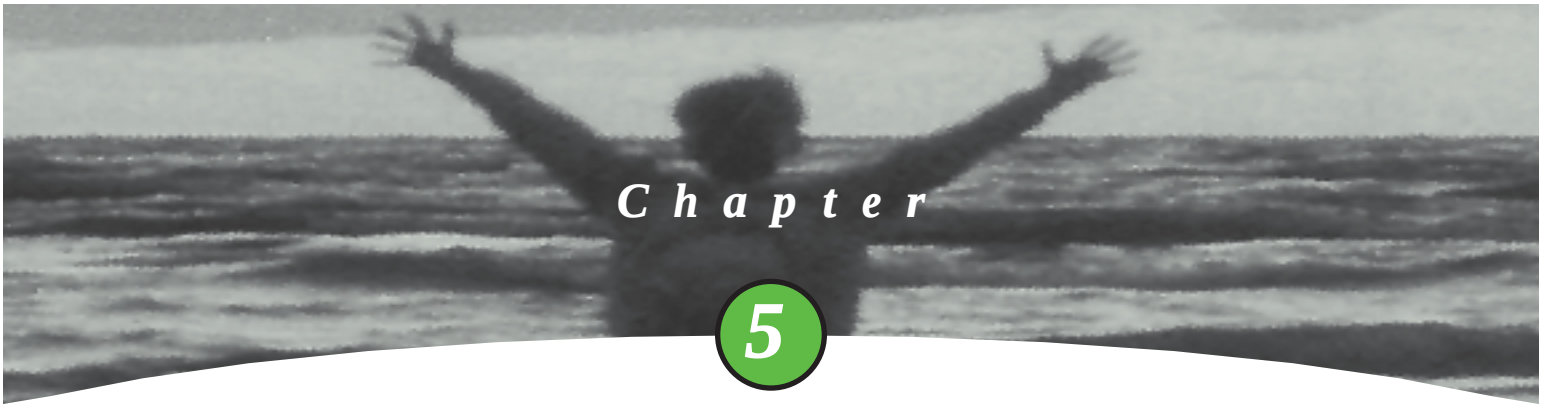


Chapter

5

Natural and Built Environments

Overview

The physical environment — both natural and that modified or built by humans — plays a crucial role in the development of a healthy child. It includes the housing in which children live, the air they breathe, the water they drink, the food they eat, the consumer products they use, and the parks and communities in which they play. Children are exposed to different hazards, within both natural and built environments.

These hazards can be divided into four areas.

Hazards caused by the physical environment: These hazards cause unintentional injuries of many types, including traffic-related injuries, drowning, animal attacks, suffocation, burns, falls, and poisoning. They are the leading cause of death and a major cause of hospitalization for children. They can also cause long-term disabilities.

Biological hazards: Infections caused by pathogenic micro-organisms are termed biological hazards. They are spread through direct contact, food, air, soil and water, and can impair child health. The consequences of these infections range from mild gastro-intestinal discomfort to death.

Chemical hazards: Chemicals released into the environment may be present in air, water, soil and food. In some situations, these chemicals may present a risk to children.

Global environmental degradation: Children face serious threats to their health from the effects of global warming and the thinning of the ozone layer.

There is a definite interconnection between the natural and built environments. For instance, the quality of air — an important component of the natural environment — is strongly influenced by human activities, such as the operation of vehicles and industrial plants. The quality of drinking water is influenced by the type of water used and the purification processes. The quality of food is affected by agricultural practices such as the use of pesticides, fertilizers, supplements and additives and the methods of storage and preparation.

Indoor air, however, is even more affected by human activity. Its quality is not only influenced by outdoor air pollutants, but also by indoor activities such as cooking and by the quality of the housing (highly energy-efficient housing with insufficient ventilation will increase indoor air pollutants). In addition, the habits of residents, such as smoking, contaminate indoor air. Environmental tobacco smoke (ETS) is a persistent indoor air contaminant. Damp houses and classrooms are breeding grounds for moulds, which are strong allergens.

Relationship to Healthy Child Development

Children are highly vulnerable to their physical environment. They are more sensitive to toxicants and hazardous conditions than their adult counterparts. This enhanced vulnerability is caused by their behaviour, their physiology and their early stage of development (Chance and Harmsen, 1998).

Behaviour

Several behavioural characteristics of children increase their exposure to physical, biological and chemical hazards in both the natural and built environments.

Children's behaviour and injury

Infancy is a time of increased mobility and discovery. However, this puts children at increased risk of falling, suffocating, and accidental poisoning. Preschool children have an increased vulnerability because of their curiosity, their growing sense of independence, and because they do not have the reasoning skills to understand danger. They are vulnerable to a wide range of injuries, particularly from falls, ingesting poison, and water- and traffic-related incidents. School-age children experience fewer injury deaths and injury hospitalizations compared with toddlers; however, these older children are involved in other injury incidents, such as those related to bicycles and playgrounds. As teenagers strive to achieve more and more independence, they experiment and take risks, which increases their chances of sustaining severe injuries (Rivara, 1994).

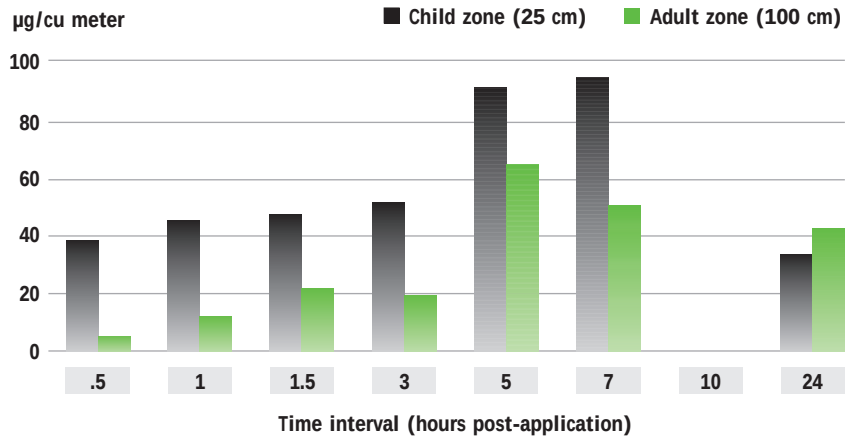
Children's behaviour and exposure to chemical and biological hazards

Children and infants in particular eat up to three times more food and drink up to four times more fluids per kilogram of body weight than older children or adults. The diets of children tend to be less varied; for example, children have unique food preferences, eat more apples, and drink more juice (National Research Council, 1993, pp. 167–192). This concentrated consumption of particular foods may mean that children have a higher exposure to chemical hazards, such as pesticide residues, than adults. In addition, young infants are likely to ingest toxic or infectious agents in dust or soil because they play on the ground, and because of their hand-to-mouth activity and teething behaviour (Calabrese, Stanek and Gilbert, 1991).

Infants and young children spend, on average, 85% to 90% of their time indoors (Samet et al., 1993). Indoor air contaminants tend to concentrate at the floor level; because children are physically smaller and spend much time on the floor, they may be exposed to higher concentrations of these contaminants than adults. Ventilation clears the air at adult heights, but children playing close to the floor won't benefit from this (Fenske, 1992). See **Exhibit 5.1** and **Exhibit 5.2.** Children often sit near or on adults and are therefore closer to the source of second-hand smoke.

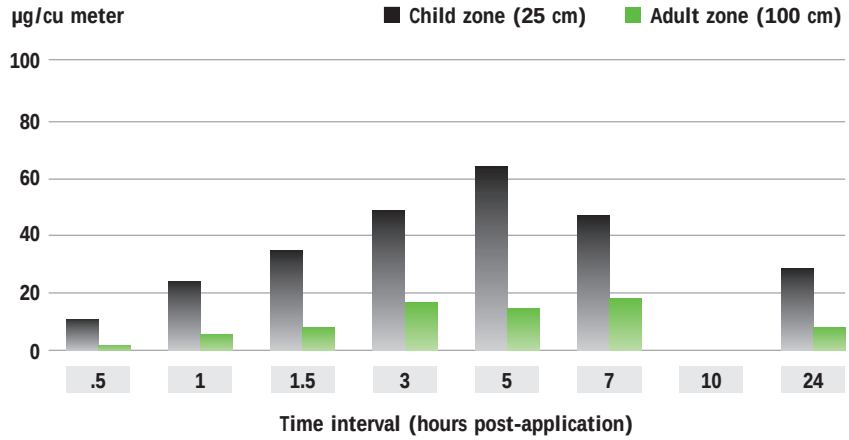
Also, children are at greater risk of exposure to air pollutants (both indoors and outdoors) because they spend more time engaged in vigorous activities compared with adults. They breathe more rapidly and inhale more pollutants per kilogram of body weight. Children engaging in vigorous activities at swimming and skating facilities may be exposed to higher concentrations of chlorinated compounds in swimming pools and carbon monoxide (CO) and nitrous dioxide (NO_2) in ice arenas (Aggazzotti et al., 1993).

5.1 Chlorpyrifos air concentrations in the breathing zone of a crawling child and sitting adult in a non-ventilated room, Canada, 1987



Source: R.A. Fenske (1992). "Differences in Exposure Potential for Adults and Children Following Residential Insecticide Application." In P.S. Guzelion et al. (eds.). *Similarities and Differences Between Children and Adults*, p. 217. Used with permission. ©1992 International Life Sciences Institute, Washington, D.C., U.S.A.

5.2 Chlorpyrifos air concentrations in the breathing zone of a crawling child and sitting adult in a ventilated room, Canada, 1987



Source: R.A. Fenske (1992). "Differences in Exposure Potential for Adults and Children Following Residential Insecticide Application." In P.S. Guzelion et al. (eds.). *Similarities and Differences Between Children and Adults*, p. 218. Used with permission. ©1992 International Life Sciences Institute, Washington, D.C., U.S.A.

Physiology and Chemical Hazards

It is now known that the fetus is exposed to toxicants, which pass through the placenta, either as a result of maternal behaviour during pregnancy (such as smoking, or alcohol and drug use) or because toxicants such as persistent organic pollutants or heavy metals are already present in the bodies of pregnant women. Although the known benefits of breastfeeding outweigh the uncertain risks associated with contaminants in human milk, the presence of elevated levels of some persistent organic chlorine contaminants such as polychlorinated biphenyls, dioxins and furans in the milk of Inuit women has raised concern. Since compounds such as lead or organochlorine (OCs) can accumulate in body tissues, exposure prior to pregnancy contributes to the overall amount stored in the mother's body and also results in exposure to the developing fetus during pregnancy (DIAND, 1997, pp. 411–412).

Small children can absorb more toxicants from ingested food, water, air, dust or soil than adults (Plunkett, Turnbull and Rodricks, 1992). For instance, children are able to absorb a greater percentage of ingested lead because their system is up to five times more efficient. In addition, an immature blood brain barrier in infants is less selective in its permeability and hence will pass lead more easily (Rodier, 1995).

A child's ability to metabolize, detoxify and eliminate toxicants can be different from an adult's. For example, an infant may be more susceptible to toxic chemicals because the detoxification enzymes in the liver and the excretion capabilities of the kidney are immature, especially in the first year (Chance and Harmsen, 1998).

Development and Chemical Hazards

Growing tissue is susceptible to interference; consequently, developing organs are more prone to functional damage. Organ development begins in the fetal stage and continues into adolescence. The growth of the organs is not linear, occurring instead in spurts. If toxic exposure occurs during these critical growth stages, the system can sustain permanent damage.

The brain is the most complex organ, needs the longest time to develop, and hence is potentially the most vulnerable to environmental influences. At all phases of growth, the brain is vulnerable to environmental influence. The brain's developmental phases are particularly crucial because of the finite nature of neural tissue growth. Critical growth periods missed or critical cell systems lost will not be replaced, unlike in some other organs such as liver or muscles, which can regenerate easily (Rodier, 1995). This disturbed neural tissue growth may cause neurological abnormalities later on in life.

Even low exposure levels of toxicants can affect organ development (Rice, 1998). The so-called hormonal or endocrine disruptors can interfere with growth at concentrations which are up to 10,000 times lower than those needed for acute toxicological effects (Colborn, Dumanoski and Peterson Myers, 1996, pp. 110–121). As yet, there is no hard evidence that endocrine disruptors have caused adverse health effects in people at levels typically found in our environment (Health Canada, 1997a, pp. 126–127).

Conditions and Trends: Natural Environment

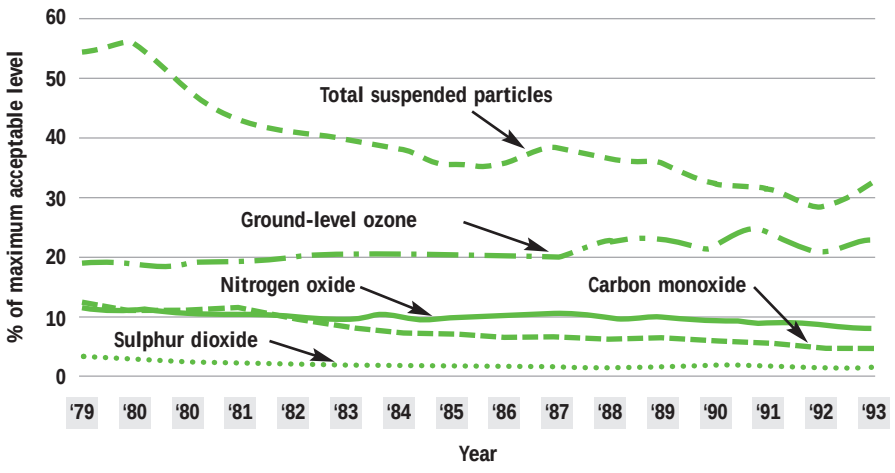
Ambient Air Quality

The major sources of air pollution are both natural and human-made. Air pollutants arise from the combustion of fossil fuels for energy generation in industrial processes, transportation and heating. Air pollutants can be transported over long distances. For example, a reddish-brown haze present in the Arctic originated in Europe and Asia (Environment Canada, 1996, p. 10-13). In the Windsor–Quebec corridor, ground level ozone originates in the United States, while Ontario's SO_2 emissions affect the air quality in the eastern United States and the Atlantic provinces (Environment Canada, 1996, p. 10-11). Other compounds, such as lead, as well as pesticides, dioxins or PCBs are transported through the air over long distances. For instance, pesticides used in Latin America, Mexico and the United States have contributed substantially to the pesticide levels in the Great Lakes and the Arctic (Environment Canada, 1996, pp. 9-14–9-20).

Because children breathe faster than adults, the amount of inhaled air relative to a child's size and weight is substantially higher (Plunkett, Turnbull and Rodricks, 1992). Children's lungs are vulnerable; during infancy and up to age 8, the number of alveoli is still increasing and growing. Effects of air contaminants on children range from coughing, wheezing and asthma to diminished lung function. These effects, in turn, result in increased hospitalizations.

Outdoor airborne contaminants that impact on children's health are sulphur dioxide, small airborne particles, ground-level ozone and lead. See **Exhibit 5.3**.

5.3 Trends in common air contaminants, Canada, 1979 to 1993



Note: Maximun acceptable levels are 82 parts per billion (ppb) for ozone (1h), 344 ppb for sulphur dioxide (1h), 213 ppb for nitrogen dioxide (1h), 13 parts per million (ppm) for carbon monoxide (8h), and 120 µg/m³ for total suspended particles (24h). Data plotted are average annual levels at all monitoring stations.

Source: Government of Canada (1996). *The State of Canada's Environment — 1996*. Ottawa: available from Environment Canada, p. 10-10. Reproduced with the permission of the Minister of Public Works and Government Services, 1998.

Sulphur dioxide

SO_2 is a highly water-soluble, irritating gas that originates from the burning of sulphur and sulphur-containing coal, gas and oil. Maximal SO_2 levels occur in winter. About 73% of the SO_2 responsible for air pollution comes from industry, specifically the metal ore industry; 23% results from the combustion of fuel from power generators, while 4% comes from heavy vehicles that burn diesel fuel. Levels of SO_2 have decreased over the years (Environment Canada, 1996, p. 10-10).

Increased levels of SO_2 affect children's health and cause acute irritation of the upper respiratory tract (i.e. the nose and throat), as well as the eyes. At higher concentrations, SO_2 may cause bronchoconstriction and ultimately a decline in lung function. Children with asthma are more sensitive to SO_2 than non-asthmatic children. It is estimated that 1% of the hospitalizations of children in Ontario result from high levels of SO_2 in ambient air (Burnett et al., 1994).

Airborne particles

Airborne particles are small particles that stay suspended in air. They vary in size and, in general, the smaller the size of the particle, the greater the health risk. Airborne particles are produced by a variety of sources both natural and synthetic. In Canada in 1992, 65% of the total emission of particles was released into the air by mining, coal, wood, and pulp and paper industries, while 22% was derived from fuel combustion, either from power generation or from residential heat production, such as wood burning. Transportation accounted for 10% of the small particle emissions. Naturally occurring events such as soil erosion, forest fires and dust from windstorms also contribute to airborne particles. Over the last 10 years, industrial particulate emissions have declined, but emissions from residential wood burning have increased (Environment Canada, 1996, pp. 10-12–10-13).

Particles smaller than 10 µm (called particulates) are not filtered by the nose and can reach the bronchial area and be deposited in the lungs. They can damage the lungs and affect the health of children. Increases in airborne particulate levels have been associated with an increase in children's coughing, hospitalizations, and impaired lung function in both healthy and asthmatic children (Dockery and Pope, 1994; Koren, 1995). Children with asthma are more sensitive to particulates than non-asthmatic children. The mechanisms by which inhaled particles injure the lung are diverse, but inflammation of the lung plays an important role (Koenig, Covert and Pierson, 1989).

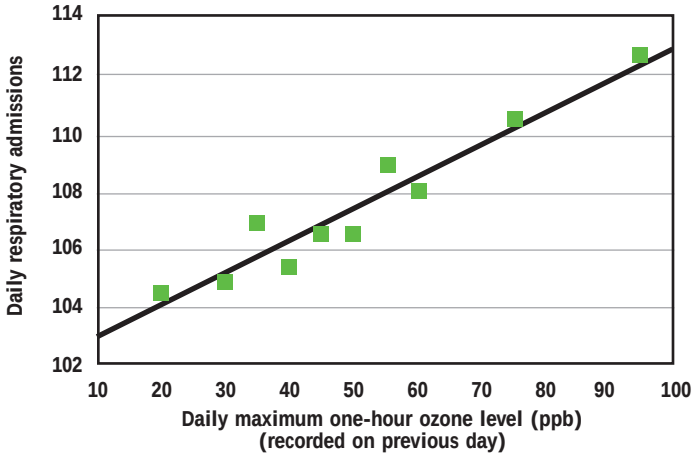
Ground-level ozone

Ground-level ozone is formed when sunlight and warm temperatures interact with oxides of nitrogen (NO_X) and volatile organic compounds (VOCs). Ground-level ozone is highest during daylight in the summer and is a major constituent of summer smog. In 1992, high annual averages of ground-level ozone were found in the Windsor–Quebec corridor, the Lower Fraser Valley and the southern Maritimes (Environment Canada, 1996, p. 10-12).

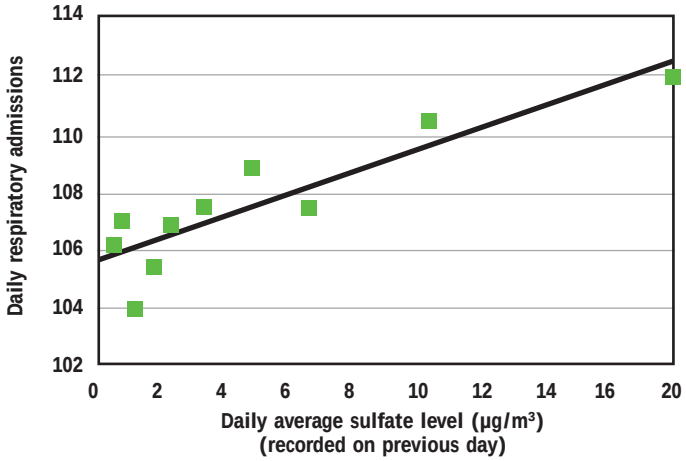
Ground-level ozone poses a unique problem for children because ozone is formed on sunny days, when children are more likely to be active and playing outside. Ground-level ozone affects children with asthma as well as children with no known pulmonary diseases. In Ontario during the summers from 1983 to 1988, it is estimated that about 15% of total hospital admissions of infants were attributable to the effect of ozone (Burnett et al., 1994). See **Exhibit 5.4**. This effect did not show a threshold, which could indicate that no safe level of ozone exists. In addition, ozone in young children may have an impact on alveoli surfaces of young children, which could affect future lung development (Richards and Brooks, 1995). Several studies have reported a decline in lung function of children after exposure to ozone (Spektor et al., 1988).

5.4 Hospital admissions for respiratory conditions — relationship to selected air quality factors, Ontario, 1983 to 1988

A. Relationship between daily respiratory admissions and daily maximum one-hour ozone levels (ppb) on the previous day, Ontario hospitals, 1983 to 1988



B. Relationship between daily respiratory admissions and daily average sulphate levels (µg/m³) on the previous day, Ontario hospitals, 1983 to 1988



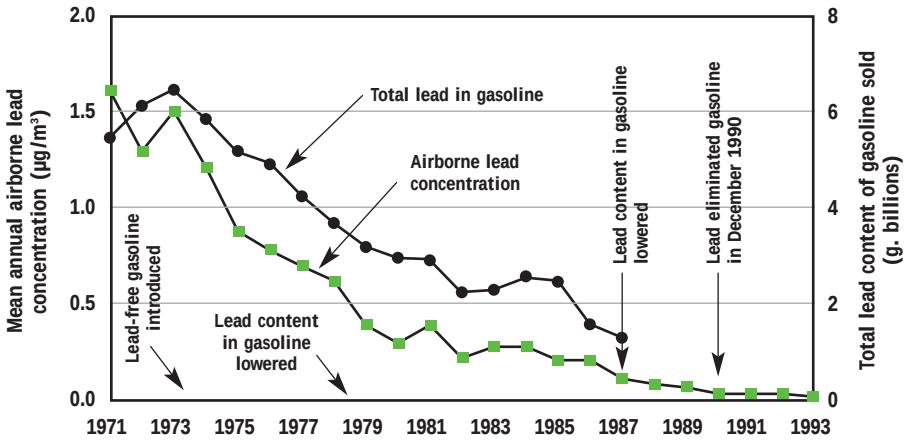
Source: R.T. Burnett et al. (1994). "Effects of low ambient levels of ozone and sulphates on the frequency of respiratory admissions to Ontario hospitals." *Environmental Research*, Vol. 65: 172–94.

Atmospheric lead

Atmospheric lead is derived mainly from vehicles burning leaded gasoline, with minor contributions from smelters and battery plants. Since the elimination of leaded gasoline in 1990, exposure to lead through ambient air is less of a concern. In Canada, levels of atmospheric lead have declined 95% since unleaded gasoline became available (Environment Canada, 1996, p. 13-11). See **Exhibit 5.5**. Over the last 25 years, the mining industry has also reduced its lead emissions (Environment Canada, 1996, p. 11-64).

The developing brain and nervous system of the fetus and young child are particularly vulnerable to lead. Adverse effects include IQ deficiencies, reading and learning disabilities, hyperactivity, and hearing problems. Even lead blood levels as low as 10µg/100 ml are associated with adverse effects; no obvious threshold for lead seems to exist (Needleman and Gatsonis, 1990).

5.5 Total lead content of gasoline sold in Ontario and mean annual airborne lead concentrations in Toronto, 1971 to 1993



Source: Government of Canada (1996). *The State of Canada's Environment — 1996*. Ottawa: available from Environment Canada, p. 13-11. Reproduced with the permission of the Minister of Public Works and Government Services, 1998.

Water and Food Quality

Quality food and drinking water are essential for the growth and health of children. In Canada, the quality of food and water in general is very good; however, biological and chemical contamination of these necessities does occur, with possible acute and long-term health effects (Health Canada, 1997a, pp. 84–85).

Some pollutants found in the water can bioaccumulate in the food chain. Substances such as persistent chlorinated compounds (PCCs) and metals such as mercury are in water at low concentrations. However, these compounds can accumulate in the food chain at incredibly high levels — 10,000 times higher in fish than in water, and in even higher concentrations in mammals and birds (Colborn, Dumanoski and Peterson Myers, 1996, pp. 87–109).

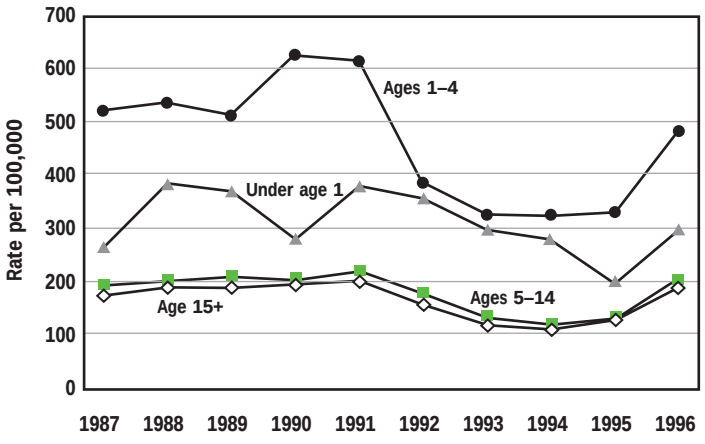
Because children eat and drink three to four times more food and fluids than adults per kilogram of body weight and eat a less varied diet, they experience higher doses of contaminants than adults per kilogram of body weight (National Research Council, 1993, pp. 172–192).

However, the Government of Canada, through Health Canada, Agriculture and Agri-Foods Canada, Fisheries and Oceans Canada and Environment Canada, has programs in place aimed at safeguarding Canada's food supply for Canadians.

Biological contamination

Both food and water are occasionally contaminated by biological agents including bacteria, viruses and protozoa. Children are more vulnerable than adults to biological contaminants. Recent data from British Columbia show that preschoolers aged 1 to 4 have the highest rates of intestinal infections. (B.C. Provincial Health Officer, 1998, pp. 65–78). See **Exhibit 5.6**. *Giardia* is the most commonly implicated protozoan parasite in outbreaks of water-borne disease. *Cryptosporidium*, also a protozoan parasite and even more chlorine-resistant than *Giardia*, was implicated in recent outbreaks. Half of the people affected by *Cryptosporidium* were children under 14 years of age (B.C. Provincial Health Officer, 1998). Food-borne illnesses result primarily from improper food handling, preparation and storage. *Salmonella* and *Campylobacter* bacteria are associated with these outbreaks (Health Canada, 1997a, pp. 110–112).

5.6 Reportable intestinal disease rates, by selected age groups, British Columbia, 1987 to 1996



Source: B.C. Provincial Health Officer (1998). *The Health and Well-being of British Columbia's Children: Provincial Health Officer's Annual Report 1997:* Victoria: B.C. Ministry of Health, p. 73.

Chemical contamination

The most common pathways of exposure to contaminants include breathing indoor air and ingesting food, water and other materials. In food, one can find heavy metals such as lead and mercury, pesticides, organochlorine compounds, and organic compounds such as mycotoxins. Vegetables and fruits may contain many natural compounds, which when tested under laboratory conditions, are found to be carcinogens. The effects of many of these natural toxicants are quite hazardous and detrimental to the health of children (Ames and Gold, 1992).

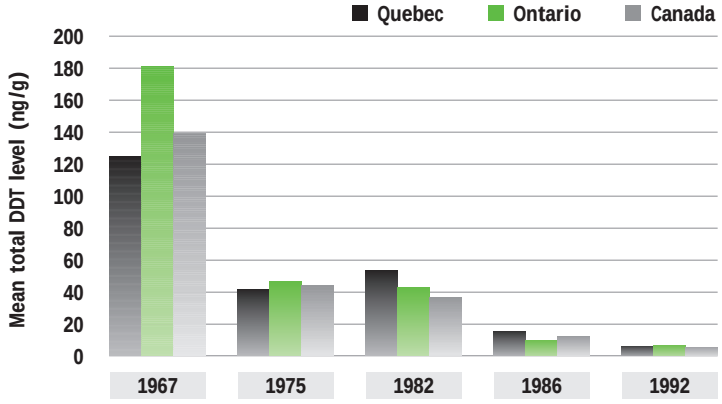
Breast milk

Breastfeeding is widely accepted as the optimum method of feeding for the first year of life. Many toxicants are found at low levels in human breast milk, including prescription drugs, methyl mercury, lead, and estrogen mimickers (Kacew, 1993). Fat-soluble and persistent compounds (e.g. PCBs, DDT, lindane, hexachlorobenzene) absorbed by the mother over her lifetime are also accumulated in breast milk and transferred to the infant during breastfeeding (Mes et al., 1993). See **Exhibit 5.7**.

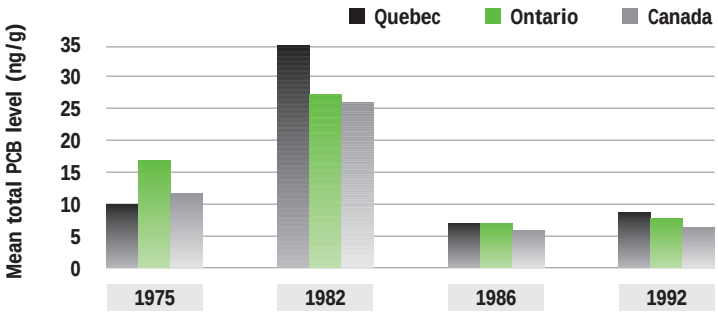
In general, the levels of these chemicals in breast milk are low. It is difficult to determine whether any related health effects originate while the fetus is in the womb or during the course of breastfeeding. There have been suggestions that exposure of infants to PCBs or dioxins in breast milk may be associated with (small) neurological and immunological abnormalities, although frequently these effects were transient (Rogan and Rogan, 1994). Since the 1970s, the levels of PCBs and organochlorine pesticides in human breast milk have dropped (Mes et al., 1993). Nevertheless, both Health Canada and the World Health Organization, among others, have concluded that human breast milk is generally the safest, most nutritious food available for human infants.

5.7 DDT and PCBs in human breast milk, Quebec, Ontario and Canada, selected years, 1967 to 1992

A. Levels of DDT in human breast milk: Quebec, Ontario and Canada, selected years, 1967 to 1992



B. Levels of PCBs in human breast milk: Quebec, Ontario and Canada, selected years, 1975 to 1992



Source: Government of Canada (1996). *The State of Canada's Environment — 1996*. Ottawa: available from Environment Canada, p. 6-49. Reproduced with the permission of the Minister of Public Works and Government Services, 1998.

Lead

Lead compounds can be found in vegetables, cereals and drinking water. Especially when vegetables are grown in soil containing lead, levels can be high and can become a dangerous source of lead in the diet (Health Canada, 1997a, p. 134). However, since lead in the environment is declining, this issue is of minimal importance in the Canadian food supply.

Methyl mercury and PCBs in fish

Inuit infants of Nunavik have high levels of mercury and PCBs in the umbilical cord blood; the mercury levels are nearly 14 times higher than those recorded in newborn babies in the general population. Their mothers had consumed large amounts of fish and fat from marine mammals, which contained increased levels of methyl mercury. Although the health effects at this level of exposure are not known, this level of exposure is a concern (Muckle, Dewailly and Ayotte, 1998, pp. 22–23). See **Exhibit 5.8**.

5.8 PCBs and mercury in umbilical cord blood, selected populations, 1993–96

A. Concentrations of PCBs* (µg/L) in umbilical cord blood

Population	N	Average†	Range
Nunavik (Quebec), Inuit‡	480	2.0	0.2–18.6
MacKenzie/Kitikmeot (NWT), Inuit¶	62	1.0	0.2–5.1
Baffin Region (NWT) Inuit§	66	1.7	0.4–28.3
NWT Déné/Métis¶	47	0.2	0.0–2.3
Lower and Mid-North Shore Montagnais††	101	2.0	0.3–15.0
Lower and Mid-North Shore coastal population††	111	1.0	0.1–8.2
NWT non-Aboriginal¶	125	0.3	0.0–1.9
Southern Quebec general population‡‡	656	0.5	0.1–3.9

* Aroclor 1260 is made by combining PCB congenerics numbers 138 and 153 and then multiplying the result by 5.2.
† Geometric average ‡ ref. no. 37 ¶ ref. no. 38 § ref. no. 39 †† ref. no. 40 ‡‡ ref. no. 41

B. Concentrations of mercury (µg/L) in umbilical cord blood

Population	Year	N	Average†	Range
Nunavik (Quebec), Inuit‡	1993–96	475	14.2	1.0–104.0
MacKenzie/Kitikmeot (NWT), Inuit¶	1994–95	62	5.7	n/a
Baffin Region (NWT) Inuit§	1996	67	10.4	0.6–75.8
NWT Déné/Métis¶	1994–95	47	1.9	n/a
Lower and Mid-North Shore Montagnais††	1993–95	102	2.1	0.2–14.0
Lower and Mid-North Shore coastal population††	1993–95	111	2.3	0.4–15.8
NWT non-Aboriginal¶	1994–95	121	1.7	n/a
Southern Quebec general population‡‡	1993–95	1109	1.0	0.2–13.4

n/a = not available
† Geometric average ‡ ref. no. 37 ¶ ref. no. 38 § ref. no. 39 †† ref. no. 40 ‡‡ ref. no. 41

Source: G. Muckle, E. Dewailly and P. Ayotte (1998). "Prenatal Exposure of Canadian Children to Polychlorinated Biphenyls and Mercury." In *Canadian Journal of Public Health*, Vol. 89, Supplement 1, p. S22.

Nitrates

High levels of nitrates are found in certain vegetables and fruits, especially when fertilizers are used extensively to grow the food. In addition, a 1993 survey in Ontario found that up to 40% of all rural wells may be contaminated with high nitrate levels and/or fecal coliform bacteria (Environment Canada, 1996, p. 11-17). High levels of nitrates in drinking water, once converted to nitrite, can give rise to serious health problems for infants. This contaminant will impair the transportation of oxygen from the lungs to the tissues of the infants, a condition known as methemoglobinemia (Bruning-Fann and Kaneene, 1993).

Pesticides

Pesticides are products registered by the federal government. One objective is to minimize applicator, bystander and consumer exposure to the pesticides and their by-products. Children may be exposed to pesticides from residues on the food and in the drinking water they consume, as well as through contact with pesticides when they are used around the home and in recreational areas such as parks. As well, children can accidentally ingest pesticides when they are improperly stored or discarded. The susceptibility of infants and children to pesticides in the diet was examined by a committee from the U.S. National Research Council (National Research Council, 1993). It identified age-related variation in susceptibility, toxicity and exposure to pesticides.

Soil Quality

Soil can become contaminated through waste disposal, pesticide use and industrial pollution. Soil contamination is usually confined to sites where chemicals have been dumped, either intentionally (e.g. at an isolated industrial site) or accidentally (e.g. from a leaking oil tank). Hazardous waste disposal sites are of special interest because many sites are located close to urban areas. Unfortunately, the scale and nature of the contaminants in old dump sites are unknown because permits, regulatory controls and records were not kept (Environment Canada, 1996, p. 12-23).

Infants and toddlers are particularly at risk from contaminated soil because they frequently place their hands in their mouth while playing and eating. The amount of soil ingested while playing outside is age dependent. It is estimated that on average, a child will consume approximately 35 mg to 50 mg of soil per day. Children with an abnormal craving or appetite for non-food substances, known as “pica,” will eat between 5 g and 10 g of soil per day (Calabrese, Stanek and Gilbert, 1991). A study correlating the levels of metals in soil with metal blood levels in children found a weak association between the two (Jin and Teschke, 1995).

Waste disposal sites

It has been difficult to assess the effects of hazardous waste disposal sites on health. The famous Love Canal case, in which industrial waste from a chemical lindane plant was deposited into the canal, has been widely studied. After the

plant was closed and the old canal bed turned into a housing development, the area became a major research site. Several studies concerning this site have indicated an association between maternal exposure and low birthweight and chromosomal abnormalities (Gochfeld, 1995).

Radiation and Global Warming

UV radiation

The ozone layer is situated in the stratosphere, between 18 km and 35 km above ground level, and shields us from excessive ultraviolet (UV) radiation. However, since the 1960s, the ozone layer has become thinner because of the release of chlorinated fluorocarbons (CFCs). These compounds are non-toxic, very stable and used extensively as cleaning fluids, refrigerants and propellants. They accumulate in the stratosphere, slowly depleting the ozone layer (Environment Canada, 1996, p. 15-19).

Exposure to UV radiation is beneficial because it produces vitamin D. However, excessive exposure causes skin burns. Infants especially have a thin skin and are prone to sunburn. Just a few sunburns in early life can increase the risk of developing skin cancer as an adult (Health Canada, 1997a, p. 75).

Radon

Radon is a naturally occurring, radioactive gas originating from uranium in the soil. It can accumulate in basements through cracks in the foundation and contaminate the indoor air. Exposure to high levels of radon is linked to lung cancer, especially in miners (Axelson, 1995); exposure to indoor radon is also associated with myeloid cancer, cancer of the kidney, melanoma, and certain childhood cancers (Henshaw, Eathough and Richardson, 1990). Henshaw, Eathough and Richardson (1990) plotted the provincial mean radon concentrations against the incidence in childhood leukemia, and found a dose-response effect. A study in Winnipeg did not find an increased risk of indoor air radon and lung cancer in adults (Letourneau et al., 1994).

Global warming

Increases in carbon dioxide (CO_2) levels in the atmosphere play a key role in the greenhouse effect; they trap energy from the sun, thereby causing a slow increase in the global temperature. (CO_2 is released by the combustion of fossil fuels.) In Canada, the average temperature has increased more than 1°C over the last century (Environment Canada, 1996, p. 15-11).

Although a warmer climate for Canada sounds appealing, the effect of a higher average temperature on child health is not clear. Global warming may contribute to more extreme weather conditions with a subsequent increased risk of storms and flooding. In addition, children can be exposed to an increasing number of infectious diseases, specifically those which are now mainly confined to more tropical areas (Health Canada, 1997a, p. 77).

Conditions and Trends: Built Environment

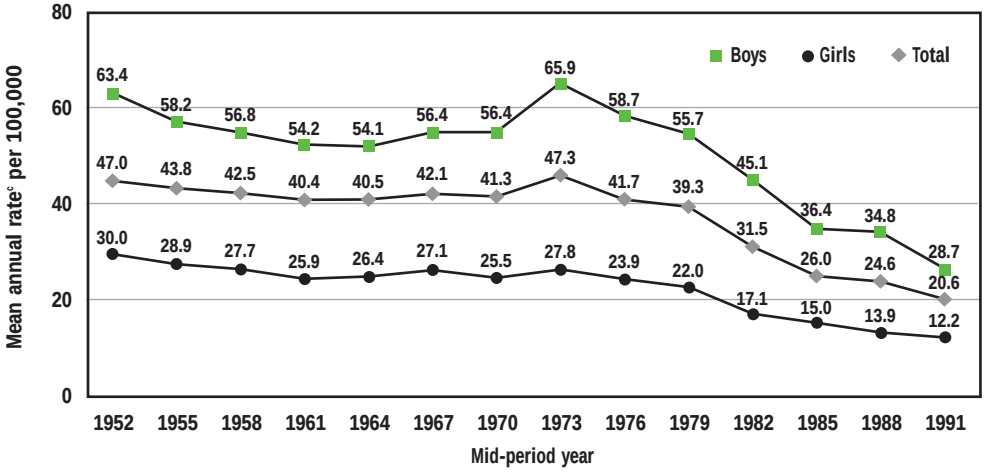
The built environment has a major impact on the health and development of children. It includes the buildings, parks, businesses, schools, road systems, and other infrastructures that children encounter in their daily lives. Children need protection and a safe physical environment. Protection from physical injuries is a key aspect of a healthy physical environment. Well-designed homes, streets, transportation systems and playgrounds promote the safety and health of children and youth.

Injuries: A Major Health Threat

Injuries are a major environmental health threat. In 1990 alone, about 1,500 children in Canada died from injuries and 81,000 were hospitalized because of injuries (Health Canada, 1997b, p. 17). Injuries are the leading cause of death for children and youth after age 1 and the second leading cause of hospitalization (respiratory illnesses are number one) (Health Canada, 1997b, pp. 16–17). While traffic injuries are the leading cause of injury death, falls are the main type of injury for which children are admitted to hospital (Health Canada, 1997b, pp. 20–21). For each child who dies from an injury, many more require hospitalization, emergency room care and follow-up visits to health professionals. The financial cost to taxpayers is great (Angus et al., 1998), and the personal cost, the residual disability and continued suffering are substantial. Injury-related deaths have continued to drop in Canada — from 31.5 per 100,000 in 1981–83 to 20.6 per 100,000 in 1990–92 (Health Canada, 1997b, p. 22). See **Exhibit 5.9**.

There is a correlation between injuries and a child's developmental stage and daily activities.

5.9 Injury-related death rates[a] for selected years, by sex, 0- to 19-year-old children and youth, Canada, 1951–53 to 1990–92[b]



a. ICD, 9th revision codes E800 to E999. This grouping includes intentional and unintentional injuries and injuries of undetermined intent.
b. Three-year periods: January 1, 1951 to December 31, 1992.
c. Denominator: Population aged 0–19, Canada.

Source: Health Canada (1997). *For the Safety of Children and Youth: From Injury Data to Preventive Measures*. Catalogue No. H39-412/1997E. Ottawa: Health Canada, p. 22.

Injury and infants

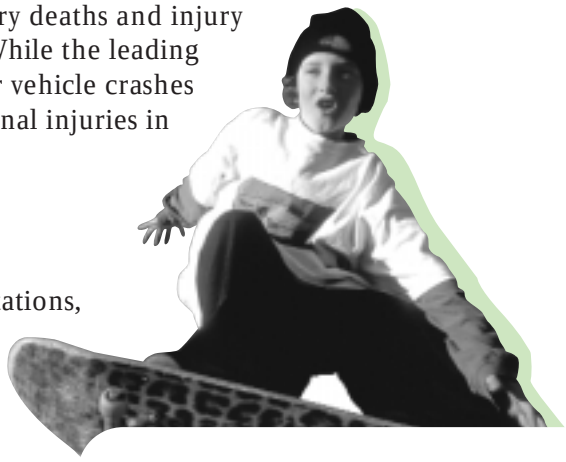
Infancy and preschool is a time of increased exploration and a time when children are likely to spend a large proportion of their time at home. Their hand-to-mouth activity increases the likelihood that they may ingest harmful substances or suffocate. For infants, suffocation is the leading cause of injury-related death while for other preschool children, traffic injuries are the leading cause of injury death (Health Canada, 1997b, p. 20). Falls are the major cause of hospitalization for infants and preschoolers (Health Canada, 1997b, p. 21). Other important causes of injuries for infants and preschoolers are: burns and scalds from sources such as hot tap water and hot beverages; suffocation/choking on foods or small objects; and poisoning (Health Canada, 1997b, p. 21; Rivara, 1994).

Injury and school-age children

By the time children reach school age, they feel competent to head to school on their own and are keen to learn, gain independence and begin to make decisions. School-age children experience fewer injury deaths and injury hospitalizations compared with toddlers and youth. While the leading cause of hospitalization is respiratory illnesses, motor vehicle crashes and bicycle mishaps are notable causes of unintentional injuries in this age group (Health Canada, 1997b, pp. 20–21).

Injury and adolescents

Adolescence is a period of rapid growth, high expectations, and a time of significant risk taking, increasing the likelihood of serious injury for this age group. In the 1990–92 period, traffic incidents were the major cause of unintentional injury death, accounting for nearly 83% of the deaths, while drownings contributed another 9%. During the same period, hospitalizations resulted from non-intentional injuries caused by traffic collisions (60%) and falls (30%) (Health Canada, 1997b, pp. 20–21).



Adolescence is a period of rapid growth, high expectations, and a time of significant risk taking, increasing the likelihood of serious injury for this age group.

Home Environment and Injuries

Housing standards and availability

Most Canadians are housed in good quality homes. According to 1991 data, the majority (68%) of Canadian households met federal adequacy and affordability standards (CMHC, 1991; CCSD, 1996, p. 29). However, the remaining families lived in substandard houses, classified as such because they needed repair, were too small for the family, or were too expensive for the family budget (CCSD, 1996, p. 30). Poor housing conditions have a direct effect on injuries because many substandard houses are often in a poor state of repair.

Safety in the home

Injuries are most likely to occur in the home. About 80% of the children under 4 years of age are injured at home (Health Canada, 1997b, p. 29). As children grow up they spend less time at home, and statistics reveal that injuries increasingly occur outside the home.

Three quarters of home-based injuries to children happen in the house while the other one quarter occur in the garden or garage (Health Canada, 1997b, p. 72). In 1993, some of the leading causes of injuries at home were falls (46.3%), burns (3.4%) and accidental poisonings (3.2%) (Health Canada, 1997b, p. 73).

Many household products including cleansers, disinfectants, medicines, alcohol, solvents, cosmetics and mothballs are potential hazards for small children and should be kept out of their reach and in child-resistant containers. Garages and basements often contain items such as paint or paint thinner, bottled or liquid gas, glue, gasoline, and other automotive products. Very young children do not have the ability to judge what is harmful, and for this reason it is not surprising that 97% of the poisonings in this age group occur while children are exploring their own homes (Health Canada, 1997b, p. 162).

Home Environment and Chemical Exposure

Indoor air

Indoor air quality is critical to children's health because they spend so much time indoors. Numerous sources of indoor contaminants influence the quality of indoor air, including exposure to second-hand smoke (ETS). Volatile organic compounds (VOCs) are released from furnishings made with pressed wood products, from household cleansers, and from personal care and pest control products. Biological agents such as moulds, dust mites and pet dander are common indoor contaminants. This "cocktail" of indoor air pollutants is further aggravated by a number of factors including the number of smokers and levels of humidity and ventilation. Adequate ventilation and the position of vents can significantly reduce the pollution levels in a house or building (Fernandez-Caldas et al., 1995). For instance, open windows will reduce indoor air pollutants efficiently at the height of a sitting adult; however, closer to the floor — the space toddlers occupy while playing — the ventilation is less efficient (Fenske, 1992).

Environmental tobacco smoke

Environmental tobacco smoke (ETS), or second-hand smoke, is one of the most common indoor air pollutants (Raizenne, Dales and Burnett, 1998, p. 45). Almost 2.8 million Canadian children under the age of 15 are exposed to ETS at home. ETS contains more than 4,000 chemicals, including benzene, tar, nicotine, particulates and other cancer-causing agents (Health Canada, 1997a, p. 60).

Children exposed to a smoke-filled environment experience numerous negative health effects (Stoddard and Miller, 1995). They are at greater risk of death from respiratory diseases and sudden infant death syndrome (DiFranza and Lew, 1996). They have more visits to the physician and are hospitalized for more lower respiratory tract infections such as bronchitis and pneumonia (DiFranza and Lew, 1996). They have a reduced lung function (Cunningham, Dockery and Speizer, 1994) and an increased susceptibility to infections from viruses and bacteria (Wjst et al., 1994). Second-hand smoke also triggers asthma attacks and increases the frequency and severity of the attacks in children (Shephard, 1992).

Volatile organic compounds

VOCs are a varied mixture of compounds, consisting of aldehydes, aromatic hydrocarbons and chlorinated compounds, to name a few. Formaldehyde is an eye and throat irritant and results from outgassing of pressed wood, urea formaldehyde foam insulation (UFFI) and glues. Other VOCs such as methylene chloride and toluene may also be released when painting (Fernandez-Caldas et al., 1995; Raizenne et al., 1998). Benzene is present in indoor air from cigarette smoke and in fumes from adjacent garages. Chloroform and 1,2 dibromoethane are derived from evaporation of tap water, especially during showering. Dichlorobenzene is derived from mothballs. If pets or pests are in the house, pesticides may be used (Raizenne, Dales and Burnett, 1998).

It is difficult to assess the health impact of the complex mixture of pollutants found in houses, schools and public buildings. Many of these compounds are carcinogenic and may increase the risk of cancer in children. In addition, some VOCs can increase the risk of neurological and behavioural abnormalities and may affect respiration (Fernandez-Caldas et al., 1995).

Water quality

For children, two important routes of exposure to lead in the house are lead in water pipes and paint. Houses built before 1950 are connected to the water mains by lead pipes; houses built before 1988 may contain copper pipes with lead solder (Health Canada, 1997a, p. 93). The adverse health effects of lead are well recognized, as discussed earlier (Needleman and Gatsonis, 1990). Tap water is a minor source of exposure to lead, with levels in untreated water generally below 1µg/L (Health Canada, 1997a, p. 93).

Home Environment and Biological Exposure

Moulds, dust mites and pet dander are very common biological contaminants in the home. These allergens can cause a number of reactions in children, especially in infants and young children who both still have an immature immune system (Bessot, de Blay and Pauli, 1994; Dales et al., 1991). Their systems may respond to allergens by developing hypersensitivity, allergies or asthma. About 25% of children have allergies (Chad, 1995).

Asthma is more frequent in younger children than older children. In boys 0 to 4 years of age, the prevalence of asthma is 15% and drops to 5% by 10 to 15 years of age (CICH, 1994a). See **Exhibit 5.10.** Development of asthma is associated with house dust mites and moulds (Marks et al., 1995), while in poorer inner-city areas, a hypersensitivity to cockroach allergens may be involved (Kang, 1996). If young children are protected from dust or pet allergens, asthma and allergies may be reduced or avoided (Bessot, de Blay and Pauli, 1994).

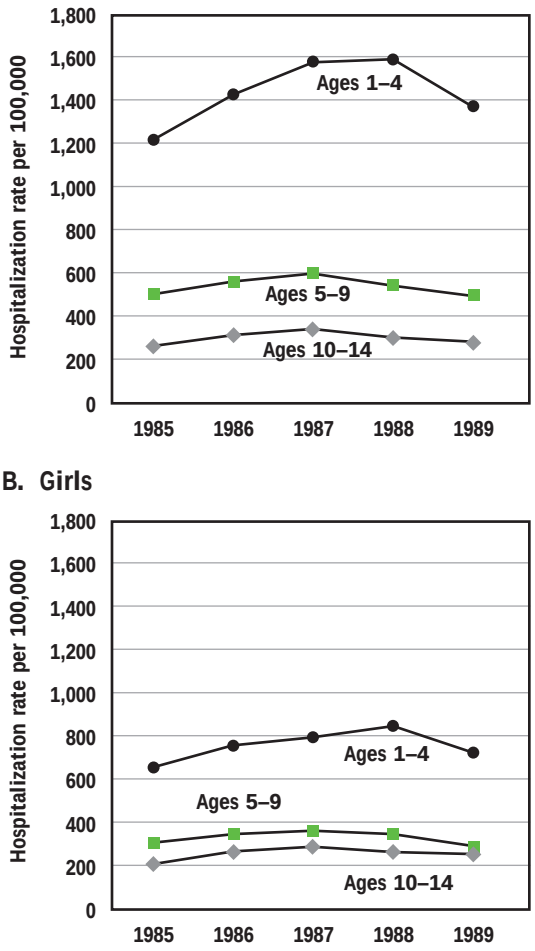
The School Environment

Since children spend a great deal of their day in school, a number of the issues mentioned above apply in this setting as well. Children in classrooms with insufficient air circulation could be exposed to numerous harmful compounds, which may cause sick building syndrome (Chester and Levine, 1994). This exposure may be made worse in school settings in which chemicals are used, such as laboratories and art and technical classrooms.

Transportation

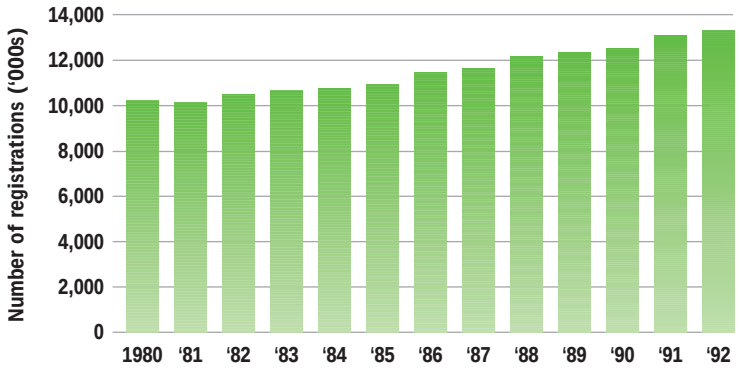
For most families, transport and mobility are essential parts of modern day life. In 1993, there were 12 million registered vehicles in Canada, respresenting almost one for every two Canadians (Environment Canada, 1996, p. 2.18). See **Exhibit 5.11**. Vehicles pose a risk because the exhaust pollutes outdoor air which in turn impacts on the respiratory health of children. Although cars are important in modern society, they place children and youth at risk of injury and death.

5.10 Trends in asthma-related hospitalization rates for children, by sex and age, Canada, 1985 to 1989



Source: Canadian Institute of Child Health (1994). *The Health of Canada's Children — A Statistical Profile*. Vol. 1, I–II8, Vol. 2, IV–14. Ottawa: CICH.

5.11 Total passenger car registrations, Canada, 1980 to 1992



Source: Government of Canada (1996). *The State of Canada's Environment — 1996*. Ottawa: available from Environment Canada, p. 2-18. Reproduced with the permission of the Minister of Public Works and Government Services, 1998.

Independence and mobility

The opportunity to gain independence during childhood is an important expression of growing up. To cycle, to walk, to use the public transportation — these are all opportunities that enhance children's daily lives. For children with disabilities, mobility and access to their environment are major factors in their ability to acquire independence. Special aids and public transportation are largely accessible to children with disabilities in major urban centres. About 7% of children 0 to 14 years old with disabilities and 4.5% of youth with disabilities have difficulty leaving their residences to take short trips. Of those in the 0 to 14 age group, almost 9% have difficulty getting together with children their own age (CICH, 1994b, pp. 158–162).

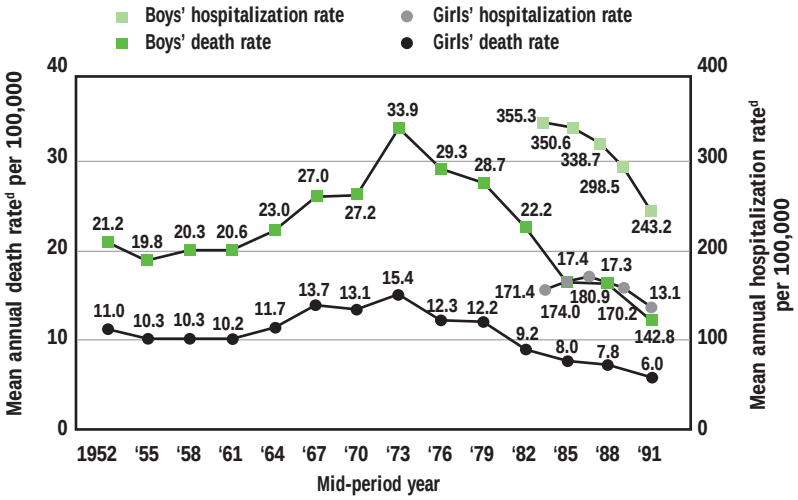
Safety on the roads

In 1990–92, on average, two children died per day as a result of motor vehicle accidents (MVAs), while more than 38 children were hospitalized. The rate of MVA injuries is age dependent, with the highest rate observed in the 15- to 19-year-old age group (Health Canada, 1997b, pp. 42, 44, 76). See **Exhibit 5.12.** For teenagers, driving is both a means of transportation and recreation. Because they are new and inexperienced drivers and have an exaggerated sense of their driving abilities, young males have a much greater risk of being in motor vehicle crashes (DeJoy, 1992). Drivers with at least five years' driving experience have half the mortality or morbidity rate compared with drivers with less than two years' experience (Health Canada, 1997b, p. 82).

In 1990–92, 116 children died as pedestrians and an additional 1,793 children were hospitalized following a collision with a motor vehicle. Those 5 to 9 years of age are the most vulnerable to this injury (Health Canada, 1997b, pp. 95–96).

In 1990–92, 46 children who were cycling died as a result of a motor vehicle collision, and an additional 3,644 were hospitalized. Most injuries occurred among children aged 5 to 14, accounting for 70% of the cycling-related deaths and 77% of the hospitalizations (Health Canada, 1997b, p. 109). It is estimated that 70% of fatal collisions were due to cyclist error (Health Canada, 1997b, p. 108).

5.12 Death and hospitalization rates for injuries related to motor vehicles and other road vehicles,[a] by sex and period, children and youth aged 0 to 19 years, Canada,[b] 1951–53 to 1990–92[c]



a. ICD, 9th revision, codes E810 to E829. Excludes any accident involving an aircraft or spacecraft (E840 to E845); a watercraft (E830 to E838); a train (E800 to E807).

b. Data unavailable for Prince Edward Island, New Brunswick, Yukon Territory and Northwest Territories.

c. Deaths, three-year periods: January 1, 1951 to December 31, 1992. Hospitalizations, two-year periods: April 1, 1982 to March 31, 1992.

d. Denominator: population aged 0–19, Canada, 1991 Census. For hospitalization rates, denominator excluded population from Prince Edward Island, New Brunswick, Yukon Territory and Northwest Territories.

Source: Health Canada (1997). *For the Safety of Children and Youth: From Injury Data to Preventive Measures*. Catalogue No. H39-412/1997E. Ottawa: Health Canada, p. 62.

Recreational Environment and Injuries

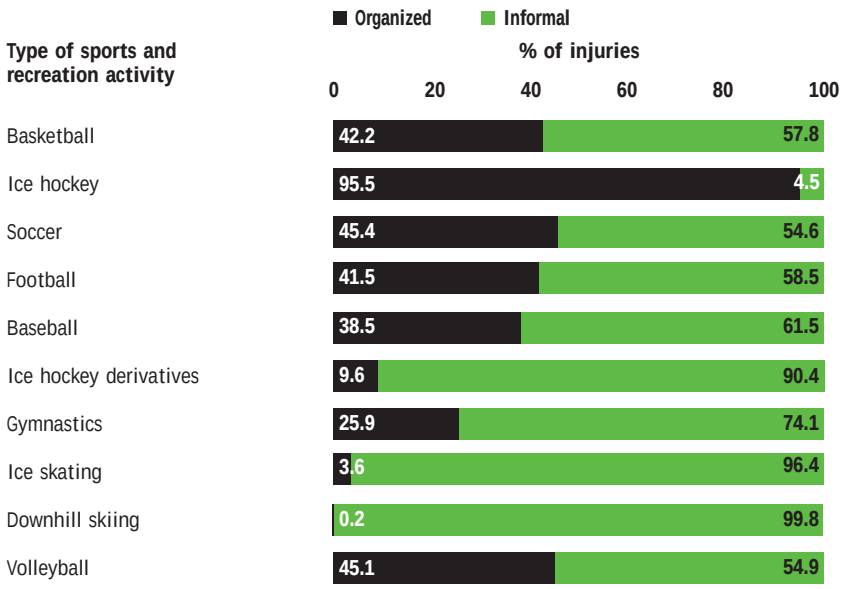
Other important environments for children and youth are playgrounds, parks and recreational buildings such as pools, gyms and arenas. Most injuries to children and youth that occur outside the home environment happen during play and leisure activities.

Playground equipment and sports settings

Playground equipment is designed to help children's development, but it can also be dangerous. Although standards for playgrounds and equipment have been established by the Canadian Standards Association (Canadian Standards Association, 1990), and were updated in 1998, playground standards are often loosely interpreted and implemented (Health Canada, 1996, p. 71). Every year, thousands of youngsters are treated at hospital emergency rooms or are hospitalized after being injured on a playground or during a sporting event. Nearly 42% of playground injuries occurred in public playgrounds and 34% at school and/or in a child-care setting. For children under 5 years of age, 50% of playground injuries happened in public playgrounds. School-age children are more likely to be injured either at school (41%) or while playing in public recreational spaces (39%) (Health Canada, 1997b, p. 201).

Most injuries to children and youth that occur outside the home environment happen during play and leisure activities.

5.13 Distribution of injuries related to the 10 leading sports and recreation activities,[a] by mode of practice, children and youth aged 0 to 19, Canada, 1993



a. Excludes drownings, near drownings and other water-related injuries, playground equipment injuries, cycling injuries and off-road vehicle injuries.

Source: CHIRPP, unpublished data, 1993.

Sports injuries are also very common. CHIRPP (Canadian Hospitals Injury Reporting and Prevention Program) data included 16,665 visits by children under 20 years of age to the emergency department in one year because of sports injuries. These injuries accounted for about 36.4% of all visits to the emergency department in the 10 to 14 age group and 40% in the 15 to 19 age group (Health Canada, 1997b, p. 221). See **Exhibit 5.13**.

Recreational Environment and Chemical Exposure

At ice rinks, children may be exposed to increased levels of carbon monoxide (CO) or nitrous oxide (NO_2) (Lee et al., 1994). At swimming facilities, children are exposed to high chlorine levels in water and air (Levesque et al., 1994). In addition, children in classrooms with insufficient air circulation could be exposed to numerous harmful compounds (sick building syndrome) (Chester and Levine, 1994).

Recreational Environment and Biological Exposure

Polluted beaches and other polluted recreational waters are a source of gastro-intestinal, respiratory and skin infections. Swimmers at several of Ontario's beaches were 2.3 times more likely to develop an infection than non-swimmers (Seyfried et al., 1985). In addition, windsurfers on the St. Lawrence River were 5.5 times more likely than observers to suffer gastrointestinal illnesses and 2.9 times more likely to develop ear, eye and skin infections (Dewailly, Poirier and Meyer, 1986).

Environment and Other Determinants

Income

Poverty increases a child's risk of injury. A study by Health Canada showed that poor children are more likely to die of injuries than other children and that children living in the lowest income neighbourhoods are at the greatest risk of dying from injuries. The rate of injury-related deaths for the poorest children and youth was 40% higher than the rate for the wealthiest children and youth (for many types of injuries) (Health Canada, 1997b, p. 54).

The children with the greatest exposure to the effects of environmental pollution are those that are poor. Poor children live in social and low-rent housing located close to industrial sites, highways and interchanges and on sites previously used for toxic waste disposal. Children in families with low incomes are at risk because they are more likely to live in houses that have not been well maintained and have faulty design. These factors contribute to the increased likelihood of poor indoor air quality from sources such as: moulds; lead (from chipping paint); and contaminants (e.g. pesticides to control cockroaches) (Chaudhuri, 1998, p. 27).

Personal Health Practices

Among the most important sources of indoor air contamination is environmental tobacco smoke (ETS). Infants and young children whose parents smoke in their presence are particularly susceptible to a number of health risks including lower respiratory infections and asthma. Thirty-nine percent of children under the age of 6 live with one or more people who smoke; 46% of Canadian households include one or more smokers (Health Canada, 1997c).

Culture: Aboriginal Children

Aboriginal children are at greater risk of injury than all other children in Canada. Injuries are a major cause of mortality for Aboriginal children and youth. Their infant injury rate is almost four times that of other Canadian infants (Health Canada, 1997b, p. 55). The injury death rate for Aboriginal teenagers is more than three times the rate for Canadian teenagers (CICH, 1994b, p. 143).

Aboriginal children are at greater risk of exposure to contaminants than other Canadian children. Risk factors such as poor housing, contaminated food sources, water supply and sanitation, and indoor and outdoor environmental contaminants make Aboriginal children especially vulnerable to the toxic effects of environmental contaminants (Postl, MacDonald and Moffat, 1994; Young, Bruce and Elias, 1991).

Aboriginal families are more often housed in accommodation that is substandard than are non-Aboriginal households. In 1996–97, 48% of the dwellings on reserves required renovations or replacement. During this same

period, 4% of the homes did not have hot or cold running water (a decrease from 17.7% 10 years ago) and 9% were without sewage disposal systems (down from 28% 10 years earlier) (DIAND, 1998, p. 48).

Gender

For every kind of injury and at every stage of development beyond age 1, boys are more likely to die or be injured than girls. Depending on the injury, boys have between two and four times more injuries than females, especially for injuries involving speed and sports (Health Canada, 1997b, p. 221). The explanation for these differences is difficult to ascertain and complex (Morrongiello, 1998).

References

Aggazzotti, G., et al. (1993). "Chloroform in Alveolar Air of Individuals Attending Indoor Swimming Pools." *Archives of Environmental Health*, Vol. 48: 250–254.

Ames, B.N., and L.S. Gold (1992). "Animal cancer tests and cancer prevention." *Monographs — National Cancer Institute*: 125–132.

Angus, D.A., et al. (1998). *The Economic Burden of Unintentional Injury in Canada*. Toronto: Smart Risk.

Axelson, O. (1995). "Cancer Risks from Exposure to Radon in Homes." *Environmental Health Perspective*, Vol. 37 (Suppl. 2): 37–43.

Bessot, J.C., F. de Blay and G. Pauli (1994). "From allergen sources to reduction of allergen exposure." *European Respiratory Journal*, Vol. 7: 392–397.

British Columbia Provincial Health Officer (1998). *The Health and Well-being of British Columbia's Children: Provincial Health Officer's Annual Report 1997*. Victoria: B.C. Ministry of Health.

Bruning-Fann, C.S., and J.B. Kaneene (1993). "The effects of nitrate, nitrite and N-nitroso compounds on human health: A review." *Veterinary and Human Toxicology*, Vol. 35: 521–538.

Burnett, R.T., et al. (1994). "Effects of low ambient levels of ozone and sulfates on the frequency of respiratory admissions to Ontario hospitals." *Environmental Research*, Vol. 65: 172–194.

Calabrese, E.J., E.J. Stanek and C.E. Gilbert (1991). "Evidence of soil-pica behaviour and quantification of soil ingested." *Human and Experimental Toxicology*, Vol. 10: 245–249.

Canada Mortgage and Housing Corporation (1991). "Families, Children and Housing Need in Canada." *Research and Development Highlights*. Issue 12.

Canadian Council on Social Development (1996). *The Progress of Canada's Children — 1996*. Ottawa: Canadian Council on Social Development.

Canadian Institute of Child Health (1994a). "Diseases of the Respiratory System." In *The Health of Canada's Children: A Statistical Profile*. Ottawa: Canadian Institute of Child Health.

Canadian Institute of Child Health (1994b). *The Health of Canada's Children: A CICH Profile*, 2nd edition. Ottawa: Canadian Institute of Child Health.

Canadian Standards Association (1990). *Guidelines on Children's Playspaces and Equipment*. CAN/CSA Z614-M90. Toronto: Canadian Standards Association.

Chad, Z. (1995). "Current approach to allergies in children." *Canadian Journal of Pediatrics*, Vol. 2: 293–305.

Chance, G., and E. Harmsen (1998). "Children are Different: Environmental Contaminants and Children." *Canadian Journal of Public Health*, Vol. 89 (Suppl. 1): S9–S13.

Chaudhuri, N. (1998). "Child Health, Poverty and the Environment." *Canadian Journal of Public Health*, Vol. 89 (Suppl. 1): S26–S30.

Chester, A.C., and P.H. Levine (1994). "Concurrent sick building syndrome and chronic fatigue syndrome: Epidemic neuromyasthenia revisited." *Clinical Infectious Diseases*, Vol. 18 (Suppl. 1): S43–S48.

Colborn, T., D. Dumanoski and J. Peterson Myers (1996). *Our Stolen Future*. New York: Penguin Group.

Cunningham, J., D.W. Dockery and F.E. Speizer (1994). "Maternal smoking during pregnancy as a predictor of lung function in children." *American Journal of Epidemiology*, Vol. 139: 1139–1152.

Dales, R.E., et al. (1991). "Respiratory health effects of home dampness and molds among Canadian children." *American Journal of Epidemiology*, Vol. 134 (2): 196–203.

DeJoy, D.M. (1992). "An examination of gender differences in traffic accident risk perception." *Accident Analysis and Prevention*, Vol. 24: 237–246.

Department of Indian Affairs and Northern Development (1997). *Canadian Arctic Contaminants Assessment Report*. Catalogue No. R72-260/1997E. Ottawa: Department of Indian Affairs and Northern Development.

Department of Indian Affairs and Northern Development (1998). *Basic Departmental Data 1997*. QS-3575-000-BB-A1, Catalogue No. R12-7/1997. Ottawa: Department of Indian Affairs and Northern Development.

Dewailly, E., C. Poirier and F. Meyer (1986). "Health hazards associated with windsurfing on polluted water." *American Journal of Public Health*, Vol. 76: 690–691.

DiFranza, J.R., and R.A. Lew (1996). "Morbidity and mortality in children associated with the use of tobacco products by other people." *Pediatrics*, Vol. 97: 560–568.

Dockery, D.W., and C.A. Pope (1994). "Acute respiratory effects of particulate air pollution." *Annual Review of Public Health*, Vol. 15: 107–132.

Environment Canada (1996). *The State of Canada's Environment — 1996*. Catalogue No. En21-54/1996E. Ottawa: Environment Canada.

Fenske, R.A. (1992). "Differences in Exposure Potential for Adults and Children Following Residential Insecticide Application." In *Similarities and Differences Between Adults and Children*. Edited by P.S. Guzelian, C.J. Henry and S.S. Olin. Washington: ILSI Press, pp. 214–225.

Fernandez-Caldas, E., et al. (1995). "Indoor Air Pollution." In *Environmental Medicine*. Edited by S.M. Brooks et al. St. Louis, MO: Mosby, pp. 419–437.

Gochfeld, M. (1995). "Soil: Sources, Dynamics, and Routes of Exposure." In *Environmental Medicine*. Edited by S.M. Brooks et al. St. Louis, MO: Mosby, pp. 515–523.

Health Canada (1996). *Building Towards Breakthroughs in Injury Control: A Legislative Perspective on the Prevention of Unintentional Injuries Among Children and Youth in Canada*. Catalogue No. H39-384/1996E. Ottawa: Health Canada.

Health Canada (1997a). *Health and Environment: Partners for Life*. Catalogue No. H49-112/1997E. Ottawa: Health Canada.

Health Canada (1997b). *For the Safety of Children and Youth: From Injury Data to Preventive Measures*. Catalogue No. H39-412/1997E. Ottawa: Health Canada.

Health Canada (1997c). *Environmental Tobacco Smoke and Children*. Ottawa: Health Canada.

Henshaw, D.L., J.P. Eathough and R.B. Richardson (1990). "Radon as a caustic factor of myeloid leukemia and other cancers." *Lancet*, Vol. 335: 1008–1012.

Jin, A., and K. Teschke (1995). *The Relation Between Exposure to Soil Contaminants and Biomarkers of Health Effects in Humans: Lead, Arsenic, Cadmium, Chromium and Benzene*. Vancouver: Province of British Columbia.

Kacew, S. (1993). "Adverse effects of drugs and chemicals in breast milk on the nursing infant." *Journal of Clinical Pharmacology*, Vol. 33: 213–221.

Kang, B.C. et al. (1996). "Experimental asthma developed by room air contamination with cockroach allergen." *International Archives of Allergy and Immunology*, Vol. 111: 299–306.

Koenig, J.Q., D.S. Covert and W.E. Pierson (1989). "Effects of inhalation of acidic compounds on pulmonary function in allergic adolescence subjects." *Environmental Health Perspectives*, Vol. 79: 173–178.

Koren, H.S. (1995). "Association between criteria air pollutants and asthma." *Environmental Health Perspectives*, Vol. 103: 235–242.

Lee, K., et al. (1994). "Carbon monoxide and nitrogen dioxide exposures in indoor ice skating rinks." *Journal of Sports Science*, Vol. 12: 279–283.

Letourneau, E.G., et al. (1994). "Case-control study of residential radon and lung cancer in Winnipeg, Manitoba, Canada." *American Journal of Epidemiology*, Vol. 140: 310–322.

Levesque, B., et al. (1994). "Evaluation of dermal and respiratory chloroform exposure in humans." *Environmental Health Perspectives*, Vol. 102: 1082–1087.

Marks, G.B., et al. (1995). "Mite allergen (Der p 1) concentration in houses and its relation to the presence and severity of asthma in a population of Sydney schoolchildren." *Journal of Allergy and Clinical Immunology*, Vol. 96: 441–448.

Mes, J., et al. (1993). "Levels of chlorinated hydrocarbon residues in Canadian human breast milk and their relationship to some characteristics of the donors." *Food Additives and Contamination*, Vol. 10: 429–441.

Morrongiello, B.A. (1998). "Preventing Unintentional Injuries among Children." In *Canada Health Action: Building on the Legacy — Volume 1, Determinants of Health: Children and Youth*. Catalogue No. H21-126/6-1-1997E. Ottawa: National Forum on Health, Health Canada, pp. 175–232.

Muckle, G., E. Dewailly and P. Ayotte (1998). "Prenatal Exposure of Canadian Children to Polychlorinated Biphenyls and Mercury." *Canadian Journal of Public Health*, Vol. 89 (Suppl. 1): S20–S25.

National Research Council (1993). *Pesticides in the Diets of Infants and Children*. Washington: National Academic Press.

Needleman, H.L., and C.A. Gatsonis (1990). "Low-level lead exposure and the IQ of children. A meta-analysis of modern studies." *Journal of American Medical Association*, Vol. 263: 673–678.

Plunkett, L.M., D. Turnbull and J.V. Rodricks (1992). "Differences Between Adults and Children Affecting Exposure Assessment." In *Similarities and Differences Between Children and Adults: Implications for Risk Assessment*, Vol. 1. Edited by P.S. Guzelian, C.J. Henry and S.S. Olin. Washington: ILSI Press, pp. 79–97.

Postl, B., S. MacDonald and M. Moffat (1994). "Background Paper on the Health of Aboriginal Peoples in Canada." In *Bridging the Gap: Promoting Health and Healing for Aboriginal Peoples in Canada*. Canadian Medical Association, pp. 19–56.

Raizenne, M., R. Dales and R. Burnett (1998). "Air Pollution Exposures and Children's Health." *Canadian Journal of Public Health*, Vol. 89 (Suppl. 1): S43–S47.

Rice, D.C. (1998). "Issues in Developmental Neurotoxicology." *Canadian Journal of Public Health*, Vol. 89 (Suppl. 1): S31–S36.

Richards, I.S., and S. Brooks (1995). "Respiratory Toxicology." In *Environmental Medicine*. Edited by S.M. Brooks et al. St. Louis, MO: Mosby, pp. 166–181.

Rivara, F.P. (1994). "Unintentional Injuries." In *The Epidemiology of Childhood Disorders*. Edited by I.B. Pless. New York: Oxford University Press, Inc., pp. 369–391.

Rodier, P.M. (1995). "Developing brain as a target of toxicity." *Environmental Health Perspectives*, Vol. 103: 73–76.

Rogan, W.J., and N.B. Rogan (1994). "Chemical contaminants, pharmacokinetics, and the lactating mother." *Environmental Health Perspectives*, Vol. 102 (Suppl. 11): 89–95.

Samet, J.M., et al. (1993). "Nitrogen dioxide and respiratory illness in children. Part I: Health outcomes." *Research Report/Health Effects Institute*: 1–32; discussion: 51–80.

Seyfried, P.L., et al. (1985). "A prospective study of swimming related illness. II. Morbidity and the microbiological quality of water." *American Journal of Public Health*, Vol. 75: 1071–1075.

Shephard, R.J. (1992). "Respiratory irritation from environmental tobacco smoke." *Archives of Environmental Health*, Vol. 47: 123–130.

Spektor, D.M., et al. (1988). "Effects of ambient ozone on respiratory function in active, normal children." *American Review of Respiratory Diseases*, Vol. 137: 313–320.

Stoddard, J.J., and T. Miller (1995). "Impact of parental smoking on the prevalence of wheezing respiratory illness in children." *American Journal of Epidemiology*, Vol. 141: 96–102.

Wjst, M., et al. (1994). "Indoor factors and IgE levels in children." *Allergy*, Vol. 49: 766–771.

Young, T.K., J. Bruce and J. Elias (1991). *The Health Effects of Housing and Community Infrastructure on Canadian Reserves*. Winnipeg: University of Manitoba, Northern Health Research Unit, Indian and Northern Affairs Canada.