Environmental Hazards: Protecting Children

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by the
Canadian Institute of Child Health

The Canadian Institute of Child Health is a national non-profit organization dedicated to improving the overall health and well- being of children in Canada. The Institute relies entirely on grants, donations and revenue from publications and resources to support and advance its work.

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Environmental Contaminants: Children Need Special Protection

Why Focus on Children?

Children are more susceptible than adults to the action of environmental toxicants. Their tissues and organs are immature and not fully developed, they have behaviours that put them at risk for increased contact with environmental contaminants and their pathways for absorption and excretion of substances taken into the body are different.

- Body systems and organs are not fully developed (Developmental Differences)
- Certain behaviours increase their contact with chemical hazards (Behavioural Differences)
- Pathways for metabolizing chemicals are different (Physiological Differences)
- After exposure to contaminants, children potentially have many more years of life and effects from chemical hazards may not be seen for decades.

I - Developmental Differences

A child's body is constantly growing and the developing organs are more sensitive to environmental toxicants. Tissues that are under development are more susceptible to interference because they rely on chemical messengers for growth. Organ development begins during the fetal period and continues into adolescence and the growth of the organs is not linear, it occurs in spurts. If any toxic exposure occurs during these critical growth stages, the system can sustain permanent damage.

- The human embryo is most sensitive to developmental damage in the first weeks of pregnancy, when a woman may not yet recognize her pregnancy.[1]

Exposure before Conception

Normal fetal development requires that a healthy egg be fertilized by a healthy sperm. Changes to either the egg or the sperm due to exposures to chemicals in the environment can compromise development.[1]

- There are several toxicants for which exposure may produce infertility or low quality sperm.[1]
- A woman's full complement of ova are developed during the fetal stage. Abnormalities in the ova can result if the fetus is exposed to certain chemicals.

Exposure in utero

The fetus can be exposed to certain chemicals because the placenta does not block their passage from the maternal circulation to the fetal circulation. The sensitivity of the fetus or the embryo to environmental toxicants depends on the stage of development at which exposure occurs.

- From the time of conception, fetal development is strongly regulated by hormonal action. Hormones such as thyroid and estrogen strongly influence brain development and lung maturation. Contaminants such as pesticides and PCBs, may disrupt normal hormone function with potentially dangerous results.
- The offspring of women exposed to a synthetic estrogen, DES, during pregnancy developed serious reproductive consequences such as vaginal cancer in adolescence.[2]
- Starting at 6 weeks of gestation, the level of testosterone determines the masculinization of the fetus.
- The immune system of the fetus is immature and is unable to react to a foreign substance by producing antibodies.
- Environmental contaminants such as mercury and lead can interrupt neurodevelopmental processes during critical periods of develop-

ment, resulting in changes to sensory, motor and cognitive function.[1]

- The number of neurons and interconnections in the brain of a growing fetus increase dramatically during gestation. An important feature of neuronal tissue growth is its finite nature; certain critical periods missed or critical cell system loss will not be replaced.[3]
- The alveoli of the lungs develop in utero. Damage to these may interfere with lung function later in life.[3]

From Birth to Adolescence

When a baby is born, the 'framework' for the structures controlling respiration, reflexes, heartbeat and bone growth are complete although the development of the organs within these frameworks continues for an additional 10 - 15 years with each organ developing at a different rate.

II - Behavioural Differences

Although children live in the same environment as adults, all children from newborns to adolescents may experience greater exposures to environmental toxicants than adults because:

- **Dependency on adults:** They are least able to protect themselves, and are dependent on adults for their protection. The newborn and young child are especially dependent on adults for risk management decisions and housing decisions.
- **Closer to floor:** The infant and toddler are shorter in stature and are frequently placed on the floor, grass, and ground where they are exposed to dust, pesticides and other contaminants that accumulate close to the ground and where ventilation is poorest. Most measurements of air quality are taken at 6 feet above the ground where adults breathe. These measurements may not reflect what the child is exposed to.[3]
- **Hand to mouth activity:** Young infants use all their senses when exploring. They look at, listen to, touch and taste everything. When young children crawl on the ground, splash, dig, or take food into unclean areas, they come in contact with potential environmental hazards such as contaminated soil, lead paint, household chemicals and pesticides on lawns and gardens. The increasing mobility of older children combined with their desire to explore and take risks often means increasing exposure to serious environmental contaminants.
- **Eating habits:** Because children eat proportionately more fruit and drink more fluids per pound of body weight than adults, food becomes a significant exposure pathway. For example, in proportion to their body weights, children eat several times more apples, bananas, grapes, pears and carrots than adults do.[4] Concern about the susceptibility of infants and children to dietary pesticides was examined by the 1993 National Research Council report Pesticides in the Diets of Infants and Children.[4]
- **Time indoors:** It is estimated that children in Canada spend up to 90% of their time indoors. For this reason infants and toddlers are more prone to the hazards of environmental tobacco smoke, pesticide residues, nitrous dioxide from gas heaters and cookers, formaldehyde (released from furniture and building materials) and various allergens including fungi and moulds that can accumulate in a house.
- **Play:** Contaminants are also found in children's recreational spaces. Children are exposed to chlorinated compounds at swimming pools, nitrogen oxides at ice rinks and toxic gases from materials in art classes. Outdoor play provides exposure to a variety of contaminants such as lead paint on playground equipment, pesticide residues, ozone, sulphur dioxide, benzene and other vehicle emissions.
- **Poverty:** The exposure to environmental toxicants is compounded by social factors such as poverty. Living in poorer quality houses, near hazardous sites, in former industrial properties and in overcrowded circumstances, often without recreational space, can have an impact on their health.[5] For example, lead is often found in low-income housing because it tends to be older and poorly maintained. Poor children are

particularly at risk to environmental toxicants because they tend to live in communities that are downhill, downwind or downstream from pollution hazards.

- **Aboriginal children:** Because of where they live and what they eat, Aboriginal children are more highly exposed to environmental contaminants than the mainstream Canadian population.[6,7] Urban Aboriginals may live in poor areas near polluting industry or high traffic, while children living on reserves who eat traditional foods may be exposed to contaminants that accumulate in the food chain.[7]

III - Physiological Differences

Physiology refers to the processes which govern absorption, digestion, metabolism and excretion of substances in the body. Children's physiology differs from that of adults, as do their reactions to toxicant exposure.

Substances enter the body by absorption through barriers such as the skin and the gastrointestinal and respiratory tracts. In children these barriers are not as well developed as in adults and thus allow the passage of more toxicants. Likewise, the distribution, metabolism and excretion of theses compounds is managed differently in a child's body.

In some cases children with genetic abnormalities have a lower capacity to convert and excrete toxicants.

It is important to note that the immature physiology may have a protective effect or a harmful effect depending on the chemical compound involved.

Absorption

- The small intestine in the newborn can have an increased absorption of some substances. In the case of calcium, this increased absorption is beneficial for growth. However, lead, which is a dangerous neurotoxicant that can impair intellectual ability, is also absorbed at a higher rate. Children will absorb 50% to 90% of ingested lead, whereas an adult will absorb 10% of ingested lead.[8]
- The skin of a newborn is a particularly absorptive. For example, at one time babies were bathed in a disinfectant solution called hexachlorophene following birth until it was realized that there was a possible risk of mental impairment as a result of neurotoxicity.[3]
- The blood brain barrier which in adults and older children prevents harmful substances from passing from the blood to brain tissue is incomplete in infancy. This can allow neurotoxic chemicals like lead to reach the brain and cause damage.

Filtration

- The kidneys filter substances from the blood and excrete them into the urine. Infant systems are not fully able to filter substances until about 5 months of age. Young children can accumulate chemicals more easily than adults because their kidneys are less capable of getting rid of them.
- Infants have a high body water content. The increased water intake needed to maintain this high body water content means that they may take in higher doses of water borne contaminants per body weight.

Metabolism

- Chemicals that are absorbed into the body are transferred to the blood for metabolism in the liver and other tissues. Once metabolized, the breakdown products are then transported to the kidneys to be excreted. In the infant these processes are reduced, resulting in longer retention of the substance in the body. Also, some partly metabolized chemicals are more toxic than the original substance.

What Can be Done to Protect Children?

Education

Educating parents and caregivers on the unique vulnerability of children to environmental contaminants can influence both exposure and treatment. Parents and children, health care providers, policy makers, teachers, community leaders, - all have a role to play in preventing exposure to environmental contaminants.

Build expertise in children's environmental health issues through education of:

- Parent's and the general public by increasing their understanding of the problem;
- children through schools, and their families by developing their environmental consciousness;
- biomedical scientists by encouraging research in this area;
- physicians, nurses and public health professionals by incorporating environmental problems into history-taking, diagnosis, treatment, referral and prevention; and
- educators by training in the topic of environmental contaminants.

Policy Making

Understanding the differences in the effects of environmental contaminants on children must become an important part of environmental policy making. Regulatory policies have not taken the characteristics of children into consideration.[9]

It is important to:

- promote pesticide regulation with the dietary characteristics of children in mind;
- ensure drinking water in schools is safe for children
- ensure that tests for safety of chemicals reflect children's unique characteristics
- use toys and arts and craft supplies which are designated to be safe for children
- set standards and testing protocol which take the enhanced sensitivity of children into account.

Facilitate the development of a multidisciplinary Child Health and the Environment Working Group to:

- determine existing body of knowledge
- ensure current knowledge is widely disseminated
- determine the key information gaps
- identify opportunities for coordination with other agencies.

Research

Further research into the association between toxicants and child health is essential, especially addressing the long-term and developmental effects, both of which are not sufficiently clear.

Establish and maintain a system of monitoring the levels of key contaminants that are released into the environment and the levels at which they are found in the body, as well as their possible health effects in children.

Identify biomarkers that can be used to assess the level of impact environmental contaminants are having on the body.

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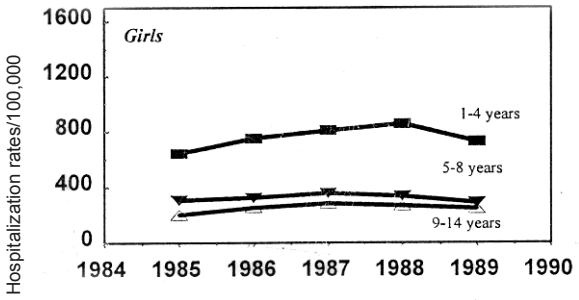
Childhood Asthma and Air Quality

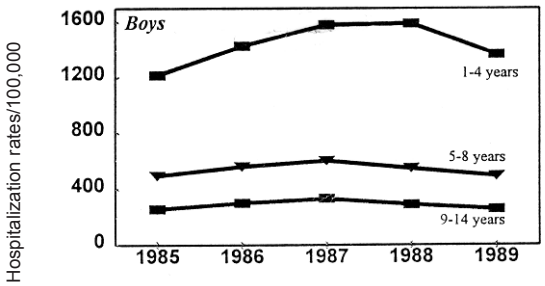
What is Asthma?

- Asthma is a chronic respiratory disease characterized by a sudden, intermittent narrowing of the airways, causing difficulties in breathing, chest constriction and coughing.
- Inflammation of the airways, and a hyper responsiveness to a variety of allergens and chemical compounds, are characteristics of the disease.

How Common is Asthma?

- Asthma is now the most frequent chronic illness of childhood.
- Many countries including Canada noted an increase in childhood asthma over the last two decades. [1]
- In 1989, hospitalization rates for eight year old children varied from 3 percent in British Columbia and Quebec to 7 percent in the Maritimes.[2]
- Hospitalization rates also vary with child age and sex:





What Causes Asthma?

- A single cause of asthma is not known but there are genetic and environmental factors that can contribute to it. Contaminants, both indoors and out, may contribute to the development of asthma. In addition, exposure to pollutant 'triggers' (in indoor and outdoor air) can aggravate asthma.

Indoor Air Contaminants

Canadian children spend as much as 90 percent of their time indoors. Tightly sealed houses become traps for airborne contaminants which may contribute to the development and aggravation of asthma. These contaminants can be divided into two groups:

- Biological contaminants (dust mites, animal dander, cockroaches, molds and perhaps bacteria)
- Chemical contaminants (environmental tobacco smoke: ETS and perhaps gases from cooking and heating appliances, building materials such as insulation, carpets and draperies)

Outdoor Air Contaminants

- An increased prevalence of asthma may be associated with exposure to ground level ozone and fine particles. [3]

What are the Consequences of Asthma?

- Asthmatic children are more sensitive to a variety of biological allergens, such as those derived from pets, and from chemical pollutants, such as sulphur dioxide, ETS or particulates.
- Asthma is the leading cause of school absenteeism. In the U.S., studies suggest children under 18 years visit a physician for an asthma-related problems five times each year.

Why Focus on Children?

- Asthma is the most frequent chronic illness during childhood.
- There are suggestions that long-term exposure to air pollutants ultimately has a negative effect on lung function in asthmatic children.
- Asthma hinders the child's ability to play which may impair development.

What Can be Done?

Research Needs

- More needs to be known about the etiology of childhood asthma and its relationship to air quality.
- The interaction of both biological and chemical contaminants on childhood asthma needs to be studied further.
- Surveillance of individuals and groups who are at risk of exposure needs to be put in place.
- Studies of the immune system and its role in asthma are required.

Education of Families

To prevent asthma from developing:

- Parents can provide a safe environment that is free of tobacco smoke, dust mites, furry and feathered pets, all of which are agents that can provoke asthma.

Indoor

- Never smoke in the house.
- Maintain humidity levels of 30-50 percent to inhibit growth of biological agent 'triggers'.
- Inhibit microorganism growth by eliminating standing water or high humidity areas in the home.
- Highest concentrations of dust mites are found in beds, bedding, carpets and upholstery. Seal beds and box springs in impermiable plastic, wash blankets and pillows in hot water.
- Keep pets outside as much as possible and never allow them in the child's bedroom.
- Groom pets weekly.
- Limit the amount of carpeting in your home.

Education of Health Care Professionals

- Professionals need to learn about the unique vulnerability of children to environmental air pollution.
- Incorporate pediatric environmental health issues into all training programs.

Government

- Make outdoor air pollutant standards more stringent to protect asthmatic children.

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Air Pollutants and Respiratory Health Effects

What is Air Pollution?

- Air pollution is a complex mixture of compounds that can vary depending on local sources and winds (which bring pollution from long distances). Major air pollutants include sulphur dioxide, particulate matter, nitrogen oxides, acid aerosols and ground level ozone.

Common Pollutants and their Sources

1. Particles

- Airborne particles vary in size — the smaller the particle the more serious the health risk.
- Particles 10 micrograms and larger are removed in the upper respiratory system, but particles 2.5 micrograms and smaller can penetrate deep into the alveoli and cause damage to the lung tissue.
- Particles are released from many sources including diesel and gas engines, mining and construction operations, fireplaces and furnaces.

2. Ground Level Ozone

- Ground level ozone is a gas formed when sunlight and warm temperatures interact with oxides of nitrogen and volatile organic compounds (VOCs).
- Levels are highest during the daytime and during summer months, downwind from congested roads and industrial smoke stacks.
- Topographic features may prevent the inflow of clean air, trapping pollution.
- Sources of VOCs and nitrogen emissions include road vehicles, smelters/refiners, dry cleaning industry, power plants and pollution from the United States.

3. Acid Aerosols

- These are acid particles which are generated when sulphur dioxide and other gases react with water.
- Much of the acid aerosols affecting southern Ontario come from the United States. Ontario's emissions affect the air quality of the Eastern States and Provinces.

Why Focus on Children?

- Young children breathe more rapidly and inhale more pollutants per kilogram of body weight.
- Children spend more time engaged in vigorous outdoor activities compared to adults.
- Infants exposed to air pollutants can have significant changes in lung function, but these are often transient.
- Infants have fewer alveoli than adults. Contaminants may impair development of alveoli.
- Children have a higher prevalence of asthma than adults. Asthmatic children appear to be more sensitive to air pollutants such as sulfur dioxide, particles and ozone.

Respiratory Health Effects

- There is some evidence that long-term exposure to air pollution reduces the growth, development and function of the lungs. [1]
- Strong associations have been found between air pollution and respiratory disease in children.
- Exercise, duration of pollution exposure and the combination of pollutants inhaled have additive effects.
- The chronic respiratory health effects in children associated with air pollution are unclear. There are confounding factors such as smoking, prematurity, low birth weight, race, poverty and gender.
- There could be a large potential burden of illness attributable to air pollution. [2]

1. Upper Respiratory Diseases

- Ozone has been associated with airway inflammation, coughing, chest tightness, pain

on inspiration and upper respiratory tract irritation.

2. Lower Respiratory Diseases

- Lower respiratory symptoms, such as shortness of breath, wheezing and chest tightness, are strongly associated with increases in particles and oxidizing gases, such as ozone and nitrous oxide. [3]

3. Lung Function

- Many studies found a decline in lung function of children after exposure to ozone.
- A decline in lung function is found in children who live close to high traffic areas. In children, acute decline in lung function as a result of particles and/or sulfur dioxide exposure can persist for several weeks.
- The effect of pollution on lung function is smaller than the effect of maternal smoking.

4. Long Term Effects

- Decreased lung function in the first year of life predicts an increase in lower respiratory illness later in life.
- In general, there is a decrease in pulmonary function found in those who live in places with high sulfur dioxide or particle levels.

5. Hospital Admissions

- Children under two years are three times more likely to be hospitalized than older children and adults.[4]
- Asthmatic children have a higher hospitalization rate than non-asthmatic children.

What Can be Done?

1. Research

- Governments need to expand their monitoring programs of key air pollutants such as airborne particles and acid aerosols.
- Epidemiologic studies to accurately measure children's exposure to pollutants are needed.

2. Education of Families

- Encourage decreased reliance on automobiles, which are prime contributors of particle emissions and ground level ozone. Maintain vehicles regularly and participate in car emissions testing programs.
- When ground level ozone is elevated, ensure that children reduce outdoor activities.

3. Education of Health Providers

- Health professionals should become more informed about air pollution in the community.
- Schools and recreational agencies should be provided with information on the health implications of smog alerts.
- Parents should be made aware of the daily variations in ground level ozone.

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Hormones Disruptors

What are Hormone Disruptors?

Hormone disruptors are substances that enter the body and adversely affect the way body systems communicate with each other. Hormone disruptors can cause problems if they:

- block natural hormones from binding with their cell receptors,
- mimic natural hormones and bind to the receptor,
- alter the production and availability of natural hormones and receptors,
- affect transport of hormones in the blood and across membranes.

Hormone disruptors interfere primarily with three hormonal systems: estrogen (the female hormone), androgen (the male hormone), and thyroid. These three hormones play a critical role in the development and function of the brain, the immune system, and the sexual and reproductive system. These hormones are very active in the fetus and infant, making the fetus and infant sensitive to the influence of hormone disruptors. Hormone disruptors can be synthetic (man-made), but also appear in high levels in certain plants (phytoestrogens). Whether there is a difference in effect between these groups in not known.

Why Focus on Children?

In a developing organism, such as a fetus or young child, the specialization of the different cell types (differentiation) is strongly dependent on hormonal action. Exposure to these hormone disruptors during sensitive developmental periods may put children at greater risk of chronic effects which are noted only after a long latency period.[1]

- Women may accumulate fat soluble chemicals during their lifetime. Increased energy expenditure during and after pregnancy can release these fat soluble compounds, exposing the fetus and infant.
- Even low-level exposure to hormone disruptors (such as dioxins) before and during pregnancy, has long-lasting effects on the offspring's reproductive success. It may interfere with the development of the second generation after exposure. [2]

What are the Health Effects?

Evidence from Wildlife Studies

Exposure to hormone-disrupting contaminants in the environment has been associated with a variety of abnormalities in many different animals:

- abnormal thyroid function (birds, fish)
- decreased fertility (birds, fish, shellfish, mammals)
- decreased hatching success (birds, fish, turtles)
- gross birth deformities (birds)
- metabolic abnormalities
- behavioural abnormalities (birds)
- feminization of males (birds, alligators, fish)
- masculinization of females (birds)
- compromised immune systems and cancers (fish, porpoises, seals)

Evidence from Human Studies

There have been cases of very high levels of hormone disruptor contamination in humans from environmental disasters, producing some of the following outcomes:

- reproductive and developmental abnormalities such as developmental delays, speech problems, behavioural difficulties and impaired intellectual development. [3,4]
- negative pregnancy outcomes, varying from an increased abortion rate to low birth weight.

While these are cases of extreme contamination, scientists are also concerned with low level exposure, the effects of which are more difficult to identify. Several prospective studies of women

who ate fish or game contaminated with PCBs, heavy metals, dioxins and/or pesticides revealed that their children tended to have developmental delays including impaired cognitive function. [5] IQ, behavioural and learning effects were still noticeable at 10 years of age. [6] Other studies reveal small transient abnormalities in the children. [3,7]

Other effects believed to be linked to hormone disrupting contaminants include:

- testicular cancer
- undescended testes and hypospadias
- decreased sperm count
- breast cancer
- infertility
- hearing loss in animals
- smaller stature

What Can be Done?

Research

Estimating the extent of human exposure to hormone disruptors in the environment is very difficult.

- Researchers need to examine exposures to all contaminants that impact hormonal activity, as well as study the contaminants in combinations, since the effects can be additive or even synergistic.
- Researchers need to consider the timing of exposure — in utero or post-natal, as well as the sources of exposure.
- The long-term effects of hormone disruptors on the nervous, immune and reproductive systems should be studied.
- Multi-disciplinary research should look at contaminants with hormone-disrupting effects to better understand how they work.
- Substances that are suspected of having estrogenicity should be assessed for acute toxicity and long-term health effects, especially for a developing fetus.
- Similarities and differences between synthetic and plant-derived hormonal disruptors need to be investigated.

Education of Families

- As much as possible, children and pregnant women should be protected from exposure to hormone disruptors.
- Most of the pesticides with hormonal action, such as DDT, have been banned in Canada. However, if pesticides with known or suspected hormonal action have been used, stay out of the house or school during treatment.

Education of Health Care Professionals

- Professionals need to produce educational materials and support studies of nursing mothers to better assess the role of environmental estrogens in human reproductive health.

Hormone Disruptors and Exposure Routes

Type of Contaminant	Examples	Exposure Routes
Pesticides	DDT and its catabolite DDE Alachlor Atrazine Tocochlorophene Chlordane	Food Pets Recreational areas
Wood preservatives	Pentachlorophenol	Houses, daycare centres and schools
PCBs Dioxins	Co-planar PCBs TCDD and others	Insulators Pesticides Incinerator gases
Plasticisers/Surfactants	Phthalates Polycarbonates Styrenes	Plastic products
Myeoestrogens	Zearolenone	Produced by moulds
Phytoestrogens	Estrogens	Produced by plants like soya

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Pesticides and Children

What are Pesticides?

- Pesticides are products registered by the federal government to control pests such as insects (insecticides), weeds (herbicides), and rodents (rodenticides). Pesticides include not only man-made chemicals, but also naturally-occurring chemicals, biological materials and mechanical, electric or electronic devices.
- The first pesticides synthesized were chlorinated organic compounds such as DDT. Some of these chemicals were found to be environmentally persistent and had toxic effects in wildlife, and were subsequently banned. Newer classes of pesticides include organophosphates and carbamates. These act by interfering with the central nervous system of insects. Overexposure to these chemicals can cause adverse effects in humans.
- Some pesticides are selective and attack only the systems of the organism for which they are intended. For instance, many herbicides interfere with photosynthesis of plants, a process that does not occur in humans. However, other pesticides are not as selective and can be harmful to non-target organisms, including humans.
- Prior to registration, the federal government reviews acute, short-term and long-term toxicology studies and exposure data and conducts health risk assessments of individuals (including infants and children) who may be exposed to the pesticide.

Why Focus on Children?

- The susceptibility of infants and children to dietary pesticides was recently examined by a scientific committee of the U.S. National Research Council.[1] The committee identified age-related variations in susceptibility, toxicity and exposure to pesticides.
- Differences in toxicity between young and mature mammals are generally modest. The younger animal may be more or less susceptible to comparable levels of exposure of pesticides depending on the specific chemical involved. [1]

Children may be exposed to pesticides through various pathways:

- Children may have contact with these chemicals when they are used around the home for insect and rodent control, for weed control on lawns and gardens, and for disinfecting swimming pools. Children can accidentally ingest pesticides when they are improperly stored or discarded.
- Children can also be exposed to agricultural pesticide residues in their diet and drinking water, and to pesticides applied in recreational areas such as parks.
- Prenatal exposure to pesticides can occur in utero if the mother is exposed to pesticides.

Types of Pesticides

There are several classes of pesticides. They are categorized by the pest they are targeted to control. The most common classes, with some special concerns, are outlined in the following chart:

Classification of Pesticides			
CLASS	**TYPES OF CHEMICAL**	**SPECIAL CONCERNS**	**EXAMPLES**
Insecticides	• organophosphates • carbamates • dinitrophenols • inorganic compounds • botanicals • chlorinated hydrocarbons • synthetic pyrethroids	• acute toxicity • some compounds causes cholinesterase inhibition	• chlorpyrifos
Herbicides	• chlorophenoxys • bipyridiliums • dinitrophenols • thiocarbamates and dithiocarbamates • substituted ureas • triazines	• some chlorophenoxy compounds linked to carcinogenicity • some compounds exert developmental effects	• 2,4-D • bromoxynil
Fungicides	• dithiocarbamates • phthalimides • organotins • inorganic compounds	• some compounds exert developmental effects	• vinclozolin
Rodenticides	• various	• acute toxicity	• warfarin • bromethalin

(Health and Welfare Canada, 1984) [2]

Child Health Concerns from Exposure to Pesticides

Acute Toxicity

- Acute toxicity can arise from a single exposure to highly toxic pesticides, such as accidental ingestion of rodenticides.

Developmental Effects

- In animal studies, some pesticides, have been linked to decreased birth weight and increased incidence of malformations.

Neurotoxicity

- Young animals have been shown to be more sensitive to acute neurotoxic effects of some organophosphates due to their immature metabolism systems.
- In humans, significant brain development occurs until at least four to six years of age and therefore exposure during this time could alter the structure or function of the human nervous system

Immunotoxicity

- In laboratory animals, the developing immune system has been shown to be more susceptible than the immune system of the adult to 2,3,7,8-TCDD, a contaminant of 2,4,5-T (which is not registered for use in Canada).[1]

Hormone Disruption

- Some organochlorine chemicals may have antiandrogenic or estrogenic actions and can disturb the normal development in the young.[3]
- Sulfonamide-based herbicides can cause abnormalities of the thyroid function, which plays an important role in growth and development.[3]

Cancer

- As a function of age, various chemicals have been shown to either increase or decrease the susceptibility of young animals to carcinogenesis which may be a result of increased rates of cell proliferation in the young and differing metabolic capabilities. [1]
- Chlorophenoxy herbicides are of interest with

respect to children given the exposure potential from their use as lawn care chemicals. They have been linked to non-Hodgkins lymphoma in various epidemiological studies but the data are not sufficient to conclude a cause and effect relationship. [4]

What Can be Done?

Research Needs

- Refinement of protocols for toxicological studies to ensure that potential effects of pesticides on the developing fetus are fully explored (e.g., neurotoxicity, immunotoxicity, endocrine system).
- Research into the physiological and pharmacokinetic differences among infants, children, and adults.
- Updating of the food consumption patterns of infants and children.
- Adequate monitoring of the food supply, both imports and food grown in Canada.
- Refinement of approaches for assessing non-dietary exposures to pesticides (e.g., characterizing rate of transfer of pesticide residues to children from treated surfaces).
- Confirmation that government is adequately addressing special considerations of children when evaluating pesticides (e.g., incorporating an additional safety factor where merited).
- Research into Integrated Pest Management (IPM) approaches to pest control.
- Implementation of a national system for reporting pesticide poisoning incidents.
- Consideration of the recommendations of the NRC's Committee on Pesticides in the Diets of Infants and Children. [1]

Education Needs

- Encourage the use of non-pesticidal alternatives whenever possible.
- Educate consumers, pesticide vendors, and pesticide applicators on the importance of reading the label and following instructions to ensure that products are used and stored safely.
- Educate consumers on how to protect children. Examples include: i) strongly encouraging that all fruits and vegetables are washed and peeled ii) stressing the importance of properly storing pesticides, and iii) placing rodenticides in tamper-proof bait stations if used in areas that are accessible to children.

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Childhood Cancers

What is Cancer?

- Cancer is defined as growth of tissue resulting from a continuous proliferation of abnormal cells. These cells have the ability to invade and destroy other tissues.
- Cancer may arise from any type of cell; therefore, cancer is not a single disease, but a number of diseases classified according to the tissue and type of cell of origin.
- Genetic factors are known to play a role in childhood cancer. Environmental factors can also play an important role in the development of cancer, either alone, or in conjunction with genetic factors at any of the following steps toward cancer development.

The Initiation Step

- During this step the DNA in the cell nucleus is damaged and can transform a normal cell into a pre-cancerous cell. Damage of the DNA can be caused by such things as ionizing radiation, alkylating agents (such as drugs) or by viruses. Once the DNA is damaged, the cell will either start to grow immediately or remain dormant for decades.

The Promotion Step

- During this phase, cell growth will be enhanced. Increased growth of a cancer cell can be influenced by hormonal disruptors, such as PCBs or dioxins, pesticides such as DDT, lindane and toxaphene or metals such as lead.

The Progression Step

- The spreading of cancerous cells to other parts of the body is called progression. In this stage, the immune system will attempt to fight the spread of cancer. Compounds which are immunosuppressants, such as metals, hormonal disruptors, and environmental tobacco smoke may enhance the spreading of cancerous cells.

Why Focus on Children?

Developing tissues can be vulnerable to damage. Cell growth and migration, both prenatally and postnatally, may be disrupted as a result of exposure to carcinogens.

- Studies in animals have demonstrated that the age of initial exposure to a chemical carcinogen has a direct bearing on the carcinogenic response; a similar association has been shown with humans.[1] The best known case is the observation of vaginal cancer in young women whose mothers took diethylstilboestrol (DES) during pregnancy.
- In children, damage done by exposure to radiation is not reversible as it is in adults. Ionizing radiation may have a profound effect on the developing nervous system. [2]

How Common is Cancer?

While cancer in children is rare, accounting for approximately 200 deaths in Canada annually, it is the most common cause of death after injuries.[3] Most childhood cancers now have a relatively good prognosis and survival into adulthood is common.

- While the death rate from childhood cancers has decreased over the last decade, the incidence increased from 1965 to 1988. Part of the mortality decrease may be due to improved diagnostic technology. It is thought that environmental factors may be contributing to the increase in incidence.

- Cancer incidence is highest in the 0 - 4 years age group. The greatest diversity of cancer types is seen in infants less than one year old.[4] The most common childhood cancer is leukemia, accounting for an estimated 32 percent of new cancer cases. Cancers of the brain and spinal cord are the second most common, constituting approximately 21 percent of new cases, while lymphomas accounted for almost 12 percent.[3]

Leukaemia

- Leukaemia is the most common type of childhood cancer and is the most extensively studied.
- Leukaemia is a cancer of the blood and the blood-forming tissues. It is characterized by overproduction of immature atypical leucocytes in the bone marrow, spleen, and/or lymph glands.

What Causes Childhood Cancer?

- The causes of cancer are unclear. However, a number of risk factors have been suggested. Chemical and infectious agents, genetic and immunological factors can contribute to cell damage.
- These factors can exert their influence at different stages of development (before conception, during pregnancy and after birth).

Factors which may increase the risk of childhood cancer include exposure to:

Ionizing Radiation and X rays

- Therapeutic radiation of cancer has been shown to increase the risk of secondary leukaemia. In a study comparing twins that had received pre-natal x-rays versus twins who had not been x-rayed, those exposed to radiation had twice the risk of leukaemia as the non-exposed twins.[5] The link between fallout from nuclear weapons tests and leukaemia is still controversial.[6]
- Some studies have suggested that living near a nuclear facility has been linked to clusters of childhood leukaemia. However, other studies show no link. Parental employment at a nuclear facility was also linked to increases in childhood leukaemia rates, while other studies did not confirm these associations.

Radon

- Radon, a radioactive decay product of radium, has been suspected in development of childhood leukaemia. While there has been a near linear relationship shown between radon exposure and childhood leukaemia, more research is needed.

Non-Ionizing Radiation (EMF)

- The role of electromagnetic fields generated by power lines and electrical appliances in the development of cancer is controversial. Some studies have suggested that the exposure of children to electromagnetic fields was linked to leukaemia, although the latest review reports no conclusive evidence. The measurements of exposure are difficult and the findings are controversial.[6]

Toxic Waste

- A cluster of childhood leukaemia cases was observed in a population near a toxic waste site. While some researchers related this to contaminated well water, other studies did not.[7] The contamination of the town drinking water with polycyclic aromatics, such as the carcinogen benzo(a)pyrene, as well as large quantities of arsenic and chromium, was thought to have happened between 1920 and 1930 from a nearby chemical plant.

Pesticides

Many pesticides are carcinogenic in laboratory animals. Human data, much of it from studies of farmers, indicate that exposure to a variety of pesticides, such as organochlorines and organophosphates may be linked to leukaemia.

- Children living on farms are exposed to pesticides by playing in fields or by contact with parents clothing. Maternal employment in agriculture may produce moderate increases in cancer rates.
- Occupational exposure to pesticides or household use of pesticides may be associated with childhood leukaemia.

Other Possible Factors for Childhood Cancers

- **Parental smoking.** According to a recent study, the risk of childhood leukaemia may increase when both parents smoke, although this finding is still controversial.
- **Drug exposure**, either prenatally or during childhood.

Childhood Exposure Leading to Adult Cancer

- **Sunburns.** The number of blistering sunburns experienced before 20 years of age, especially in fair-skinned children, is a key determinant of melanoma later in life.[8]

What Can be Done?

Research

- There are few well established environmental causes of childhood cancer and the evidence concerning risk factors such as electromagnetic fields, pesticides and radon is not conclusive at this time. Continued research is essential and better quantification of risk is needed.
- Other risk factors, such as income, education, low birth weight, diet, smoking and certain occupational exposures have been suggested and more research is needed to assess the contribution of genetic and environmental factors.
- Age-specific trends in cancer incidence should be examined to understand the contributions of genetic and environmental factors.

Education of Professionals

- Health care providers should counsel parents and prospective parents to reduce their own exposure and the exposure of their children to environmental contaminants.
- Parents should be encouraged to stop smoking.
- Health care providers need to be aware of the risk of exposure to radiation, industrial chemicals, pesticides and electromagnetic fields

Education of Families

- Minimize exposure of children to direct sunlight and use sunscreen.
- Avoid using tobacco.
- Consume alcohol in moderation.
- Eat food low in animal fat with more fruits and vegetables.

Cancer Types Potentially Linked to Exposure

EXPOSURE TO	DAMAGE DONE TO	THOSE EXPOSED	PLACE OF EXPOSURE	CANCER TYPE SUSPECTED
Radiation - X-Rays - Radioactive compounds	Initiation	Paternal Maternal Child	Hospitals Home Nuclear reactors	leukaemia, thyroid, brain, breast[a], skin[a], melanoma[a], soft tissue sarcoma[a], osteosarcoma
Electromagnetic fields	Cell growth stimulation	Paternal Maternal Child	Home School Work	leukaemia[b], brain[b], lymphoma[b], soft tissue sarcoma[b]
Pesticides	Initiation Promotion Progression	Paternal Maternal Child	Agricultural industries Home School	leukaemia, brain cancer, neuroblastoma, Ewing sarcoma, Wilms tumor[b], lymphoma[b]
Drugs - Diethylstilboestrol - Alkylating agents - Chloramphenicol - Immunosuppressive therapy	Initiation Promotion Progression	Maternal Child		vagina[a], neuroblastoma[b], soft tissue sarcoma[b], leukaemia[b], osteosarcoma[b], Non-Hodgkins lymphoma, Hodgkin's disease
Environmental Tobacco Smoke	Initiation Promotion Progression	Paternal Maternal Child	Home Daycare	leukaemia, lymphoma[c]
Epstein-Barr Virus	Initiation	Child		Burkitts lymphoma

[a] Usually develops in adulthood
[b] Evidence to date is inconsistent or preliminary
[c] Cigarette smoking is unequivocally linked to lung cancer. The evidence to date for childhood passive smoking as a casual agent of subsequent lung cancer in adulthood is inconclusive.

adapted from Zahm 1995 [6]

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Breastfeeding : Safe and Best

Why Focus on Breastfeeding?

Breastfeeding is widely accepted as the optimum method of infant feeding for the first year of life or more. Since 1978, the World Health Organization and Health Canada have made the promotion of breastfeeding a primary goal.[1]

- Breastfeeding is recognized by the Breastfeeding Committee of Canada as unequalled in providing nutritional, immunological and emotional nurturing for the growth and development of infants, as well as protection from respiratory disease, otitis media, gastroenteritis and Sudden Infant Death Syndrome.[2]
- Beyond infancy, the benefits include protection against childhood cancers, insulin dependent diabetes, allergies and Crohn's disease, as well as improved cognitive development and fewer learning disabilities. [2]
- Exclusive breastfeeding for the first 6 months of an infant's life will provide protective effects against various illnesses.[3]

How Does Breast Milk Become Contaminated?

The concern is that our food chain can be contaminated with pollutants found in industrial and agricultural products.

- Fat soluble and persistent compounds such as the organochlorine compounds, organometals or PCBs and dioxins bioaccumulate in food. For example, the concentration of PCBs in phytoplankton is 0.0025 parts per million (ppm), in smelt it is 1 ppm, while herring gull eggs contain 124 ppm. This indicates that the contaminant concentration increases approximately 50,000 times as it moves up the food chain.[4]
- Fat soluble compounds which are absorbed by the mother can accumulate in breast milk and be transferred to the infant.[5] Two comparative studies of breast milk from Inuit women on the east coast of Hudson Bay revealed levels of PCBs that were five times higher than in the breast milk of women from southern Quebec. [6,7] The Inuit people of northern Canada have a high intake of PCBs due to a diet composed primarily of fish, seal and whale meat — all of which are high in fat and high in the food chain.[8]
- The health effects from high levels of contaminants in the Artic is not fully understood.
- Since the 1970s, levels of contaminants, such as PCBs and organochlorine pesticides, in human breast milk have dropped. [9]
- While there may be concerns about various contaminants in breast milk, there is agreement that breastfeeding should continue to be encouraged. Health professionals are urged to continue to support and promote breastfeeding — the benefits still outweigh the risks. [8,10] Breast fed and bottle fed babies don't grow in the same way. Breast fed babies don't put on as much fat as bottle fed infants, but are more robust. In addition, the alternatives to breastfeeding are not free of contaminants.[3]

Why Focus on Children?

Developing human beings — in the womb and through puberty — are uniquely vulnerable to environmental toxicants. [11]

- Infants and children differ from adults in their ability to metabolize, detoxify, and excrete toxic chemicals.[12]
- The diets of many newborns are limited to milk. In 1990, national statistics revealed that 80 percent of mothers breastfed initially. Just under 25 percent of women aged 25 to 34 years and 37 percent of women aged 35 to 44 years said they breastfed their last baby for more than six months. [13]

Key Contaminants and Effects

There are many compounds such as pharmaceu-

ticals, high dose vitamins, natural and man-made toxins that can be passed on to the infant through breast milk.

- Infants are exposed to nicotine and other chemicals from cigarette smoke via breast milk.[14]
- A Dutch study found that small negative immunological abnormalities caused by dioxins in breast milk were outweighed by the immunological benefits of breast milk. A similar study found no effect of PCBs in the breast milk on neurodevelopmental abnormalities in children. [8,15]
- Mercury levels in breast milk are comparable to those in maternal blood and umbilical cord blood. [16] Exposure to mercury can result in adverse visual, behavioural and developmental effects. [17]
- Solvents from dry cleaning can be absorbed and passed into breast milk, producing obstructive jaundice. Solvents in breast milk have also been implicated in increased cancer rates in infants.
- Aflatoxins in breast milk can produce liver and kidney damage.

What Can be Done?

Research Needs

- Define consumption levels that are safe for infants and children.
- Support studies of nursing mothers to help provide a better understanding of contaminants and their effects.
- Monitor the concentrations of contaminants present in populations such as anglers and hunters and members of first nations.

Education of Families

Lactating women and their families can minimize exposure to contaminants:

- by avoiding or restricting the intake of wild game and fish from areas known to be contaminated,
- by avoiding usage and exposure to pesticides,
- by washing and peeling all fruits and vegetables,
- lactating mothers should avoid crash diets or excessive weight reduction as this mobilizes the release of toxins from maternal fat stores into the maternal blood system and breast milk.[18]

Education of Health Professionals

- Health professionals need to provide educational material on now exposure to contaminants can be reduced.
- Health professionals need to work collaboratively with other organizations to develop educational material.
- Health professionals should advise mothers about the risks of taking prescription and over-the-counter drugs during lactation.

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Preconception and Reproductive Abnormalities

Why Preconception?

Exposure to toxicants may have an impact on the ability of prospective parents to conceive and on the development of their child. Many factors can cause damage to sperm and oocytes, thereby impeding the success of reproduction. This damage can occur at any time prior and right up to conception.

- During the fetal stage, toxicants may interfere with the formation of the female organs and damage the oocytes formed at this time. Exposure to toxicants may also impede the reproductive processes throughout the reproductive years. Persistent chlorinated compounds, which act as hormone disruptors, and metals such as lead can accumulate in the body and exert their effect as they are released into the system during the high energy demands of pregnancy.
- In males, toxicants (especially hormone disruptors) can affect the formation of the male reproductive organs in the fetal stage. In addition, exposure to toxicants of an adult male can influence the reproductive organs, especially the ability to produce sperm.
- In both sexes, factors such as malnutrition, smoking, use of alcohol, pharmaceuticals and other drugs, and infections can interfere with this complex process of reproduction.

What Effects Can be Seen?

There is a growing realization that both occupational and environmental exposure to toxicants and radiation can have negative impacts on reproduction [1] such as:

- decreased fertility in both sexes
- increased pregnancy loss
- abnormal development of the fetus and newborn, including malformations and low birth weight.

Female Reproductive Disorders

Female reproduction is vulnerable to environmental toxicants and radiation; however, not enough is known about exposure to toxicants and oocyte abnormalities, partially because oocytes, unlike sperm, are difficult to collect. There are indications that:

- Hormones play an important role in the development of sex organs during the fetal stage. The development of these organs can be affected by hormone disruptors such as PCBs or dioxins. Moreover, the quality of the oocytes formed during fetal development may be compromised. [3]
- Adult females may have alterations in their menstrual cycle when exposed to organic solvents such as carbon disulfides. The effects of hormonal disruptors on the menstrual cycle is not known.

Male Reproductive Disorders

Several toxicant exposures in males may produce infertility (no sperm, no viable sperm or impotence) or low quality sperm (increased chance of spontaneous abortion or abnormalities in children). [2]

- Use of tobacco and alcohol has been associated with impotence, a decreased sperm count, and sperm abnormalities.
- Abnormal sexual organ development may occur as a result of exposure of the male fetus to hormonal disruptors such as PCBs, dioxins or chlorinated pesticides.
- A reduced sperm count is associated with exposure to high levels of radiation, and to metals, such as cadmium and lead, or pesticides such as chlordane or DBCP. A reduced sperm count may lead to infertility.
- Sperm abnormalities (abnormal shape and/or chromosomal abnormalities) are associated with exposure to radiation, pesticides, heavy metals and organic solvents such as carbon disulfides. For instance, male exposure to lead and mercury in the workplace has resulted in dose-related disturbances to sperm. A reduced sperm quality may lead to spontaneous abortions, birth

defects, and an increased risk of chronic diseases.

Contaminants of Concern

A wide range of agents can adversely affect reproductive outcomes. Heat, vibration, tobacco, alcohol, drugs, chemicals including heavy metals such as lead, cadmium, pesticides and organic solvents have all been implicated.[4] The US Reproductive and Developmental Toxicants Report identified 30 environmental contaminants which are reproductive and developmental toxicants [5] several of which are mentioned in the table on page 25.

The extent to which exposures affect reproductive outcomes is difficult to determine because:

- Measuring exposure to reproductive toxicants is difficult to assess.
- Contaminants rarely appear singularly and the additive and synergistic effects of compounds have rarely been explored.
- Most data on reproductive toxicity has come from animal studies. These studies have examined spermatogenesis, fertility, sex organ development and sexual behaviour. Human studies have focused on birth defects and miscarriage, making a comparison difficult.

What Can be Done?

Research

The identification of chemical pollutants in human tissues is a pressing concern. It is essential that research examine the outcomes of reproductive toxicity.

Education of Families

Damage to reproductive organs caused by environmental contaminants is difficult to correct or repair. Prevention is, therefore, important. To be effective, prevention must involve both fathers and mothers. A few suggestions include:

- fostering a greater awareness of the possible exposure to chemicals in the workplace which can have long lasting reproductive effects. This is important for both males and females. Reduce occupational exposure to organic solvents, pesticides or radiation.
- avoiding the use of alcohol and tobacco products by both fathers and mothers before and during pregnancy
- reducing consumption of meat and fish, especially the fatty areas, which may be contaminated with hormonal disruptors or metals

Education of Health Care Professionals

- Develop courses on the effects of occupational exposure on reproductive health at both the undergraduate and graduate level.
- Encourage health care professionals to obtain an accurate, up to date occupational history of their patients.
- The occupational health community should work with medical, nursing and other health professional schools to develop appropriate educational materials.

Contaminants that Adversely Affect Preconception and Reproductive Development			
TOXICANTS	SEX	OUTCOMES	SOURCES
Metals - lead - methyl mercury - cadmium		impaired fertility menstrual disorders spontaneous abortion	solder lead pipes batteries paint ceramics smelter emissions
		impaired fertility abnormal sperm	
Hormone Disruptors - PCBs, dioxins - DDE, DDT - Hexachlorophene - Phthalates		impaired fertility menstrual disorders spontaneous abortion endometriosis breast cancer	isolators, incinerators pesticides pulp and paper plastics
		impaired fertility reduced sperm count prostate and testicular cancer	
Other pesticides - DBCP		reduced sperm count infertility	contaminated well water agriculture manufacturing
Solvents - Carbon disulfides		impotence reduced sperm counts infertility	textiles
Vinyl monomers		decreased fertility chromosome aberration spontaneous abortion	plastic manufacturing
Gases - nitrous oxides - ethylene oxides		decreased fertility spontaneous abortion	anaesthetic gases hospitals
Radiation		chromosomal abnormalities spontaneous abortion	medical and dental offices electronic industries nuclear industries
		chromosomal abnormalities sterility	
Alcohol		mental abnormalities	alcoholic beverages
		impotence decreased fertility chromosomal abnormalities	
Tobacco Smoke		spontaneous abortion low birth weight	cigarette smoking environmental tobacco smoke
		impotence decreased fertility	

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Prenatal Exposure and Reproductive Effects

Why Prenatal?

The brain, central nervous system and other organs are most susceptible to damage at conception and during fetal development because it is a time of rapid growth. The blood-brain barrier—the protective boundary between the general circulation and the brain, is incomplete until one year after birth. There are many opportunities for a developing organ to be damaged because growth and development does not occur in a linear and homogeneous fashion.

There is a growing body of research on the association between prenatal exposure to environmental contaminants and a broad spectrum of outcomes ranging from:

- spontaneous abortions
- low birth weight/prematurity
- birth defects
- cancer
- neurological effects
- endocrine and immunotoxic effects

Contaminants

- Many factors can interfere with the ability to have a healthy child, including infections, very young maternal age, diet, maternal education, socioeconomic status, stress and prenatal care.
- Metals such as lead and methylmercury are shown to adversely influence reproduction and fetal development. Young girls who absorb excessive amounts of lead during childhood will store it in their bones. During pregnancy, lead is mobilized from the bone and will cross the placenta, exposing the developing fetus.
- Polychlorinated biphenyls (PCBs) and related dioxins are a group of chemicals that may adversely affect fetal development. This has been noted particularly among the children of women who consumed large quantities of PCB-contaminated fish.
- Persistent chlorinated pesticides such as DDT may mimic hormonal action and interfere with normal fetal development.[1] Maternal and cord blood lead levels of 10-15 micrograms/decalitre appear to be associated with reduced gestational age and reduced weight at birth. [2]
- High levels of radiation can have devastating neurological and immunological effects on the growing fetus.

Adverse Effects of Prenatal Exposure

- Exposure to contaminants after conception may result in death of the fetus, birth defects, low birth weight and prematurity, developmental or behavioural disabilities, and cancer.
- Other possible adverse effects include immunotoxic effects and disrupted activities of certain hormones.
- Reproductive hazards have been associated with high level exposure to environmental contaminants, but it is difficult to assess the effect of low level exposure over extended periods of time.

Low Birth Weight/Prematurity

- Several studies based on epidemiologic research of fish-eating populations in the Great Lakes examined the potential association between long term and low- level exposure to PCBs, methylmercury and DDE. They revealed reduced birth weight, head circumference and gestational age. [3] However, similar infant growth and health studies found no effect.

Developmental and Neurological Outcomes

- Environmental disasters in Japan and Iraq which exposed children during the fetal peri-

od to high levels of methylmercury resulted in abnormal reflexes, reduced motor tone and abnormal motor development. [4]

- Exposure to methylmercury during prenatal development has been associated with blindness, deafness, seizures, abnormal reflexes, retarded motor development, learning, memory and psychological effects.[5] Exposure to much lower levels of methylmercury did not produce any of the abnormalities found in the Canadian Study of Prenatal Exposure to Methylmercury in the Aboriginal Population.[6]
- Lead is especially toxic to the developing fetus. Epidemiologic studies have provided consistent evidence that prenatal exposure to lead as low as between 2 - 15ug/dl in the blood can result in adverse developmental, neurobehavioral, psychomotor and cognitive effects (e.g. low IQ). [7]
- Several studies have shown that newborns exposed prenatally to low levels of PCBs can have adverse developmental and neurobehavioral effects. The fish- eater studies from the Great Lakes revealed that developmental effects on the fetus and children range from subtle behavioural changes to obvious neurological damage. Low level exposure to PCBs has been shown to produce decreased muscle tone, weaker reflexes at birth, decreased visual recognition, and poorer verbal skills. However, studies sometimes produce conflicting or inconclusive results. [7]

Cancer

- Low dose prenatal irradiation may be associated with a small increase in leukemia. A study of twins revealed that irradiated twins were twice as likely to have leukemia compared to the non-irradiated twins. [8] However, this association may be attributed to selection factors for prenatal X-rays.
- Prenatal exposure to pesticides (chlordane) was associated with neuroblastoma and childhood leukemia. [9]
- Exposure to pesticides during pregnancy because of agricultural occupation was associated with leukemia, brain cancer and Ewing's sarcoma. [9]

What Can be Done?

Research

- Further research regarding exposure for pregnant women or women of child bearing age is needed.
- Further research regarding the long term neurodevelopmental effects of contaminants is required.
- Testing and evaluation of toxicants should reflect the increased vulnerability of the fetus. There is a need for improved methods to detect and measure intrauterine developmental toxicants.
- A list of environmental chemicals of high concern for their effects on reproduction and development should be identified.

Education of Families

- A mother's environment and behaviour are important determinants of the exposure of the fetus. Education programs are needed to help families reduce exposure to toxicants.

Education of Professionals

- To recommend ways for pregnant women and women of childbearing age to limit their exposure to lead, methylmercury, PCBs and dioxins.
- Develop awareness campaigns to educate public about release of contaminants in the environment.

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Neurodevelopmental Effects of Neurotoxicants

What are Neurodevelopmental Effects?

- A toxic agent can affect the developing nervous system in many ways, including the proliferation, differentiation and migration of newly formed neuronal cells. Furthermore, toxic agents affect the processes of axon and dendrite growth, development of neurochemical systems, synapse formation, and myelination. Any such interference can be expected to disturb one or more of these developmental processes and contribute to neurodevelopmental abnormalities.
- Damage to the immature brain can result in mental deficiency, developmental language disorders, learning disabilities, motor disorders, organically-caused disorders of attention and behaviour, and structural malformations such as spina bifida. All of these disorders have a neurological basis.

Why Focus on Children?

- Since fetuses, infants and children are particularly sensitive, neurotoxicant exposure can result in progressive or irreversible neurodevelopmental or neurobehavioural change. The effects can be lifelong.
- The effect of toxicants on the brain is dependent on the timing of exposure. Brain development is ongoing throughout pregnancy, into the first two years of life and beyond. Systems undergoing rapid development are vulnerable and toxic agents will affect processes undergoing development at the time of exposure. Neurons do not regenerate, and the blood-brain barrier is incomplete until after the first year of life.

What Causes Neurodevelopmental Disorders?

- Many factors, both physiological and social, can contribute to neurodevelopmental problems in children. It is becoming clear that exposure to contaminants (drugs, pesticides, household and industrial contaminants, food additives and metals) during the prenatal and postnatal period can interfere with normal neurodevelopment.

Exposure to such substances may produce adverse neurodevelopmental effects including:

- mental deficiency
- learning deficits
- attention deficits
- hearing abnormalities, including deafness
- motor disturbances
- behavioural disorders

Contaminants Released into the Environment

Today there are more than 70,000 chemicals used commercially. Very few have been tested for their potential to affect brain development and function. Children are at risk for exposure to at least four groups of substances: metals, neuroactive pesticides, hormone disruptors and drugs.

METALS

Lead

- Globalization of trade means that consumer goods, which may contain lead, such as crayons, toys, blinds, and dishes, can be imported into Canada or purchased by Canadians abroad. Blood lead levels as low as 10 micrograms/decalitre are associated with adverse effects and no obvious threshold for lead seems to exist. [1] Adverse effects

include impairment of intelligence, neurobehavioural function and hearing.
- Lead is particularly harmful to the developing brain and nervous system of the fetus and young child.

Exposure routes for lead include:

Water
- tap water
- lead-based home plumbing

Air
- emissions from manufacturing plants
- hobbies, crafts and leisure activities
- occupational exposure
- environmental tobacco smoke

Food
- produce from contaminated soil
- ceramic and glassware
- lead-soldered cans
- infant formula

Soil, Dust and Paint
- ingested contaminated soil
- dirt and dust in the home
- paint dust and chips from building deterioration or renovation
- imported PVC miniblinds (pre 1997)

Mercury
- Methylmercury is the most neurotoxic form of mercury. Accidental exposure of pregnant woman to methylmercury has resulted in severely neurodevelopmentally damaged children. [2] The effects of low levels of methylmercury on the fetus and child are not sufficiently known.
- Methylmercury bioaccumulates and is found primarily in fish and marine mammals living in mercury contaminated waters.
- It is also found in some fungicides (in paint) and is used in religious ceremonies among several Hispanic and Caribbean ethnic groups.
- Silver dental amalgams contain 50 percent inorganic mercury. Therefore, pregnant and nursing women are advised to avoid having dental amalgams placed in or removed from teeth.

Manganese
- In contrast to lead and mercury, manganese is an essential metal and certain levels are needed for the proper development of the fetus and child. At high levels manganese is neurotoxic, therefore guidelines exist for safe levels of manganese in air.

PESTICIDES
Exposure routes for pesticides include food, air, water and soil. According to a National Academy of Sciences report, the pesticides considered to cause the most potential damage to the nervous system are the organophosphates, carbamates, and organochlorine insecticides.
- Children may be exposed to higher levels of pesticides than adults. They generally drink more water and eat more fruit, which may be treated with pesticides. Pregnant mothers may also consume food contaminated with pesticides.
- Pesticides used in the home and yard may pose a threat to children. Compared to adults, children are at risk of exposure to higher levels of pesticides after spraying. The concentration of the pesticide tends to be much higher closer to the ground where children play. [3] In agricultural areas, children may be exposed to pesticides in the air from aerial spraying, as well as from the clothing of parents who work with pesticides.
- Some pesticides have been found in source and well water in agricultural areas. A 1990 Environmental Protection Agency survey found that 10.4 percent of rural community wells were contaminated with one or more pesticides. [4]

HORMONE DISRUPTORS
- Some endocrine disrupting chemicals can undermine neurological and behavioural development. [5] Chlorophenoxy-herbicides like 2,4-D and 2,4,5-T, are used in weed control and forestry. They are considered to

have low toxicity to mammals, but are sometimes contaminated with dioxins which are potent hormone disruptors.
- A variety of lipid-soluble compounds, such as PCBs, DDT and certain plasticizers, can disrupt hormones, such as thyroid stimulating hormone (TSH) and sex hormones, which are critical for normal brain and sexual development.
- Women who consumed fish contaminated with PCBs had children who exhibited small but significant neurodevelopmental effects, including lower IQ and poorer reading comprehension.[6, 7]

What Can be Done?

Research and Policy

Testing of metals, pesticides and chemicals of concern including:
- tests for neurotoxicity
- tests for developmental neurotoxicity
- tests for endocrine effects
- priority toxicants that include sensitive biomarkers of exposure and neurodevelopmental outcomes in infants and children.

Education of Families

- Programs are needed to help families make informed choices and modify eating habits and lifestyle in order to reduce their exposure to metals, pesticides and hormone disruptors.
- Families can reduce exposure by minimizing the use of solvents and pesticides in the home, and by storing paint and paint removers in the garage or shed.

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