. For more detailed information, visit www.motherisk.com.

Genetic Variability

The combined genetic material from a human sperm and egg provides the basic blueprint for creating a new human being. Within that blueprint, however, there is enormous variability. Called genetic "polymorphisms," alternate forms of genes (sometimes called genetic variants), will determine differences in human form and function. This variety includes everything from eye colour and skin pigmentation, to the ability to break down toxicants in the body, or to the presence of some diseases. Certain genetic traits can interact with factors in the environment (infectious organisms, chemicals, nutrients, etc.) and result in adverse health effects. For example, the evidence suggests that the genetically inherited disease cystic fibrosis may be worsened by exposure to environmental tobacco smoke.

Polymorphisms, or genetic variants, exist in different frequencies among various subgroups of the human population. People with certain genetic polymorphisms can be more susceptible to harmful effects from environmental hazards than people who do not have the same genetic variants. For example, a study of leukemia risks and exposure to pesticides among children in Quebec showed that leukemia risks were higher in children who carried certain genetic mutations and were exposed to pesticides in the womb. The genetic mutations affected liver enzymes that transform (or metabolize) foreign substances in the body, including pesticides. The role of these enzymes in pesticide metabolism or the reason that specific mutations are linked to cancer susceptibility has not been well studied.





Chapter Three: Health Effects of Concern

Health effects from some environmental exposures can be relatively specific, mainly affecting particular tissues, while others can act at numerous sites in the body, contributing to multiple effects. Individual health effects are typically the result of many, often interrelated, causes, of which environmental risk factors may be one component.

This chapter describes the major health effects of concern in children according to seven overall categories:

- The respiratory system
- The developing brain and nervous system
- Cancer
- Human reproduction and child development
- The endocrine system
- The immune system
- Multiple health effects

Moulds

Moulds are fungi that thrive in moist environments. Energy efficiency measures have contributed to tightly sealed and often inadequately ventilated buildings that can create such environments. Poorly maintained buildings can also contribute to excess moisture. Typical locations for mould growth include bathrooms, kitchens, basement walls and floors, and around windows. Moulds reproduce via tiny spores that are airborne and can cause many health effects depending on the particular species (thousands of species exist), the degree of exposure and individual susceptibility. Effects can include eye and skin irritation, headaches, respiratory infection, difficulty breathing, worsening of asthma symptoms and allergic reactions. Some moulds produce highly toxic mycotoxins that can cause serious health effects. The relatively rare black mould *Stachybotrys chartarum* has been found in some Canadian school portables. The presence of this fungus in severely water-damaged homes in Cleveland, Ohio, was linked to severe hemorrhagic pneumonia in infants. Although a cause–effect relationship remains unproven, this fungus produces potent toxins that animal studies show can damage lung tissue and suppress the immune system. Note that not all mould that appears black is this particular strain.

Childproofing Tips: If you use a humidifier, clean the water container and filter often and keep humidity levels at 30 to 50 per cent. If you have a damp basement, ensure that exterior downspouts direct water away from the foundation, repair cracks in the foundation, insulate exposed pipes and use a dehumidifier. Ensure exterior venting of clothes dryers, cooking stoves and bathrooms, and discard water-damaged items that cannot be cleaned or dried out.

For more information on controlling mould and humidity see

- Canada Mortgage and Housing Corporation at www.cmhc-schl.gc.ca
- City of Toronto’s fact sheets on mould at www.toronto.ca/health/mould.htm and indoor air at www.toronto.ca/health/hphe/pdf/air_checklist.pdf
- Health Canada’s website about dampness, mould and indoor air at www.hc-sc.gc.ca/english/iyh/environment/indoor_air.html and about cool mist humidifiers at www.hc-sc.gc.ca/english/iyh/products/humidifiers.htm
- US Environmental Protection Agency’s (US EPA) website about mould at www.epa.gov/eftpages/airindoormold.html.
- Healthy Spaces Resources website at www.cfc-efc.ca/healthy-spaces/resources_en.php.

The Respiratory System

Strong scientific evidence shows that indoor and outdoor air pollution contributes to childhood asthma and other respiratory effects. Other contributing factors include a child’s individual genetic make-up and exposure to other asthma-inducing factors, such as pet dander, moulds and infections. The range of respiratory effects in children associated with indoor and outdoor air pollution includes

- asthma incidence (i.e., new cases)
- worsening of asthma symptoms in known asthmatics
- allergic disorders
- increased bronchitis
- decreased lung function and increased susceptibility to respiratory infections.

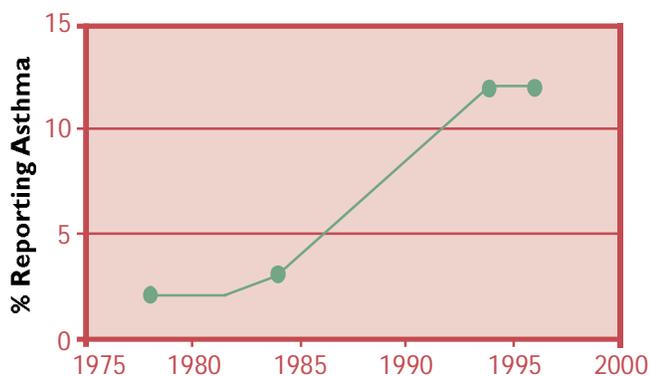
Large numbers of children are affected. Health Canada statistics during the 1990s revealed that, compared to 15 years earlier, the number of children with asthma

quadrupled. In 1997, 12 per cent (or at today's population level, nearly 950,000) of Canada's children and youth under the age of 20 had physician-diagnosed asthma. Many more children experience less severe respiratory problems for which health researchers confirm air pollutants as contributing causal factors. Asthma is the leading cause of child hospitalization among young children (age one to nine years) and one of the leading causes of school absenteeism.

For more detailed information on air pollution, see Pollution Probe's *Smog Primer* at www.pollutionprobe.org/Publications/Primers.htm.

Figure 6: Reported Asthma Prevalence, Birth to 19 Years in Canada, 1978–1996.

1984 survey included children 0–14 years only. Percentages are weighted estimates.



Source: Health Canada, 1999.

Asthma

Asthma is a chronic disease of the lungs and airways characterized by periodic acute episodes. During asthma attacks, airway linings become inflamed, swollen and partially blocked, causing coughing, wheezing and difficulty breathing. Attacks can last from hours to days and, in rare cases, can be fatal.

Asthma results from the interaction of a genetic predisposition to asthma with environmental triggers. These triggers vary for different people and can include airborne toxicants from fossil fuel and tobacco combustion and allergens from dust mites, cockroaches, pets and mould. Scientists have confirmed that toxicants and allergens can both trigger asthma attacks and play a role in inducing the onset of asthma in a previously healthy person. Environmental tobacco smoke is a particularly important contributor to childhood asthma and considerable evidence also implicates outdoor air pollution, especially in areas of heavy traffic. Less well understood is the possible contribution of some pesticides as triggers for asthma. Research continues on the nature of these complex relationships. In the meantime, investment in public education and government regulations that improve indoor and outdoor air quality can help children with a genetic predisposition to asthma avoid the triggers that bring on, or worsen, the disease.

Childproofing Tips: Outdoors — drive less, and walk and bike more, but follow advice about reduced activity during smog alerts. **Indoors** — vent gas stoves to the outdoors, have them inspected annually and never use them to heat a room. Don't smoke cigarettes or allow cigarette smoking in a child's home. Clean floors and surfaces regularly and ensure routine ventilation of indoor spaces. Control for dust mites and moulds.

For more information see The Lung Association at www.lung.ca and www.yourhealthyhome.ca.

Learning and Developmental Disorders and Disabilities

Brain-based disorders (or disabilities) can range from mild to severe across a wide spectrum of effects or syndromes, including a combination of effects on learning, behaviour, social competence and emotional reactivity. There are numerous and often overlapping sub-categories of conditions, and children can often be diagnosed with more than one condition. These conditions are diagnosed according to criteria set out by the American Psychiatric Association in the Diagnostic and Statistical Manual of Mental Disorders (DSM IV). Diagnosis and classification is imprecise, difficult and often controversial, thus making it difficult to research and treat these disorders. New frameworks of thinking about these disorders are slowly emerging.

The following categories are a simplified version of how these disorders are classified with some specific examples provided in each.

Disorders of learning affect cognitive (learning) functioning. Learning disorders include, for example, specific learning disabilities, dyslexia and mental retardation.*

Disorders of behaviour are characterized by overly disruptive or aggressive behaviour. Conduct Disorder (CD), Oppositional Defiant Disorder (ODD) and Attention Deficit Hyperactivity Disorder (ADHD) all fall into this category.

Disorders of social development are characterized by social dysfunction, restricted behaviours and difficulty with communicating. Rett's Syndrome, Asperger's Syndrome and autism are examples.

**The term "mental retardation" is generally viewed as objectionable in Canada. It is still used in older texts and in the current US literature. Because most of the references used in this Primer are taken from the US literature, the authors have used the term mental retardation so as not to misinterpret others' reports. The preferred term in Canada is "intellectual disability."*

The Developing Brain and Nervous System

Substances that can harm the brain are said to be neurotoxic. They are called neurotoxins or neurotoxicants. When they are known or suspected to affect the developing brain and nervous system, these substances are called developmental neurotoxins. There are many substances which some evidence suggests may be developmental neurotoxins. As the issue is a highly complex one to investigate, many information gaps remain to be filled.

Environmental exposures to toxic substances are known, or more often suspected, to contribute to the following kinds of health effects and conditions related to brain development and functioning:

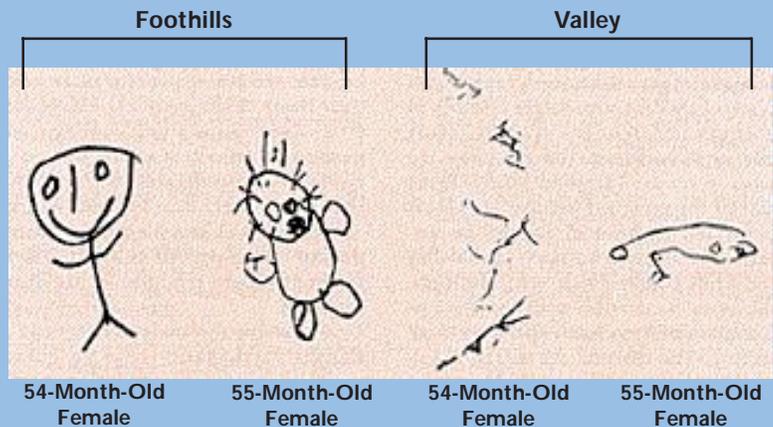
- Intellectual deficits manifested as lower school performance, IQ deficits, learning disabilities, lower scores on aptitude tests, other cognitive and motor deficits
- Autism spectrum disorders
- Attention Deficit Hyperactivity Disorder (ADHD)
- Visual or hearing deficits
- Behavioural problems, such as propensity to violence
- Altered thyroid function (impacting brain development — see discussion about the endocrine system).

Strong evidence of neurotoxicity, in the form of laboratory, clinical and epidemiological data demonstrating these associations, exists for a small number of substances as being

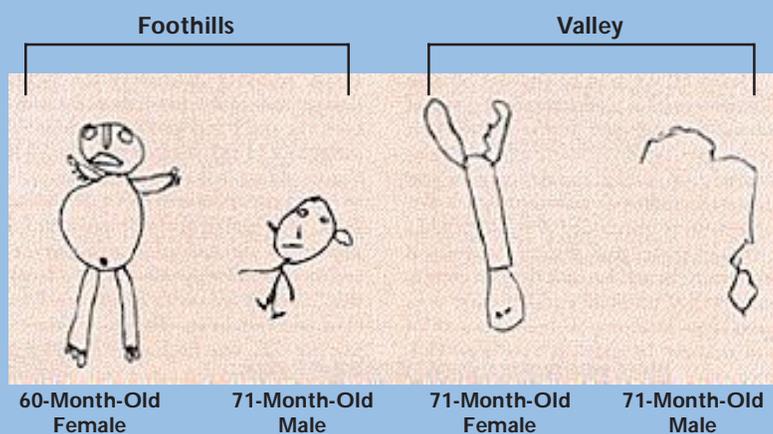
Pesticide-exposed Children in Mexico

The effects of pesticides on the developing human brain are of increasing concern because some widely used insecticides, particularly the organophosphates, exert their toxic effects by interfering with the nervous system of insects. In a well-known study conducted in Mexico, two groups of children were tested for nervous system impacts from pesticide exposure. One group lived in an area with heavy use of agricultural pesticides (valley), while the other group lived in an area with minimal pesticide use (foothills). Compared to the less-exposed children, the more highly exposed children had less stamina and coordination in doing various tasks, bad memory, and were less creative in their play activity and less able to draw recognizable pictures of people and objects. There were no direct measurements of pesticide exposure in either group of children. Also, the agricultural practices and types of pesticides used in the community with the more highly exposed children could be expected to create conditions of significant pesticide exposure not typical for agricultural communities in Canada. Agricultural communities often have greater pesticide exposure than non-agricultural communities. One of many concerns raised by this study is whether there is an adequate margin of safety for nervous system effects on children from pesticide exposures more commonly experienced in the general population, including in Canada.

Representative drawings of a person by four-year-old Yaqui children from the valley and foothills of Sonora, Mexico.



Representative drawings of a person by five-year-old Yaqui children from the valley and foothills of Sonora, Mexico.



Source: Guillette, E., M.M. Mercedes, A. Guadalupe, et al. 1998. An anthropological approach to the evaluation of preschool children exposed to pesticides in Mexico. *Environmental Health Perspectives* 106: 347–353.

Building the Human Brain

Brain development starts in early pregnancy and continues throughout the teenage years.

Developmental stages occur in a precise sequence, building on previous stages. The first stage, called proliferation, starts with the formation of many brain cells (at birth the human brain has 100 billion brain cells). Many of these brain cells, or neurons, migrate or move. They also differentiate (alter their form or function) to accomplish different purposes in the brain.

Part of the process of differentiation is the formation of synapses to connect brain cells. More specific wiring occurs with the formation and refining of neural circuits. This stage relies on targeted, preprogrammed cell death that continues through adolescence.

In a newborn, most brain cells are not yet formed into these complex connections. Still to be fully developed are those parts of the brain that accomplish thinking and recall, and emotional and social behaviour. At the age of three a child's brain has developed 1,000 trillion connections (synapses) among brain cells. If the development process is altered at any of these stages, those that follow can also be compromised.

Developmental neurotoxins can affect some or all of the many stages of brain cell production, function, differentiation and migration. Some neurotoxic chemicals act by altering levels of neurotransmitters, or chemical messengers, responsible for some brain development and for communication between neurons. Still others can disrupt brain development by interfering with, or altering the function of, hormones in the thyroid gland that play a key role in fetal brain development.

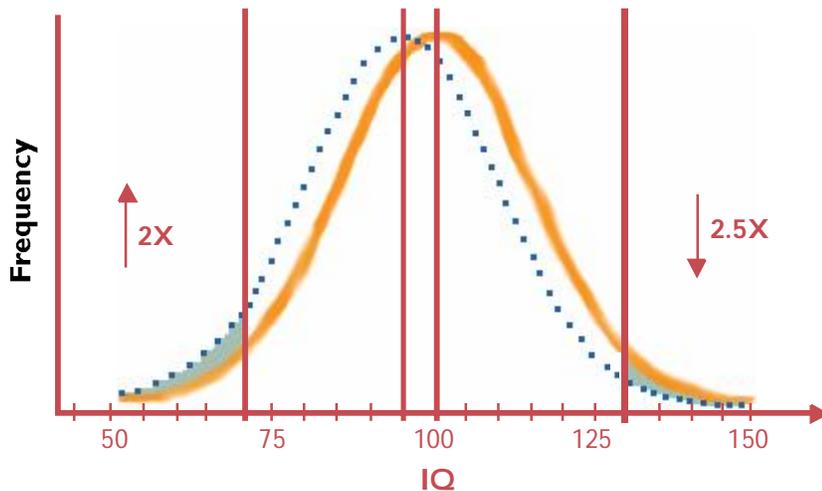
neurotoxins. These include the metals lead and methylmercury, nicotine (prenatal maternal smoking), ionizing radiation, dioxins and some pesticides, solvents and PCBs (industrial chemicals discontinued in the 1970s, but still circulating in the environment).

Our understanding of the neurotoxic effects of methylmercury and PCB exposure comes mainly from situations of localized and relatively high levels of exposure. Concern remains about the neurotoxic effects of low-level exposure to these substances experienced by much larger segments of the population. At low exposure levels, the evidence is strongest for lead and PCBs. There is fairly consistent evidence of neuropsychological deficits from low-level prenatal PCB exposure, but findings for low-level prenatal methylmercury exposure are inconsistent. Environmental links to learning disabilities and autism are suspected, but supporting evidence is inconclusive.

Scientists suspect that many more substances are neurotoxic than are currently known as such. Some pesticides are known to be neurotoxic in animal studies, and links have been drawn from limited human data. The animal studies have prompted increased regulatory attention towards reducing children's exposures to certain pesticides to avoid harmful effects on the developing brain and nervous system. Evidence is also increasing about the neurotoxic properties of substances that are similar in many important ways to dioxins and PCBs. In particular, there is growing evidence about the developmental neurotoxicity, as well as other hazardous properties, of the flame retardants, PBDEs.

In the face of such ignorance about the neurotoxicity of environmental contaminants, trends in these health effects are troubling. The prevalence of neurobehavioural and neurodevelopmental effects among children in Canada is strikingly high. According to data collected for the National Longitudinal Survey on Children and Youth (which reported in 1997), 26 per cent of children in Canada aged six to 11 years had at least one identifiable emotional/behavioural, academic or

Figure 7: Impacts Across a Population. When a neurotoxic substance, such as lead, causes a slight downward shift in IQ, the effect might be insignificant in a single individual. However, across a population, the effect can be profound. This figure shows the difference between the normal distribution of IQ values in a population (solid curve) with a mean IQ of 100 (shown by the solid line) and what happens when there is an overall population IQ shift downward by five points (the dashed curve). In the population with the lower average IQ, if you consider the shaded tails of the new distribution, there are 2.5 times fewer individuals with IQs greater than 130 and double the number of persons with IQs less than 70 (which is the clinical definition of mental retardation/intellectual disability).



Source: Rice, 1998.

“You get only one chance to develop your brain. Developmental neurotoxicity therefore has high priority in environmental health.”

Source: Grandjean, P. 2004. “Neurodevelopmental Disorders in Children: Some Old and Emerging Threats.” *EEA/WHO/Collegium Ramazzini Workshop: Children in Their Environments.* Budapest, 22 June 2004.

social problem. Further, 16 per cent of children in Canada aged four to five years showed delayed vocabulary skills. According to the Autism Society of Canada, autism rates in Canada have climbed from an estimated one in 10,000 children 20 years ago to an apparent rate of one in every 200 children (or 50 per 10,000). There are uncertainties about the true prevalence of autism, but for reasons unknown it is three to four times more common in boys than girls and has been found throughout the world in families of all racial, ethnic and social backgrounds.

The numbers of children with these conditions appear to be equally high in the US. US statistics for the year 2003 show that almost five million US children three to 17 years of age (eight per cent) had a learning disability, with boys more often affected (nine per cent) compared to girls (six per cent). As well, almost four million children in the US three to 17 years of age (six per cent) had ADHD in 2003. Boys were more than twice as likely as girls to have ADHD (nine per cent versus four per cent). Increases in these conditions may be influenced, in part, by an increase in diagnosis. However, limited evidence does suggest that the actual occurrence of the conditions has increased in recent years.

Clearly, very large numbers of children are affected by learning and behavioural problems. It is important to recognize that multiple risk

factors contribute to these conditions, including various aspects of parenting and socioeconomic conditions. Consequences are often serious and lifelong, affecting children, their families and their communities. The potential role of environmental contaminants in these conditions, even the few that are well studied, is poorly understood. The evidence that does exist suggests that low-level prenatal PCB exposure, or prenatal and early life lead exposure, can permanently affect the developing brain.

Hence, unlike the evidence about air pollution discussed above, there is not enough evidence to pin the high rates of neurodevelopmental and behavioural conditions on exposures to neurotoxic substances in children's environments. Nor would a relationship be simple or direct, given the complexity of the human brain and its developmental stages and the many factors at work during a child's social and emotional development. The large numbers of suspected neurotoxins, and the similarly large numbers of children affected by nervous system problems, is a "red flag" that prompts environmental researchers to identify a need to look closer at this situation. If environmental contaminants are implicated in these brain-based conditions, the opportunity to prevent damage to children's brains may be significant, and for many children could make a big difference to the course of their entire lives.

Cancer

Cancer includes a wide spectrum of cancer sub-types. There can be multiple contributing causes, including environmental risk factors, all of which vary for different forms of the disease.

Cancer is a condition of abnormal cell growth, unregulated by normal mechanisms in the body. Children's bodies, particularly when in the womb, undergo more frequent cell division during development than do adult's bodies. This faster rate of cell division can potentially result in a larger number of cell mutations. Other characteristic differences between children and adults, described in Chapter Two, also contribute to a child's chance of developing cancer during childhood or later in life. These differences include children's greater exposure to, and tendency to absorb and retain more toxic substances, their immature and developing systems, particularly the immune system, and the reality of having many more years of life ahead of them than do adults.

Childhood cancer is very rare in Canada and children are generally diagnosed with fewer and different cancer types than are adults. The most common childhood cancers in Canada are leukemias, cancers of the

Arsenic in Pressure-treated Wood

The green-tinged wood used on decks, railings and children's play grounds — pressure-treated wood — may be treated with chromated copper arsenate (CCA), a chemical wood preservative and essentially a pesticide. It contains arsenic, a known human carcinogen. In humans, chronic exposure can cause cancer, toxic effects in the nervous and cardiovascular systems, and skin lesions (including skin cancer); in experimental animals, arsenic is known to cause immune system toxicity. A voluntary phase-out of pressure-treated wood for residential use began in Canada in January 2004. Though industrial use continues, CCA-treated wood is now banned for non-industrial uses in Canada. Tests show that arsenic can be available on the surface of this wood and can build up in soil immediately below it. Alternative treated wood products are also green-tinted. Precautionary steps should be taken to avoid arsenic exposure from CCA-treated wood purchased before January 2004.

Childproofing Tips: Wash children's hands after contact with CCA-treated wood. Cover picnic tables made from CCA-treated wood. Never burn CCA-treated wood — this releases toxic chemicals. Saw, sand and machine CCA-treated wood outdoors. Wear a dust mask, goggles and gloves. Do not mulch or compost the sawdust or wood chips. Removal or replacement of CCA-treated structures is not generally recommended by regulatory agencies. Coating the surface with a penetrating wood sealant (not paint) has been shown to reduce available arsenic. Regular reapplication of the sealant is necessary.

For more information, see

- US EPA's information about effectiveness of sealants at www.epa.gov/oppad001/reregistration/cca
- Environment Canada's Safe Handling Information at www.ccasafetyinfo.ca/index.html
- Pest Management Regulatory Agency Fact Sheet at www.pmra-arla.gc.ca/english/pdf/facts/fs_ccare.pdf

Despite the CCA phase-out, remember that pressure-treated wood still contains a pesticide. Similar precautions are necessary. For product-specific safety information, see www.ptw-safetyinfo.ca.

brain and nervous system, and lymphomas. The connection between toxic substances and cancer has received a lot of research attention in comparison to the scientific evaluation of other health effects, such as neurotoxicity. However, this research is overwhelmingly about cancer in adults — whether human or animal. It is not clear how exposure to most substances relates to childhood cancers, and to what extent it accounts for changes in childhood cancer rates over time.

Although many substances have been identified as carcinogenic, or as suspected carcinogens, this does not mean that such substances would cause childhood cancers (the time between first exposure



Photo Credit: Mark Surman

to a carcinogen and cancer diagnosis in humans is often 20 years or more). The causal mechanisms for childhood cancer are poorly understood, but exposures in the womb during rapid fetal cell division likely pose the greatest risk.

There is evidence from animal studies showing that early-life exposures can increase the rate of childhood cancer and the rate of certain cancers among adults. For example, a child exposed to ionizing radiation has a lifetime cancer risk up to double that of an adult exposed to similar levels of radiation.

Canadian cancer statistics for the period 1997–2001 show that cancer was diagnosed in an average of 1,285 children every year and 287 died each year from the disease. Annual statistics since 2001 reflect a similar pattern. For 2005, the National Cancer Institute of Canada estimates that 1,250 children in Canada under the age of 20 will be diagnosed with cancer and that 190 will die of the disease. Childhood cancer incidence (the number of new cases per 100,000 children per year) increased in Canada between 1974 and 1984, but has not increased since that time. Childhood cancer death rates have decreased because of improved cancer treatment.

Not seeing any clear upward trend in childhood cancer incidence could reflect Canada's relatively small population (especially since specific types of childhood cancer are relatively rare). In the US, with a much larger population of childhood cancer cases with which to discern trends, the incidence of all cancers in children increased nearly 21 per cent between 1975 and 1998. This

is an increase of about one per cent per year over two decades. Steady increases occurred in the same cancers seen in children in other industrialized countries, including leukemia, brain cancer and non-Hodgkin's lymphoma (NHL). In the case of NHL in children in the US, the incidence rate has increased by 30 per cent since the 1970s.

There is an ongoing debate in the scientific literature about the issue of whether childhood cancer incidence is increasing. Some experts consider earlier and improved diagnosis as sufficient explanation. Others consider that additional factors, including environmental contaminants, may be involved. Analysis of time trends is challenging, and both influences may be operative. European data appear to show a steady increase. In a recent study looking at 30 years of data from 35 European countries, researchers found a one per cent per year increase in childhood cancers — a finding that is similar to the trend data in the US.

While the jury is still out on the exact contribution of improved diagnosis to increased childhood cancer incidence, the fact remains that the types of cancers affecting children in industrialized countries are the same. Although still very rare, cancer remains the leading cause of illness-related death for children in Canada more than one year of age.

In contrast, there is clear evidence that cancer incidence among young adults (aged 20–44 years) in Canada has increased substantially.

Since the 1970s, among young adults in Canada an overall upward trend in cancer incidence has been apparent of greater than two per cent per year increase, or just under 20 per cent per decade. Significant increases in cancer rates have occurred for thyroid cancer in men (4.2 per cent per year) and women (6.6 per cent per year). Non-Hodgkin's lymphoma has increased in both sexes (3.5–4.2 per cent per year), as well as lung and brain cancers among women (1.9–2.0 per cent per year). In addition, testicular cancer has increased among men (1.7 per cent per year).

The causes of these increases are not known. Since cancers develop after a long latency period, early childhood, prenatal or parental preconceptional exposures during windows of vulnerability could be a contributing factor to these rising cancer rates in young adults.

One form of cancer — melanoma or skin cancer — is clearly linked to childhood sun exposure. The occurrence of severe sunburns during childhood or adolescence substantially increases the risk of melanoma during adulthood (although UV exposure risk continues for adults). Exposure to ionizing radiation (e.g., relatively high-intensity x-rays) is also a proven carcinogen and is known to pose a greater risk to children than adults. Likewise, early life exposure to asbestos increases an individual's lifetime cancer risk.

Table 2 summarizes the evidence about several childhood cancers associated with three categories of environmental exposures — pesticides, solvents and petrochemicals/industrial by-products.

Table 2: Some Childhood Cancers Associated with Selected Environmental Exposures

Note: Evidence of these associations comes from retrospective studies that have found an increased likelihood of childhood cancers among exposed people (parents or children) compared to groups not similarly exposed. Some studies show only weak associations. For several childhood cancers of concern (leukemia, brain cancer, non-Hodgkin’s lymphoma, and soft-tissue sarcoma) similar associations have been seen with adult exposures, particularly to pesticides. Some of these results are also supported by laboratory animal studies.

Source: Adapted from Gouveia-Vigeant, et al. 2003.

Cancer Type	Categories of Toxic Substances, or Specific Substances, Where Known/ Specified in Original Studies	Location and Timing of Exposure
Leukemia	Professional pest control services, pest strips, pesticides.	Residential exposure during pregnancy, up to age three and during childhood.
	Solvents: trichloroethylene and tetrachloroethylene.	Environmental exposures during pregnancy and childhood.
	Solvents (unspecified). Solvents: benzene, alcohols.	Paternal occupational exposures, prior to pregnancy.
	Solvents: chlorinated solvents, methyl ethyl ketone.	Paternal occupational exposure before and during pregnancy and after birth of child.
	Diesel exhaust. PAHs. Dioxin.	Air pollution exposure during childhood.
	Motor vehicle exhaust (nitrogen dioxide).	Paternal occupational exposure before pregnancy.
	Hydrocarbon-related occupations.	Maternal occupational exposures during pregnancy.
Acute Lymphocytic Leukemia (ALL)	Pest strips, insecticides, rodenticides, garden herbicides and products for tree infestations. Pesticides (unspecified).	For the first five exposure noted: residential exposure to mothers during pregnancy. For pesticides (unspecified): maternal occupational exposure during pregnancy.
	Solvents: trichloroethylene, carbon tetrachloride and perchloroethylene (e.g., used in dry cleaning).	Maternal occupational exposure before and during pregnancy, after birth of child; and childhood environmental exposures.
	Exhaust. PAHs. Gasoline.	Maternal occupational exposures before pregnancy (exhaust and PAHs) and during pregnancy (PAHs and gasoline).

Table 2 *continued*: Some Childhood Cancers Associated with Selected Environmental Exposures

Cancer Type	Categories of Toxic Substances, or Specific Substances, Where Known/ Specified in Original Studies	Location and Timing of Exposure
Acute Non-Lymphocytic Leukemia (ANLL)	Pesticides (unspecified).	Maternal residential exposure during pregnancy, paternal occupational exposure in jobs held more than 1,000 days and childhood residential exposure.
	Solvents (unspecified). Petroleum Products.	Paternal occupational exposure (timing unspecified).
	Solvents: benzene. Gasoline.	Maternal occupational exposure during pregnancy.
Nervous System Tumour	Pesticides (unspecified). Solvents (unspecified).	Paternal occupational exposure near conception (pesticides: farm or forestry).
	Motor vehicle exhaust (nitrogen dioxide).	Childhood environmental exposure.
Brain Tumour	Insecticides, including flea and tick products; sprays and foggers. Pesticides (unspecified).	For pesticides (unspecified): maternal residential (farm) exposures during pregnancy. For the rest: maternal residential exposure during pregnancy.
	Pest strips, flea collars, herbicides or insecticides.	Residential exposure during childhood.
Neuro-blastoma	Pesticides (unspecified).	Residential exposure during childhood.
	Solvents: benzene, alcohols, lacquer thinner, turpentine. Hydrocarbons, including diesel fuel.	Paternal occupational exposure (timing unspecified).
	Aromatic hydrocarbons and aliphatic hydrocarbons.	Parental occupation exposure (timing unspecified).
Non-Hodgkin's Lymphoma	Insecticides, including professional extermination.	Residential exposure during childhood.
Soft Tissue Sarcoma	Garden pesticides.	Residential exposure during childhood.
Wilms' Tumour	Pesticides (unspecified).	Residential exposures. Parental (farm) occupational exposures. Timing not specified in either case.
	Hydrocarbons.	Parental occupation exposure (timing unspecified).

Human Reproduction and Child Development

Human reproduction and the development of the embryo, fetus and child include a finely tuned sequence of events. Thinking about these events in a circle is helpful (see Figure 8). Different entry points on the circle describe stages through which all humans pass: germ cells (sperm and egg), *in utero*, infancy, childhood, adolescence and becoming a parent. Of course, some people do not have children and some stages are different for males than females. For example, girls are born with all the ova (eggs) they will release during their entire reproductive lives. Exposure to toxic substances for a woman carrying a female fetus therefore has the potential to affect her grandchildren if toxic effects are exerted during formation of the fetal ovaries and ova. Males produce sperm continuously during their adult reproductive years. Sperm may be influenced by recent, ongoing or prior occupational or environmental exposures.

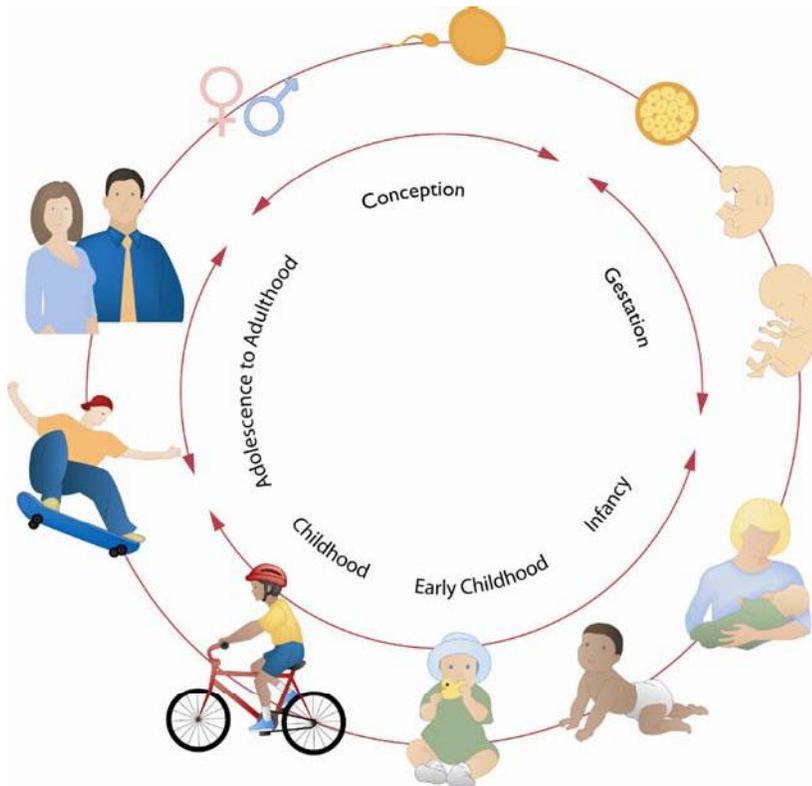
When problems occur during human reproduction, or during fetal or child development, they can be the result of many factors. Some environmental exposures are known to affect the reproductive health of parents and/or the developing fetus or child, and many more are suspected.

Reproductive toxicants have adverse effects on the male and female reproductive systems. They can

- interfere with sexual functioning or reproductive ability from puberty throughout adulthood
- cause loss of the fetus during pregnancy
- in the female reproductive system, bring about changes in sexual behaviour, onset of puberty and menstrual cycling, and can cause decreased fertility and gestation time, and decreased lactation, as well as premature menopause (e.g., exposure to lead can result in menstrual disorders and infertility, while carbon disulfide, mercury and PCBs can cause irregularities in the menstrual cycle)
- in the male reproductive system, bring about changes in sperm count or shape, altered sexual behaviour, and/or increased infertility (e.g., exposure to phthalates, PCBs and organochlorine pesticides has been associated with changes in sperm quality; lead is known to reduce male fertility; carbon disulfide and the pesticides chlordecone (kepone), ethylene dibromide (EDB), and dibromochloropropane (DBCP) are chemicals known to disrupt male reproductive health).

Reproductive disorders in men and women can result from chemical exposures of their parents or that they experienced in the womb, childhood or adulthood. Studies have detected lead, pesticide and other toxicants in both follicular fluid (surrounding the female egg) and semen, meaning that human eggs and sperm are directly exposed to chemical contaminants. If exposures

Figure 8: The Continuum of Human Development. With the exception of stages that are unique to one gender or for those individuals who do not have children, all human beings pass through the developmental stages illustrated here. In addition to the prenatal “windows of vulnerability” (illustrated in Figure 5), sensitive stages continue through these developmental processes. Hence, at all times across the human population, a window of vulnerability is always open.



that occur before conception result in chromosomal abnormalities or a mutation in the egg or sperm DNA, there can be developmental effects in the offspring. If these exposures result in permanent alterations in the egg or sperm DNA, the result can be multigenerational effects, such as occurred with exposure to the drug diethylstilbestrol (DES).

DES — Multigenerational Effects

Diethylstilbestrol (DES) is a synthetic hormone developed in the 1930s that was marketed as a treatment for many ailments, including the prevention of miscarriage in pregnant women. Between five and ten million Americans (mainly women) were exposed to DES before it was taken off the market in 1971. Pregnant women and their fetuses accounted for most of these exposures.

Mothers who had taken DES were later found to have higher rates of breast cancer. More surprising, however, and entirely unexpected, was the fact that their sons and daughters exhibited high rates of reproductive organ abnormalities, reduced fertility, adverse pregnancy outcomes, rare reproductive cancers and immune system disorders. One cancer in particular, vaginal adenocarcinoma, served to raise the alarm about DES because it was occurring too frequently in adolescent girls and young women, a population in which it should have been extremely rare. Whether these or other lingering effects will persist into the third generation following DES exposure remains to be seen.

The www.scorecard.org Reference Tool for Health Effect Information

The www.scorecard.org website, maintained by Washington-based Environmental Defense, provides lists of substances suspected or recognized as contributing to human health effects. Lists are provided of:

- suspected neurotoxins
- suspected carcinogens
- recognized and suspected developmental toxins
- recognized and suspected reproductive toxins
- suspected endocrine toxins
- suspected immunotoxins and
- suspected respiratory toxins.

The lists are prepared and regularly updated by teams of scientists who review the published scientific literature. Information sources include well-established toxicology texts and extensive databases created by government agencies at the state and national levels in the United States (e.g., the Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry, the California Environmental Protection Agency and more). Internationally-based information sources are also used, including databases created by the International Agency for Research on Cancer, the World Health Organization's International Program on Chemical Safety, and more. A website that uses these lists to provide information about pollutant releases in Canada is www.pollutionwatch.org.

Reproductive health of parents overlaps somewhat with the developmental health of an embryo or fetus in situations in which a reproductive toxicant affects the outcome of a pregnancy. Developmental toxicity in a fetus or child can result from prenatal exposures to toxicants experienced by the mother. Paternal exposures are also of concern. For example, occupational exposure of men to vinyl chloride has been associated with increased rates of spontaneous abortion in their female partners. As well, exposures resulting in developmental effects can occur prior to conception, and among children who were exposed prenatally or in childhood.

Developmental toxicants are agents that adversely affect the developing embryo, fetus or child. Effects can include

- early fetal death (spontaneous abortion)
- late fetal death (stillbirth)
- low birth weight
- decreased head circumference and body length at birth
- preterm delivery
- birth defects
- visual and hearing deficits
- cerebral palsy (congenital)
- chromosomal abnormalities
- intellectual deficits/mental retardation, as well as less severe biological dysfunctions, or psychological or behavioural deficits that may not manifest until later in childhood.

Known human developmental toxicants at high-level exposures include methylmercury, lead, ionizing radiation and PCBs contaminated by dioxins and furans. Organic solvents, some pesticides and some air pollutants are suspected as developmental toxicants. Additional chemical exposures are also suspected. For lists of recognized and suspected reproductive and developmental toxicants, visit www.scorecard.org.

Of course, not all of the developmental effects listed above will result from exposure to developmental toxicants. Health effects result from what is called the “mode of action” or “mechanism of toxicity” of a particular substance or physical agent. Timing matters as well. A toxicant may be capable of causing a birth defect during early pregnancy when organs and limbs are forming. The same toxicant may exert a different effect later in the pregnancy, such as during the rapid brain development of the third trimester.

For example, organic solvents appear to have different modes of action at different points in a pregnancy. Animal studies have demonstrated toxic effects, such as early fetal death and birth defects, from prenatal exposure to organic solvents. Similar effects have been found in some studies of occupationally exposed women. Additional studies have found associations between prenatal solvent exposure (in occupational settings) and increased risk of detrimental effects on the developing nervous system, including deficits in visual and cognitive functioning. These effects could be reflective of impacts during third trimester brain development.

Some pesticides are similarly implicated as human developmental toxicants from studies of occupational exposure and a large number of animal studies. Maternal occupational exposure to pesticides has

Organic Solvents

Organic solvents are lipophilic, or “fat-loving,” and readily evaporate at room temperature (i.e., they are volatile). They can rapidly dissolve grease, are readily absorbed through the skin, lungs and gastrointestinal tract, and disperse to various body tissues, including the placenta. They also tend to accumulate in the body’s fatty tissues. Widely used in the home and industry, solvents are in vapours from gasoline, lighter fluid, spot removers and other cleaners and disinfectants, degreasers, aerosol sprays, cosmetics, adhesives, paints and finishes, paint strippers and many other common products. Houses with attached garages may have relatively high benzene levels from stored vehicles or gasoline-powered machines. Occupational exposure settings include dry cleaning, hair salons, working with paint removers, thinners, floor and tile cleaners, glue and laboratory reagents. Maternal prenatal exposure to specific organic solvents has been linked to effects on reproduction and the developing nervous system. The most extensively studied organic solvent is ethanol (the alcohol in wine, beer or spirits); the detrimental effects on the fetus of maternal alcohol abuse are well established.

Childproofing Tips: Avoid prenatal exposure to solvents (such as during home renovations) and never drink alcohol during pregnancy. Ensure plenty of ventilation in hair salons and dry-cleaning establishments and seek alternative, low-solvent cosmetic and cleaning products. Ensure attached garages are well sealed from the rest of the home. Ensure products containing solvents are tightly closed and spillage is carefully controlled. **Closely follow label instructions.** If entry doors to the home pass through the garage, do not use them routinely or set up outgoing ventilation at the door.

For more information on low-solvent alternatives to common products, see the Nova Scotia Allergy and Environmental Health Association’s “Guide to Less Toxic Products” at www.lesstoxicguide.ca and Children’s Health Environmental Coalition’s “HealtheHouse” at www.chechnet.org/healthehouse.

Dealing With Pests

Pest problems, especially indoors, are unpleasant; some pests can worsen allergies and asthma. However, when pesticides are used in a residential setting, especially indoors, they can be a major source of overall pesticide exposure (from all sources, i.e., air, water, food, etc.) and can significantly increase children's exposures. Pesticide poisoning is also possible if children gain access to pesticide containers.

Childproofing Tips: Seek out safer, non-toxic alternatives to pest control, often by eliminating the conditions pests need to grow (e.g., outdoors — plant groundcovers that discourage weed growth and follow non-toxic lawn care practices; indoors — correct moisture problems to avoid mould, and keep counters clean and food in sealed containers to deter mice and insects). Where possible, use traps or other physical or mechanical methods, instead of poisons. There may not always be a low toxicity alternative, so seek out options that present the lowest exposure risk, such as baits, gels or pastes, rather than powders or sprays. **Closely follow label instructions** and ensure safe storage and dispose of unused pesticides as hazardous waste.

For more information visit

- Health Canada's Pest Management Regulatory Agency at www.pmr-arla.gc.ca
- Environment Canada's National Office for Pollution Prevention and the Federation of Canadian Municipalities at www.pestinfo.ca
- Pesticide Action Network of North America at www.panna.org/panna
- National Coalition Against the Misuse of Pesticides at www.beyondpesticides.org
- Toronto Public Health Pesticides Information at www.toronto.ca/health/pesticides/index.htm
- Canadian Association of Physicians for the Environment at www.cape.ca

been associated with increased risk of a variety of different birth defects. Children of male pesticide applicators (in agricultural settings) have been found to have higher rates of birth defects.

Prenatal exposure to some of the organophosphate pesticides has been associated with reduced head circumference at birth and reduced birth weight and length. These studies conducted at Columbia University looked at urban exposures in New York City, mainly related to indoor pest control. Researchers looked at time trends in these exposures and health outcomes. They found a correlation between lower exposures (following regulatory action) and the weakening of associations with impaired fetal growth. The study authors note that their findings lend support to regulatory actions that require the phase out of residential use of pesticides.

Air pollution also appears to act as a developmental toxicant. In a study in Vancouver, researchers confirmed results found in China, the Czech Republic and the US relating maternal prenatal exposure to air pollution and increased risk of low birth weight and premature birth. Other studies have shown associations with air pollution and cardiac birth defects.

Finally, the various stages of human reproduction and development occur as a result of many different chemical signalling processes by hormones in the endocrine system. There is emerging evidence that impacts on reproductive and/or developmental health, including some of the effects discussed above, may result from effects that are mediated through the endocrine system.

The Endocrine System

The endocrine system includes the body's hormone-producing glands — the pituitary gland and hypothalamus located in the brain, the adrenal glands on top of the kidneys, the female ovaries and male testicles, the pancreas in the abdomen, and the parathyroid and thyroid glands in the neck. This complex system coordinates and regulates communication between cells through the use of hormones, which act as chemical messengers. When hormones come into contact with their target cells, they attach to receptors, which then trigger those cells to respond in specific ways.

These many chemical and cellular exchanges of information orchestrate the varied stages of human development and the maintenance and coordination of the body functions that result in normal growth, development and good health. For example, hormones and their target cells help to create “homeostasis,” which refers to the steady state of blood sugar levels, body temperature and other aspects of healthy metabolism.

Hormones play a wide spectrum of roles throughout the human lifetime. As all parents and teenagers know, hormones are part of the process of human sexual maturation. Hormones continue to be involved throughout the process of the monthly release of eggs, the development of sperm, sexual behaviour, fertilization, conception and the many stages of human development. The endocrine, immune and nervous systems are closely linked and hormones play key roles in brain development and nervous system functioning.

Thyroid hormones are worthy of special mention. They influence all the major body systems, including basal metabolism, heart rate, blood pressure, body temperature and other functions. Moreover, healthy functioning of a pregnant woman's thyroid gland is critical to fetal brain development beginning in the first weeks of pregnancy and continuing until birth. Too much thyroid hormone — hyperthyroidism — can

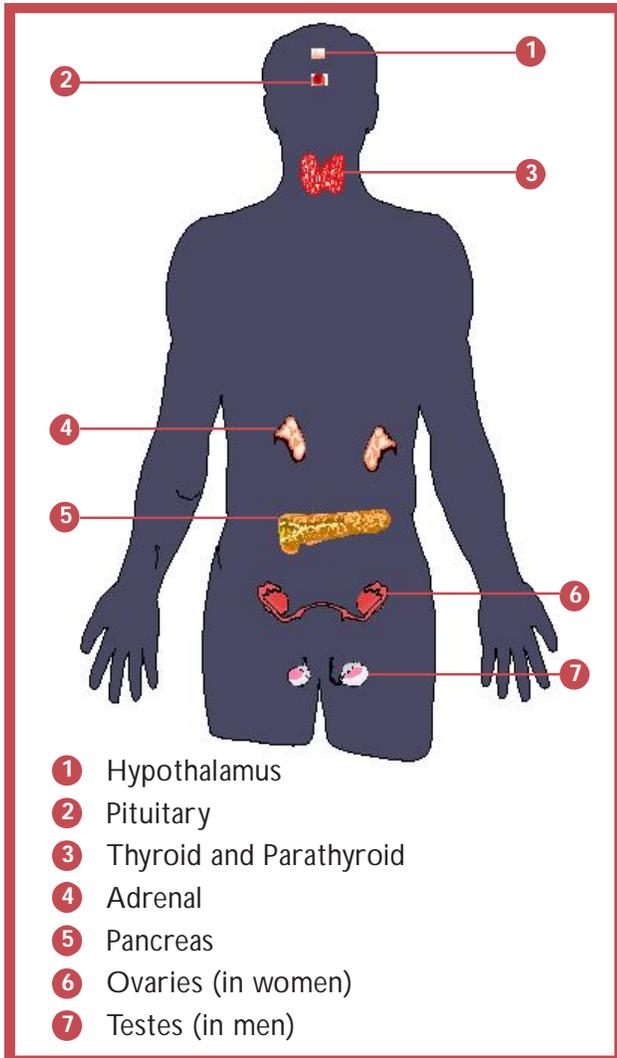
Chemicals and Thyroid Disruption

“The thyroid system is so complex that understanding its normal function is difficult enough, but deciphering environmental disruptions to it is staggeringly complex.”

Source: Brown, V. 2003. Disrupting a Delicate Balance. *Environmental Health Perspectives* 111(12).

Most of the substances implicated in endocrine disruption are often suspected of affecting, or are known to affect, the hormones of the thyroid gland. These include PCBs, PBDEs (flame retardants), dioxins, ethylene-bisdithiocarbamates (EBDCs — carbamate fungicides) and perchlorate (component of jet fuel). The key concern about thyroid hormone interference is the impact on fetal brain development. Over 90 separate compounds (including those noted above) have been identified as having thyroid disrupting properties. To complicate matters further, multiple mechanisms exist that can alter thyroid function. Finally, ionizing radiation is a known cause of thyroid cancer, tragically confirmed in the epidemic of childhood cancer that occurred after the Chernobyl nuclear plant accident. Thyroid cancer is the fastest rising type of cancer in young adults in Canada.

Figure 9: The Endocrine System. The major glands of the endocrine system are shown here, including both the male testes and female ovaries, for illustration purposes only.



Source: www.emcom.ca

result in low birth weight, premature birth and, in some cases, birth defects. Too little hormone — hypothyroidism — can result in cerebral palsy, deafness and severe intellectual deficits/mental retardation. Even small changes, higher or lower, in thyroid hormone levels during fetal brain development can result in children with motor coordination and balance problems. As well, though research is inconclusive, some studies show associations between maternal hypothyroidism and problems with neuropsychological development, including IQ deficits.

Many scientists are concerned that exposure to chemicals in the environment can interfere with the communication network that is the human endocrine system. Variously called “endocrine disruptors,” “endocrine modulators” or “hormonally active agents,” some chemicals appear capable of interfering with communication between cells. They can block hormones (and decrease hormonal activity), mimic hormones (and increase hormonal activity) or affect the production, transport, action and removal of hormones.

Chemical interference with the endocrine system has the potential to contribute to a wide range of effects on the structure and function of other body systems, especially the reproductive system. Endocrine disruption can also affect brain development, the development of hormone-related cancers, and immune function. Evidence so far comes from studies of laboratory animals, some wildlife studies and limited human epidemiological studies. While much more research is needed, the following is a list of

possible impacts of exposure to endocrine disrupting chemicals:

- Adverse pregnancy outcomes, including spontaneous abortion and stillbirth, changes in sex ratio (fewer male babies conceived and born resulting in a lowered sex ratio)
- Male birth defects of cryptorchidism (undescended testicles) and hypospadias (defect in male urinary tract)
- Decreased sperm count/quality
- Adult testicular cancer, given that cryptorchidism is a known risk factor
- Premature menarche (onset of menstruation) and precocious (unusually early) puberty; polycystic ovary syndrome (PCOS), which is associated with chronic anovulation and polycystic ovaries
- Shortened lactation (unrelated to behavioural choices)
- Neurobehavioural effects (from neurotoxins exerting thyroid hormone dysfunction during exposure *in utero*)
- Endocrine-mediated immunotoxicity
- Cancer promotion at endocrine sites (breast, endometrial, testes, prostate, and thyroid) by substances with estrogenic activity (from prenatal/perinatal or otherwise early-life exposure).

Multiple effects in the male reproductive system have been grouped together as Testicular Dysgenesis Syndrome (TDS), a term used to describe a cluster of related developmental effects that all may have a common causal origin, including environmental exposures. The cluster of effects in TDS includes the birth defects cryptorchidism and hypospadias, poor semen quality (i.e., reduced sperm count, more abnormal sperm), subfertility and perhaps also testicular cancer.

The incidence of cryptorchidism and hypospadias is rising in industrialized countries, although trend data are inconsistent. Some studies have shown associations between environmental (i.e., background) exposure levels to phthalates and PCBs (as measured in urine and blood serum, respectively) and some measures of sperm quality. There are inconsistent reports

Lake Apopka Alligators

A 1980 accident at a pesticide company released the pesticide difocol, DDT and DDT metabolites,* into the water of Lake Apopka, Florida. High levels of exposure very quickly caused the death of the majority of the lake's alligator population. Over a decade later, the alligator population had never recovered and was found to have high rates of unusual reproductive abnormalities that lowered their ability to reproduce. Males had malformed penises, only 20 per cent of the eggs that were laid hatched, and those that did had unusually high death rates. Young males had low testosterone levels, while young females had high estrogen levels and abnormal ovaries. The pesticides acted like the naturally occurring sex hormone, estrogen, resulting in feminized males and a variety of other reproductive health problems affecting the health of generations of alligators to come.

** DDT has been banned in Canada for many years. Difocol is a chlorinated insecticide registered in Canada for domestic and commercial applications, primarily to kill mites.*

Source: Guillette, L.J. et al. 1994. Developmental Abnormalities of the Gonad and Abnormal Sex Hormone Concentrations in Juvenile Alligators from Contaminated and Control Lakes in Florida. *Environmental Health Perspectives* 102: 680–688.

Phthalates

Phthalates are chemicals that are used to soften polyvinyl chloride (PVC) plastic. They are in soft vinyl products, such as children's toys, medical equipment, flooring and packaging. They are also used in some cosmetics, paints and lubricants. Concern about exposure during normal use of these products prompted the European Union to ban phthalates in children's toys in 2005 as a precautionary regulatory response to evidence of health risks. Phthalates are lipophilic, or "fat-loving," and can migrate from plastic into fatty foods. Major sources of phthalates include food in plastic packaging, especially fatty foods, fish and shellfish, cosmetics and indoor air where phthalates are released from plastic materials, coatings and flooring. Like many toxic substances in consumer products, phthalates have surprised us since they are showing up routinely in human biomonitoring studies, reflecting widespread human exposure and uptake. Their toxicity is not fully understood and effects vary by individual phthalate. Some are better studied than others, but multiple health effects are suspected, including endocrine disruption, in particular, resulting in effects on male reproduction.

Childproofing Tips: Don't oven-bake or microwave food in plastic containers or with plastic lids or covers (even those designed for use in the microwave); instead, transfer the food to a glass or porcelain container or replace the plastic lid with a plate (in the microwave) or foil (in the oven). Avoid soft vinyl toys for young children. Minimize or prevent the exposure of older children to cosmetics and seek out phthalate-free alternatives. Remove torn or otherwise deteriorated vinyl flooring and ventilate well after removal. Choose fabric shower curtains, backpacks, etc., instead of soft vinyl.

The Environmental Working Group provides a US-based list of phthalate-free products (with general applicability to Canada) on-line at www.ewg.org/issues/cosmetics/phthalatefree.php.

from many areas in the industrialized world of declining sperm counts. Evidence remains insufficient to extend the TDS theory to include testicular cancer in young men. However, there is a clear upward trend in testicular cancer among young men in many countries, including Canada, and cryptorchidism is a known risk factor for the later development of testicular cancer.

The TDS theory suggests that these effects in the male reproductive system result from endocrine disrupting chemicals affecting male gonadal development during the very early stages of pregnancy (in the embryo), as well as during later stages of fetal development. Genetic susceptibility may also be a factor.

Substances already known to be highly toxic, and which also appear to be endocrine disruptors, include several persistent substances:

- PCBs (although production was discontinued in the 1970s, PCBs are persistent and still circulate in the environment)
- dioxins and furans (by-products of combustion and some industrial processes)
- organochlorine pesticides (many of which are banned in Canada but, like PCBs, are still in global circulation due to their persistence), particularly DDT and its breakdown product DDE.

Limited scientific information, again primarily from animal and other laboratory studies, reveals the potential for endocrine disrupting ability of

- several of the phthalates (found in many different plastics and cosmetics)
- bisphenol A (used in polymers, resins, dyes, flame retardants and dental sealants and found in many products, including pop cans, hard plastic food and water containers, etc.)
- nonylphenol ethoxylates (surfactants in detergents)
- additional pesticides (often chlorinated) — specifically the fungicides vinclozolin, iprodione and procymidone and EBDCs
- perchlorate, used as an oxygen source in missile and rocket fuel
- brominated flame retardants, including PBDEs, pentabromophenol and tetrabromobisphenol A (found in multiple consumer goods, such as foam, fabrics, casings for computers and many other electronic appliances, etc.)
- organotin compounds (used as pesticides on marine craft).

Many more substances are suspected of being capable of endocrine disruption. For a list of suspected endocrine disrupting substances see www.scorecard.org. Finally, endocrine disruption is also possible from natural sources, such as phytoestrogens in some plants. As well, some medications, such as birth control pills and postmenopausal hormone replacement therapy, are used to intentionally manipulate the endocrine system. Unintended environmental exposures of uncertain risks have been identified with the detection of these and other pharmaceuticals in surface and drinking water in Canada. For more information from Environment Canada, visit www.nwri.ca/research/pharmaceuticals-e.html.

The Immune System

The body protects itself against infectious agents and certain other foreign material in two main ways: barrier and immune system defences. Barrier defences include skin, mucous membranes, stomach acid and the cough reflex.

If harmful organisms or allergenic particles get through these barriers, the innate immune system barriers take over first. The innate immune system recognizes (through ancient, somewhat primitive recognition systems) that these substances are “foreign” and uses enzymes, white blood cells, chemicals (such as interferon) and proteins to attack them. *Acquired* or *adaptive immunity* builds up over time as the body is



Photo Credit: Mark Surman

PBDEs — The New PCBs

Polybrominated diphenyl ethers, or PBDEs, include over 200 compounds, three of which are commonly used as flame retardants and heat stabilizers in thousands of products. PBDEs often make up a significant portion of the plastics in building materials, television and computer casings, hand tool housings, and the foam and fabrics of textiles and furniture. Since use began in the late 1970s, numerous studies now document widespread environmental contamination. PBDEs are detected in indoor and outdoor air, house and office dust, rivers, lakes and sediment, wildlife and food. Levels are rising rapidly in human breast milk, with the highest levels recorded in North American women. Chemically similar to dioxins and PCBs, PBDEs appear to have the same wide range of toxic effects. From animal studies and limited human data, there is evidence of thyroid hormone disruption and additional endocrine system effects. There is also animal evidence that PBDEs are toxic to the developing nervous system and act as reproductive toxicants. They are suspected carcinogens, and animal studies show they may have additive effects with PCBs and dioxins. The European Union banned the sale and use of two of the three most widely used PBDEs — Penta-BDE and Octa-BDE — in January 2003 and expects to ban the third — Deca-BDE — within the next few years. State governments in California and Maine have instated similar bans.

Childproofing Tips: Ask retailers whether they carry PBDE-free products, and if not, why not. Cover any exposed foam on household items, or discard if it is crumbling or cannot be contained. Avoid high-fat foods because, like other persistent organic pollutants (POPs), PBDEs accumulate in fatty tissue and concentrate up the food chain. Ask the federal government to follow the leadership of the European Union and ban PBDEs. For more information see the PBDE Collection on the CPCHE website at www.healthyenvironmentforkids.ca/english/special_collections/fulltext.shtml?x=784.

exposed to various antigens (foreign substances). In response, the body creates antibodies or directly attacks a specific antigen. *Artificial immunity* is another form of acquired immunity created in the body by various vaccines. Babies have *passive immunity* obtained from their mother's immune system *in utero* and if they are breastfed.

Immune system disorders occur when the immune system under-reacts (suppression), overreacts, (stimulation, or more accurately, upregulation) or reacts inappropriately. Suppression results in a decreased ability to fight infection, while upregulation causes the body to form antibodies and react against certain substances that are not necessarily toxic. Sensitization plays a role in the development of asthma and allergies.

Effects of environmental exposures on immune system development and functioning are poorly understood. Evidence exists to link PCBs and dioxins with immunotoxic effects. Some evidence also implicates organochlorine pesticides, and limited animal data exist suggesting immune system effects from other pesticides. Animal studies point to a range of possible effects of ultraviolet (UV) exposure that are not fully understood or confirmed, including lower resistance to infection, promotion of skin cancer and reduced effectiveness of vaccinations.

Multiple Health Effects

It is convenient to separately describe the many systems of the human body, but it is important to remember that they develop and function together as an integrated whole. Likewise, exposure to environmental risks can be separately described. For example, exposures occur in air, water or food. In reality, children are exposed via multiple pathways to multiple risks (chemical, biological, physical), some of which are capable of exerting multiple effects.

Certain exposures are of particular significance because they can lead to a variety of health effects, sometimes simultaneously. Lead, mercury, arsenic, PCBs, dioxins, furans, ionizing radiation, many pesticides and air pollutants are either known to contribute, or are suspected of contributing, to multiple health effects. For example, many pesticides are capable of causing a range of acute effects and have been linked to one or more of the following chronic effects: increased risk of cancer, neurological deficits, respiratory problems, immune system dysfunction and endocrine and reproductive disruption.

Air pollution is strongly associated with asthma and other respiratory impacts. It also contains known carcinogens, such as are found in diesel exhaust. However, recent studies are also finding associations between maternal exposure to urban air pollution and developmental effects, including reduced birth weight and preterm birth, some cardiac birth defects and chromosomal abnormalities in fetal cord blood, perhaps indicating a greater risk of cancer later in the child's life.



Photo Credit: Mark Surman

Similarly, high or ongoing exposure to UV radiation can lead to premature aging of the skin, increased risk of skin cancer later in life, retinal damage, increased risk of future cataracts, and weakening of the immune system. Hormonally active agents (or endocrine disruptors) appear to have the capacity to affect reproduction and development, the brain, the immune system and the development of cancer.

Exposures that can or may contribute to multiple health effects are of particular concern. Control measures and precautionary steps to reduce or avoid exposure should be given high priority for the sake of protecting prenatal and child health.

Photo Credit: Health Canada



Chapter Four: Children's Exposures

Describing Exposure

Two obvious questions arise about children's vulnerability to the health concerns raised in the previous chapter: 1. Where do exposures to environmental risks occur? 2. What can we do about it? While saying that chemicals are everywhere is basically true, it is not very helpful. We need to know which sources and routes of exposure matter the most, and which ones we can do something about.

Describing exposure involves looking at the ways thousands of substances are dispersed throughout the environment. Exposure can be measured directly as contaminant levels in blood or other tissues. Indirect measures include contaminant levels in air, water, food and soil or dust. Daily intake is estimated from each of these environmental media.

Exposure to a substance does not necessarily result in absorption into the body. The skin, lungs and digestive system in an adult can partially or fully block the entry of some substances. In children's bodies these mechanisms may be immature or not yet functional. Once inside the body, a substance may act at the point of absorption, or travel through the bloodstream and come into contact with various body tissues, systems and organs, or it may accumulate in fat or bone. Factors that affect the

Fish Advisories: Limiting Methylmercury Exposure

Fish is a nutritious source of protein and omega-3 fatty acids, essential for healthy brain development and functioning. Most fish are contaminated with methylmercury to varying degrees. Levels are especially high at the top of either freshwater or marine food chains. Mercury emissions from many sources, the largest being coal-fired electricity plants, travel through aquatic ecosystems, where they are biotransformed to methylmercury by aquatic microorganisms. Levels increase in concentration up the food chain, a process called biomagnification. Women and children, but especially pregnant and nursing women, face an ironic and disturbing dilemma. They should eat fish to obtain omega-3 fatty acids. These nutrients are always important, especially so during pregnancy to promote healthy fetal brain development. At the same time, pregnant women need to avoid the brain damaging impact of fetal exposure to methylmercury.

Childproofing Tips: Continue to eat fish, but choose fish carefully. Fish advisories are directed at women of child-bearing age, pregnant and nursing women and children under age 15. Fish advisories can be confusing because they are different between the US and Canada, they can vary for different age groups, for different fish species and even within the same species of fish, such as different forms of tuna. Health Canada recommends that pregnant women, women of child-bearing age and young children limit consumption of shark, swordfish and fresh or frozen tuna to a single meal per month. In contrast, the US FDA and US EPA recommend that this group completely avoid shark, swordfish, king mackerel and tilefish. However, for fresh or frozen tuna, the US limit is less precautionary, at one

...continued on next page

degree to which a substance can affect a child's health can include

- the amount or "dose" received, including the true "internal" dose or the amount of a toxin actually absorbed
- the possibility of conversion to less or more toxic breakdown products
- the toxicity of the substance
- the rate of excretion and/or breakdown to harmless substances
- the persistence of the substance and its ability to bioaccumulate
- the frequency of exposure
- the route of exposure (inhalation, ingestion and/or absorption)
- the duration of exposure (short term versus long term)
- the timing of the exposure
- other substances present at the time of exposure.

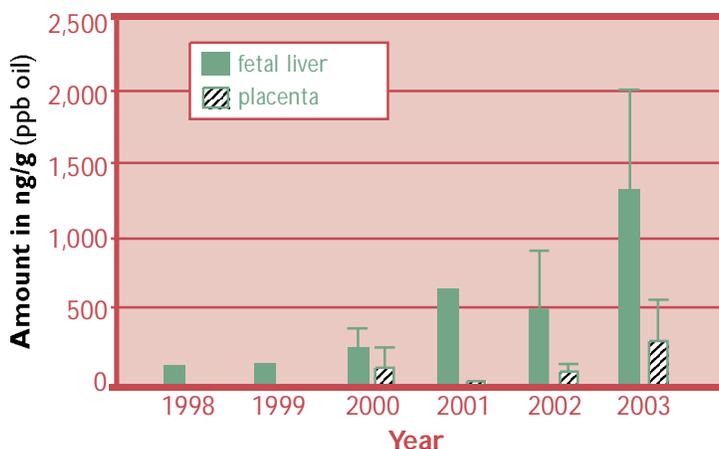
For all of these factors considerable variability can occur for many reasons, including genetic differences, a child's age or level of development at the time of exposure (especially when exposure takes place during a developmental window), behaviour, gender, nutritional status, general state of health and poverty, among others.

Clearly there is much to consider in measuring or estimating exposure. For the sake of describing children's exposures, the rest of this chapter looks at special circumstances (in the womb and during breastfeeding) and then describes exposures according to four media: air and dust (indoors and outdoors), water and food. Additional information about preventing or avoiding particular exposures is contained in the childproofing tips sprinkled throughout this Primer and in Chapter Six.

In the Womb: The First Environment

In the womb, the blood vessels of the placenta carry the oxygen, water, nutrients and other substances needed by the developing embryo and fetus. The placenta also serves as a two-way connection enabling the fetus to send hormonal signals to the mother's body. Functioning somewhat like a semipermeable membrane, the placenta is very effective at blocking most bacteria. But, it cannot always block or detoxify metals or other chemicals, particularly those that are small, light, and easily dissolved in fat. A pregnant woman's daily intake of contaminants in air, water and food, and her accumulated body burden of contaminants can, in most cases, readily cross the placenta and expose the developing embryo and fetus. Recent evidence shows that metabolic processes in the placenta can actually magnify the concentration of methylmercury. As a result, methylmercury levels in fetal blood can be about 70 per cent higher than in the maternal bloodstream.

Figure 10: Amount of Brominated Diphenyl Ethers (BDEs) in Canadian Fetal Liver and Placenta Samples



Source: Doucet J., D.L. Arnold, et al., 2004.

Fish Advisories: Limiting Methylmercury Exposure (continued)

meal per week. For fish with a lower mercury content, including canned light tuna, shrimp, salmon, pollock and catfish, the US EPA and US FDA recommend these fish be chosen within an overall limit of no more than two fish meals per week. However, for white (albacore) tuna, the advice is one meal per week as part of a two meals per week overall limit. Health Canada does not issue advisories for canned tuna or for overall weekly limits on fish consumption. Other fish likely to have lower mercury levels include farmed trout, haddock, tilapia and flounder.

For more information about mercury and fish advisories see

- Health Canada at www.hc-sc.gc.ca/english/protection/warnings/2002/2002_41e.htm
- US FDA and US EPA at www.cfsan.fda.gov/~dms/admehg3.html
- *Guide to Eating Ontario Sport Fish* at www.ene.gov.on.ca/envision/guide
- Pollution Probe's *Mercury in the Environment: A Primer* at www.pollutionprobe.org/Publications/Primers.htm
- OPHA position paper on methylmercury in fish at www.opho.on.ca/2004/mercury_fish.html
- SeaFoodWatch, for information about choosing fish that are caught or farmed sustainably, at www.mbayaq.org/cr/seafoodwatch.asp
- Physicians for Social Responsibility and the Association of Reproductive Health Professionals, for information about mercury levels and sustainability of harvesting, at www.mercuryaction.org/fish.

Breast Milk: The First Food

Human offspring are immature at birth. Indeed, human babies are born far more immature than most other species. Healthy development that occurs after birth is enabled and enhanced by breast milk and breast feeding.

The first breast “milk” is a yellowish substance called colostrum that begins to develop in the breast by mid-pregnancy. It is full of proteins, vitamins, antibodies, growth-promoting substances and living immune cells. Colostrum and breast milk help an infant fight off disease by imparting temporary immunity from the mother during the early months since immune system development is incomplete at birth.



Photo Credit: Mark Surman

The digestive system is also not fully developed at birth. Breast milk assists in speeding up the growth of the intestine and, in ways not yet fully understood, helps build up the communication system between the gut lining and the developing immune system.

Breast milk also assists in developing a child’s permanent immune system, and studies have shown that breast milk lowers the risk for, and severity of, a wide range of diseases, including respiratory illness, ear infections, allergies, gastrointestinal diseases, including diarrhea, and possibly even diabetes and cancer.

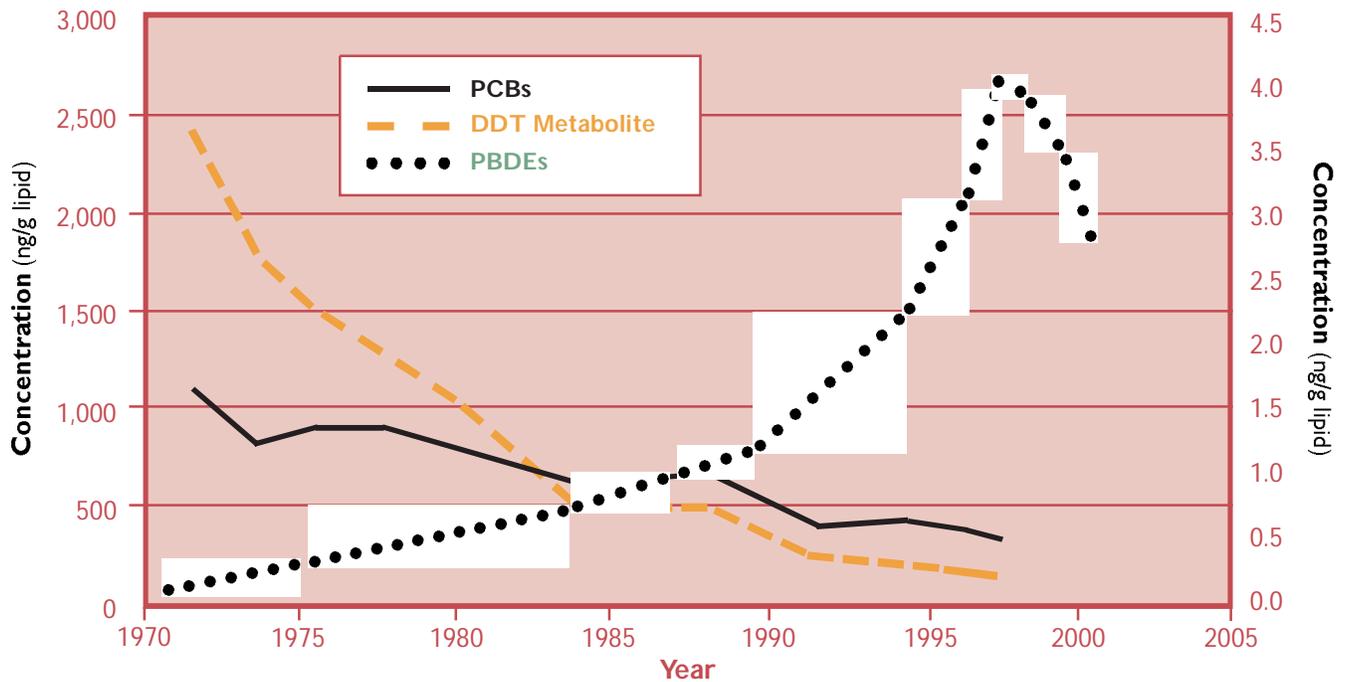
Research also suggests that breast milk and breastfeeding contributes in many important ways to brain and cognitive development. In studies comparing breastfed to formula-fed babies researchers have found that breastfed babies are more mature, secure and assertive, score higher on developmental tests, are less likely to have learning disabilities and have higher IQ scores. This research also finds that the longer breastfeeding continues the greater is the difference between breastfed and formula-fed children on intelligence scores. Moreover, breastfed children had more rapid development of vision, earlier mastery of motor skills, and fewer emotional and behavioural problems.

Mothers who breastfeed also experience less postpartum bleeding, better bone health, and lower rates of ovarian and premenopausal breast cancers later in life than mothers who don’t breastfeed. Alongside these many benefits are profoundly important and valuable emotional benefits for both mother and child.

Breast milk contains everything an infant needs for the first six months of life. It also contains trace amounts of industrial chemicals, pesticides, flame retardants (PBDEs) and heavy metals. Fat-soluble substances are of particular concern since they will concentrate in breast milk in proportion to the amount in the mother's adipose (fatty) tissues. Several contaminants found in breast milk are persistent organic pollutants (POPs), including banned pesticides like DDT (or its breakdown products), PCBs, dioxins and PBDEs.

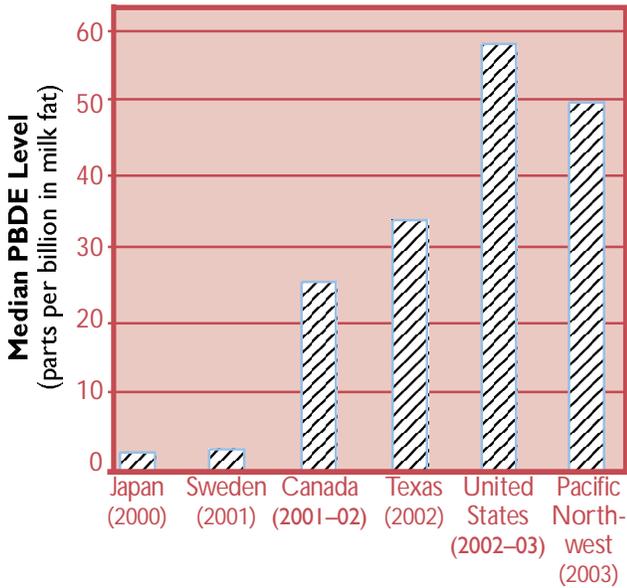
Breast milk, still the perfect food for babies, comes from the mother's body. As a result, breastfeeding babies, not their parents, are at the very top of the food chain. While DDT and PCBs are still found in breast milk, levels have declined steadily since these substances were discontinued and/or banned in the 1970s. Dioxin levels have also dropped in breast milk, alongside and following regulatory controls. In contrast, in North America, PBDEs have been steadily increasing in breast milk since measurements began in the early 1990s. Swedish breast milk samples collected since the early

Figure 11: Trends in Chemicals in Breast Milk, Sweden



Source: Adapted from NRDC (www.nrdc.org/breastmilk/chems.asp) and Hooper and She, 2003.

Figure 12: International Levels of PBDEs in Breast Milk



Source: Northwest Environment Watch, 2004.

1970s show a steady increase in PBDE levels since the late 1970s. However, in Sweden and other European countries, breast milk PBDE levels have been decreasing since a ban was placed on these substances in the late 1990s in response to the breast milk findings, alongside concern about their toxicity (see Figure 11).

There is inadequate evidence to assess the risk of potential harmful effects from typical infant exposures to contaminants in breast milk. For PCBs, most studies that found links to neuropsychological deficits among school-age children showed that these were associated with prenatal, but not postnatal, exposure. However,

research in this area is limited, and it is difficult to differentiate between exposures in the womb and those from breastfeeding. Researchers often consider exposures in the womb to be of greater concern than breastfeeding because of the greater vulnerability of fetal development.



Breast is Best! All major health organizations, including Health Canada, the Canadian Paediatric Society, the American Academy of Pediatrics and the World Health Organization, continue to support the value and importance of breastfeeding, even in an environment contaminated with toxic substances. In 2002, the World Health Organization (WHO) reviewed the existing evidence on breastfeeding and, together with UNICEF, called on the health and other relevant sectors to protect, promote and support exclusive breastfeeding for the first six months of a child's life, as well as continued breastfeeding until children are at least two years old.
Photo Credit: Mark Surman

Concern about contaminants in breast milk must be balanced against the proven health benefits of breast milk and the risks associated with commercial infant feeding products. The use of infant feeding products, including formula, is sometimes necessary. Standards and practices are in place to ensure safe manufacture and use. However, the manufacture, preparation and use of these products provide opportunities for contamination with bacteria (if the formula is made up with microbiologically contaminated water) and potentially toxic substances. In general, infant formula, like any food, contains trace levels of contaminants. For example, metals (e.g., lead, aluminum and cadmium), POPs (e.g., PCBs and dioxins) and phthalates have been found in infant feeding products. Contaminant profiles of infant formula and breast milk are slightly different, with breast milk generally containing higher levels of the persistent substances that accumulate in the food chain. Often made or reconstituted with tap water, infant feeding products are also subject to contamination by any trace levels of toxic substances in the water used. If well water is used, nitrates and nitrites are a possible concern. Health Canada recommends well water be tested at least twice per year if water is used in infant feeding products to avoid the risk of “blue baby” syndrome (or methemoglobinemia).

Indoor Air and Dust

Children spend over 80 per cent of their time indoors, most of it in the home. Exposures can vary in different circumstances, such as urban, suburban or rural areas, indoors in houses or apartments, and with proximity to traffic or industry. Poverty can also contribute to greater home exposures, as described in Chapter Two. In addition to food and water, described below, the two major categories of exposure in the home are indoor air

Indoor Dust

Recent studies of indoor dust in the UK, Europe and the US have found a wide array of chemicals, all of which originate from consumer products:

- Phthalates, likely originating from vinyl flooring and any other softened plastics or vinyls, such as shower curtains
- Alkylphenol compounds used in cosmetics and other personal care products
- Brominated chemicals used as fire retardants in furniture and electronics
- Organotin compounds used to stabilize PVC plastics or to kill dust mites in carpeting
- Short-chain chlorinated paraffins used in plastics, paints and rubbers.

Additional studies have found residues of pesticides and heavy metals in indoor dust. Lead from old paint is of particular concern. It is estimated that 50 per cent of the daily lead intake of two-year old urban children occurs by ingestion of house dust through normal hand-to-mouth behaviour.

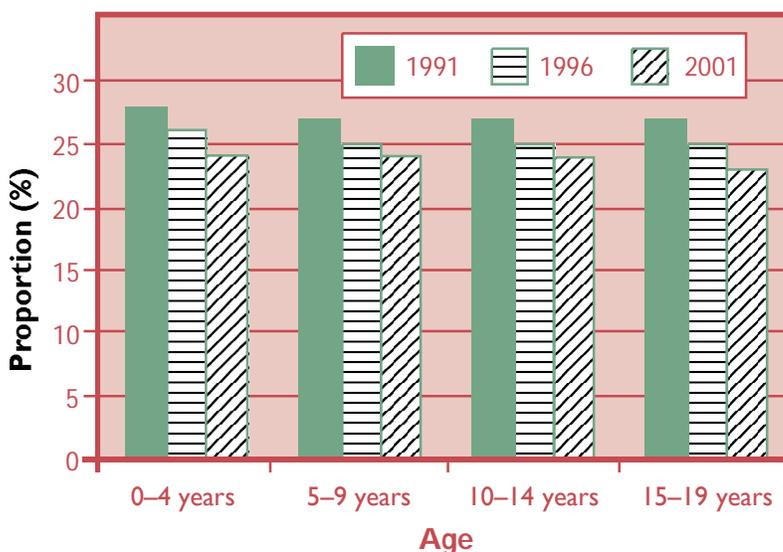
Childproofing Tip: Treat house dust as an environmental health risk that requires physical removal. Clean with moisture — wet mopping instead of dry dusting — or use a vacuum cleaner. Don’t allow children or pregnant women to empty a vacuum bag. Carefully dispose of vacuum cleaner bags; don’t compost them. Dispose of dust rags carefully, or wash separately. Apply the same precaution with lint from clothes dryers, and dust and dirt inside vehicles. Ensure frequent hand washing, especially before eating or preparing food.

Carpeting

Newly installed carpeting can emit VOCs or other semi-volatile compounds from the carpeting material itself, the carpet backing, and chemicals applied during or after manufacturing to serve as flame retardants. Imported carpets may also be treated with pesticides for transport. Off-gassing of such substances can continue for many months. Older carpeting becomes a repository for dust and other chemicals that settle out of the air. The amount of dust in a square metre of an older carpet may be 400 times higher than on a bare floor in the same house. In the presence of dampness, carpeting can be a site for mould growth. Most commercial carpet cleaners also contain chemicals that can contribute to respiratory symptoms and eye irritation.

Childproofing Tips: Reconsider the need for carpets at all, especially in children's play areas. Choose "environmentally friendly" carpeting and rug shampoos. Ensure good ventilation after installation of new or professionally cleaned carpets. Consider covering hard surfaces with area rugs that can be shaken out or washed easily. When replacing carpeting, prioritize areas in which children spend a lot of time. Vacuum existing carpeting frequently and ventilate well. Remove shoes at the door and use washable floor mats at entry points and wash them regularly.

Figure 13: Lead Risks in Canadian Homes. A large proportion (about 25 per cent) of children in Canada live in pre-1960 homes. This figure shows percentages according to data from the 1991, 1996 and 2001 national census. Paints manufactured before 1976 can contain dangerous levels of lead. Prior to 1960, lead levels in paint could be extremely high — in some cases as high as 50 per cent by weight. All old paint should be considered a lead hazard, during regular wear and tear (paint chips and any associated house dust) and especially during renovations (or when refinishing old furniture).



Source: Statistics Canada. Census of Population, 1991, 1996 and 2001.

and dust, as well as the special circumstances of renovations and some hobbies.

Indoor air quality is of increasing concern. Quality has deteriorated often because of measures to obtain increased energy efficiency, resulting in less ventilation of indoor exposure sources. The US EPA considers indoor air pollution to be one of the top five environmental hazards to human

health and cites measurements of indoor air pollutants that are two to five times higher than pollutants outdoors and, in some cases, up to 100 times higher. For some pollutants, such as lead and pesticides, indoor sources appear to be of greater importance than outdoor sources.

Scientific understanding about indoor air exposures is a recent and rapidly growing field. There is no doubt that second-hand smoke, also called environmental tobacco smoke (ETS), presents a serious health hazard for children. ETS exposure and other residential factors, including use of a gas stove or oven and presence of a dog in the home, may account for nearly 40 per cent of the physician-diagnosed cases of asthma in the US. Other indoor exposures believed to increase the risk of asthma and other respiratory problems include inhalable particles from fireplaces or wood-burning stoves, VOCs (see sidebar) and biological allergens like moulds, pet dander, house dust mites and cockroaches.

An increasing body of evidence is confirming that indoor dust is a complex mixture of particles and chemicals that can be highly contaminated. It is a very important exposure medium for children, due to crawling and hand-to-mouth behaviour, and also should be recognized as an exposure risk for pregnant women, depending on cleaning practices.

Sources of the particles and substances in house dust include outdoor soil and street dust that is tracked indoors, settling of indoor air pollutants, indoor use of pesticides, the tracking indoors of pesticides used outdoors, human and animal dander (skin flakes), clothing, carpets, rugs, flooring, furniture, bedding and other consumer goods, as well as any deteriorating of "high traffic" painted surfaces.

Volatile Organic Compounds (VOCs)

The smell of glue, paint, air fresheners, new furniture or carpets, mothballs and many cleaning and personal care products is a sign that volatile organic compounds (VOCs) are being released into the air. VOCs include a large group of organic (carbon-containing) compounds that are readily volatile (airborne) at room temperature. For new furniture or carpets, these smells are often called "off-gassing." Common VOCs in indoor air include formaldehyde, phenol, benzene, xylene and toluene, and are associated or suspected in a range of reproductive and/or child health concerns. VOC emissions are highest right after the use or installation of products and materials, and their reduction over time varies considerably. VOCs from new paint will drop quickly and be minimal within a few weeks, while those from pressed wood products or some carpeting can persist indoors for years. Several toxic VOCs are associated with cigarette smoke.

Childproofing Tip: Prevent or reduce VOCs indoors by choosing low-VOC products and materials, variously labelled "non-toxic," "environmentally friendly" or "low-VOC." In general, fewer VOCs are emitted from natural, untreated materials compared to synthetic and/or treated materials. Choose carpet-free options for children's play areas.

For more information on VOCs see Pollution Probe's *Primer on Volatile Organic Compounds (VOCs)* at www.pollutionprobe.org/Publications/Primers.htm.

Riding in Cars and Buses

Many children in Canada ride to school in buses, most of which are currently powered by diesel fuel. The International Agency for Research on Cancer considers diesel exhaust a probable human carcinogen. Diesel exhaust is also linked to eye and respiratory system irritation, aggravation of asthma and allergies, and possible effects on the growth and development of children's lungs. Two US-based studies confirm that levels of diesel exhaust are considerably higher inside buses (between four and ten times higher) than outside. Exposures are highest in and around idling buses and higher at the back of the bus than the front and when the windows are closed. The indoor air of cars is also a "micro-environment" of elevated exposure. Studies have found that benzene levels can be four times higher and carbon monoxide levels up to ten times higher inside a car than outside. Hence, these additional "indoor" sources can greatly increase children's exposure to air pollutants, adding to the already serious problem of urban air pollution.

Childproofing Tip: Drive less.

Don't leave your car idling. Support measures to enact anti-idling policies for buses, improved exhaust systems, programs to switch to cleaner fuels and longer term transition to new technologies.

A wide variety of chemicals are used to make products soft or hard, durable or flexible, coloured, fragranced, thick, scratch-resistant, flame-resistant or stain-resistant. There is increasing evidence to show that many of these chemicals can become part of indoor air or dust during regular use of products. If they are persistent, often the very properties that enable stain-resistance or flame-resistance, they can build up in the indoor environment.

Schools, Child Care and Recreational Facilities

Just as within the home, indoor air pollution can be present in schools, child care and recreational facilities. While national data are not available in Canada, studies from the US indicate that half of the schools there have indoor air quality problems; regional studies in Ontario have found similar circumstances.

Schools are particularly challenging places to address indoor air quality issues. Resources are limited and in many cases funding has been cut back. There are large concentrations of people placing heavy demands on school facilities and equipment, which can prompt the use of strong cleaning products and/or pesticides.

When school buildings are aging and in need of frequent maintenance and repairs, dust levels, mould and pest problems can increase. Ongoing maintenance and periodic renovation activities can also contribute to poor indoor air quality. Additional sources of air contaminants include chemicals in some art supplies, photocopiers and laminators, perfumes and furnishings. Dust in the school can also contain lead from paint and soil, pesticides, and various contaminants found in indoor dust, described above. Air quality in the school will be strongly influenced by the

amount of air flow in the building. Low rates of air exchange contribute to poor indoor air quality, illustrating the additional challenge of trying to minimize the cost of heating large buildings while also possibly needing to keep windows open in older buildings that often lack good ventilation systems.

Many of the same issues arise in early learning and child care facilities depending on their location, maintenance practices and the age of the buildings. About 1.4 million children in Canada, or about 50 per cent of children zero to six years old, spend approximately eight hours a day, five days a week, in early learning or child care facilities. Particularly challenging is the rate at which infection can spread among a large group of young children. The need to control germs in accordance with public health requirements can contribute to greater exposure and uncertain risks from strong chemicals in cleaning products.

In indoor ice rinks, the use of gasoline-powered ice maintenance machines can raise carbon monoxide (CO) and nitrogen dioxide (NO₂) levels. Swimming pools have long been associated with health concerns related to microbiological contamination. There are, however, other exposures from these same sources that may have the potential to affect child health. Children who swim frequently can be exposed to high levels of disinfection by-products (from the heavy chlorination of



Photo Credit: Comstock

swimming pool water) through inhalation and skin absorption. High levels of chlorine in the air above swimming pools can irritate and damage the lungs, aggravating and possibly even playing a role in causing asthma. Proper ventilation, as well as proper handling and maintenance of equipment in recreational facilities, is essential. The important health benefits for children of regular exercise should not be offset by health risks from exposure to airborne hazards.

Urban Air Contaminants of Concern

- carbon monoxide (CO)
- nitrogen dioxide (NO₂)
- sulphur dioxide (SO₂)
- diesel and gasoline exhausts
- numerous volatile organic compounds (VOCs)
- numerous polyaromatic hydrocarbons (PAHs)
- ground-level ozone (O₃)
- particulate matter (PM) — course, fine and ultra-fine (PM₁₀, PM_{2.5} and PM_{1.0} where the subscript refers to the particle diameter in microns)

Childproofing Tip: Walk or bike to school (for information see www.saferoutestoschool.ca). Don't idle vehicles, especially when transporting children or waiting near schools. Follow advice about reducing activity levels during smog alerts. Monitor symptoms, especially in known asthmatics, during smog alerts and modify activity levels, as appropriate. For more information see Chapter Six and Pollution Probe's *Smog Primer* at www.pollutionprobe.org/Publications/Primers.htm.

Outdoor Air

Air pollution is a serious problem in and near Canada's urban areas, where most children live. Numerous substances harmful to children's health are in the air, and the situation gets worse when summer temperatures increase, although smog alerts can occur at any time of the year. Smog is created from a noxious mixture of pollutants, including ground-level ozone, particulate matter (PM) and other pollutants (see sidebar, Urban Air Contaminants of Concern). The main culprit is combustion of fossil fuels, gasoline and especially diesel fuel, by cars, trucks and buses. Fossil fuel burning by industry, particularly coal-fired power plants, is another major contributor to urban air pollution. Household activities also contribute, including via woodstoves and fossil fuel-powered lawnmowers.

Particulate matter (PM) is essentially a mixture of toxic substances. On the surface of each particle is a complex mixture of sulphates, nitrates, ammonium ions, elemental carbon, PAHs, other toxic organic compounds and metals.



Photo Credit: Health Canada

Paradoxically, the smaller the PM, the greater is the surface area that these toxic substances can cover. Size also influences how PM is inhaled. Coarse PM is typically inhaled into the upper respiratory tract, where it may be coughed up and perhaps swallowed. Fine and ultra-fine particles are respirable, which means they are taken deep into the lungs, where it is possible for some to cross directly into the blood stream.

Smog is also a mixture. It is made up mainly of ground-level ozone, nitrogen oxides and other toxic gases, and PM. Ozone itself is created by the reaction between nitrogen oxides and VOCs in the presence of sunlight, one of the factors explaining why smog is elevated in summer. PM_{2.5} results from chemical reactions in the air (between nitrogen oxides, sulphur dioxide and VOCs); these reactions can elevate smog levels in all seasons.

Additional air contaminants include more than 600 different VOCs, many of which are released when burning fossil fuels. Other sources include steel-making, petroleum refining, fuel-refilling, industrial and residential solvent use, paint application, manufacturing of synthetic materials, such as plastics and carpets, food processing, agricultural activities, and wood processing and burning.

The burden of illness attributed to air pollution is very high. In 2004, Toronto Public Health estimated that the five common air pollutants (PM₁₀ and PM_{2.5}, NO₂, SO₂, ground-level ozone and CO) contributed to about 1,700 premature deaths and 6,000 hospitalizations per year in Toronto from a wide range of cardiorespiratory ailments, in addition to affecting tens of thousands of people, including many children, with less serious health outcomes.

Atlanta Olympics

The 1996 summer Olympic Games in Atlanta, Georgia, offered a unique opportunity for scientists to study the effects on air quality of a dramatic decrease in levels of vehicular traffic. Over the 17 days of the Olympics, traffic was reduced using a combination of increased public transportation, promotion of commuting changes to shift travel demand away from rush hour periods, road improvements and traffic restrictions in the downtown area. Compared to the four-week periods immediately before and after the games, peak ozone concentrations were down by more than 25 per cent during the Olympics. Levels of other pollutants, such as CO and PM, also dropped. During the Olympic Games there was a dramatic 42 per cent drop in asthma medical emergency events and a 19 per cent decrease in children requiring hospitalization for asthma. These effects were largely attributed to traffic changes and reduced air pollution. The Atlanta experience highlighted the degree to which automobiles contribute to poor air quality (particularly in urban areas), while also showing that traffic reduction measures can dramatically improve public health, even in a short period of time.

Source: Friedman, M.S. et al. 2001.

Children Eating Organic Food Less Exposed to Pesticides

Researchers in Seattle compared children who ate organic foods (fruits, vegetables and juices) to those who ate conventional pesticide-treated, but otherwise similar, foods. They measured the levels of metabolites (breakdown products) of organophosphate (OP) pesticides in the children's urine. OP pesticides are suspected developmental toxicants and suspected neurotoxins. The children who ate organic foods had significantly lower OP exposure than the children who ate conventional foods. The authors of the study concluded that eating organic foods shifted children from an exposure range of uncertain risk to one of negligible risk and suggested that choosing organic produce provides a fairly simple way for parents to reduce childhood pesticide exposure.

Source: Curl, C. et al. 2003. Organophosphorous Pesticide Exposure of Urban and Suburban Preschool Children with Organic and Conventional Diets. *Environmental Health Perspectives* 111(3): 377–382.

Food

There are some toxicants for which food and water, particularly food, are the major sources of human exposure. In most cases, the same substances discussed above with respect to exposures *in utero* and in breast milk are of similar concern in food.

Substances that build up in the food chain do so because they are "lipophilic," which means "fat-loving." These substances bind to fats and rarely dissolve in water. When such substances are persistent in the environment, as with PCBs, PBDEs, dioxins and organochlorine pesticides, they build up in fat tissue and concentrate up the food chain. Human exposure to such substances is therefore greatest in fatty foods derived from animals.



Photo Credit: Mark Surman

For the well-studied persistent organic pollutants (POPs), like PCBs, dioxins, and banned pesticides, such as DDT and its breakdown product DDE, the major sources of human exposure are known to be food, especially fatty foods and breast milk. The same is true for bisphenol A (very widely used in resins, dyes, flame retardants, dental sealants, pop cans and hard plastic containers). For nonylphenol (a surfactant in detergents), exposure is mainly via food and water. For the phthalates (used in numerous plastic products, food packaging, cosmetics and other products), major sources are food in plastic packaging, contaminated fish and shellfish, and fatty foods. Methylmercury exposure also occurs mainly through food, especially certain fish. Finally, foods can contain trace levels of pesticides, although these residues on foods in Canada are commonly within existing regulatory limits, with fairly rare exceptions.

There are various ways to respond to the contamination of food, many of which have to do with following a healthy diet (discussed further in Chapter Six). However, as with the contamination of breast milk, individual responses and choices can only go so far. Regulatory action is necessary to prevent such exposures in the first place.

Water

Drinking water quality will vary depending on the original water source and treatment methods. Most drinking water in Canada is municipally-treated, although about 20 per cent of the population depends upon well water. Trace levels of contaminants can occur in drinking water. These contaminants, such as metals or chemicals, can arise from industrial sources or from agricultural uses of pesticides. Lead can also enter drinking water from the water supply pipes. Microbial contaminants, such as *E. coli*, and other pathogens, are of particular concern and need to be killed via disinfection techniques. For well

Multimedia Exposure: PBDEs in Food, Air and Dust

PBDEs are showing up everywhere — in algae, plants, food and people, and in river and lake sediment from the North to the South Pole. Like lead pollution, human activity has created global contamination; this time, however, the source is not tailpipes or industrial stacks, but rather consumer products. PBDE levels in the foam backing of carpets or in furniture are so high (five to 30 per cent by weight), an Environment Canada scientist has stated that homes might as well have an open container of the pure chemical sitting on a shelf volatilizing into the air. Indoor spaces become contaminated and appear to be the main source for outdoor contamination. As semi-volatile and fat-soluble substances, PBDEs are being directly inhaled, settling out in house dust (creating greater exposure risks for children) and building up in fatty foods. Unlike other POPs, such as DDT and PCBs, for which over 90 per cent of exposure is thought to be in foods, PBDE exposure is more complicated. Because the sources are so different, the environmental pathways and ultimate exposure media are also different. Research continues, but so far it appears that three major exposure media exist for PBDEs — indoor air, food and indoor dust.

Lead in Drinking Water

Lead contamination is so pervasive that low-level exposure can occur in air, food, soil, dust and drinking water. The contribution of lead and most other contaminants from drinking water to overall exposure is usually fairly small, except under certain circumstances. But, since lead is probably harmful at any exposure level, precautions should be taken. Water pipes made entirely of lead are increasingly rare, but may still exist as water intake pipes in the oldest parts of some cities (for example, in homes that were built before 1950). More common is lead-soldered copper plumbing. Until this use was banned in the late 1980s, all copper plumbing was joined with lead solder. When water sits in contact with these joints for several hours (for example, overnight or throughout the work or school day) the lead can go into solution in the water. As time passes, minerals tend to build up in the plumbing and make this solder less likely to migrate into the water. However, if the source water is “soft” or acidic, such as can occur on the Canadian Shield, this mineral build-up is less likely and, as a result, lead is more likely to make its way into the water. Some brass taps and faucets can also contain lead.

Childproofing Tips: For urban homes built in the first half of the 1900s, ask municipal officials if water supply pipes are made of lead and ask about their strategy for the accelerated removal of lead water supply pipes. If you use a water filter, check whether it is able to remove lead and be sure to regularly replace filters as recommended by the manufacturer. In homes built before 1990, flush water that has been standing in pipes for several hours. Flush until it runs cold (about a minute) before using for cooking or drinking and especially for making baby formula. Never use water from the hot water tank for cooking or drinking. Take extra precautions where water is “soft” or acidic, such as at cottages or homes located on the Canadian Shield. For more information see Health Canada at www.hc-sc.gc.ca/english/iyh/environment/lead.html and US EPA at www.epa.gov/lead.

water, elevated levels of nitrates can be a significant health concern, especially for babies, and regular testing is necessary.

Water treatment processes by municipalities can remove some, but not all, metal or chemical contaminants in the source water. The water is treated with chlorine or other disinfectants for microbial safety, but the chemicals used for disinfection can create trace levels of toxic by-products in the water.

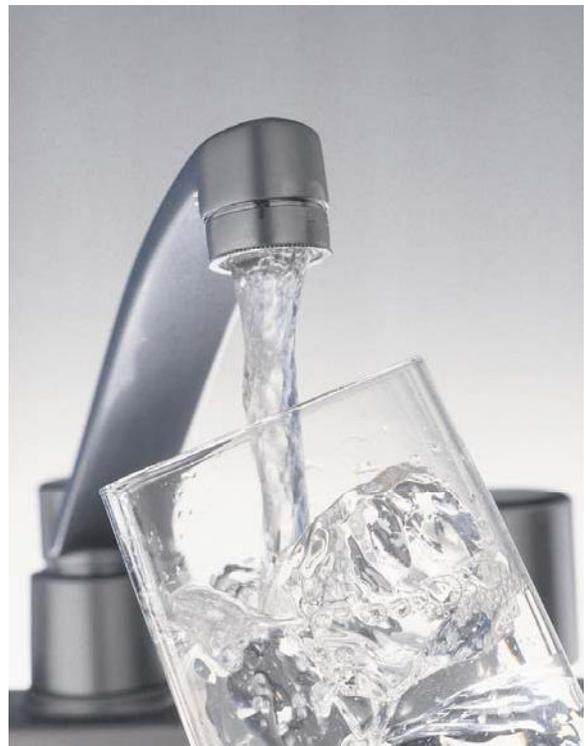


Photo Credit: Comstock

While chlorination is essential for protecting people from serious and often deadly waterborne diseases, it is not without risks. A number of substances, called disinfection by-products (DBPs), are created by the reaction of disinfectant (often chlorine) with naturally occurring organic material in raw water, either from groundwater or surface water supplies. The higher the level of this naturally occurring organic material, generally the higher will be the levels of resulting DBPs. An important group of DBPs are the trihalomethanes (THMs), including chloroform, a suspected carcinogen in humans and known to be carcinogenic in animals.

Some DBPs are suspected of causing spontaneous abortion, low birth weight and several kinds of birth defects in humans. Some evidence also exists for a relationship to DBP exposure and neural tube defects when women do not take multivitamin supplements, specifically the crucially important folate (or folic acid) supplement, during early pregnancy. Limited evidence also exists of associations between DBPs and childhood cancer and some additional cancers in adults.

Exposure to DBPs from drinking water occurs mainly from water consumption. Additional exposure occurs from inhaling steam in the shower, via skin contact in the bath, or in steam from the use of automatic dishwashers, particularly when chlorine-containing dishwashing detergents are used.

Drinking Water — Risks and Benefits

There are uncertain and probably very low risks associated with disinfection by-products (DBPs), the chemicals created in drinking water as a result of water chlorination/disinfection. However, it is well established that water disinfection is essential for controlling microbial contamination. The addition of disinfectants also ensures that the water stays free of pathogens as it travels through the water distribution system. Once drawn from the tap, chlorine will dissipate quickly if left to stand.

Childproofing Tip: Let municipally-treated tap water stand for 15 minutes or longer (to let the chlorine dissipate) before preparing juice, coffee, tea, formula or other infant feeding products. If you use a water filter, ensure regular maintenance. If filters are not changed regularly they can trap bacteria, which can be released to the water. Since contaminants build up on the filter, an old filter can break down and release a “surge” of contaminants into a single serving of water. If you rely on well water, ensure water is tested for nitrates at least twice a year (to avoid risk of methemoglobinemia or “blue baby syndrome”).

For more information, see Health Canada, Water Quality and Health at www.hc-sc.gc.ca/hecs-sesc/water and Pollution Probe's Drinking Water Primer at www.pollutionprobe.org/Publications/Primers.htm.

Photo Credit: Mark Surman



Chapter Five: What Is Being Done?

“It takes a village to raise a child.”

– African proverb

Much is happening to address the environmental exposures and health risks facing children. Much remains to be done.

Prenatal and childhood exposures to environmental hazards can have lifelong consequences for each child and for all of society. Such early exposures need to be minimized and/or prevented and everyone must play a part. This chapter introduces some of the activities being undertaken by researchers, governments, industry and communities to minimize environmental exposures. Chapter Six looks at practical steps that can be taken by individuals, families and others involved with children.

Resources for Parents and Health Care Providers

The **Motherisk Program** is a joint project of Toronto's Hospital for Sick Children and the University of Toronto. It conducts research and provides information and counselling services on a Canada-wide basis for women, their families, and health professionals on the safety/risk of exposure to drugs, chemicals, radiation, and infection during pregnancy and lactation (www.motherisk.org).

Pediatric Environmental Health Specialty Units (PEHSUs) have been established on a regional basis in ten centres, generally in hospitals, across the US. There is also one Canadian clinic in Edmonton and another in Mexico. In the US, these clinics are federally funded. All provide direct clinical care, as well as extensive research activities. All have their own websites linked to the site of the Association of Occupational and Environmental Clinics at www.aoec.org/pehsu.htm.

For more information, see the Ontario College of Family Physicians at www.ocfp.on.ca, the Canadian Association of Physicians for the Environment at www.cape.ca and the Greater Boston Physicians for Social Responsibility — Pediatric Environmental Health ToolKit at <http://psr.igc.org/ped-env-hlth-toolkit-project.htm>.

Research

There is significant research attention on environmental health risks, both internationally and in Canada, by independent and government-affiliated scientists. Much work has also been done, particularly by environmental and health groups, to summarize the scientific literature and the policy responses.

Canadian researchers have conducted some valuable research into the field of children's environmental health, particularly with respect to the problem of POPs contamination in the far north and the effects of contaminants in Great Lakes wildlife. However, the Canadian contribution to researching the problems and injecting results into improved policies is, on the whole, quite limited. For research and related policy measures, Canada relies heavily on other countries, particularly the US.

Flowing from a 1997 Presidential Executive Order, the US has established and funded a national network of pediatric specialty research units in universities and hospitals (see sidebar) to focus on this issue, and a national office of children's environmental health based in the US EPA (online at <http://yosemite.epa.gov/ochp/ochpweb.nsf/homepage>). Partnerships across national health agencies, such as the Agency for Toxic Substances and Disease Registry and the Centers for Disease Control and Prevention, have resulted in ongoing biomonitoring programs (see sidebar in Chapter Two) and the proposed National Children's Study (see sidebar).

International Commitments

The need to protect children from toxic exposures is supported by a number of international agreements, declarations and initiatives. Though only paper agreements, sometimes including only limited ability to force action, they help to establish a shared vision, rationale and starting points for action.

Table 3: Selected List of International Commitments to Protect Children

Links to these and associated documents concerning policy declarations to protect children are collected on-line at www.healthyenvironmentforkids.ca/english/special_collections/fulltext.shtml?x=703.

Year	Agreement	Summary
1989	United Nations Convention on the Rights of the Child	The highest attainable standard of health and healthy environments for play defined as basic human rights for children. Canada is a cosignatory.
1997	Declaration of the Environment Leaders of the Eight on Children's Environmental Health (including Canada)	Acknowledgement by G-8 nations of the threat that toxic substances pose to children's health, and establishment of a framework for domestic, bilateral and international efforts to improve the protection of children's health from environmental threats. Action areas include risk assessment and standard setting, lead, drinking water, air quality, environmental tobacco smoke and endocrine disruptors.
1999	Third Ministerial Conference on Environment and Health — Commission of the European Communities and the World Health Organization Regional Office for Europe — London Declaration	Recognizes the special vulnerability of children and prenatal health to environmental threats, the many determinants of health, and the need for prevention-oriented policies. Commitment to focus on asthma and allergies, accidents and injuries, environmental tobacco smoke, precautionary public health measures in areas of emerging concern, and monitoring and reporting on progress (see 2004 Action Plan for Europe, below).
2000	North American Commission for Environmental Cooperation Resolution on Children's Environmental Health	Acknowledges children's vulnerability to environmental health risks, prevention as the most effective means of protecting children, and parents' right to know about potentially harmful substances. Commits to developing a trilateral cooperative children's health agenda with initial focus on asthma and other respiratory diseases, lead and other toxic substances. Establishes Expert Advisory Board, research agenda and public education goals.

The US National Children’s Study

Under the *Children’s Health Act* of 2000, the US authorized the National Institute of Child Health and Human Development and a consortium of federal agencies to conduct the **National Children’s Study**. This ambitious study will be national in scope and will define environment very broadly to include the many biological, physical, social, genetic, cultural and other factors that can affect health. Results will be published periodically as the study continuously follows a large population of families, including 100,000 children from before birth to age 21. Impetus for the study comes from increasing trends in health problems among US children, including obesity, asthma, childhood cancer and certain birth defects. The study will attempt to evaluate how low-level exposures to chemicals and social and dietary factors interact with the genetic make-up of children to cause adverse health effects. More information is available at www.nationalchildrensstudy.gov.

Table 3 *continued*: Selected List of International Commitments to Protect Children

Year	Agreement	Summary
2001	Stockholm Convention on Persistent Organic Pollutants	International treaty designed to end production and use of 12 persistent pollutants and/or classes of pollutants. Targets substances that are known or associated with multiple health effects in children or that affect reproductive health.
2002	United Nations Special Session on Children (May); World Summit on Sustainable Development (August)	UN Special Session includes environmental protection, among many other important priorities for protecting children worldwide. World Summit, also among many other priorities, resolved to address the causes of ill health, including environmental causes, with particular emphasis on women and children and other vulnerable groups.
2002	World Health Organization Healthy Environments for Children Alliance (HECA)	Initiated following 2002 World Summit on Sustainable Development. HECA is a worldwide alliance focused on intensifying global action on environmental risks to children’s health arising from the settings where they live, learn, play and work. For more information see www.who.int/heca/en .
2003	Intergovernmental Forum on Chemical Safety (IFCS) Forum IV (November, 2003 in Bangkok, Thailand)	Multistakeholder alliance concerned with the sound management of chemicals. Forum IV focused on child-specific recommendations for action by governments and stakeholders to reduce chemical risks and prevent exposure. Canada is a signatory to the IFCS. For more information see www.who.int/ifcs .
2004	Children’s Environment and Health Action Plan for Europe	Establishes four regional priorities for Europe — safe water, injury prevention, indoor and outdoor air, and chemical-free environments — and detailed action steps for each.

Government Roles: Shared Responsibilities

Canada's federal government has legislation directed at protecting both the health and environment of Canadians. This responsibility is shared between Health Canada and Environment Canada. Several federal laws come into play with respect to children's health and the environment. These are supported by regulations, policies and guidelines, the funding of in-house and external academic research, education and outreach activities, and representation of Canada in international activities and initiatives.

Responsibility for population health and environmental protection is shared further between the federal, provincial and territorial governments in Canada. Like their federal counterparts, and sometimes in partnership with them, provincial and territorial governments are involved in research and monitoring. These activities contribute to understanding the nature of environmental exposures and health impacts or provide support to federal or provincial regulatory programs. Legal responsibilities at the provincial level include health care programs and delivery within a shared funding arrangement with the federal government. On environmental matters, the provinces and territories are responsible for a wide range of activities related to the monitoring and enforcement of environmental laws.

Responsibility to reduce environmental exposures is also shared with industry. For example, alongside regulatory approaches, the Ontario Ministry of the Environment uses additional tools, such as environmental leadership agreements with industries. In some sectors, when facilities are determined to be environmental leaders, they may receive recognition and other incentives, the objective being to build good

The Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty directed towards ending the production and use of some of the most poisonous chemicals in the world. Signed in 2001, the treaty came into force in 2004, prompting ratifying countries (50 so far, including Canada) to establish national implementation plans. It targets a "dirty dozen" chemicals and groups of chemicals, including hexachlorobenzene, dioxins and furans, PCBs and several organochlorine pesticides, such as DDT, chlordane, mirex and four others. Canadian negotiators and indigenous peoples played a valuable leadership role in the multi-year process that led to the development of this treaty, often pointing out the alarming levels of these substances in the Canadian Arctic and in the breast milk of Inuit women. They were able to note Canadian research from the Department of Indian and Northern Affairs' Northern Contaminants Program documenting exposure data and suspected health effects. In August 2004, the Commission of the European Union recommended an additional nine chemicals be added to the POPs treaty, including pesticides, flame retardants and other industrial chemicals used in manufacturing.

For more information, see United Nations Environment Program on-line information about the Stockholm Convention at www.chem.unep.ch/pops, Environment Canada's POPs index at www.ec.gc.ca/pops/index_e.htm, the Northern Contaminants Program at www.ainc-inac.gc.ca/ncp/index_e.html and the Canadian Environmental Law Association's POPs treaty collection at www.cela.ca/coreprograms/detail.shtml?x=1763.

Ontario: Best Start Resource Centre and Early Years Centres

Best Start: Ontario's Maternal Newborn and Early Child Development Resource Centre is a key program of the Ontario Prevention Clearinghouse and is funded by the Government of Ontario. Best Start supports service providers across the province of Ontario working on health promotion initiatives to enhance the health of expectant and new parents, newborns and young children. It provides services in the areas of consultation, training, information and resources. Best Start is also a member of the **Ontario Health Promotion Resource System** — a group of organizations sharing common goals, resources and expertise. Best Start is on-line at www.beststart.org. An additional website devoted to providing public resources for prospective parents — both men and women — about preconception health issues is available at www.healthbeforepregnancy.ca.

In addition to Best Start, Ontario's **Early Years** program is establishing community-based Early Years Centres across the province to provide services to parents and prospective parents. In other provinces, similar programming exists, often funded as a priority item, within the Canada Health and Social Transfer Program. Names vary from province to province (or territory); they are often called early child development initiatives. For more information, see Ontario Early Years Centres at www.ontarioearlyyears.ca/oeyc/en/home.htm.

These programs promote healthy lifestyles prior to conception, and healthy prenatal and child development in many ways. They are obvious locations for either situating, or expanding, existing programs and educational materials about ensuring prenatal and child health through the avoidance and prevention of exposure to toxic substances.

relationships and share responsibility for environmental stewardship.

Both the federal government and individual provinces and territories have various laws and programs for regulating industrial emissions to air and water, or to control transport and disposal of wastes. While many laws and standards exist across the country that set a range of limits on emissions, the system of controlling hazardous emissions to the environment is largely one of applying “end-of-pipe” controls to a relative handful of substances for which good information exists about environmental or human health hazards.

For some pollutants, the federal, provincial and territorial governments establish Canada-wide Standards (CWS). These standards are established within the Canadian Council of Ministers of the Environment (CCME), which is composed of provincial, territorial and federal government environment ministers. CWS' exist for smog-forming air pollutants, mercury and dioxins from specific sources. For more information see CCME's website at www.ccme.ca.

Finally, across Canada, some municipalities have developed a variety of initiatives, some in partnership with other groups, to protect the health of children from harmful toxic substances. For example, pesticide by-laws restrict or prohibit pesticide use. By-laws can also prohibit or limit smoking or idling motor vehicles. Public educational programs to accompany such by-laws are key ingredients to their success. Municipalities also make investments (often jointly with provincial or federal programs) in

public transportation, tree planting programs for homeowners (or to create shade in playgrounds), hazardous waste collection and disposal programs, asbestos abatement programs, and much more.

Schools, school boards, and early learning and child care facilities can also play a role in ensuring the environmental health of children. With so much time spent in early learning and child care facilities, in school buildings, on school grounds and in school buses, children's exposures during their early learning and school years are significant. Indoor air quality, particularly in school portables, is a major challenge. Some school boards have implemented progressive policies to reduce chemical exposures.



Photo Credit: Mark Surman

Pesticide By-laws: Blazing a Trail in Hudson, Quebec

During the 1990s, many local governments and school boards recognized the potential impacts of unnecessary or “cosmetic” pesticide use on public health. They began to phase out pesticide use on public lands and school grounds, in some cases by 90 to 100 per cent. In the small Montreal suburb of Hudson, Quebec, a municipal by-law also limited pesticide use on private property. Although more than 30 other Quebec municipalities followed the Hudson example, Hudson was sued by two lawn care companies. The 10-year legal battle finally ended in June 2001 at the Supreme Court of Canada. In a unanimous decision, the court denied an appeal (already lost in two levels of the Quebec courts) by the two companies. The decision confirmed that Hudson had the power to pass a by-law, in response to community concerns, to protect the general welfare of the public.

Events in Hudson began with a group of concerned residents motivated to protect their health and their children's health and ended by opening the door for municipalities across the country to make their own decisions about the degree to which they allow pesticide use on private property. The work done by the small town of Hudson has resulted in many (over 60 by the end of 2004) Canadian municipalities — large and small — now proposing and passing similar by-laws to restrict the unnecessary or “cosmetic” use of pesticides.

For more information, see the Partnership for Pesticide Bylaws on-line collection of materials at www.healthyenvironmentforkids.ca/english/special_collections/fulltext.shtml?x=787, the Environment Canada National Office for Pollution Prevention and Federation of Canadian Municipalities website on pest management at www.pestinfo.ca and Toronto Public Health's pesticide resources at www.toronto.ca/health/pesticides/index.htm.

Pest Management in Schools

Some schools boards, such as the Toronto Catholic District School Board, have implemented pest control programs based on integrated pest management (IPM) principles. Pest control options are chosen in hierarchical order, beginning with prevention of pest habitat, application of barrier methods, response to problems according to careful assessment, and monitoring and matching the response to the degree of the problem. Pest control contractors visit schools on Friday evenings, assess the problem, apply non-toxic controls and are not allowed to apply pesticides unless they obtain prior approval from the school board's Occupational Health and Safety Department. In addition, outdoor herbicide use is prohibited across the entire school board.

See also Health Canada's Tools for Schools at www.hc-sc.gc.ca/hecs-sesc/air_quality/publications/tools_school/toc.htm.

The use of IPM approaches in some contexts (e.g., in lawn care) has come under considerable criticism for giving a misleading impression that pesticide use has been reduced or eliminated. While it may be the case that the hierarchical approach described above is applied, pesticides remain part of the approach. In some cases the only real change in practice is one of public relations, that is, to state that IPM practices are followed when in fact the overall use of pesticides remains unchanged.

Childproofing Tip: When IPM practices are used or promoted in locations where children live, learn or play, be wary and ask questions. The most precautionary approach is not to use pesticides unless pests pose a threat to human health and non-toxic alternatives have been unsuccessful.

Community Involvement

Public interest groups across Canada are engaged in child health and environment issues in many ways. From community-based organizations to large provincial or nationally focused groups, the actions of public interest, citizen-based organizations will continue to be a crucial ingredient in addressing prenatal and child health issues.

New and necessary alliances have formed, particularly between health care providers and environmental organizations. In fact, it is fair to say that such alliances in the US were the principal catalyst for change throughout the 1990s. Major law reform activities in the US, such as changes to the *Food Quality Protection Act* and the *Safe Drinking Water Act*, to better account for child health issues, occurred because of the alliances and collaborative research between health care professionals and environmental organizations. These alliances also prompted major research initiatives within and alongside agencies in the US government and in universities and hospitals across the US. The large movement for environmentally safe schools in the US also occurred in conjunction with these other activities.

Similarly, in Canada, there is a long history of collaboration among organizations that have addressed environmental risks to children's health. Notably, throughout the 1980s, the campaign to accelerate the phase-out of lead from gasoline in Canada owed its success to the collaborative work of the Learning Disabilities Association of Canada, the Canadian Environmental Law Association, Pollution Probe, the Canadian Institute of Child Health, the South Riverdale Community Health Centre (in

Toronto) and several other groups who participated in the Canadian Coalition for Lead-free Gasoline. Support for the child health objectives of this environmental law reform initiative also came from the Canadian Medical Association, the Canadian Pediatric Society, the Ontario Public Health Association, and other health and environmental organizations.

The leadership role of many of these organizations, including ongoing collaboration to make health and environmental connections, continued through the 1990s. For example, in 1997 the Canadian Institute of Child Health and Pollution Probe sponsored the first national conference (*What on Earth?*) on children's health and environment issues, the proceedings of which were published in a special supplement to the *Canadian Journal of Public Health*. A collaborative research project by the Canadian Environmental Law Association and the Ontario College of Family Physicians investigated child health and environmental linkages in Canada, including a detailed review of whether the law was protective of children's health. The results of that work influenced the reform of federal pesticide legislation and other law and policy initiatives concerning children's health. As well, the research was further developed into on-line educational materials for the Canadian Association of Physicians for the Environment. These are but examples.

Many groups across Canada, too numerous to mention, are focusing their research and public educational work on environmental health issues, often with a focus on children. In some cases, a more general environmental health message is brought to a child audience through innovative educational programs in the schools. For example, the Labour Environmental Alliance Society (LEAS), based in Vancouver, works with students and teachers to do a school and workplace audit to identify hazardous products used in and around schools and to propose safer substitutes. The children are encouraged to conduct similar audits at home. For more information and to download the LEAS CancerSmart Consumer Guide see www.leas.ca.

Outdoor Classrooms; Green Communities

The Evergreen Foundation (www.evergreen.ca) is a national non-profit organization with a mandate to bring nature into cities in the form of healthy, sustainable, natural outdoor spaces. The "Learning Grounds" program brings students, teachers and communities together to transform schoolyards into vibrant and natural outdoor classrooms. Through helping to create wildflower meadows, ponds and vegetable patches, children learn to appreciate the meaning and value of nature and its importance to their health and well-being.

Green Communities Canada (GCC) (formerly the Green Communities Association) is a national association for non-profit organizations that delivers innovative, practical environmental solutions to Canadian households and communities (www.greencommunitiescanada.org).

GCC programs of direct benefit to children's health include Pesticide Free Naturally, Active and Safe Routes to School (www.safestostschool.ca), Well Aware (www.wellaware.ca), among others.

Progressive Action By and For Industry

Interface Inc.: With offices in more than 100 countries, this company is the largest commercial carpet manufacturer in the world. Its stated commitment is to actively seek opportunities to improve sustainability, and it considers regulatory standards a minimum. Within Green Procurement Programs, when Interface buys materials or products it takes account of environmental characteristics alongside more traditional criteria of performance, quality and purchase price. Product design models revolve around the use of renewable material that can easily be reclaimed and recycled. Along with a variety of other tools to improve sustainability, the company reported savings of US \$120 million worldwide between 1995 and 2002. For more information, see www.interfacesustainability.com

SC Johnson: This company's stated commitment to environmental protection is accomplished by decreasing the release of potentially harmful emissions into air and water, and reducing waste. In the 1990s, the company adopted the principles of eco-efficiency and made use of opportunities to reduce, reuse, recycle and refill. An innovative step was the development of the *Greenlist*TM process, which directly influences the company's supply chain. By developing and applying screening criteria to its raw materials, the company makes the best possible raw material product choices, ending up with safer and healthier products, and rewarding its suppliers with more business, thus "greening the supply chain."

For additional information see the Canadian Centre for Pollution Prevention at www.c2p2online.com, Chlorine-free Products Association at www.chlorinefreeproducts.org, Clean Production Action at www.cleanproduction.org and Lowell Center for Sustainable Production at www.sustainableproduction.org.

Crop Life Canada, the trade association that represents companies that produce and distribute pesticides, encourages its members to voluntarily adopt stewardship programs. These activities include promotion of careful storage of pesticides, removal and recycling of pesticide containers (at 1,200 container collection sites across Canada) and collection and safe disposal of obsolete (often banned) old pesticides. For more information, see www.croplife.ca.

Ongoing efforts to coordinate and consolidate the work of groups across the country occur within the Canadian Partnership for Children's Health and Environment (CPCHE). CPCHE (www.healthyenvironmentforkids.ca) is an affiliation of organizations formed in 2001 and working together to protect children from exposure to environmental contaminants.

Member organizations are among the leading voices on children's environmental health issues in Canada, including:

- Canadian Association of Physicians for the Environment (www.cape.ca)
- Canadian Child Care Federation (www.cccf-fcsge.ca)
- Canadian Environmental Law Association (www.cela.ca)
- Canadian Institute of Child Health (www.cich.ca)
- Environmental Health Clinic, Sunnybrook and Women's College Health Sciences Centre (www.sc.ca/programs/wcacc/clinicsandservices/environmentalhealth)
- Learning Disabilities Association of Canada (www.ldac-taac.ca)
- Ontario College of Family Physicians (www.ocfp.on.ca)
- Ontario Public Health Association (www.opha.on.ca)

- Pollution Probe (www.pollutionprobe.org)
- South Riverdale Community Health Centre (www.srchc.com)
- Toronto Public Health (www.city.toronto.on.ca/health)

The CPCHE website provides extensive resources and links to resources on the topic of prenatal and child health. It is also a portal site providing centralized access to resources prepared by CPCHE partners.

One example of joint activity among these partners is a project led by the South Riverdale Community Health Centre (in Toronto) and working with Toronto Public Health and the Environmental Health Clinic of Sunnybrook and Women's College Health Sciences Centre. These groups developed a prenatal education project called *Hidden Exposures Affecting Reproduction and Pregnancy*. The partners produced a series of fact sheets that are brought to prenatal educators via educational and interactive forums. This initiative raises awareness among prenatal educators and, through them, among women and families planning or expecting a baby, of the potential risks of exposure to various environmental hazards, as well as ways to minimize those risks. In 2002, the project received an award for health promotion and innovation from the Canadian Institute of Child Health. The full package of materials will be made available in 2005 on the SRCHC website (www.srchc.com) and will also be linked through the CPCHE portal website.

Regulating Environmental Risks: Have We Learned from Past Mistakes?

Lead — The Cautionary Tale

The regulation of lead in gasoline provides an important regulatory lesson on the need to act with precaution in the face of scientific uncertainty and the possibility of serious harm. It is also a classic case study of the complexity of environmental health problems. Although some of the hazards of lead have been known since antiquity, the subtle effects of exposure to low levels took a long time to fully understand.

Lead occurs naturally in the Earth's crust, but is tightly bound to other minerals. Environmental contamination and human exposure to lead has occurred almost entirely from human activities. Industrialization in the 19th century dramatically increased lead levels in the environment, but it was through the addition of lead to gasoline that human populations brought about global lead contamination. A gradient of contamination was created that closely followed traffic density. Widespread use of lead in paint resulted in contamination of indoor environments and exterior residential soil. Other sources included lead-based solder used to seal food cans, lead pipes and other plumbing materials.

These mostly historical uses of lead, particularly in gasoline and paint, have created a reservoir of lead contamination that will remain a serious exposure risk for decades to come.

Estimating the Cost of Illness from Environmental Exposures

Research into the economic burden of disease and disorders from exposure to environmental hazards suggests that exposure prevention could result in massive savings in health care, human productivity and myriad social costs.

- It is estimated that \$54.9 billion is spent annually on environmentally-induced disease in US children (Landrigan et al, 2002). This total includes \$9.2 billion for certain neurobehavioural disorders (intellectual deficits/mental retardation, autism and cerebral palsy), \$43.4 billion for lead poisoning, \$0.3 billion for childhood cancer and \$2 billion for childhood asthma. These estimates are considered low. The study used conservative assumptions and excluded related costs to families or later complications of these health conditions. The study is also based on current incomplete knowledge of the role of environmental contaminants in child health outcomes.
- Another study estimates the cumulative annual social and economic costs to the US and Canada of between \$568 billion and \$793 billion for a range of diseases in adults and children considered to be candidates for “environmental causation” (Muir and Zegarac, 2001). The estimated costs to Canada alone are \$46–\$52 billion per year. Assuming at least ten per cent and up to 50 per cent of these costs as environmentally-induced, annual estimated costs for the US and Canada together are between \$57–\$397 billion.
- In 2005, the Ontario Medical Association conservatively estimated that two air pollutants (ground-level ozone and fine particulate matter) will be responsible for over 5,800 premature deaths, over 16,800 hospital admissions, nearly 60,000 emergency room visits and over 29 million minor illness days, costing Ontario almost \$1 billion in a single year.

Childhood lead poisoning was identified as a clinical diagnosis in 1892. In the 1920s, animal experiments showed that lead exerted its effects by poisoning the brain and nervous system. By the 1940s, early evidence revealed the more subtle effects on learning and behaviour from lower exposure levels. Despite mounting evidence regarding the toxicity to children of low-level lead exposure, it was not phased out of paint until the late 1970s, or out of gasoline until the early 1990s (in most, but not all countries) at which point millions of children had been affected. Nor are new or ongoing sources of lead in consumer products adequately controlled.

By the 1960s, lead in gasoline was an integral part of a vast chain of commercial interests in lead mining and refining, lead recycling, lead additive production, petroleum refining and vehicle manufacturing. Commercial interests, particularly those directly involved in lead industries, objected strenuously to concerns about suspected child health effects from environmental lead contamination.

By the end of the 1980s, 20 years’ worth of scientific research confirmed the hazards of low-level exposure. It was commonly understood that lead could harm a child’s brain. But few realized that we learned of these effects by allowing widespread exposure to lead and carefully documenting the effects. Only then was lead finally regulated out of gasoline.

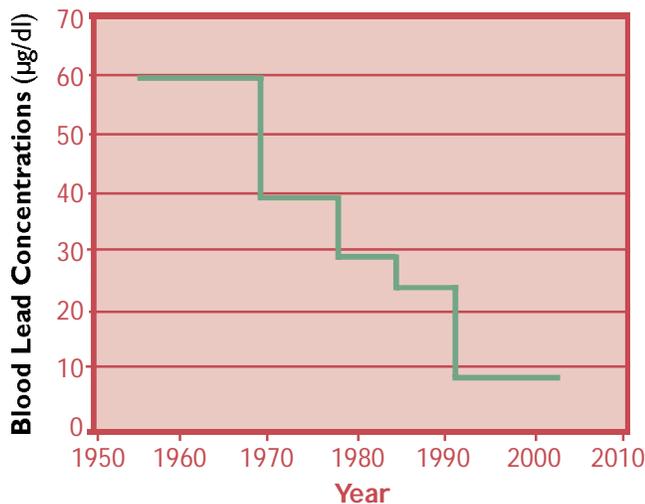
The most recent scientific evidence indicates that there is no safe level of exposure to this potent developmental neurotoxin. Elements of the lead story that are too often repeated in environmental debates include:

- ignoring early warnings (from animal evidence, occupational accidents or otherwise high levels of exposure)
- lengthy disputes over evidence of harm, fuelled by those with a commercial interest in lead production and use
- the necessity of highly complex and costly

scientific investigations to understand how low-level exposure can cause subtle and hard-to-measure health effects

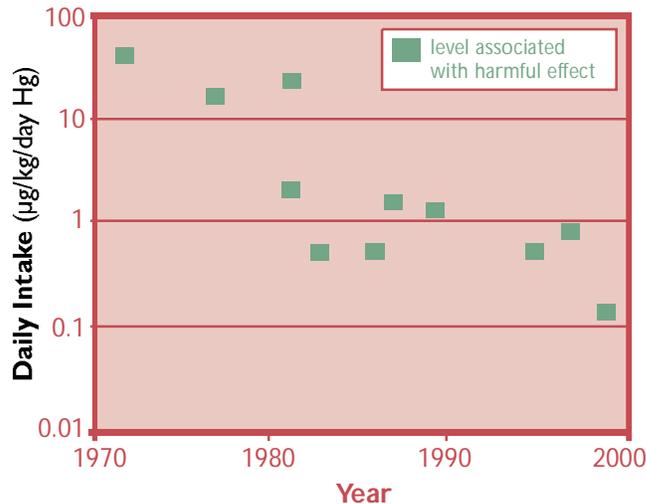
- a lengthy process of gathering information that steadily serves to confirm and expand upon initial concerns, including warnings that harmful effects during development can result in permanent damage
- failure to take regulatory action until *after* clear evidence of harm is confirmed following widespread exposure affecting millions of children.

Figure 14: Blood Lead Concentrations Considered to be Elevated



Source: Centers for Disease Control. 1991.

Figure 15: Declining Threshold of Harm for Mercury



Source: Schettler, T. et al. 2000.

Figures 14 and 15 provide two examples of how exposure levels considered to be harmful have continued to drop over time as scientific evaluations have continued, including via measuring effects in exposed populations of children.

Moving Forward: Dealing with the “Backlog”

The lead story also illustrates how time-consuming the process of addressing deep-seated problems can be. The legacy of 20th century industrial growth and change includes a staggering number of chemicals.

Society does not have the time or resources available to study each chemical in the way that lead was studied, nor can we postpone action until we are sure of their effects. Regulatory agencies worldwide, including in Canada, face an enormous challenge. There is a large backlog of substances in commercial use, including pesticides, which have not been fully, or even partially, assessed for their toxicity, especially for impacts on prenatal or child health. Understanding about effects on the developing brain is perhaps the largest gap in this information vacuum.

As with the story of lead, the substances that present the greatest challenges are those that are in high-volume production and that are often extremely valuable in terms of commercial profits or providing jobs or other useful, or even essential, goods and services in society.

Equally challenging is the need to address the many kinds of pollution emissions that result from industrialized society. In Canada, more than 23,000 substances in commercial use have yet to be fully evaluated. In addition, about 50 per cent of the active ingredients in pesticides (representing thousands of products on the market) need to be re-evaluated. The good news

in this very troubling situation is that since the mid-1990s, alongside the increasing understanding about prenatal and child health risks, governments have modified evaluation procedures to take greater account of child health concerns. Some of these changes have been enshrined in law.

The bad news is that progress on getting through the backlog is painfully slow. Health Canada is responsible for examining the health risks posed by new and existing substances in commercial use in Canada. Environment Canada considers the environmental risks. The combined assessments of these two departments determine the federal government’s choice of regulatory or other management responses. The environmental departments of provincial governments are also involved in examining risks of environmental exposures and setting standards. In fact, most legally enforceable standards for environmental protection in Canada are in place at the provincial level. The federal government tends to set guidelines only; for example, for contaminants in air and water or soil. For pesticides, standards are established by both levels of government.

In all cases, regulatory agencies apply the tools of risk assessment and risk management (see sidebar) to set standards for environmental exposures.

Much depends on the actions of both the provincial and the federal levels of government to get through the backlog and ultimately reduce exposure to toxic substances in Canada. Across the board, most provincial standards for air and water quality need to be updated or initiated. At

the federal level, three laws are of particular interest: the *Canadian Environmental Protection Act*, the *Pest Control Products Act* and the *Hazardous Products Act*.

The *Canadian Environmental Protection Act* (CEPA) requires that all substances used in Canada be assessed for environmental and human health impacts. Deadlines have been established for addressing the backlog of substances needing evaluation. The 23,000 substances are to be categorized by 2006 according to criteria for toxicity (including their environmental persistence and ability to bioaccumulate) and exposure potential. The approach is essentially an efficiency measure so that further detailed assessments can be conducted on substances of priority concern.

Once a substance has been fully evaluated (often an extremely lengthy exercise), a determination is made whether the substance is “toxic” as defined under CEPA. If a substance, or group of substances, is found to be “CEPA-toxic” a range of management options is considered up to, but not necessarily including, regulation. As of 2004, only 69 full evaluations had been conducted on substances, or groups of substances, in Canada.

The progress of pesticide re-evaluation has come under considerable criticism for being equally slow. The *Pest Control Products Act* was recently revised, though the new provisions will not be in force until January 2006 at the earliest. The revised law will

Risk Assessment of Toxic Substances

Risk assessment is an important decision-making tool. Risk is the measure of a) the hazard to health, and b) the likelihood of exposure to that hazard occurring. Risk assessment combines scientific evidence of health or environmental impacts with data about exposure, or models of exposure (where actual exposure data are lacking). Expert opinion is also employed, often because of insufficient or incomplete scientific data. Hence, informed “guesswork” is part of looking at all of the available information to estimate risk. Risk assessment is integrated with subsequent risk management steps, which look at relative risks posed by different response options. The risk management step also attempts to account for broader issues, such as cost and societal impacts. The final decision regarding risk could ensure the least harm to children’s health or, more often, could be tempered by considerations about the financial impact of the final decision on a particular sector of the economy.

As an evolving tool for decision making, risk assessment has yet to overcome some important limitations. The use of complex scientific data in risk assessment can create an illusion of certainty when the actual information base is very limited. It is a slow process that typically examines substances one at a time. Recent advances allow for a complex examination of groups of substances that act with similar toxic action. But, techniques do not exist to evaluate the combined effects of real-world combinations of multiple chemical exposures of dissimilar toxic action. The many complexities involved in understanding human development also present major scientific challenges within risk assessment. While lengthy assessment processes continue, sometimes for several years, exposure also continues. This “wait and see” approach is not conducive to a preventive, protective approach to dealing with toxic substances.

Lack of evidence of an effect is not equivalent to evidence of lack of an effect.

What is “CEPA-toxic”

Section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA) defines a substance as “toxic” if it is entering or may enter the environment in a quantity or concentration or under conditions that:

- a. have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
- b. constitute or may constitute a danger to the environment on which life depends; or
- c. constitute or may constitute a danger in Canada to human life or health.

require any new pesticides and those needing re-evaluation to be assessed according to new, more child-protective approaches. Deadlines for the re-evaluation of older pesticides vary over the next few years for different pesticide groups and are coordinated with similar deadlines established under the *Food Quality Protection Act* in the US.

Finally, there is Canada’s *Hazardous Products Act*. Written in the late-1960s, this law is almost entirely reactive, meaning that it is not structured to prevent problems before they occur. Rather, this law typically responds only to very serious problems, including death, resulting from consumer products. It is extremely rare for regulatory action to occur under this law and, if action is taken, it is extremely slow. Many people have the mistaken belief that if a product is available it has been evaluated and deemed safe for sale and use. Not only is this not the case, this law does not provide the government with the legal power to issue product recalls or demand the removal of products from store shelves.

With increasing evidence pointing to consumer products as either contributing to, or being the major source for, certain contaminant exposures, the *Hazardous Products Act* is a serious impediment to taking progressive regulatory action. Recent examples of hazards in products abound, including lead in jewellery, perfluorochemicals (non-stick surfaces) in cookware, PBDEs in electronics and home furnishings, phthalates in toys and food wrap, bisphenol A in resins and dyes, and nonylphenol in detergents. While CEPA can play a role in assessing these substances, a determination of toxicity under CEPA has little impact upon their continued use in consumer products. For example, lead was deemed toxic under CEPA in the early 1990s. That decision has had almost no impact upon the importation of lead-containing consumer products that has continued since that time.

Assessing Multiple Effects and Multiple Exposures

In efforts to measure, evaluate and regulate risks from environmental exposures, the focus is typically on one effect or one contaminant at a time, and often in isolation from other effects or exposures.

The ability to measure multiple exposures and evaluate multiple effects barely exists. Some scientific evidence has been gathered to address what are called additive or synergistic effects of exposure to multiple substances (see text box definitions). There is quite a lot of evidence about substances that appear to act with common mechanisms of toxicity, such as groups of substances like dioxins or PCBs or the organophosphate pesticides. To evaluate entire groups, such as the organophosphates, techniques are also being developed to aggregate (add together) exposures (e.g., from air, water and food) of the same substances to get a more complete picture of total exposure.

These techniques for aggregating exposure and evaluating common mechanisms of toxicity will only be able to address groups of similar substances, such as the organophosphate insecticides. This is a start at addressing the real-world situation of humans who are exposed to thousands of chemical contaminants. However, it does not even scratch the surface of measuring and evaluating the combined effect of many groups of dissimilar substances for which multiple low-level exposures are routine and multiple effects are known or suspected.

Definitions for “Real-World” Exposures

Additive Effect: When two or more substances act together and the combined effect is equal to the sum of the individual effects (e.g., $2+2=4$).

Antagonistic Effect: When two or more substances interact together and one or more of these substances partially or fully counteract(s) the other(s). The combined effect is less than the sum of the individual effects (e.g., $2+2<4$).

Synergistic Action: When two or more chemicals reinforce each other's effects (i.e., their combined effect exceeds 1. the additive effect; and 2. the individual effect).

Aggregate Exposure: The total exposure to a single chemical by multiple pathways (through food, drinking water, soil, etc.) and routes of exposure (oral, dermal, inhalation).

Cumulative Risk: Risks from exposure to two or more distinct chemicals sharing a common mode of action or mechanism of toxicity.

Common Mode of Action or Mechanism of Toxicity: Two or more distinct chemicals that exert the same or similar toxic effect on target organisms. For example, certain pesticides (the organophosphates) kill insects by interfering with the normal action of cholinesterase, an enzyme used in the insect nervous system. Since cholinesterase is involved in the normal functioning (and development) of vertebrate nervous systems (including humans) this mode of action is of concern in humans, especially in a child's developing brain.

The Wingspread Statement on the Precautionary Principle

Different definitions of the Precautionary Principle exist. The Rio Declaration (reproduced on page 16 of Chapter One) speaks to “serious or irreversible damage” and the application of “cost-effective” measures. Leading scientists investigating environmental health issues formulated 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.

The Wingspread Statement focuses more broadly on environmental risks in contrast to the notion of awaiting threats of serious or irreversible damage. It also omits the qualifying language of actions being based on their cost-effectiveness.

For more information see the Science and Environmental Health Network at www.sehn.org/wing.html.

The Precautionary Principle: Better Safe than Sorry

The precautionary principle simply means “better safe than sorry.” It suggests that everyone — individuals, organizations, communities, industries, scientists and governments — can exercise caution in the face of what appear to be potentially dangerous situations. As a decision-making tool, it responds directly to the lack of full scientific certainty that exists across the board when we deal with the complexities of environmental health issues. The principle to follow is that lack of full scientific certainty should not be used as an excuse to postpone action in situations where there is the possibility of harm to human health or the environment.



Photo Credit: Health Canada

In Canada, the precautionary principle and related policy concepts and tools (such as pollution prevention) are very slowly being integrated into thinking and policy related to children's environmental health. The Rio Declaration (reproduced on page 16 of Chapter One) version of the precautionary principle has been incorporated somewhat vaguely (because it is in the preamble to the law and not enshrined within it) into the *Canadian Environmental Protection Act*. More recently it was included in revisions (for certain decisions only) to the forthcoming *Pest Control Products Act*. The implementation of this new law governing pesticides in Canada will need to be watched closely. It has the potential to provide significant improvements in ensuring protection of child health from pesticide exposure. The forthcoming

(expected in 2006) parliamentary review of CEPA offers additional opportunity for improving the legal footing for applying precautionary measures to the regulation of toxic substances. The *Hazardous Products Act* does not incorporate precaution and is overdue for a rewrite. At the provincial level, laws and policies can be similarly reviewed for precautionary reform. At the local level, pesticide, anti-smoking and anti-idling by-laws are all good examples of precautionary action. For more information see CELA's collection of materials on the precautionary principle at www.cela.ca/coreprograms/detail.shtml?x=1329 and Pollution Probe's report, "Applying the Precautionary Principle to Standard Setting" at www.pollutionprobe.org/Publications/Policy.htm.

Photo Credit: Mark Surman



Chapter Six: Creating Healthy Environments for Children

We know a lot already about how to keep children healthy and protected from harm. The basics include providing healthy food, clean water, sufficient rest, safe homes and play areas, and prevention-based medical and dental care. For babies, and especially crawling infants and toddlers, childproofing is standard practice in most Canadian homes.

Childproofing includes a suite of changes, generally in a child's home environment, that are intended to prevent injury and exposure to poisons. Furniture and other heavy items are rearranged, barriers are placed at stairways, electrical outlets are plugged and various childproof locks or lids are placed on cupboards, doors, drawers and containers. Outside, play areas, pools and ponds are fenced, and car seats are mandatory. On the whole, these are mostly physical barriers to items or situations that can cause death, injury or toxic exposures. The concept of childproofing is sound, with a strong track record of success.

Similarly, precautionary measures are routine during pregnancy and in the advice women receive about prenatal care. For example, it is standard practice for labels on medicines, whether prescription or over-the-counter, to suggest either routine

avoidance during pregnancy (and breastfeeding as well) or to be taken only under a doctor's direction. Doctors and other health care providers urge pregnant women and women trying to conceive to avoid known risk factors, such as alcohol and tobacco, dental and other x-rays, and to eat healthy food, get plenty of rest and supplement their diet with prenatal vitamins that include folic acid (known to prevent spinal cord birth defects).

For environmental exposures, the concept of childproofing needs to be expanded in two ways. First, it should be stretched across a longer period of time, extending from three months prior to conception until adulthood. Second, childproofing, including prenatal care, needs to be expanded to include a wider range of potentially hazardous exposures.

This Primer contains a lot of information on environmental exposures, "childproofing tips" and resources for finding more detailed information. This final chapter provides a "top ten" list of strategies to reduce or prevent exposures to keep children safe and healthy. Where suggestions are made for indoor settings, they apply equally to home, school and child care environments. Although lengthy, these lists are not comprehensive. As with all childproofing techniques, the first line of defence is to focus on prevention, and to adopt the precautionary approach of "better safe than sorry." If there is a chance of harmful effects, seek to avoid exposures and seek out safer alternatives.

The Environmental Childproofing Top Ten List

1. Healthy Living and Healthy Eating
2. Handwashing and Dustbusting
3. Healthy Indoor Air
4. Outdoor Air Pollution Reduction
5. Toxic Use Reduction
6. Safe at Play
7. Safe Renovations
8. Special Measures in Rural and Northerly Settings
9. Be an Informed Consumer
10. Get Involved



Photo Credit: Mark Surman

1. Healthy Living and Healthy Eating

The first obvious, but still very important, priority for ensuring prenatal and child health is a healthy lifestyle and a healthy diet, including the following:

- **Don't smoke.** If you smoke, quit. If you've quit before, try again. Don't smoke during pregnancy or in a child's indoor environment (including in the car).
- **Eat a balanced diet** (see Healthy Foods below).
- **Avoid all alcohol during pregnancy.**
- **Avoid, if possible, dental x-rays and placement of mercury fillings during pregnancy.**
- **Apply healthy diet suggestions to reduce contaminant levels in breast milk** (including organic foods and especially eating less animal fat).
- **Follow fish advisories** — this is extremely important for pregnant and nursing women, children and women of child-bearing age.
- **Breastfeed your baby as long as possible** (exclusively for the first six months and up to age two years, if you can manage it).
- **Be physically active and take steps to reduce stress.**

Healthy Foods: Fortunately, foods that are good nutritional choices also tend to have less environmental impact and a lower contaminant burden:

- **A diet that includes whole grains, fruits, vegetables, non-animal proteins** (e.g., beans, soy products) and low-fat animal products will result in less accumulation of toxic substances in the body. **Don't avoid fish, but follow fish advisories.**
- **Fresh food with minimal additives or processing is known to be lower in contaminants, such as heavy metals, than processed foods.** Food additives known to be unhealthy include nitrates in processed or cured meats, such as hot dogs and cold cuts.



Photo Credit: Mark Surman

- **Local produce, in season, means less distance from field to table, allowing for less use of pesticides and preservatives.** Shorter transportation distances also help improve air quality.
- **Choose organic produce.**
- **Aim for a variety of fruits and vegetables so that children are not repeatedly exposed to the same types and levels of pesticide residues.**

- When your food budget is tight, stretch the organic food dollar by choosing organic for foods higher up the food chain that tend to have a higher contaminant burden (e.g., dairy, eggs and meat), or focus on foods with the smallest price differential between organic and non-organic. Choose organic foods when children will only eat a limited range of the same foods.
- Avoid burnt food, particularly from the barbeque (to avoid exposure to cancer-causing PAHs) and avoid using “non-stick” cookware at very high temperatures (to avoid releasing perfluorochemicals).
- Do not store or serve food or drink in leaded crystal or lead-glazed pottery (be cautious of brightly coloured imported earthenware from China, Mexico and Italy). Use cookware that is in good condition, discarding chipped enamel pots, scratched non-stick cookware, pitted or worn aluminum pots, and chipped or cracked ceramic containers.
- Avoid heating (especially in the microwave) food or drinks in plastic containers or covered with plastic film.
- Health Canada advises that all women who could become pregnant should be taking a multivitamin containing 0.4 mg of folic acid every day. To reduce the risk of neural tube defects, the vitamins should be taken three months prior to conception and through the first three months of pregnancy. For more information see www.hc-sc.gc.ca/english/folicacid/index.html.



Photo Credit: Mark Surman

- During breastfeeding, ensure the mother gets plenty of rest, healthy food, especially extra calcium, and adequate water consumption to maintain a strong milk supply. Lead follows the calcium route in the body; if dietary calcium is insufficient, calcium will mobilize out of bones and teeth, taking stored lead with it into breast milk. Similarly, during pregnancy, a healthy diet high in calcium and iron will reduce lead uptake and lead mobilization from storage in bones and teeth.

2. Handwashing and Dustbusting

Metals, pesticides and many more substances are tracked in from outdoors (by people, pets, stroller wheels, and other sources) and end up in house dust and carpets and on indoor surfaces, where they become important sources of exposure to children. Indoor sources of contaminants, often from consumer products, are also of increasing concern. Contaminants in housedust will be concentrated in vacuum bags, dryer lint and cleaning equipment.

Hand-to-mouth behaviour, especially in very young children, continuously exposes children to whatever is on their, often sticky, hands or other surfaces. Regular handwashing reduces uptake and prevents communicable disease transmission. Handwashing is especially important before eating or preparing food. Anti-bacterial and disinfection products are of questionable value and may even interfere with the normal development of a healthy immune system. They offer protection in situations of very real threats of disease transmission, such as backed-up sewers or cleaning up after handling raw meats (although very hot, soapy water and good kitchen hygiene works too).

Dustbusting Tips:

- Take your shoes off at the door.
 - Use doormats that can be washed frequently. (Studies confirm that doormats prevent very large amounts of dust and dirt entering your home. They can be very contaminated, so wash them separately.)
 - Clean up house dust with moisture — wet mopping instead of dry dusting — or with a vacuum cleaner.
- Use an efficient vacuum cleaner with a powerhead once a week on rugs and floors (twice a week in homes with a crawling child).
 - Do not change/empty the vacuum cleaner bag or the bin in a central vacuum if you are pregnant. Do not allow children to do these tasks.
 - Avoid dust exposure by carefully disposing of vacuum cleaner bags/central vacuum bin contents — do not compost this material.
 - Dispose of dust rags carefully, or wash separately.
 - Don't use the same cleaning equipment, such as brooms, dustpans and rags, in the home as are used in basement or garage workshops (where toxic substances may be used or stored, either currently or in the past).
 - Avoid contaminating your child's home environment with "take-home" exposures from parental occupations. If you work with chemicals, or in commercial or residential construction, especially in renovations, take extra care to isolate your shoes and clothing. Remove clothing and shower before occupying rooms and furniture where children spend their time. Store soiled work clothing separately from other clothes; launder separately as well.
 - **Precautionary Assumption:** Clothes dryer lint is likely as contaminated as house dust. Dispose of it carefully and don't use it for making home-made paper or other crafts with children.
 - **Precautionary Assumption:** The dust and dirt inside and on the surface of your car or other vehicles is likely contaminated with toxic substances.

3. Healthy Indoor Air

Regular ventilation helps to flush out any toxicants in indoor air and replenish oxygen levels. Dust removal with moisture helps prevent additional exposure during cleaning and avoids simply blowing it into the air to be inhaled or to settle again on surfaces.

Tips for Healthy Indoor Air:

- Practice regular ventilation of indoor spaces, but don't undermine energy efficiency gains. Set up a fan for two or three minutes at an open window. Use a timer as a reminder to close it.
- Install ventilation fans for gas stoves and in bathrooms.

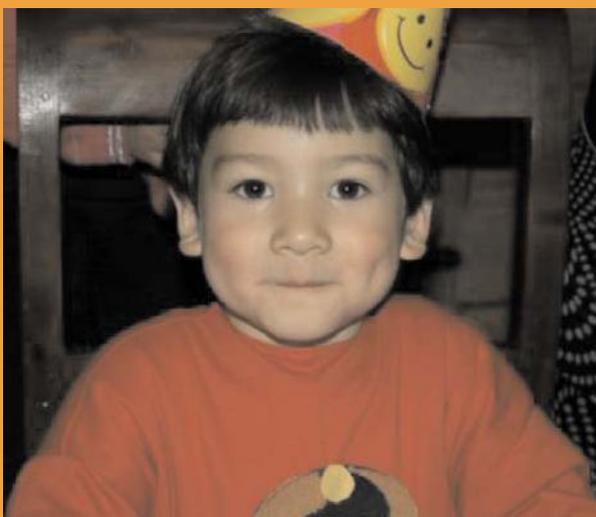


Photo Credit: Mark Surman

- **Do not smoke** in the home or in the car (remove the lighter and the ashtray).
- **Don't let children sleep with pets.**
- Follow tips for dustbusting (#2 of the Top Ten).
- Follow toxic use reduction measures (# 5 of the Top Ten).
- Follow safe renovation practices (# 7 of the Top Ten).
- Be an informed consumer (#9 of the Top Ten).
- See additional information and childproofing tips about moulds, organic solvents, phthalates and PBDEs (in Chapter Three), VOCs and indoor dust (in Chapter Four) and carpeting (in Chapter Five).
- **Protect your home from carbon monoxide:** open the garage door before starting the car and never run gas-powered appliances in a closed garage; ensure regular cleaning of ductwork from any natural gas or propane appliances and ensure vents are never blocked; have chimneys, fireplaces and furnaces checked annually; don't operate gas barbeques indoors or in any attached, enclosed areas (e.g., garages); and install CO detectors on every floor and replace them every three to five years).
- Investigate indoor air quality issues at schools and child care and recreational facilities (see Get Involved, #10 of the Top Ten).

4. Outdoor Air Pollution Reduction

With the high burden of illness that already exists among children from air pollution, reducing outdoor air pollution is critically important. While it may seem surprising to think that children's health can be protected by turning off excess lighting, these and many other energy conservation measures will reduce the need to produce electricity and will therefore improve air quality.

Improving Outdoor Air Quality:

- Drive less.
- Find a car-pooling buddy.
- Take public transit.
- Support measures to curb urban sprawl.
- Follow the advice of public health officials during smog advisories.
- Encourage children to walk or bike to school. See the Active & Safe Routes to School program at www.saferoutestoschool.ca.
- Choose an energy-efficient vehicle.
- Practice all forms of energy efficiency and water conservation (to reduce fossil fuel combustion for heating homes, the use of water, the need for producing electricity and for purifying and pumping drinking water).
- Don't idle your vehicle.
- Where possible, avoid busy streets during peak traffic times when walking with small children or pushing strollers.
- Never burn plastics or other synthetic materials, such as carpeting or furniture containing foam or that is treated with varnishes or other coatings.
- Never burn (green-tinged) pressure-treated wood.

- Choose a manually powered lawnmower, buy an energy efficient mower, or eliminate grass in your landscaping. *Mow Down Pollution*, an initiative run by the Clean Air Foundation, encourages recycling of higher-polluting gasoline mowers and trimmers (www.cleanairfoundation.org/mow_down).
- Take the *One-Tonne Challenge* (www.climatechange.gc.ca/onetonne/english).
- Order a free 20/20 *The Way to Clean Air* planner to reduce home and vehicle energy use by 20 per cent at www.toronto.ca/health/2020/index.htm.



Photo Credit: Mark Surman

5. Toxic Use Reduction

Chemicals in household cleaning products (liquids and powders, polishers, drain cleaners) and cosmetics or personal care products create foam, dissolve grease, remove stains, dissolve mineral build-up, and add colour, fragrance and more. Many cleaning products contain chlorine-based or other very strong chemicals. The cleaning power of the product is often far beyond what is needed to clean most household dirt.

Chemicals in cleaning products can leave chemical residues on surfaces and contribute to indoor air pollution. Many different chemicals are used in the home, such as during renovations, pest control, and operating and maintaining vehicles or other small motorized equipment. Chemicals may also be brought into the home when clothes are dry cleaned; occupational circumstances can also contribute to “take-home” exposures on shoes or clothing. Many of these chemicals have not been adequately, if ever, tested for their effects on prenatal or child health. Some chemicals are associated with known or suspected hazards. Choice is often available in the form of less-toxic or non-toxic alternatives.

Toxic Use Reduction Tips:

- Choose from widely available “green” or non-toxic cleaning products (e.g., see the *Guide to Less Toxic Products* at www.lesstoxicguide.ca).
- Avoid chlorine-based cleaning products (especially in dishwashing powder to reduce exposure to DBPs in the steam).
- Where a strong cleaning product is necessary, buy the least amount necessary to do the job and choose creams and liquids to avoid inhaling particles in powders and sprays.
- Ventilate well and keep children away until odour is gone. For products with hazard symbols, follow label instructions carefully. See Health Canada’s *Aim for Safety — Target the Label* at www.hc-sc.gc.ca/hecs-sesc/cps/publications/label.htm. Ensure unused toxic cleaning products are closed tightly, stored safely (high and out of reach of children) and/or disposed with household hazardous waste.
- Avoid dry cleaning or find a service that uses non-toxic methods (specifically ask whether they avoid the use of perchloroethylene). When in doubt about the chemical used, hang all dry cleaning outdoors (or in a well-ventilated location) for at least two hours before storing indoors.
- Avoid pesticide use, indoors and outdoors, and seek safer, non-toxic pest control alternatives. If pesticides become necessary, for health or safety reasons, seek the least toxic options, follow label instructions carefully, store them tightly closed in childproof locations and dispose of unused portions with household hazardous waste. See Toronto Public Health’s *Pesticide Free: Guide to Natural Lawn and Garden Care* at www.toronto.ca/health/pesticides/natural_lawn_guide.htm.
- For head lice control, use only the permethrin-based pediculocides on children or try alternatives to using pediculocides (classified as drugs, these

are pesticides that kill head lice). See on-line resources at the US-based National Pediculosis Association at www.headlice.org, the Canadian based Lice Squad at www.licesquad.com and Toronto Public Health at www.toronto.ca/health/pdf/head_lice_factsheet.pdf.

- Follow safe renovation practices (#7 of the Top Ten).
- Be an informed consumer (#9 of the Top Ten), especially with respect to following label instructions.
- See additional information and childproofing tips about organic solvents, dealing with pests, phthalates and PBDEs (in Chapter Three), VOCs (in Chapter Four) and carpeting (in Chapter Five).
- Investigate practices for the use of toxic substances in schools and child care settings (see Get Involved, #10 of the Top Ten).

Personal Insect Repellents

In response to the rising risk of mosquito-borne West Nile Virus (WNV), public health agencies recommend the use of personal insect repellents, along with other measures, such as protective clothing, mosquito netting and avoiding outdoor activities at dusk. Most repellents contain DEET, a chemical associated with neurotoxic effects in children when exposure occurs above recommended limits. Used sparingly, these products are considered effective in protecting against WNV infection. Label instructions should be carefully followed. DEET should never be applied to children under age six months. A product containing ten per cent DEET or less is recommended for children aged six months to two years, but with a maximum of one application per day. Up to three applications are considered acceptable for children aged two to 12 years. Repellent should be applied lightly to exposed skin and to clothing, but never on cuts, wounds, sunburn or skin that will be covered (by clothing or blankets). Children's hands, face and eyes must be avoided.

Toronto Public Health recommends that parents take the most precautionary approach available and use a product intended specifically for children (those with the lowest DEET concentration possible, and not more than 10 per cent) and follow label directions for the number of times applied per day. For those who prefer not to use DEET, consider using the newer approved products; for example, soybean oil or eucalyptus-derived products which appear to provide comparable efficacy to 10 per cent DEET.

Note that the eucalyptus-based product should *not* be used on children under three years of age. For citronella products, the federal government recommended, in the fall of 2004, the discontinuation of those applied directly to the skin due to uncertain risks of reproductive toxicity. Citronella candles and other applications are excluded from this recommendation. DEET is not considered a risk during pregnancy or breastfeeding, but this conclusion is not based on detailed study in humans and Toronto Public Health recommends that women consider non-chemical methods instead. Finally, older products that combined insect repellents and sunscreen have been banned. Discard any unused containers of these combined products with household hazardous waste. For more information from Toronto Public Health visit www.toronto.ca/health/westnile/wnv_personalprecautions.htm.

6. Safe at Play

Children need to play. Their social, physical and emotional health and well-being depend on it. Outdoors they need to be protected from UV radiation, their activities should be modified appropriately during smog alerts, and care is essential with the use of personal insect repellents. Once again, consumer products pose unexpected risks. Toys and arts, crafts and hobby supplies can contain harmful substances. Lead has been found in some crayons, paints and sidewalk chalk. The solvents in glues, adhesives and magic markers can emit VOCs. Soft plastic toys made of PVC can contain phthalates that leach out as toys are mouthed.

Government action and consumer pressure have caused manufacturers to start switching to other plastics. In 1998, a Health Canada advisory recommended



Photo Credit: Health Canada

disposing of soft vinyl teething toys and rattles and issued a list of those considered safe; however, some known to be unsafe may still be on the market and in homes. Painted toys, made before the 1970s, may contain lead or other toxic chemicals. Inexpensive, imported toys and trinkets often contain lead and are inadequately regulated.

Tips for Ensuring Safe Indoor and Outdoor Play:

- **Prevent UV exposure.** Cover up small babies or stay in the shade; sunscreen is not recommended until babies are six months of age or older. All children should wear sun hats and sunscreen. Covering up or staying out of the sun, especially during the peak hours of 11:00 am to 3:00 pm, is far preferable to relying on sunscreen.
- **Arrange for outdoor activity to take place away from high traffic areas.**
- **Time children's outings during periods of low traffic activity.**
- **Modify outdoor activity levels when air quality is poor.** Follow smog advisory advice.
- **Support measures to seal or replace arsenic-treated wood play structures in your community.** Ensure that sealed structures are regularly monitored. Wash children's hands after playing on structures built with all types of pressure-treated (i.e., pesticide-treated) wood.
- **Apply a wood-penetrating sealant to backyard play structures or decks made with arsenic-treated wood.**

- Adults who pursue hobbies that use or generate toxic substances (including furniture refinishing) should do so outside the home in studio spaces specifically designed for these types of activities. Try to choose non-toxic or low-toxic materials. Avoid take-home exposures on shoes or clothing or isolate these items and launder clothing separately. For at-home hobbies, isolate these activities from the rest of the home in areas not accessible to children. Activities in the home should be well ventilated to the outdoors, with vented air unable to create outdoor hazards in children's play areas.
- Pregnant women should avoid all activities that involve the use of oil paints, solvents, varnishes, paint strippers, lead compounds (including soldering), or dust-producing activities.
- For children's hobbies, ensure supervision, use non-toxic products, follow safety instructions on the label, keep materials in original containers (so you can always read the label) and store them safely. Children should not eat or drink while using arts and crafts materials. See Health Canada at www.hc-sc.gc.ca/english/iyh/products/arts.html.
- Avoid and/or discard toys made of soft vinyl, particularly those for teething babies.
- Investigate your entire home for lead-containing consumer products (see sidebar).
- Discourage children from sucking or chewing on non-food, non-toy items.
- Discourage young girls from using nail polish and nail polish remover as these can contain hazardous chemicals.
- Discourage children from using hair dyes, especially permanent dyes and darker colours (suspected in cancer and other health effects).

Lead in Consumer Products

Lead is the most extensively studied of all toxic substances. It is known to be highly toxic and unsafe at any exposure level to young children. Nevertheless, it remains poorly regulated in consumer products. Since banning it from gasoline in 1990, a steady stream of almost entirely imported consumer products has been discovered — in some cases via lead-poisoned children. The use of lead in products continues for the same reasons as in Greek and Roman times: It is cheap, easy to melt and form, and provides durability, flexibility and colour. Toxic levels have been found in PVC mini-blinds, the paint of clothing zippers, crayons and candlewicks. It is also found in some imported glazed pottery and, by definition, lead crystal, and is especially plentiful in inexpensive jewellery, some of which was the subject of the largest product recall in US history in late 2004.

Childproofing Tips: Carefully discard any plastic mini-blinds (the metal ones are okay) bought before 1997, or old blinds of uncertain age (take care with disposal as surface dust is highly contaminated with lead). Search toy, trinket and jewellery boxes for jewellery that has a dull grey colour or is heavy for its size. Be especially sure to discard items that will readily “draw” a grey line on paper. Check birthday party favour bags or inexpensive “surprise bags” containing several items and sold at discount prices. Check for these same items on your own key rings. Never let an infant or child suck or chew on leaded jewellery or key ring ornaments. These items can contain as much as 50 per cent pure lead and are therefore exceptionally dangerous.

7. Safe Renovations

The destruction and removal of floors, walls, fixtures and appliances can release many harmful substances into the surrounding environment. Air, and especially dust, from renovations can contain asbestos, mineral fibres, lead, pesticides and mould. New building materials, the adhesives, sealers and other products used, and the rebuilding process also release substances, including VOCs such as xylene, benzene and formaldehyde, dust and fungicides.

Lead is of particular concern. Over 60 per cent of Canadian homes were built before 1976, when the first regulatory step was taken to phase out lead in paint. Lead was used in paint to lend strength and durability, so lead content will be greatest on “high traffic” surfaces, such as door, window and baseboard trim, kitchen and bathroom cupboards, banisters and railings, radiator covers and their metal surfaces. For the same reason, outdoor paint often has higher lead content than indoor paint. Lead also helped to create specific colours, including white, red and yellow. While all old paint is suspect (including on old furniture), these colours can mean particularly high lead content. As paints deteriorate through wear and tear, paint chips themselves are hazardous, but lead also accumulates in household dust.

Renovations, especially activities like stripping or sanding painted surfaces, can generate very high levels of lead in dust. The soil immediately adjacent to older buildings can often be highly contaminated with lead from the historical occurrence and maintenance of painted surfaces.

Asbestos is another significant concern since it is known to cause cancer in humans and no safe level of exposure has been identified. Homes built or renovated between 1920 and 1970 can have asbestos-containing products, such as ceiling tiles, old vinyl flooring, shingles, textured paints, and stove, furnace and pipe insulation. Asbestos is a risk if fibres are disturbed and inhaled. Age, damage, construction activities (sanding, sawing, scraping) and cleaning can all release tiny asbestos fibres into the air.

Tips for Safe Renovation:

- **Take extreme care with dust control during renovations, especially of old painted surfaces.**
- **Pregnant women and young children should be kept out of spaces being renovated until the work is completed and the space has been well cleaned and ventilated.**
- **Pregnant women should avoid all home renovation activities. Particular care should be taken to avoid oil paints, solvents, varnishes, paint strippers, and dust or other residue created by old paint removal.**

- Pre-adolescents and children going through puberty are experiencing a major life change mediated by natural chemicals (hormones). From the ages 10 through 15, it is prudent to avoid adding more (synthetic) chemicals to that mix. **Don't ask them to help with home renovations and ensure they are not exposed to others using these materials, especially oil-based paints, varnishes, related cleaning solvents, adhesives and other materials that emit VOCs.**
- Avoid renovating in the winter when ventilation is difficult.
- If asbestos-containing materials are undisturbed, leave them alone. You can also cover them to avoid future damage/disturbance. For identifying and/or removing asbestos-containing materials, find a qualified professional in the telephone book under Asbestos Abatement. Extreme care is necessary when asbestos-containing materials are removed or repaired. Hire a professional. For more information, see Canada Mortgage and Housing Corporation at www.cmhc-schl.gc.ca, The Asbestos Institute at www.asbestos-institute.ca and Health Canada at www.hc-sc.gc.ca/english/iyh/environment/asbestos.html.
- Vermiculite insulation (manufactured before 1990) can contain asbestos fibres. Avoid disturbing it and ensure access is unavailable, such as in an open attic. Do not remove it yourself. See asbestos removal information above and Health Canada's on-line factsheet at www.hc-sc.gc.ca/english/iyh/products/insulation.htm.
- Choose low-VOC paints, finishes, adhesives and other products.
- **Closely follow label instructions** for all home renovation products.
- For more information on healthy renovation visit Canada Mortgage and Housing Corporation at www.cmhc-schl.gc.ca.
- **Precautionary Assumption:** Deteriorating or otherwise disturbed layers of old paint (including on old furniture) should *always* be considered a very dangerous source of lead for pregnant women, women of child-bearing age and children. The older the paint, the higher the lead content. For detailed information about lead paint removal and management, see Health Canada's "Lead-Based Paint" at www.hc-sc.gc.ca/english/iyh/products/leadpaint.html, CMHC's "Lead Precautionary Measures" at www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/92-206.pdf and the US EPA's resources about lead at www.epa.gov/lead.

8. Special Measures in Rural and Northerly Settings

Living in a rural setting or in the north, including at summer cottages, presents specific circumstances and practices that can increase exposure to environmental hazards. In particular, backyard burning of waste materials can be a significant source of toxic air contamination. Although many things *will* burn, not all should be burned.

Tips for Rural and Northerly Settings:

- If water supply is a local lake or well water, have the water checked regularly for microbiological and, if circumstances warrant, chemical contamination. Also check nitrate levels as elevated levels can present significant hazards to babies and small children. For more information, see the Well Aware program coordinated by Green Communities Canada at www.greencommunitiescanada.org.
- Recognize the hazards of backyard burn bins. Eliminate burn bins or burning piles entirely or ensure that only paper, leaves, brush or wood are burned.
- Burning coloured paper or boxboard is not advisable as it releases metals and other chemicals used in the colouring and labelling. Since packaging often contains both paper and plastic, burning it without separating out the plastic will release highly toxic substances, including dioxin, into the air.
- **Never** burn garbage, plastics of any kind, carpeting, furniture, old painted wood, green-tinted pressure-treated wood, pesticide containers, or any other synthetic materials or brightly coloured boxboard or paper, such as gift wrapping paper. All of these materials can release highly toxic substances when burned.
- Take extreme care with on-farm pesticides to prevent exposures to children, pregnant women and women of child-bearing age and recognize that farm homes may be at special risk of becoming contaminated with pesticides — follow measures for dustbusting and avoiding “take-home” exposures.
- Follow fish advisories and find out if any contamination issues exist for local country foods (e.g., wild game).
- If wood burning is a principal heat source, follow indoor air quality tips. Recognize that fireplace ash contains harmful particulate matter and heavy metals. Although occasionally good for top-dressing soil, don’t use in food-producing soil and treat it primarily as waste requiring landfill disposal.

9. *Be an Informed Consumer*

People often think of environmental health issues as having to do with smokestack or tailpipe emissions outdoors. While these are important exposure sources, industrialization and widespread use of chemicals has just as much to do with effects on health from consumer products. In many cases, these products can create exposure to toxicants indoors where children spend most of their time.

Many people are vigilant about reading labels on food products. Walk down any grocery store aisle and you are almost guaranteed to see someone reading a label. The same vigilance needs to be applied to many other consumer products, especially pesticides and products used for home renovations. Unfortunately, Canadian requirements for providing information on product labels are inconsistent and often incomplete. Requirements to label products with their chemical ingredients are generally limited to situations of very serious hazards. Clear labelling requirements exist for hazardous ingredients that are flammable, explosive, corrosive or highly toxic. Ingredients must be listed alongside hazard symbols. For the vast majority of products containing substances of known, or more often, emerging concern, such ingredients are rarely listed on product labels; nor are they generally subject to labelling requirements. In November 2006, new labelling requirements come into force for ingredients in cosmetics, and consumers will have better information in this area. For more information see www.hc-sc.gc.ca/english/iyh/products/cosmetics-ingr.html.

Where label instructions are provided on hazardous substances, such as pesticides, paints, solvents or other products, following these instructions is extremely important. To use the example of pesticides, the Pest Management Regulatory Agency within Health Canada decides, based on its determination of health and environmental risks, in what ways and in what quantities a pesticide product can be used (allowable uses). It also determines recommended mitigation measures, such as wearing personal protection like gloves and masks. All of this information is contained in the label instructions. Within this regulatory regime, there is an acknowledgement that there are risks associated with these products. But, the risks are deemed acceptable by a calculated margin of safety and by the assumption that risks are managed via labelling information. This approach is what is implied when statements are made such as “the product is safe when used as directed.”

Following label instructions is important because if you use more of the product than the label recommends (such as two or three applications of DEET per day on a one-year-old child instead of the recommended single application per day) you could be going beyond the exposure level considered to be “of acceptable risk.” To use the example of a paint removal product, the label typically warns of potential damage to the eyes and recommends wearing safety glasses. Without following these instructions, eye injury can occur.



Source: Health Canada. www.hc-sc.gc.ca/hecs-sesc/cps/staysafe/preschool/get_ready.htm#2

Tips on Being an Informed Consumer:

- Remember that there is almost always a non-toxic or lower risk alternative for most products. Research it. Shop around. Ask questions.
- Consumer demand and consumer opinions shape the marketplace. Tell retailers that you appreciate having the lower risk or safe alternatives; express your concerns with retailers who don't provide these alternatives.
- Limit cell phone use by children.
- See Health Canada's on-line information about cosmetics and many other products in the "Products" section of the *It's Your Health* website at www.hc-sc.gc.ca/english/iyh/products/index.html.
- Many recycling options now exist — think before you throw something out, especially "e-waste" (cell phones, computers) and associated materials (e.g., printer cartridges). Find out about recycling options offered by your municipality or by retailer take-back programs, such as are provided for rechargeable batteries at Canadian Tire, Zellers, RadioShack and other retailers, or on-line at www.call2recycle.com.
- Avoid products containing multiple hazard symbols.
- Product labels list the name and contact information of the manufacturer or distributor. Contact them with questions about the product.
- **Precautionary Assumption:** In Canada, most consumer products probably have not passed through a government/regulatory approval process.
- **Precautionary Assumption:** Products that are very inexpensive and imported from developing countries may contain hazardous substances because occupational, environmental and health standards are often lacking. Unscrupulous practices may be especially the case for products originating in countries that host "export processing zones" where large volumes of products are generated by a low paid workforce.

10. Get Involved

Individual action by parents and concerned citizens is important. However, responsibility for cleaning up various environmental messes or regulating toxicants in consumer products must be shared across corporations, manufacturers, retailers and all levels of government. These groups often need to be urged to make change happen. They need to hear from the public, parents and organized groups looking out for the best interests of children.

The problem of breast milk contamination is probably the best example of why it is necessary to get involved in solving environmental problems. On a personal level, would-be and pregnant mothers can make lifestyle changes to reduce chemical exposures, such as buying organic food or eating less animal fat. These are important and worthwhile steps. But, many exposures are beyond such individual control. And taking such steps will not do anything to reduce a woman's accumulated body burden of chemicals. (Ironically, breastfeeding is the best known means of removing accumulated stores of POPs from the human body.) Nor can it be the responsibility of breastfeeding women alone to resolve an ultimately global problem.

Political action is necessary. Clear evidence shows that when persistent substances are banned, their concentrations in breast milk decline over time. The evidence that PBDE levels are rising dramatically in breast milk has prompted debate, but no clear regulatory action by the federal governments in Canada or the US. Meanwhile, exposure continues for an entire generation of children and will continue well into the

future. We know enough from the experience of PCBs and DDT that rising levels of similarly persistent and toxic substances in breast milk should result in swift regulatory action. We need to follow the lead of the European Union and ban PBDEs. Better still, regulatory approaches and policies that more broadly require the use of inherently safe materials are necessary to prevent such contamination in the first place.

Getting Involved:

- After looking at indoor air quality, dust control and toxic use practices at home, do the same in child care settings, schools and recreation facilities. Work together with other parents, staff and administrative boards. Are policies in place to ensure healthy indoor air and low-risk playgrounds, toys, pest control and cleaning practices? Use Health Canada's "Indoor Air Quality: Tools for Schools — Action Kit for Canadian Schools" (www.hc-sc.gc.ca/hecs-sesc/air_quality/publications/tools_school/toc.htm).
- Insist that industry, manufacturers and retailers ensure healthy product design, stewardship, and lifecycle and supply chain management from cradle to grave; that they find safe alternatives to toxic processes and products; and that they provide access to and information about non-toxic products and services.
- Work in your community on the issues you are concerned about. If you cannot get directly involved in the bigger picture work, support those groups that do.

- There is much work to do and many choices for action. Children's environmental health and the long-term benefits for all of society will be improved when pressure is created for policy change. Insist on:
 - reduction and ultimate elimination of child poverty
 - further reductions in all toxic and smog-forming air pollutants
 - research and promotion of safer, non-toxic alternatives to toxic chemicals and pesticides
 - the progressive elimination of all persistent toxicants, such as lead, mercury and PBDEs and the reduction of other known and suspected toxic substances from consumer products
- the mandatory evaluation of all potentially hazardous substances for their impacts on the developing brain
- more research into child health and environment issues (including a national biomonitoring program and Canadian-based longitudinal studies similar to the US-based National Children's Study)
- reform of Canada's antiquated *Hazardous Products Act*
- enshrining the precautionary principle and mandatory child health protective measures into the *Canadian Environmental Protection Act*
- pesticide by-laws in every community in Canada.



Photo Credit: Mark Surman

Key References

Note that a much more comprehensive list of references for the scientific evidence summarized in this Primer is contained in a companion report by Toronto Public Health, of which much of this Primer is a shorter, popularized version *Environmental Threats to Children: Understanding the Risks, Enabling Prevention* (available on-line in September 2005 at www.toronto.ca).

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Glossary

ADHD: Attention Deficit Hyperactivity Disorder.

Antigen: A substance (protein, toxin, enzymes, foreign body, etc.) that is capable of inducing a specific immune response, including the development of antibodies.

Association: The relationship between an exposure and a disease. Such a relationship does not necessarily demonstrate a cause–effect relationship.

Birth defect: Any defect present in a baby at birth, irrespective of whether it is caused by a genetic factor or by non-genetic prenatal events. Common birth defects include heart defects, cleft lip or palate, Down Syndrome, spina bifida and limb defects. Birth defects are the leading cause of infant mortality in Canada.

Bioaccumulation: Some pollutants are excreted more slowly than they are absorbed and are thus stored in the body for long periods of time. Total pollutants in the body (the “body burden”) may increase if the organism is repeatedly exposed to bioaccumulating substances for a long period of time.

Biomarker: Biological materials, enzymes, hormones, etc., that change when exposed to contaminants. See also biomonitoring.

Biomagnification: Pollutants “biomagnify” when their concentration increases as animals eat contaminated plants or other animals. For example, when pollutants in plants are passed on to animals repeatedly feeding on the plants, the animals may accumulate higher levels of contaminants in their own bodies than were originally found in the plants. This is because the animals eat many plants and do not excrete most of the absorbed pollutants. Levels of contaminants can increase up the food chain.

Biomonitoring: Biomonitoring involves measuring and analyzing chemicals, hormone levels or other substances in biological materials (e.g., blood, urine, breath) to estimate exposure, or to detect biochemical changes in the exposed subject before or during the onset of adverse health effects. Biomonitoring sometimes refers to a specific indicator for a particular disease/functional disturbance (e.g., a blood test for lead).

Blood–brain barrier: A term that encompasses multiple mechanisms that control access of blood components to the brain; the fetal and neo-natal blood–brain barrier is more permeable than the adult barrier to small lipophilic molecules.

Body burden: The total amount of a chemical in the body. Some chemicals build up in the body because they are stored in fat or bone and/or are eliminated very slowly.

Carcinogen: A substance (e.g., a chemical) or an agent (e.g., ionizing radiation) that causes cancer.

Childhood cancer: Among all age groups, the most common childhood cancers are leukemia, lymphoma and brain cancer. As children enter their teen years, the incidence of osteosarcoma (bone cancer) increases. Sites affected are different for each type of cancer, as are treatment and cure rates. In almost all cases, childhood cancer appears to arise from non-inherited mutations in the genes of growing cells.

Children: Life stages encompassing prenatal through to end of adolescence. See page 7.

Cognition/cognitive: The act or faculty of knowing or perceiving. Pertaining to or having the power of cognition, knowing.

Contaminants: Substances foreign to a natural system or present at unnatural concentrations; unwanted substances that have entered the air, food, water or soil. Contaminants may be chemicals, living things (e.g., bacteria or viruses) or the products of radioactivity. Some contaminants are created by human (e.g., industrial) activities while others are the result of natural processes.

Cotinine: A major metabolite of nicotine and regarded as the best biomarker (in active smokers and in nonsmokers) of recent exposure to environmental tobacco smoke (ETS).

DDT: Dichloro-diphenyl-trichloroethane. A persistent insecticide used worldwide until it was banned in most countries in the 1970s.

DEET: N, N-diethyl-m-toluamide. Personal insect repellent for mosquito control.

Developmental toxicants: Agents that cause adverse effects to the developing embryo, fetus or child. These effects usually result from maternal exposure to toxic chemicals before or during pregnancy, but can also result from paternal exposures. Early postnatal contact with developmental toxicants can also affect normal development.

Dioxins and furans: Among the most toxic chemicals known. Numerous types in each group, these chemicals are by-products of combustion, degradation of other chemicals and some industrial processes.

EBDCs: Ethylenebisdithiocarbamates are a group of non-systemic (surface acting) fungicides.

E-coli: Bacterial species (numerous strains exist) found in human and animal intestines.

Endocrine disruptors (also called hormonally active agents): Synthetic chemicals and natural plant compounds (and some pharmaceutical drugs) that may affect the functioning of the endocrine system (the communication system of glands, hormones and cellular receptors that control the body's internal functions). Many of these substances have been associated with developmental, reproductive and other health problems in wildlife and laboratory animals. There is concern that they could affect humans in similar ways.

Epidemiology: The study of the frequency, distribution and determinants of disease risk in human populations. Also the field of medicine concerned with the determination of the specific causes of localized outbreaks of infection (such as hepatitis), toxic disorders (such as lead poisoning), or any other disease of known cause.

ETS: Environmental Tobacco Smoke (second-hand smoke). The smoke released by idling lit tobacco products (cigarettes, cigars, pipes), and smoke exhaled by smokers after puffs. ETS contains hundreds of toxic chemicals, including over 40 cancer-causing chemicals.

Fish advisories: Public notices issued by local, provincial or national environmental or health agencies that warn about the need to limit or avoid consumption of certain fresh or salt water species, generally those that are predator species at the top of aquatic food chains. Most advisories are directed at pregnant or nursing women and young children, as well as women of child-bearing age.

Food chain: The food chain is a series of organisms, each consuming the organism below them in the chain, and being consumed by the next higher organism. Green (chlorophyll-containing) plants are at the bottom of every food chain; green plants convert sunlight into food energy for the rest of the organisms in the food chain. Because organisms at each level of the food chain use up most of the energy they consume, energy is lost at each level, limiting the length of the chain. The extra buoyancy of water allows for some of this energy to be conserved, thus allowing more levels in aquatic food chains. With more levels, contaminants can continue to concentrate (biomagnify). Hence the greater contamination of fish by methylmercury and the need for fish advisories. In nature, food chains usually combine to form food webs.

Food web: Found in any natural community, a food web contains many interlinked food chains. Humans are at the highest level of many food webs and their breastfed infants are higher still.

Incidence: The number of new cases of a disease occurring in a defined population within a specified period of time. Frequently presented as the number of new cases per 1,000 or 100,000 people per year.

Inorganic chemicals: Chemicals that do not contain carbon. Examples include metals like lead, mercury and cadmium, as well as salt and asbestos.

Intrauterine growth restriction (IUGR): A low birth weight infant with a birth weight below the lowest decile for gestational age. See also: low birth weight.

Ionizing radiation: A physical agent — ions — released during the spontaneous radioactive decay into small elements of radionuclides emitted during medical X-rays, the regular operation of nuclear power plants, and, in potentially massive amounts, as a result of nuclear accidents and the testing or use of atomic weapons.

Latency period: The period of time between exposure to a disease-causing agent and the first appearance of signs or symptoms of the disease.

Learning disabilities: Refers to a number of disorders that may affect the acquisition, retention, understanding or use of verbal or nonverbal information. These disorders affect learning in individuals who otherwise demonstrate at least average abilities essential for thinking and/or reasoning. Learning disabilities result from impairments in one or more processes related to perceiving, thinking, remembering or learning. They range in severity and may interfere with the acquisition and use of one or more of the following:

- oral language (e.g., listening, speaking and understanding);

- reading (e.g., decoding, phonetic knowledge, word recognition, comprehension);
- written language (e.g., spelling and written expression);
- mathematics (e.g., computation, problem solving).

Lipophilic/hydrophobic: Literally “fat-loving” or “water-averse.” Used to refer to substances that bind to fat molecules, and as a result often concentrate up the food chain and reach their highest levels in high fat foods, such as whole milk, cheese, fatty meats and oily fish.

Lipophobic/hydrophilic: Literally “fat-averse” or “water-loving.” Used to refer to substances that stay in solution in water and tend not to bind to either particles or fatty molecules.

Low birth weight: An infant that weighs less than 2,500 grams at birth. See also: IUGR.

Melanoma: Dangerous type of skin cancer.

Mental retardation: A disability characterized by significant limitations both in intellectual functioning and adaptive behaviour as expressed in conceptual, social, and practical adaptive skills. This disability originates before age 18 and is often more simply defined in terms of an individual having an IQ <70, but other criteria, beyond intellectual capacity, are generally considered.

The term “mental retardation” is generally viewed as objectionable in Canada. It is still used in older texts and in the current US literature. Because most of the references used in this Primer are taken from the US literature, the authors have used the term mental retardation so as not to misinterpret others’ reports. The preferred term in Canada is “intellectual disability.”

Metabolism: Total biochemical and energy processes that maintain life in organisms. Includes the conversion of one compound into another, the building up of larger molecules from smaller ones (anabolism), and the breakdown of compounds (catabolism) to release life-sustaining energy.

Methylmercury: Organic mercury compound formed by moulds and bacteria.

Neurotoxicants: A biological or chemical substance or agent that has an adverse effect on the structure or function of the central (including the brain) and/or peripheral nervous system. Toxicants that exert adverse effects on the developing brain or nervous system are called developmental neurotoxicants.

Organic chemicals: Chemicals containing carbon, usually combined with hydrogen and other elements, such as oxygen, nitrogen, or chlorine. Vegetable matter, petroleum and plastics are examples of organic materials, as are PCBs, DDT, and polyvinyl chloride.

Organochlorine compounds: A wide variety of synthetic organic compounds containing chlorine particularly notable for their persistence and stability. Some have been deliberately manufactured (e.g., several pesticides, including DDT, PCBs, though these are now banned or greatly restricted in use). Others are breakdown or reaction products, such as dioxins formed from incineration of products like PVC plastic. All are now widely distributed in the environment.

Organophosphates: Organic chemicals containing phosphorous, some of which are involved in cellular energy metabolism. Nerve gas (no longer manufactured) and organophosphate pesticides (still used but regulatory restrictions increasing) are based on the same chemistry and can interfere with important aspects of cellular energy metabolism in nervous system tissues, including in the brain.

PAHs: Polycyclic aromatic hydrocarbons include a large number of toxic chemicals, including several cancer-causing chemicals, created from the combustion of organic material, including fossil fuels. Exposure occurs via air pollution, but most PAHs are adhered to fine particulate matter; unlike VOCs, they are not very volatile.

PBDEs: Polybrominated diphenyl ethers. Widely used in consumer products as flame retardants.

PCBs: Polychlorinated biphenyls. Manufactured for transformer cooling oil and numerous other applications. No longer manufactured and use is restricted because of carcinogenic properties and persistence in the environment.

Persistence: Refers to chemicals or agents that remain a long time in the environment. For example, lead and mercury persist in the environment because they are stable elements; PCBs are chemically stable compounds that resist degradation. Mercury and PCBs cycle between environmental media, including air, water and food chains.

Phthalates: Compounds used to make some plastics soft and flexible. A plasticizer compound.

PMRA: Pest Management Regulatory Agency. Agency within Health Canada responsible for registering pesticides for use in Canada.

Polychlorinated naphthalenes: Chemicals used for cable insulation. Persistent and bioaccumulative and recommended by the European Commission (in 2004) as candidates for addition to the Stockholm Convention on Persistent Organic Pollutants.

POPs: Persistent organic pollutants. Chlorinated organic compounds characterized by resistance to natural breakdown, consequent persistence and bioaccumulation in the environment. Also often highly toxic.

Prevalence: The number of events (e.g., instances of a given disease or other condition in a given population at a designated time). Note, this is a number not a rate. See also Rate and Incidence.

Rate: In epidemiology, an expression of the frequency with which a certain circumstance (e.g., asthma incidence in children) occurs in relation to a certain period of time, a fixed population, or some other fixed standard. The use of rates, rather than raw numbers, is essential for comparison of experience between populations at different times or different places.

Reproductive toxicants: Chemical substances or agents that cause adverse effects on the male and female reproductive systems. Toxicity may be expressed as alterations of sexual behaviour, decreases in fertility, loss of the fetus or abnormal fetal genital development during pregnancy. Interference with sexual function may occur from puberty through adulthood.

SCCPs: Short-chained chlorinated paraffins. Chemicals used in metal working and leather finishing, and recommended by the European Commission (in 2004) as candidates for addition to the Stockholm Convention on Persistent Organic Pollutants.

SIDS: Sudden Infant Death Syndrome (also called Crib Death). Refers to the sudden and unexpected death of apparently healthy babies. Exact cause is unknown, but risk factors include exposure to environmental tobacco smoke (during pregnancy or after birth) and sleeping on the stomach.

Teratogen: Any substance or factor that can cause structural or functional malformations of an embryo or fetus, which are also known as congenital malformations or birth defects. Known teratogens include certain chemicals, viruses and ionizing radiation.

Toxic substances: Substances capable of causing harm to humans, animals or other living things. In common usage, the term refers to chemical substances that are capable of causing harm at very low levels of exposure, while providing little or no benefit.

US EPA: United States Environmental Protection Agency.

US FDA: United States Food and Drug Administration.

UV Radiation: Ultraviolet radiation emitted by the sun or used industrially (e.g., for sterilization purposes).

VOCs: Volatile organic compounds. Organic gases and vapours in the air. Examples of sources include the burning of fuels, dry cleaning operations, and the evaporation of organic compounds from solvents, paints, or other coatings.

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