Air

Chapter Highlights:

In Canada, the quality of our air is generally good and is improving. Since the 1970s, there have been significant reductions in air pollution levels in some urban areas. Despite this, air pollution has a measurable impact on our health. For example, it is estimated that more stringent fuel and vehicle emission standards would result in health benefits valued at about $1 billion per year in Canada.

- Asthma is a respiratory disease that affects more than one million Canadians, resulting in more than 60 000 hospital admissions and 250 000 days in hospital annually from 1990 to 1993 and more than 450 deaths annually from 1990 to 1995. In 1990, the total cost of asthma was estimated at over $500 million. Asthma is a common chronic illness among children and is the leading cause of school absenteeism. The rate of hospitalization for asthma has increased by 27% for boys and by 18% for girls in the last decade. Asthma can be triggered by a variety of airborne contaminants, such as dust mites, insect feces, pet dander, pollen and fungi.
- Since the 1980s, tobacco smoking has been banned from many public places. In 1994, employees reported that about 80% of Canadian workplaces had smoking restrictions. In the past few decades, the proportion of adults who smoke has declined steadily. However, the overall proportion of smokers aged 15 and older has stabilized at about 31% since the mid-1980s. Recent research suggests that each year, an estimated 40 000 Canadians die from smoking and about 300 non-smoking Canadians die of lung cancer caused by prolonged exposure to other people's tobacco smoke.
- Air quality is improving as a result of reductions in levels of most common air pollutants. Between 1979 and 1993, concentrations of several major air pollutants—including particulates, carbon monoxide, nitrogen oxides and sulphur dioxide—declined significantly. Over the same period, however, average ground-level ozone levels in Canadian cities climbed by 29%, although there was a 50% reduction in severe pollution episodes (i.e. where levels exceeded air quality objectives). Recent studies have revealed a strong association between the number of hospital admissions in Canada for respiratory symptoms and air pollutant levels on the previous day.
- Indoor air quality is an increasingly important issue in Canada. Depending on the types of contaminants present, new air quality problems, such as sick building syndrome, can be created. However, when properly designed, constructed and operated, modern homes and office buildings can be energy efficient *and* provide a healthy environment.
- Ultraviolet (UV) radiation is one of the main causes of skin cancer in Canada. In 1995, more than 55 000 Canadians developed various forms of skin cancer. Over the last 15 years, the incidence of malignant melanoma (lethal skin cancer) has doubled. This is likely due to our modern habit of suntanning rather than the recent depletion of the ozone layer, because skin cancers can take years to appear.
- Since 1895, average global temperatures have increased by 0.5°C. Climate models predict that temperatures will further increase by about 0.3°C *per decade* over the next 100 years, as a result of a steady increase in atmospheric levels of "greenhouse gases," which trap the sun's infrared radiation. If global warming of this magnitude occurs, it could trigger profound environmental and health effects, such as widespread coastal flooding, an increase in severe weather events and the northward migration of tropical diseases.

AIR

Introduction

One of the worst episodes of air pollution in modern history occurred in London, England, in December 1952, when a temperature inversion trapped pollutants near the ground and kept them from dissipating for days. Four thousand people died of chronic bronchitis and other respiratory illnesses aggravated by an acidic smog—a dangerous combination of coal smoke, airborne acids and water vapour.[16,77]

Fortunately, Canadians have never experienced such a catastrophic event, although air pollution does have a significant impact on our health (see Figure 8). For example, scientists have estimated that the common use of less-polluting vehicles and fuels in Canada will result in health benefits valued at $24 billion between 1997 and 2020.[78]

What Is *Air*?

Air is a mixture of gases that surrounds the Earth and makes up our atmosphere.[30] Pure air consists of 21% oxygen and 78% nitrogen by volume, plus traces of other gases, such as argon, carbon dioxide and water vapour.[30] In practice, air may contain literally thousands of chemical and biological substances, of both natural and human origin. As a result, the composition of air can vary significantly both from one location to another and between the indoor and outdoor environments.

How Does Air Become Contaminated?

Outdoor air contaminants come from both natural and human sources. Natural sources include smoke from forest fires, wind-blown dust from soil and volcanoes, fungi, bacteria, plants and animals. Pollutants are also released by motor vehicles, industrial processes, the burning of fossil fuels or wood and other human sources.[79] The levels of different contaminants in outdoor air are influenced by such factors as population density, the degree of industrialization, local pollution emission standards, season, climate and daily weather conditions.

Air pollutants may originate from local sources or remote locations. They can travel thousands of miles across borders and oceans or from one urban area to another.[30] This phenomenon, called "long-range atmospheric transport," is common around the world. Even areas that are far from urban and industrial centres, such as the Arctic, can receive pollutants carried by winds from North America, Russia, Asia and Europe.[80,81]

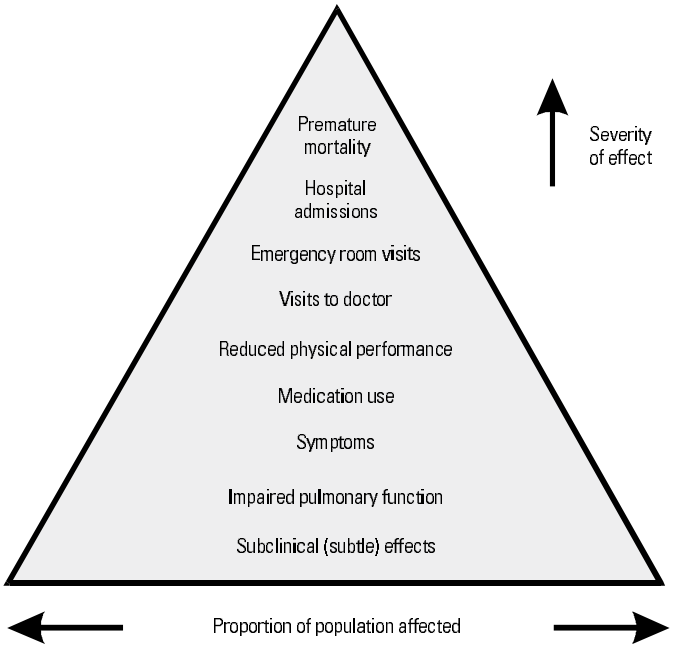


Figure 8
The Cascading Effects of Air Pollution

Research demonstrating premature deaths and increased rates of hospitalization due to certain air pollutants could in fact reflect a very large burden of illness in the population. Figure 8 shows this "cascading effect" and is adapted from the *Canadian Respiratory Journal* 1995; 2 (3): 155–160.

Source: ***Outdoor Air and Your Health: A Summary of Research Related to the Health Effects of Outdoor Air Pollution in the Great Lakes Basin,*** *Health Canada, 1996, p. 3.*

Sources of Indoor Air Pollution

Indoor air quality is an increasingly important issue in Canada. Canadians spend nearly 90% of their time indoors,[82] and people who are particularly susceptible to the effects of air pollutants, such as infants, the elderly and the infirm, probably spend even more time indoors.[72] Indoor air pollution may originate from outdoor and indoor sources. For example, pollutants released by motor vehicles and factories—such as carbon monoxide and fine particulates—may also contaminate indoor air as a result of the natural flow of air inside and outside buildings.[83,84]

Indoor air pollutants can also arise from building materials and furnishings, heating and cooking, the use of consumer products and the ground upon which the structure is built.[72] Common pollution sources and contaminants include tobacco smoke, formaldehyde, kerosene from heaters, cleaning products, paints and varnishes.[30,85] Radon, a naturally occurring radioactive gas, can accumulate in indoor air in areas where underlying soils and rocks have a high uranium content (e.g. granite, shale, phosphate) or where the soil readily permits the movement of soil gas. Biological contaminants, such as moulds and bacteria, are generally found at higher levels indoors.[30] Poor ventilation can increase the level of indoor air contaminants.

Air Quality and Our Health

Air pollutants may pose a health risk to Canadians either directly through inhalation or indirectly through their effects on the environment.[30] For example, the deposition of airborne substances on vegetation, soil, rivers and lakes can result in contamination of food and drinking water supplies.

When inhaled, air pollutants can cause a variety of health effects. The ultimate impact of a contaminant depends upon a number of factors, such as its physical properties (e.g. size and acidity), the concentration of the contaminant in inhaled air, the rate and depth of breathing and the health of exposed individuals.[86] Health effects associated with different air pollutants include asthma attacks, breathing difficulties, respiratory inflammation and illnesses, heart problems, decreased lung capacity and premature death.[87,88] Several groups, including young children, the elderly, the infirm and people with respiratory illnesses, may be more susceptible to the health effects of air pollution, as

Children and Air Pollution[91]

Children are generally more vulnerable to air pollution than adults under age 65 because they tend to spend more time outdoors and have a higher respiration rate than adults, which means they take in more air (and hence more air pollutants) per kilogram of body weight. In addition, lungs are actively developing and growing during infancy and childhood. They reach full maturity only when children enter their late teens. Up to eight years of age, children produce alveoli, the principal unit of lung tissue.[90] Pollutants such as ground-level ozone may interfere with normal lung growth and function by affecting lung surfactant, a fluid that is essential to the growth and function of new alveoli.

may those involved in outdoor physical activities, such as cyclists, joggers and outdoor workers.[87,89]

Asthma

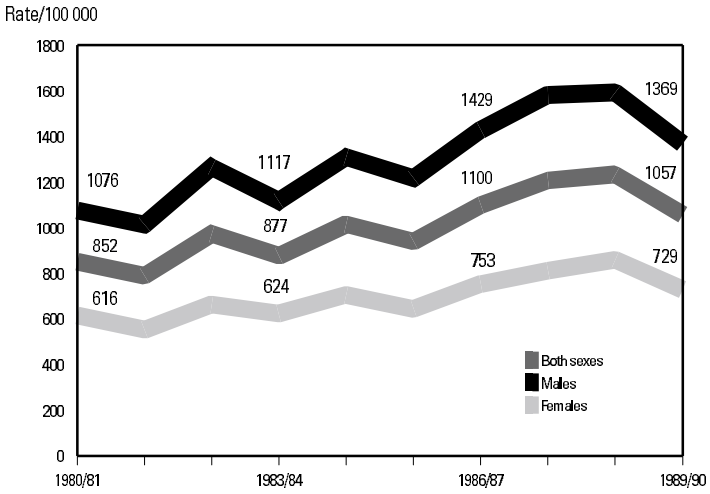
Asthma is a respiratory disease that affects more than one million Canadians, resulting in more than 60 000 hospital admissions and 250 000 days in hospital annually from 1990 to 1993 and more than 450 deaths annually from 1990 to 1995.[92] In 1990, the total cost of asthma in Canada was estimated at $504–648 million—a figure that includes both medical treatment and lost productivity costs.[93]

The 1978 Canada Health Survey estimated the prevalence of asthma among the population 15 years of age and over to be 2.3%.[94] Thirteen years later, the 1991 General Social Survey estimated the prevalence of asthma in Canada to be 6% for the same age range.[95] The most recent national data on asthma prevalence are from the 1994/95 National Population Health Survey, which estimated that 6.1% of the population aged 15 years and over had been diagnosed as having asthma by a health professional.[25] These surveys did not include children, who tend to have a higher prevalence of asthma; therefore, the actual prevalence of asthma in the total population may be higher than 6.1%.

Asthma attacks are characterized by breathlessness and may be accompanied by coughing and wheezing. Asthma attacks may be triggered by a number of factors, including viral infections, dust mites, insect feces, pet dander, pollen, fungi, exercise, tobacco and wood smoke, cold air, hair spray, paint, exhaust fumes and smog.[96–98]

Asthma is a common chronic illness among children and is the leading cause of school absenteeism.[99] The rate of hospitalization for asthma has increased by 27% for boys and by 18% for girls in the last decade (see Figure 9). This probably represents only the sickest children, with many more having the illness.[91,99] A 1988 survey of Canadian children revealed that gas stoves, exposure to environmental tobacco smoke (ETS), home dampness and the use of humidifiers are associated with higher asthma prevalence rates.[100]

Figure 9
Hospitalization for Asthma, One to Four Years of Age, Canada, 1980/81 to 1989/90



Source: ***The Health of Canada's Children: A CICH Profile, 2nd Edition,*** *Canadian Institute of Child Health, 1994, p. 49. Reproduced with permission of the Canadian Institute of Child Health, 1997.*

The Student Lung Health Survey[101]

In 1995 and 1996, Health Canada's Laboratory Centre for Disease Control conducted a survey of asthma in school children (ages 5–19) in nine public health units across Canada. Approximately 39 000 children (with their parents) were given a screening questionnaire to determine if they had ever been diagnosed with asthma. Those who reported a recent history of asthma were asked to participate in a more in-depth telephone interview. The data collected from this survey are used to investigate the prevalence, incidence and severity of asthma, asthma management, environmental control measures, asthma education, utilization of health services and prevalence of allergies (hay fever, food and eczema). The results show that the prevalence of self-reported, doctor-diagnosed asthma in the nine health unit districts is 13.0% among 5- to 19-year-old school children.

How Clean Is Our Air?

Outdoor Air Quality

Since the 1970s, air quality has improved substantially in Canada's urban areas (see Figure 10 in the section "Common Air Pollutants"). Generally, levels of the most common air pollutants—airborne particulates, ground-level ozone, carbon monoxide, sulphur dioxide and nitrogen oxides (NO_x)—are well below the maximum acceptable levels established by the federal government. For example, in 1992, ozone levels were below the one-hour maximum acceptable level of 82 ppb over 99.5% of the time.[102] However, despite these encouraging trends, air pollution remains a problem in some areas of Canada.

Indoor Air Quality

To improve energy efficiency, many Canadian homes and buildings were built in the 1970s to reduce the rate of air exchange between the outdoor and indoor environments. These airtight, well-insulated buildings required less fuel and thus reduced heating bills. However, by reducing the flow of fresh air from outside, we encourage the buildup of contaminants, such as natural radon gas or human-made chemicals from building materials and furnishings. Depending on the types of contaminants present, new air quality problems can be created.[30,103,104] However, when properly designed, constructed and operated, modern homes and office buildings can be energy efficient *and* provide a healthy environment.

Key Issues

The following sections describe the health issues associated with airborne contaminants to which Canadians are directly exposed through inhalation, including tobacco smoke; commonly measured air pollutants, such as ground-level ozone, carbon monoxide and particulates; biological agents, such as fungi, bacteria and dust mites; hazardous organic compounds, such as benzene; metals, such as lead, cadmium, chromium and nickel; and radon and other natural or artificial radionuclides in the air.

Tobacco Smoke

Until the 1960s, smoking was widely accepted, and its health risks were largely unknown or ignored. At one time, even hospitals and other health facilities distributed cigarettes to patients on a regular basis. However, attitudes towards smoking have changed dramatically in recent decades. The dangers of active smoking (in which smoke is inhaled directly from a cigarette, cigar or pipe) and passive smoking (in which bystanders inhale the smoke from the burning tip of a cigarette, cigar or pipe and exhaled smoke) are well understood. Tobacco has been banned from many public places; in 1994, workers reported that about 80% of Canadian workplaces had smoking restrictions.[105]

Despite this, smoking is still the leading cause of preventable illness and premature death in Canada.[106] Tobacco is responsible for an estimated 40 000 deaths every year.[21] In Canada, the annual death toll from tobacco may exceed the combined toll from traffic accidents, suicides, murder, AIDS and illicit drug use.[107]

Smoking

Tobacco smoke contains more than 4000 chemical compounds, including heavy metals such as lead and cadmium, pesticides and fertilizers, which are absorbed by tobacco plants from the surrounding soil. Nicotine and roughly half of the 4000 other chemicals found in tobacco smoke are naturally present in the green tobacco leaves themselves. The remaining substances are produced by chemical reactions when tobacco is cured and burned.[108]

Many of the chemical compounds found in tobacco smoke are harmful and can cause a range of health problems. For example, carbon monoxide combines with human blood and reduces the body's ability to use oxygen. At elevated levels, carbon monoxide causes nausea, headaches and dizziness.[109] Formaldehyde and other aldehydes can irritate the eyes, nose and throat. Tobacco smoke is also a significant indoor source of polycyclic aromatic hydrocarbons (PAHs). Exposure to high levels of PAHs, which occur in tars and soot, can cause lung disease and aggravate asthma and heart and

lung disorders.[109] Up to 90% of all cases of emphysema and chronic bronchitis are also caused by smoking.[56]

At least 50 of the compounds present in tobacco smoke are known to cause or promote cancer. Smoking increases the risk of developing lung cancer (and cancers of the throat, mouth, tongue, lip, larynx, pharynx, bladder, kidney and pancreas), cardiovascular disease, bronchitis, other respiratory diseases and strokes.[56,110] Approximately 85% of lung cancers are directly related to smoking, of which about 90% are fatal. In 1995, 78.9 males per 100 000 and 33.3 females per 100 000 died of lung cancer in Canada.[45] Today, lung cancer is the principal cause of cancer deaths in women.[56]

Did you know?

Research by the U.S. Centers for Disease Control indicates that 46% of all tobacco-related deaths are due to cardiovascular disease, 26% are due to lung cancer, 14.3% are due to chronic bronchitis and emphysema, 7% are due to other cancers and 6.7% are due to other causes.[111]

Smoking also poses additional health concerns for women. For example, smoking together with the use of oral contraceptives increases the risk of heart disease among women by 10 times. Smoking increases a woman's risk of both osteoporosis and cancer of the cervix. Smokers have more complications during pregnancy, including a greater number of miscarriages, premature births and still-births. Smoking restricts the flow of oxygen and blood supply to the fetus. Recent studies indicate that second-hand smoke can reduce birth weights, especially if the fetus is exposed to smoke in the third trimester.[56]

In Canada, the proportion of adults who smoke has declined steadily, although the overall smoking prevalence has stabilized since the mid-1980s. Moreover, today's smokers are smoking fewer cigarettes than in previous years and have fewer opportunities to smoke, because many public places are now smoke-free. Despite these trends and the fact that most individuals realize that tobacco is addictive and harmful, almost one-third of Canadian adults still smoke, as well as 24–30% of 15- to 19-year-olds.[112,113]

Environmental Tobacco Smoke (ETS)

Environmental tobacco smoke (ETS) —also known as passive or second-hand smoke—is a combination of exhaled smoke and the smoke from cigarettes, cigars or pipes. ETS is the

The 1994 Health Canada Survey on Smoking

According to the 1994 Health Canada Survey on Smoking, Canadian smokers come from all walks of life. Overall, 31% of Canadians over 15 years of age smoke cigarettes, and 25% say they smoke every day.[54] Less than 10% of all current smokers say they have never tried to quit smoking.[114]

The proportion of Canadians who smoke is highest among 20- to 24-year-olds (40%) and lowest among those 65 and over (16%).[115] College-educated people with adequate incomes are less likely to smoke than less-educated, lower-income Canadians.[116] For example, 33% of low-income women smoke, compared with 23% of women in higher income brackets. Similarly, only 14% of university graduates are daily smokers, compared with 28% of those who have not completed high school.[117] Among Aboriginal Canadians, 57% of adults smoke cigarettes, and 46% say that they smoke every day.[118]

The majority of current smokers took up their habit before they reached age 18. The survey found that more than 50% of males and females aged 10–19 believe that it is easy to buy cigarettes[119] and that 52% of tobacco retailers were willing to sell cigarettes to people under 18 years of age.[120] The most common reasons for starting to smoke are peer pressure and the smoking behaviour of friends, according to 70% of 15- to 19-year-old Canadians. Among this age group, 79% said that more than half of their close friends smoke. Only 16% of non-smoking youth said the same thing.[113,121]

most harmful and widespread of all indoor air contaminants.[56] The smoke from the tip of a burning cigarette contains twice the amount of nicotine, three times the tar and five times the carbon monoxide of the smoke inhaled by a smoker—although the levels of these compounds are diluted in the surrounding air.[56] Tobacco smoke not only poses a significant health risk for smokers but can also compromise the health of people around them.

Everyone who comes into contact with people smoking is at risk of exposure to second-hand smoke. Approximately two-thirds of the smoke produced by a burning cigarette is never inhaled by the smoker but contaminates the surrounding air. The 1994 National Survey on Smoking conducted by Health Canada found that almost half of the population aged 15 and over is exposed to ETS on a daily basis.[54]

Fifty-six percent of Canadians, including both smokers and non-smokers, report being physically irritated in some way by ETS.[54] Second-hand smoke can cause respiratory problems and heart disease and increases the risk of sudden infant death syndrome. It is estimated that more than 300 non-smokers in Canada each year die of lung cancer caused by prolonged exposure to other people's tobacco smoke.[22]

Did you know?

In 1991, the direct health care costs attributable to smoking in Canada were an estimated $2.5 billion. When the costs of residential care, worker absenteeism, fires and lost future income are added, the total costs attributable to smoking rise to $15 billion.[21]

Protecting Our Health

Since 1985, a coalition of Canadian health organizations and all levels of government has supported a National Strategy to Reduce Tobacco Use, which aims to produce a generation of non-smokers.[56] Significant milestones in the war on tobacco include:

- the introduction of antismoking policies in the 1980s, which helped to lower both the number of cigarettes smoked and the overall prevalence of smokers in Canada. Between 1980 and 1990, tobacco consumption in Canada decreased by more than 30%[56];
- the 1988 *Non-Smokers' Health Act*, which restricted smoking in federal government workplaces. More than 350 municipal by-laws and policies restrict smoking in public places across the country;
- the 1989 *Tobacco Products Control Act*, which prohibited all forms of tobacco advertising and required health warnings on packages. In September 1995, however, the Supreme Court of Canada struck down key sections of the Act, ruling that the ban on advertising was contrary to freedom of expression as protected by the *Canadian Charter of Rights and Freedoms*[122];
- the February 1994 National Action Plan to Combat Tobacco Smuggling, under which the federal government and some provinces lowered tobacco taxes and funded (from a surtax on tobacco manufacturing profits) a three-year Tobacco Demand Reduction Strategy. This Strategy combined legislation, research and public education to reduce Canadians' use of tobacco;
- the 1994 *Ontario Tobacco Control Act*, which raised the legal age for buying cigarettes in Ontario, abolished cigarette vending machines and increased penalties for selling to minors; and
- *Bill C-71* (the *Canadian Tobacco Act*), which was introduced by Health Canada to strengthen the federal government's tobacco control strategy. The new legislation, which became law in April 1997, includes measures to prohibit tobacco ads on broadcast media, billboards, street kiosks, bus panels and counter-top displays in stores; ban cigarette vending machines and the mail-order distribution of tobacco; increase the health information displayed on tobacco packages; and require proof of age for people purchasing tobacco products.

Did you know?

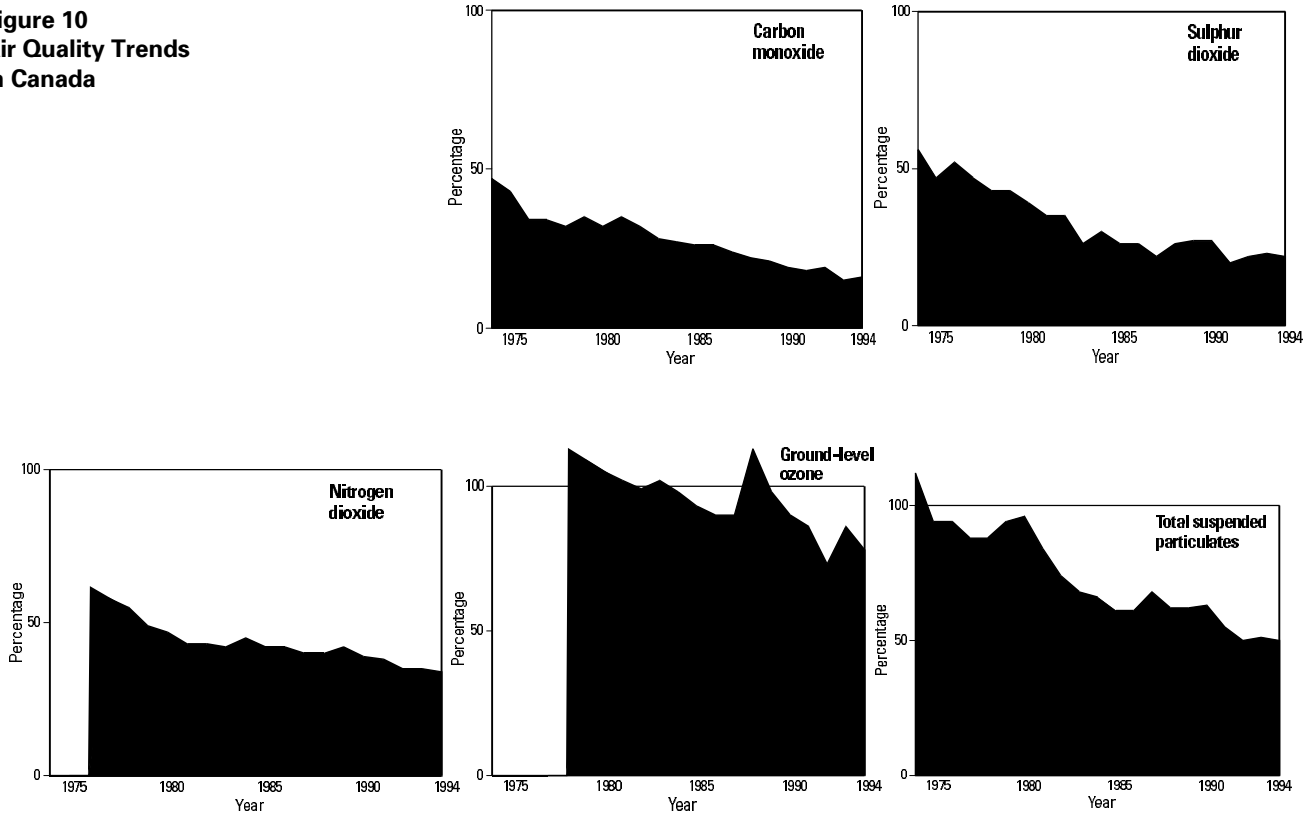
Strong links have been made between tobacco advertising, tobacco packaging and the use of tobacco products. Health experts believe that tobacco advertising serves to trivialize the hazards of tobacco use and enhances the social acceptability of smoking. Cigarette packaging is a particularly effective promotional tool, because it is often seen throughout the day by current and would-be smokers.[123,124]

What You Can Do

The health risks associated with tobacco smoke suggest that it is beneficial to avoid tobacco smoke whenever possible. For smokers, the best and most difficult option is to quit smoking. A large proportion of people who try to quit smoking ultimately fail because of their intense craving for nicotine and difficult withdrawal symptoms. According to the U.S. Surgeon General[125–127] and the Royal Society of Canada,[128] nicotine is an addictive drug that causes effects similar to those of heroin and cocaine. The good news is that, for those who successfully kick the habit, the body is able to reverse much of the harm caused by tobacco smoke, especially if quitting occurs early in life.[129]

For advice on how to stop smoking, contact your family physician or municipal health department or consult the publication *Tobacco Use Cessation Programs: An Inventory of Self-Help and Group Programs. 1996 Update*, which is available from the Publications Office of Health Canada.

Figure 10
Air Quality Trends in Canada



The figures show trends in the annual average levels of sulphur dioxide, nitrogen dioxide, and total suspended particulates, and peak statistics for carbon monoxide and ground-level ozone in Canadian cities. Figures are plotted as a percentage of the maximum acceptable level.

Source: Pollution Data Branch, Environment Canada. Reproduced with permission of the Minister of Public Works and Government Services Canada, 1997.

Common Air Pollutants

The most commonly measured outdoor air pollutants in Canada include particulates, ground-level ozone, carbon monoxide, sulphur dioxide and nitrogen oxides (see Figure 10). These substances are the principal ingredients or precursors of smog and acid rain.

Particulates

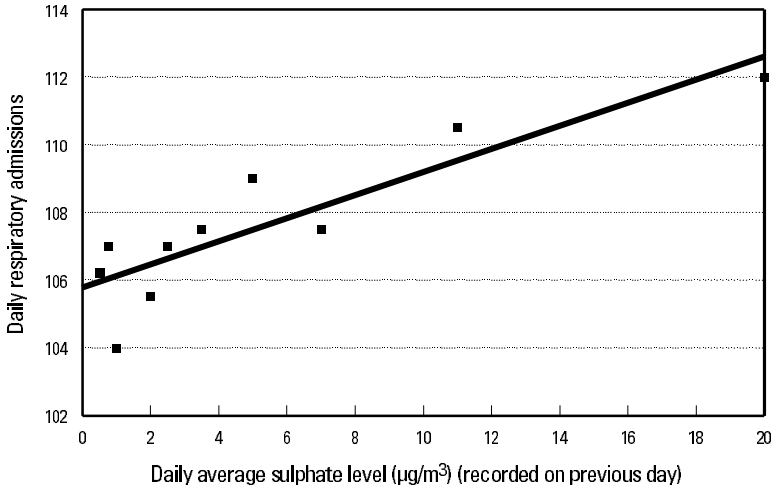
Airborne particles or "particulates" are very small solids and liquids that vary in size and chemical composition.[87] Solid particulates include chemical contaminants and living organisms, such as viruses, pollen grains, bacteria and fungal spores. Liquid particulates include mists, aerosols and fogs.[130] Particulates often have chemical contaminants attached to them, such as PAHs, metals and acidic sulphates.[81] High levels of particulates may occur in outdoor and indoor air at any time of the year.

Airborne particulates are produced by a variety of natural and human sources. Naturally occurring particulates include wind-blown dust, soil, pollen, soot from forest fires and sea salt. Human sources of outdoor particulates include vehicle exhaust emissions, industrial emissions, road dust, agriculture, construction, wood burning, mining, smelting, pulp and paper processing, metal processing and transportation.[131,132]

Indoor particles may be released by outdoor or indoor sources of contamination. Cigarette smoke is one of the principal sources of indoor air pollution.[84,133] In office buildings, the average level of particulates detected in smoking areas is 3–10 times higher than the level in non-smoking areas.[134] Other sources include cooking; vacuuming and dusting; heating, ventilation and air conditioning systems; consumer products, such as spray disinfectants, cleaners and repellents; and unvented clothes dryers.[133]

Average levels of airborne particulates in Canadian cities fell by 38% between 1979 and 1993 as a result of controls on vehicle and industrial emissions, an increase in road paving and restrictions on the burning of garden wastes.[102,135] Some communities have also introduced "no burn" days to limit wood smoke emissions when weather conditions are unfavourable.[136] Despite such initiatives, it is not known whether levels of inhalable PM_{10} particles—which have a diameter of less than 10 µm (a millionth of

Figure 11
Relationship Between Daily Hospitalization Rates and Daily Average Sulphate Levels on the Previous Day



Source: ***Outdoor Air and Your Health: A Summary of Research Related to the Health Effects of Outdoor Air Pollution in the Great Lakes Basin,*** *Health Canada, 1996, p. 2.*

a metre)—or the even smaller $PM_{2.5}$ particles (<2.5-µm diameter) also declined over this period. These smaller particles appear to pose a greater health risk, because they are more likely to travel past natural defences in the nose and throat deep into the lungs.[137]

Short-term exposure to airborne particulates at the levels typically found in urban areas in North America is associated with a variety of adverse effects, including respiratory symptoms and heart disease.[81,138] Particulates can irritate the eyes, nose and throat and cause coughing, breathing difficulties, reduced lung function and an increased use of asthma medication.[139–141] Exposure to particulates is also associated with an increase in the number of emergency department visits by people with asthma,[142,143] an increase in hospitalizations of people with cardiac and respiratory disease[10] (see Figure 11) and increased mortality.[138,144]

Some studies suggest that acid aerosols are a particularly important component of particulate air pollution, but this is not certain. Short-term exposure to acid aerosols is associated with coughing, reduced lung function and an increase in hospital admissions for respiratory problems.[145,146] Other studies have shown an association between long-term exposure to acid aerosols and bronchitis, as well as reduced lung function in children.[147–150]

Did you know?

Air quality indices are a convenient method of translating air pollution concentration data from the National Air Pollution Surveillance (NAPS) Network, which operates across Canada, into information that the general public can easily understand and use. Air quality indices are based on measurements of five common air pollutants for which there is evidence of adverse effects on human health and the environment at specified outdoor levels: carbon monoxide, sulphur dioxide, nitrogen dioxide, ozone and total suspended particulates. An index can also contain subindices that are responsive to the public's perception of air quality, such as reduced visibility and odour, which is reported as total reduced sulphur. Ontario's Air Quality Index (AQI), for example, is a province-wide monitoring and information system that provides the public with a continuous measure of outdoor air quality and includes the five pollutants noted.[81,157]

What You Can Do

Here are some tips to reduce your risk of exposure to airborne particulates:

- Avoid taking unnecessary car trips to reduce the production of particulates.
- Avoid strenuous outdoor activity on days when outdoor air quality is poor.
- Ensure that filters and air conditioning systems in your home are properly installed, maintained, cleaned and/or replaced regularly according to manufacturers' instructions.
- Avoid the use of aerosol products indoors.
- Ensure that your clothes dryer is properly ventilated.
- Use distilled or deionized water in ultrasonic humidifiers to minimize particle formation.[85]
- Avoid exposure to tobacco smoke in indoor environments as much as possible.[133]

Ground-Level Ozone

Ozone is a poisonous gas that is naturally present in outdoor air; in the upper atmosphere, it plays the vital role of blocking out harmful ultraviolet (UV) rays. Ozone is also produced at ground level when two kinds of pollutants, nitrogen oxides and volatile organic compounds (VOCs), react in the presence of sunlight. Other sources of ozone include photocopying machines and electrostatic air cleaners, although indoor concentrations of this gas are generally lower than the levels found in ambient air. Ground-level ozone is both the main component of smog and a contributor to the "greenhouse effect"—the process in which certain atmospheric gases warm the Earth's surface by trapping solar energy in the form of heat.[152]

From 1979 to 1993, the average concentrations of ground-level ozone in urban areas climbed by 29% (see Figure 10), despite a 50% reduction in severe ozone episodes.[135] Ozone levels tend to peak in the summer months. Canada has one of the world's most stringent air quality objectives for ground-level ozone. The federal government has established a maximum acceptable level for ozone of 82 ppb over a one-hour period. This air quality objective is most often exceeded in southern Ontario, southern Quebec, southern New Brunswick and the Fraser Valley.[87] A significant proportion of the ozone pollution in the Windsor–Quebec City corridor and the Maritimes is due to transboundary pollution from the United States.[131] In the Lower Fraser Valley of British Columbia, the surrounding mountains create a pocket in which pollutants from the Vancouver area can collect and accumulate.[131]

What Is Smog?[81,152]

The word "smog" was coined several decades ago to describe the combination of smoke and fog in the atmosphere, which is often visible as a brownish yellow haze over urban areas. A complex product of motor vehicle exhaust and industrial pollution, smog most often occurs over large cities, although suburban and rural communities are not always spared. Smog tends to form under conditions of bright sunlight, high temperature and a stationary air mass. Therefore, the afternoons and early evenings of hot summer days are peak smog periods; by late in the day, the sun's rays have "baked" the exhaust from motor vehicles and industries into smog.[153]

Ground-level ozone is the principal ingredient of smog. Smog may also contain acidic air pollutants, peroxyacetyl nitrate, particulates, nitrogen oxides, sulphates and carbon monoxide. The health effects of smog resemble those of ozone. However, because smog is a mixture of pollutants, its effects can vary, and the impact of one pollutant may be intensified when the pollutant is combined with another. More research is required to identify and understand fully the health effects of various chemical combinations and of long-term exposure to low levels of smog.

Did you know?

Ozone pollution is more common in some rural areas of southwestern Ontario than in nearby industrial centres. This is because nitrogen oxide emissions, which are generally higher in urban areas, can convert ozone (O_3) into oxygen (O_2), thereby reducing ozone levels in towns and cities.[131,152]

Short-term (a few hours) exposure to elevated ozone levels can irritate the eyes, nose and throat and cause respiratory problems, such as coughing and painful deep breathing.[154] The impact of ground-level ozone is worsened by outdoor exercise, because more air—and thus more ozone—is inhaled.[152] Exposure to harmful levels of ozone during outdoor activities is associated with shortness of breath and decreased lung function,[155,156] work capacity and athletic performance.[85,154] Ground-level ozone also increases the susceptibility of asthmatics to common allergens,[157] the number of emergency department visits by people with asthma[143,158,159] and the number of hospital admissions for respiratory conditions.[160–162] Studies involving laboratory animals suggest that long-term exposure to ozone may decrease the lungs' ability to fight disease and accelerate the rate at which lung tissue ages.[152]

Children may be particularly susceptible to ozone's effects, because they tend to spend more time outdoors engaged in physical activity.[82] The elderly may also be more susceptible, because they are more likely to suffer from cardiorespiratory conditions. In addition, an estimated 5–20% of the general population may for some reason be highly sensitive to ozone.[152]

What You Can Do

Ground-level ozone concentrations are highest in the summer months. You can reduce your exposure to this pollutant by:

- avoiding strenuous outdoor exercise from mid-afternoon to early evening when ozone levels reach their peak;
- avoiding outdoor activities in heavy traffic areas, especially during rush hour[152]; and
- adhering to smog advisories, if possible.

Carbon Monoxide

Carbon monoxide is an invisible odourless gas formed from the combustion of material containing carbon.[135] Natural sources of carbon monoxide include volcanic, marsh and natural gases; the world's oceans; forest fires; and electrical storms. Carbon monoxide is also a product of gasoline and diesel engines and industrial processes that involve burning fuel to generate electricity or heat.[30,102] In Canada, average carbon monoxide levels in urban air fell by 56% between 1979 and 1993, owing primarily to a reduction in automobile emissions (see Figure 10).[135]

Indoor sources of carbon monoxide include gas stoves, kerosene heaters, tobacco smoke, fireplaces and furnaces. In an airtight house, carbon monoxide may reach harmful levels when a fireplace is in use. This is because operating appliances, such as furnaces, ventilation fans and dryers, tend to create a backdraft, sucking chimney air back into the house.[163] The extent of exposure of the general population to carbon monoxide is not known.

When inhaled, carbon monoxide reduces our ability to use oxygen. Once in the bloodstream, the gas dissolves and reacts with hemoglobin, a protein found in red blood cells, reducing its capacity to carry oxygen to body tissues. Health effects associated with relatively low-level, short-term exposure to carbon monoxide include decreased athletic performance and aggravated cardiac symptoms. At the levels typically found in large U.S. cities, carbon monoxide may increase hospital admissions for cardiac diseases.[164,165] At elevated concentrations, carbon monoxide can cause nausea, headaches and dizziness; at extremely high levels, it can be fatal.[30,152] People who are particularly at risk from carbon monoxide poisoning include those with heart or respiratory disease, anemia or blood circulation problems; pregnant women; infants; the elderly; and heavy smokers.

What You Can Do

Here are some tips to reduce your risk of exposure to carbon monoxide:

- Avoid running vehicle engines in an attached, closed garage.[109]
- Avoid exercising near heavy traffic areas at rush hour.[152]
- Use devices such as unvented kerosene heaters only in properly ventilated areas.
- Ensure that fireplaces are drawing well and that furnaces have a sufficient air supply.
- Avoid exposure to tobacco smoke.[72,109]
- Consider installing a carbon monoxide sensor (commercially available in many hardware stores across Canada). Be sure to follow the manufacturer's instructions regarding installation and proper maintenance.

Sulphur Dioxide

Sulphur dioxide is a corrosive, colourless gas with a strong odour that is chemically converted in the atmosphere into acidic pollutants such as sulphuric acid and sulphate particles.[81] One of the principal contributors to "acid rain," sulphur

Controlling Acid Rain

Launched in 1985, the Canadian Acid Rain Control Program is a successful partnership involving federal and provincial governments, industry and environmental interest groups. The program was established to reduce total sulphur dioxide emissions in the seven easternmost provinces—Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland, which bear the brunt of acid rain—by 40% of 1980 levels by the year 1994. In fact, sulphur dioxide emissions fell by 56% from 3.8 million tonnes in 1980 to 1.7 million tonnes in 1994, as a result of industrial process changes, the installation of smoke stack scrubbers and fuel switching.[166]

Transboundary emissions from the United States are responsible for more than 50% of the acid rain falling in Canada.[166] To address this problem, Canada signed a bilateral Air Quality Agreement with the United States in 1991. Under this Agreement, Canada's obligations include the establishment of a permanent national limit on sulphur dioxide emissions of 3.2 million tonnes by the year 2000 as well as a 10% reduction in projected nitrogen oxide emissions from stationary sources by the same year. The United States must reduce its annual sulphur dioxide emissions by 9 million tonnes and nitrogen oxide emissions by 1.8 million tonnes by the year 2000.[166–168]

In 1995, Canada began developing a new national strategy on acidifying emissions to help meet its ongoing international commitments on acid rain. The goal of the strategy is to minimize the health and environmental impacts of acidifying emissions and to ensure that Canadian resources that are not now damaged by acidifying emissions do not become damaged in future. Health Canada is contributing scientific expertise to the national strategy,[169] which involves the joint efforts of federal and provincial governments and various stakeholders. The strategy will set objectives for sulphur dioxide and nitrogen oxide emissions beyond the year 2000.[167,170]

dioxide is a product of oil and gas processing, ore smelting and the burning of coal and heavy oil.[135] From 1979 to 1993, average sulphur dioxide levels in eastern Canada fell by 46% (see Figure 10), primarily as a result of reductions in smelter and power plant emissions under the Eastern Canada Acid Rain Control Program[135] and a switch from oil to natural gas for home heating.

Studies involving laboratory animals suggest that sulphur dioxide causes effects at levels higher than those usually found in outdoor air. Sulphur dioxide can cause breathing problems in people with asthma, but at relatively high levels of exposure.[163] There is some inconsistent evidence that exposure to elevated sulphur dioxide levels may increase hospital admissions and premature deaths—effects that have been observed for sulphate particles.

Nitrogen Oxides

Nitrogen oxides are a family of gases that can be transported long distances in our atmosphere and, like sulphur dioxide, undergo transformation into acidic air pollutants, such as nitric and nitrous acid.[81,171] Nitrogen oxides also play a key role in the formation of ground-level ozone. Nitrogen oxides are formed naturally during lightning storms and by nitrogen-fixing soil bacteria. In addition, nitrogen oxides are a by-product of the burning of fossil fuels, such as gasoline, diesel fuel, natural gas, oil and coal, for transportation, home and industrial purposes. In indoor air, gas stoves and unvented kerosene heaters are the main sources of nitrogen oxides.

In Canada, total nitrogen oxide emissions remained relatively constant between 1980 and 1990,[166] although there was a significant drop in nitrogen dioxide levels over Canadian cities. In 1990, mobile sources such as cars and trucks accounted for 35% of total nitrogen oxide emissions, industrial sources accounted for 23% and electric utilities contributed 12%.[166]

The NO_x/VOCs Management Plan

In 1989, the Canadian Council of Ministers of the Environment established the NO_x/VOCs Management Plan to help control emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), the primary precursors of ground-level ozone.[173] Under this program, Health Canada provides advice on health-related issues.

To achieve significant reductions in NO_x and VOC levels, the program is pursuing a variety of strategies, including improvements in energy efficiency, fuel reformulation, changes in fuel combustion and production processes, improvements in emission control devices and the prevention of vapour leakage from fuel storage tanks.[81,131] For example, the Canadian petroleum industry has installed equipment in the Vancouver and Toronto areas to reduce the accidental release of VOCs during the transfer of gasoline between facilities.[172]

Did you know?

Average levels of nitrogen dioxide in Canadian cities declined by 28% between 1979 and 1993 (see Figure 10), despite an estimated 13% increase in the distance travelled by motor vehicles.[135] Contributing factors included improved fuel efficiency, the increased use of emission control devices, stricter new car emission control standards and voluntary emission reduction agreements from automobile manufacturers.[172] Further emission reductions are being sought through the introduction of tougher performance standards on exhaust emissions from new vehicles.[166]

At elevated levels, nitrogen oxides can impair lung function, irritate the respiratory system and, at very high levels, make breathing difficult, especially for people who already suffer from asthma or bronchitis. Exposure to high concentrations of nitrogen oxides may also affect the body's ability to defend itself against bacterial and viral infection. Prolonged exposure to elevated nitrogen oxide levels is associated with an increased incidence of respiratory illness. Children are particularly sensitive to the effects of nitrogen oxides.[30]

For more information about nitrogen oxides and other common air pollutants, consult the following Health Canada publications:

- *Air Care—A Parent's Guide to Air Quality and Health*;
- *Air Quality and Health in Saint John*;
- *Exposure Guidelines for Residential Indoor Air Quality* (this publication lists acceptable levels of ozone, carbon monoxide and other indoor air contaminants);
- *Health Effects of Acid Air Pollution*;
- *Indoor Air Quality and You*; and
- *Outdoor Air Quality and You*.

Biological Agents

Canadians spend, on average, about 90% of their time indoors, where they often come in contact with air pollutants of biological origin.[109] Biological agents commonly found in the indoor air environment include micro-organisms, such as fungi and bacteria; dust mites; and seasonal allergens, such as pollen (these are also a problem in outdoor air). By contrast,

most viruses do not survive for long periods in indoor air, although relative humidity, temperature and the presence of other pollutants can affect their survival and spread.[30,134,174] Factors that promote the growth of micro-organisms and dust mites include humidity, dampness and inadequate ventilation.[163,175]

Fungi

Fungi, particularly moulds, are capable of growing on virtually any surface, including wood, glass, paint, rubber, textiles and electrical equipment.[176] Moulds thrive in the moist environments associated with building leaks, flooding or excess humidity—conditions often found in basements, bathrooms and kitchens.[130,174] Other sources of moisture in new homes may include new concrete, plaster, paint and wood.[175,176]

Moulds and other fungi release a variety of potentially harmful products. For example, an estimated 10–15% of the North American population is allergic to fungal spores.[30,176] Some moulds produce substances called mycotoxins, which can cause respiratory and flu-like symptoms.[177] Moulds also release VOCs, gases and liquids that vaporize at room temperature. Fungal VOCs give damp carpets and other mouldy materials their musty smell.[163] So far, scientists have identified more than 500 VOCs produced by fungi.[176] Although little is known about their health effects, fungal VOCs appear to cause symptoms ranging from stuffiness to wheezing in some people.[30]

The incidence of mould-related illness within the Canadian population is unknown, partly because personal exposure to airborne moulds is difficult to measure.[178] Although studies have shown that residents of damp homes tend to have a higher incidence of respiratory symptoms, factors other than moulds may be to blame. For example, high humidity is often a reflection of inadequate ventilation, which could result in elevated levels of human-made VOCs and other pollutants.[30]

Bacteria

Like moulds, bacteria thrive in moist environments. They can grow directly in water and are dispersed indoors both as spores and via tiny water droplets suspended in the air, called aerosols. Aerosols containing bacteria are released primarily by humans (and animals)—during sneezing, coughing or speaking—or from water sources such as humidifiers, showers and faucets. Once airborne, bacteria may survive for significant periods of time, depending upon the droplet size, the air temperature and the relative humidity.[30]

Some water-borne bacteria normally found in the outdoor environment can multiply and spread within the home. For example, certain types of bacteria (and fungi) can cause "humidifier fever," an allergic response to the airborne organisms or their toxic by-products, which are known as endotoxins. Bacterial endotoxins can also cause fever, chest tightness and flu-like symptoms. People with asthma may be particularly sensitive to endotoxin compounds.[134,163]

One of the worst infections associated with airborne bacteria is Legionnaire's disease, which is named after a 1977 outbreak during an American legion convention at a U.S. hotel. This disease is caused by *Legionella*, an organism that grows in warm water containing organic material. Air conditioning systems in large buildings, evaporative condensers and hot water systems may serve as reservoirs of these bacteria. Different strains of *Legionella* vary in their ability to cause infection, and different people vary in their susceptibility to infection. In most cases, the organism causes mild flu-like symptoms, which disappear without medical treatment. However, some strains of *Legionella* can cause a serious and potentially lethal pneumonia.[30,134]

Dust Mites

House dust mites are tiny animals that live on the small pieces of skin shed by humans every day. These creatures dwell in places where human skin accumulates, particularly bedding, upholstery and carpets. Dust mites thrive in humid or damp conditions, and their numbers decline when the relative humidity drops below 50%.[91,174] An estimated 5–30% of the North American population and 40–80% of people with asthma are allergic to house dust mites—specifically, a protein found in their feces.[163] A recent Canadian study showed that dust mite allergen levels are dependent upon a range of factors, including the type of bedding and the number of occupants in a house.[179]

Did you know?

An allergen is any foreign substance, such as mould, pollen or animal dander (tiny particles of skin and hair), that triggers an inappropriate immune response—i.e. an allergic reaction—in the human body. House dust is a potential source of multiple allergens, including dust mites, animal dander, moulds and some food allergens.[180]

Seasonal Allergens

Primarily an outdoor air problem, seasonal allergens reach peak environmental levels at specific times of the year. Examples include grass and tree pollens, mould spores and ragweed pollen. Ragweed season extends from mid-July to mid-October in Canada. In susceptible individuals, airborne allergens can cause upper airway symptoms, such as sneezing, nasal congestion and asthma.[181]

What You Can Do

Here are some ways to prevent the growth and spread of airborne allergens and micro-organisms[182]:

- Keep your home clean and free of dust.
- Control humidity and ensure adequate ventilation in your home to prevent persistent condensation on walls and windows.
- Repair leaky roofs, walls and basements.
- Disinfect mouldy surfaces with a solution of bleach in water: about 1 cup or 250 mL of bleach in 5 L (1 gallon) of water (be sure to follow the safety instructions on the product label).
- Regularly clean and disinfect stagnant water sources, such as humidifier tanks and air conditioners.
- In cases of severe humidity or contamination problems, check with your provincial/territorial, regional or local health department or search in the Yellow Pages under air pollution control.
- Consult your physician if you suspect that you or your family suffers from health problems caused by microbiological contamination of air.

For more information, consult the following Health Canada publications:

- *Ultrasonic Humidifiers and Respiratory Problems*;
- *Fungal Contamination in Public Buildings: A Guide to Recognition and Management*; and
- *Microbiological Contamination of Residential Indoor Air*.

Canada Mortgage and Housing Corporation (CMHC) also has several publications on how to reduce and avoid excess humidity and condensation in your home.

Hazardous Organic Compounds

Outdoor air contains thousands of natural and synthetic chemical compounds, most of which are present at very low levels.[30,134] Two of the largest families of airborne contaminants are VOCs and PAHs.[134] VOCs contribute to the formation of ground-level ozone. Most VOCs are present at higher concentrations indoors than outdoors.

Benzene

Benzene is a VOC that occurs naturally in crude oil and in many petroleum products. It is also a by-product of the incomplete combustion of organic substances.[188] The combustion of gasoline and diesel fuels accounts for about 76% of atmospheric benzene emissions.[189] In Canada, airborne benzene levels are generally four times higher in city centres than in rural areas.[135] From 1989 to 1994, average benzene levels in urban air declined by more than 33%, owing largely to stricter emission controls on vehicles.[135]

Canadians are exposed to benzene primarily via indoor air, cigarette smoking and automobile-related activities—such as refuelling gas tanks.[188] Food and drinking water, by comparison, contribute very little to our total daily intake of this contaminant. Long-term exposure to high levels of benzene in the workplace is associated with bone marrow damage, immune system disruption and an increased risk of developing leukemia, a cancer of the white blood cells.[188] The health effects of exposure to environmental levels of benzene are unknown. However, the highest reported concentration of benzene in urban air in Canada is over 100 000 times less than the level at which adverse effects have been observed in laboratory mammals.[190]

VOC Levels in Canadian Homes[186,187]

In 1992, Health Canada conducted a national survey to determine the occurrence of volatile organic compounds (VOCs) in 754 randomly selected, single-family residences. The survey identified more than 100 different VOCs, many of which were associated with such activities as tobacco smoking, the combustion of organic fuels and the use of consumer products. The results showed that less than 1% of the population is exposed to very high levels of individual contaminants. Health Canada is currently studying exposure to some VOCs in laboratory animals to determine the levels at which the VOCs cause adverse health effects.[183–185] These results will assist in determining acceptable levels of exposure for humans.

Other Volatile Organic Compounds (VOCs)

Trichloroethylene

Trichloroethylene is a synthetic compound used primarily as a solvent in the metal-degreasing and dry-cleaning industries. It is also present in some household products, such as correction fluids, rug cleaners, paint removers and strippers, adhesives and spot removers. For most Canadians, the principal route of exposure to trichloroethylene is inhalation of indoor air.[191]

Long-term exposure to high levels of trichloroethylene in the workplace is associated with adverse liver and cardiovascular effects, kidney damage and other diseases.[191] In addition, studies have shown that trichloroethylene can cause cancer in laboratory animals.[191,192] However, it is not known whether the levels typically found in indoor air pose a significant health risk to Canadians.

Tetrachloroethylene

Tetrachloroethylene (perchloroethylene) is related to trichloroethylene. It is the principal solvent of Canada's dry-cleaning industry, and it is also used for metal degreasing and in various manufacturing processes. Tetrachloroethylene is present in automotive cleaners, suede protectors, paint removers and strippers, water repellents, silicone lubricants, aerosol cleaners, spot removers, adhesives, wood cleaners and other products. Canadians are exposed to tetrachloroethylene primarily via indoor air, as a result of its presence in household products and the presence of residual tetrachloroethylene on recently dry-cleaned clothes.[193]

Short-term exposure to high levels of tetrachloroethylene is associated with symptoms ranging from eye, throat and nasal irritation to dizziness and nausea. At very high concentrations and after long-term exposure, tetrachloroethylene can cause cancer in some laboratory animals, although it is unclear whether these results are applicable to humans.[193,194]

Methylene Chloride

Methylene chloride, or dichloromethane, is a colourless commercial chemical with a mildly sweet odour that is used primarily in paint removers, as a foam blowing agent and as a component of aerosols.[195,196] Direct contact with this chemical can cause skin irritation. Short-term exposure to elevated concentrations of methylene chloride vapours can cause sluggishness, irritability, lightheadedness, nausea and headaches. Health Canada has classified methylene chloride as a probable human carcinogen, based on studies that show it can cause cancer in laboratory animals.[195,196] However, it is not known whether the levels typically found in indoor air pose a significant health risk to Canadians.

Protecting Our Health

The Canadian Council of Ministers of the Environment has developed environmental Codes of Practice for dry-cleaning and degreasing facilities to prevent or reduce emissions of trichloroethylene, tetrachloroethylene and other solvents. In addition, the federal government has deemed methylene chloride, trichloroethylene and tetrachloroethylene "toxic" under the *Canadian Environmental Protection*

Methylene Chloride-Based Paint Strippers[196]

Methylene chloride, or dichloromethane, is the principal component of some commercially available paint removers. When methylene chloride-based paint strippers or other organic solvents are used indoors, the air can become contaminated. People at risk include those who are directly handling these products as well as other occupants of the buildings in which they are being used.

Here are some safety steps to follow when using methylene chloride-based paint strippers:

- Be sure to follow the instructions on the container.
- Ensure that your work area is properly ventilated. Place an electric fan beside an open window to blow contaminated air outside. If the object on which you are working is portable, consider moving the work outdoors to ensure that you have adequate ventilation.
- Always wear goggles and gloves.
- If stripper gets on your skin, wash it off right away with soap and water.
- Wear a good-quality breathing mask designed for use with organic chemicals. This can be purchased at paint or safety equipment outlets.
- Keep paint dust and stripper-soaked scrapings from being spread around the house. Wear a pair of coveralls and work shoes in the work area.
- If you develop breathing problems, dizziness, nausea or headaches while working with paint strippers, get some fresh air immediately.
- Limit intensive exposure by taking frequent fresh air breaks.
- Never eat, drink or smoke while removing paint.
- Consider hiring a skilled tradesperson if you do not want to be exposed to the hazards of chemical strippers.

Act (CEPA). As a result, Health Canada and Environment Canada are now working with other organizations to reduce the environmental levels of these substances.[197]

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a family of complex organic compounds formed by the partial combustion of fossil fuels, organic matter and garbage.[85] PAHs frequently adhere to the surfaces of particulates, on which they may be transported long distances. Over 100 different kinds of PAHs have been detected in airborne particulates.[133] Forest fires are the principal source of PAHs in our atmosphere, followed by aluminum smelters. Other significant sources include residential wood burning, agricultural burning and open air fires, incineration, transportation and various industrial processes.[198] PAH compounds are naturally present in barbecue and tobacco smoke.

Canadians are exposed to PAHs primarily through tobacco smoke, wood smoke, contaminated air and food. At high levels, PAHs can cause bronchitis; lung discomfort and irritation; aggravation of existing heart, respiratory and asthma symptoms; and dermatitis and other skin conditions.[70,85] Several PAHs have been shown to cause cancer in laboratory animals, including benzo[a]pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene and indeno[1,2,3-cd]pyrene.[198] Scientists at Health Canada, the University of Quebec, McGill University and the University of Montreal have examined the link between occupational exposure to PAHs and the incidence of different cancers. They found that PAHs may increase the risk of developing lung, esophageal, pancreatic and prostate cancer.[199]

Scientists at Health Canada have deemed five PAHs "toxic" to human health under CEPA. As a result, efforts are under way at the federal and provincial levels to reduce the health risks associated with exposure to PAHs in our environment. The focus is on reducing emissions from the steel-manufacturing, aluminum-smelting and wood preservation sectors.

What You Can Do

Here are some simple steps you can take to minimize PAH levels in indoor air[133]:

- Ensure that household combustion systems, such as wood-burning and coal-burning stoves, are properly installed, maintained and operated under well-ventilated conditions.
- Avoid tobacco smoke.
- Do not burn wood that has been treated with wood preservatives.
- Do not barbecue indoors.
- Use an overhead fan to remove fumes when cooking.
- Do not use open fireplaces.

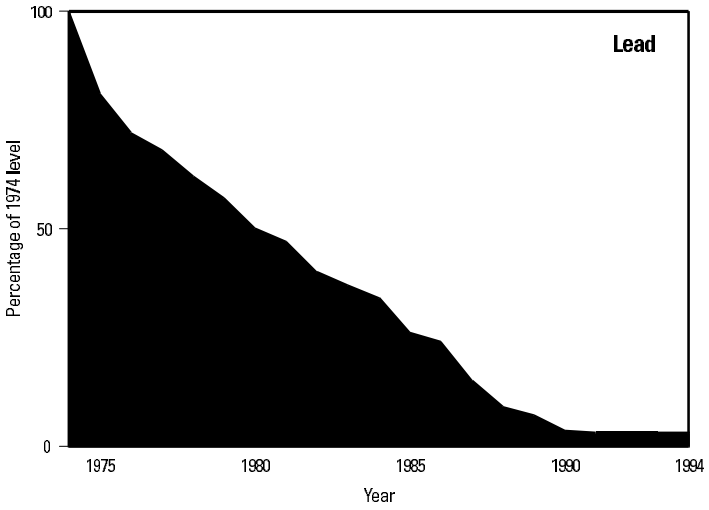
Metals

Canadians are exposed to a variety of airborne metal compounds. Metallic contaminants of primary concern in our atmosphere include lead, cadmium, chromium and nickel.

Lead

Lead occurs naturally and is widely distributed throughout our environment. Since the Industrial Revolution, concentrations of lead in air, water, food and soil have risen steadily—particularly since the 1920s, when lead compounds were added to automobile gasoline and lead batteries were introduced.[30] After reaching a peak in the 1970s, lead emissions in Canada have decreased dramatically as a result of federal regulations on leaded gasoline and other commercial products. By December 1990, levels of lead in the air of most Canadian cities had fallen below the detectable limit[200] (see Figure 12). However, lead contamination of soil, sediments and water remains a problem.

Figure 12
Average Lead Levels in Our Atmosphere, 1974–1994, as a Percentage of 1974 Levels



Source: Pollution Data Branch, Environment Canada. Reproduced with permission of the Minister of Public Works and Government Services Canada, 1997.

Today, Canadians are exposed to lead primarily through food, although airborne dust and dirt, soil and water can also contribute significant amounts to our total daily intake. Recent research suggests that there may be no level of exposure below which lead does not have some impact, however small, on human health. Elevated levels of lead in blood are associated with behavioural and developmental problems in children and adverse reproductive effects in adults.[201]

Under CEPA, the use of lead in fuel was phased out in December 1990—except in critical equipment such as farm, marine and commercial transportation and piston-driven aircraft engines, in order to avoid premature engine wear.[202] As a result, lead emissions from automobiles have declined from a peak of 14 000 t in 1973 to essentially negligible levels since 1991.[203]

Cadmium

Cadmium is present in our atmosphere as a result of both natural processes (e.g. weathering, erosion, forest fires, volcanic eruptions) and human activities, particularly metal smelting and refining, power generation and heating and transportation.[85,204] Although cadmium concentrations are generally quite low in urban and rural air, levels near smelters and other point sources of contamination may be 10–100 times higher.[204,205]

For non-smokers in the general population, food is the principal source of exposure to cadmium, accounting for more than 99% of the total daily intake, although studies have shown that the human body absorbs cadmium more readily from air (up to 50%) than from food (about 5%).[204] Tobacco is also a significant source of cadmium. Smokers inhale an estimated 20 times more cadmium per day than non-smokers, although cadmium levels in tobacco smoke have declined significantly since the 1960s.[85,206] People living in the vicinity of smelters and other point sources of contamination may be exposed to cadmium levels higher than those to which the general population is exposed.[204]

Studies conducted in other countries suggest that long-term exposure to elevated levels of cadmium may cause mild kidney damage. In addition, Health Canada has classified inorganic cadmium as a probable human carcinogen, based on studies that show it can cause cancer in laboratory animals that have inhaled high levels of these compounds over long periods of time.[204] However, it is not known whether the levels typically found in our environment are sufficient to cause cancer and kidney damage.

Chromium

Chromium is the seventh most abundant element on Earth. In Canada, chromium is used primarily in the production of stainless steel, heat-resistant metals, bricks and mortars. Natural sources of airborne chromium include wind-blown dusts, volcanic emissions, marine aerosols, forest fires and vegetative debris. In addition, an estimated 84 t of chromium enter the Canadian atmosphere each year from human activities, including power generation and heating, transportation and various industrial processes.[207]

Food is the main source of exposure to chromium for all age groups in Canada, followed by tobacco smoke, soil, water and outdoor air. Like cadmium, the human body absorbs chromium more readily from air than from food. Most of the chromium to which we are exposed exists in the "trivalent" form, which is considered an essential dietary element.[207] To a lesser extent, Canadians are also exposed to "hexavalent" chromium, a more harmful form of the metal. Hexavalent chromium compounds are associated with an increased risk of respiratory cancers in occupationally exposed workers. However, it is less likely that the levels typically found in our air are sufficient to cause cancer.[207]

Did you know?

Some individuals are highly sensitive to trace amounts of chromium or nickel compounds and may suffer an irritation called contact dermatitis when one of these metals touches their skin. Up to 22% of women and 3% of men are allergic to soluble nickel compounds, which occur on nickel-plated, nickel-lined or stainless steel pots, pans, utensils and costume jewellery. Up to 2% of North Americans are allergic to hexavalent chromium compounds, which are also found in stainless steel products.[207,208]

Nickel

In 1994, Canada was ranked number two in the world in nickel production, based on an output of some 144 000 t.[209,210] Nickel and its alloys are used in a wide variety of industrial applications for the automobile, shipbuilding, electrical, oil, food and chemical industries.[208] Nickel enters our atmosphere from natural sources, such as soil dust, sea salt, volcanoes, forest fires and vegetation, and from human activities, particularly metal production and the combustion of fossil fuels.[208]

For Canadians, food is the principal source of exposure to nickel. Air accounts for less than 0.1% of our total daily intake of nickel, and average airborne nickel levels are more than 5000 times less than the lowest levels at which adverse effects have been observed in laboratory animals.[208] However, people living in the vicinity of smelters and other sources of contamination may be exposed to nickel concentrations significantly higher than those to which the general population is exposed. Health Canada has concluded that certain forms of nickel, including "soluble," "sulphitic" and "oxidic" nickel compounds, are carcinogenic to humans, based on an increased rate of respiratory cancers among workers

exposed to high doses in occupational settings. However, there is no evidence that nickel in its pure metallic form causes cancer in humans.[208]

Protecting Our Health

Health Canada has concluded that cadmium, hexavalent chromium and certain forms of nickel (with the exception of metallic nickel) are "toxic" to human health under CEPA. As a result, Health Canada and Environment Canada are working with other government agencies, industry, consumer groups and environmental organizations to reduce our exposure to these substances. The focus is on reducing emissions from key industries that release cadmium, chromium and non-metallic nickel compounds into our environment, including the steel-manufacturing, metal-finishing, base metal-smelting and electric power sectors.[211]

Radiation

Ionizing Radiation

By far the most important route of exposure to ionizing radiation in our environment comes from natural radionuclides present in the atmosphere—specifically, radon gas that is released into air from soils. Most of our exposure to ionizing radiation is from natural sources, and the inhalation of air containing radon and its decay products may account for more than two-thirds of this dose.

Most of the artificial radionuclides released into the global environment have come from nuclear weapons tests. In addition, low levels of radionuclides are released into the air during the routine operations of nuclear facilities. There is also the potential for large accidental releases that could have a significant impact on human health and the environment.

Humans may be exposed to airborne radioactivity either internally or externally. Internal irradiation of tissues and organs such as the lungs may occur if airborne radionuclides are inhaled and retained in the body. By contrast, external irradiation may occur through exposure to ionizing radiation emitted by radionuclides present in air or deposited on soil, vegetation and human structures. Airborne radionuclides may also appear in water and food supplies, as happened following the atmospheric nuclear weapons tests of the 1950s and 1960s.

Did you know?

Since 1959, the National Environmental Radiation Monitoring Network of Health Canada has monitored the levels of radioactive aerosols in air as well as the radioactivity of precipitation. Radioactive aerosols result from both naturally occurring radionuclides and human-made radionuclides released from atmospheric nuclear weapons tests, nuclear power facilities, hospitals, research centres and nuclear accidents, such as the Chernobyl reactor accident. The current program consists of 25 monitoring stations across Canada, which provide important information on levels of radioactivity in the environment.

Radon

Radon-222 is a colourless, odourless, chemically inert gas that is naturally radioactive. Radon is a natural product of the radioactive decay of radium-226 (^{226}Ra), an element commonly found in rock and soil, which itself is produced by the decay of uranium-238 (^{238}U). Radon further decays to produce other radionuclides, which emit high-energy alpha particles.

High levels of radon are associated with rock formations and with soils that readily permit the movement of soil gas. High levels also occur at sites contaminated with by-products of uranium or phosphate mining.[30,212]

Radon found in soil and rock can contaminate indoor air by seeping through dirt floors and other small spaces, such as cracks in concrete walls and floors and basement drains.[212]

Because radon is chemically inert, most of the radon that people inhale is subsequently exhaled. However, some of its radioactive decay products can stick to airborne dust particles. When inhaled, they often remain in the respiratory system, where they irradiate the lungs.[30,212]

Studies involving Canadian uranium miners and other groups have shown that exposure to high levels of radon is associated with an increased risk of lung cancer.[212] Based on similar results obtained in the United States, scientists have estimated that about 1 in 10 lung cancer deaths may be due to radon exposure in indoor air.[213] This is much less than the risk associated with exposure to tobacco smoke. Exposure to both radon and tobacco smoke may further increase the risk of lung cancer. Although radon and its decay products have the potential to cause harm, the available evidence to date suggests that they are unlikely to be a problem for most home-owners in Canada.[212]

In the late 1970s, Health and Welfare Canada conducted a national survey measuring radon concentrations in 14 000 homes in 19 cities across Canada. The survey found that radon levels were generally quite low in Canadian homes, although levels varied greatly from city to city. The strength or activity of a radioactive source is a measure of its rate of decay and is expressed by a scientific unit called the becquerel (Bq), where 1 Bq is defined as one atomic transformation or disintegration per second. Average radon concentrations measured in the Health and Welfare Canada survey ranged from about 6 Bq/m^3 in Vancouver to 57 Bq/m^3 in Winnipeg, where the highest levels were detected[103,214] (see Figure 13).

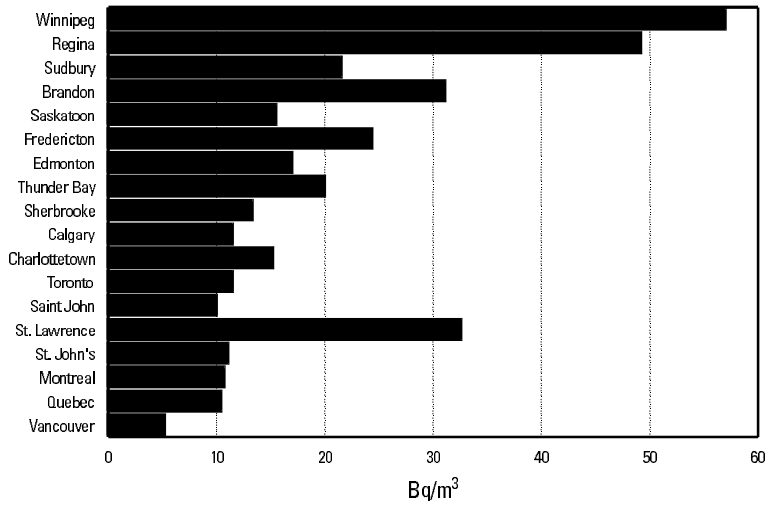


Figure 13
Levels of Indoor Radon in Various Canadian Cities

Source: Created from Table 1 of "Design and Interpretation of Large Surveys for Indoor Exposure to Radon Daughters," in ***Radiation Protection Dosimetry*** *1984; 71 (4): 303–308, Létourneau EG et al.*

Note: Results for Halifax are not available.

What You Can Do

Because most of our exposure to ionizing radiation comes from radon gas, the best way to reduce your risk of exposure to ionizing radiation is to reduce radon levels in your home as much as possible. Health Canada and the provinces have recommended that radon levels inside homes not exceed an average annual concentration of 800 Bq/m^3 in the normal living area. Studies indicate that less than 0.1% of all homes in Canada may contain radon levels that are sufficiently high—above 800 Bq/m^3—to warrant remedial action. Because there is some risk, however small, at any level of exposure, home-owners may wish to reduce radon levels even further. Ultimately, it is the choice of each home-owner to determine what levels of exposure to radon are acceptable.

If you would like to test your home for radon, the simplest option is to purchase a commercial radon detector, such as the charcoal canister or alpha track detector. Both of these devices must be exposed to the air in your home for a specific period of time. Charcoal canisters can be used only for a period of two to five days; alpha track detectors can be used for three months to a year. In both cases, the detector must be returned to a laboratory for analysis. Consult the Yellow Pages or contact provincial/territorial health authorities for the names of contractors who may be able to provide a measurement service.[212] For information on how to reduce potential sources of radon levels and radon exposure, contact the nearest CMHC office.

Ultraviolet (UV) Radiation

UV light is a form of non-ionizing or low-energy radiation that is invisible to the naked eye. Our principal source of exposure to UV light is natural solar radiation, although UV rays are also released by commercial products, such as UV lamps in tanning salons and spas, germicidal lamps and UV lasers.[85] The stratospheric ozone layer, a thin layer of gas located high in the Earth's atmosphere, shields us from most of the sun's UV rays. Since 1979, however, there has been a steady decrease in the amount of ozone present in the upper atmosphere, because of damage caused by industrial chemicals such as chlorofluorocarbons (CFCs).[215]

Residential Radon and Lung Cancer in Winnipeg[55]

In 1994, researchers at Health Canada and the University of Manitoba reported the results of a study comparing the radon concentrations in homes of lung cancer patients with those in homes of healthy volunteers in Winnipeg, Manitoba. Between 1983 and 1990, the researchers interviewed 738 people who had been recently diagnosed with lung cancer and 738 volunteers who had not been diagnosed with lung cancer. Radon detectors were placed in all of the homes in which participants had lived in the Winnipeg area for at least one year. The homes were subsequently monitored for a full year. The research team found essentially no increase in the risk of lung cancer due to exposure to radon in Winnipeg homes. The number of people involved in the study was sufficient to indicate that the risk from naturally occurring radon is less than 10% of the overall lung cancer rate.

Did you know?

For every 1% decrease in stratospheric ozone, there is a 1.1% increase in UV-B—the most harmful wavelengths of UV light—at the Earth's surface. Today, UV-B levels are about 5–10% higher than levels before 1980.[216]

Some exposure to UV radiation is beneficial, because it helps produce vitamin D, although dietary sources are also available.[216] However, UV rays pose a health hazard to anyone who is exposed for long periods of time, particularly when the sun is most intense: on clear days in midsummer between 10:00 a.m. and 4:00 p.m. Overcast conditions slightly reduce exposure levels, although up to 80% of UV rays can penetrate haze, fog and light clouds. Canadians are routinely exposed to both short- and long-wavelength UV radiation. Used in sun lamps and tanning salons, shorter-wavelength UV-A causes immediate tanning and eventual wrinkling of the skin. Longer-wavelength UV-B rays penetrate deeper into human skin and are 1000 times more likely to cause sunburn.[30]

Up to 80% of our UV exposure typically occurs before age 18, because children and teenagers tend to spend more time in the sun than adults. A child can get a serious sunburn in only 10 minutes on a hot summer afternoon.[217] As children have more skin relative to body mass, burns tend to be more serious. Infants are particularly vulnerable to UV radiation because they are born without a developed skin protection system. Even babies with deeply pigmented (dark) skin are vulnerable to UV rays. Moreover, infants cannot always communicate their discomfort, nor can they move into the shade on their own.

Two or more serious sunburns in childhood can increase the risk of skin cancer, the most common form of cancer in Canada, later in life. In fact, exposure to UV radiation is one of the principal causes of skin cancer.[30,218] In 1995, more than 55 000 Canadians developed skin cancer, and the numbers are rising rapidly. Over the last 15 years, the incidence of malignant melanoma (the most lethal skin cancer) has doubled.[216] This increase is likely due to our modern habit of suntanning rather than the recent depletion of the ozone layer, because skin cancers can take years to appear. A thinner ozone layer, however, will certainly place future generations more at risk.[216]

Besides sunburns, prolonged exposure to UV rays can cause premature aging and wrinkling of the skin, depression of the immune system, allergic reactions and eye problems, such as inflammations, cornea damage and cataracts.[85,216]

Protecting Our Health

Publications are available from Health Canada on the risks of overexposure to UV radiation, and the Department is conducting research on the Canadian population's sensitivity to UV damage. Health Canada's Radiation Protection Bureau is developing sun lamp regulations and is also responsible for assessing the health risks of environmental UV radiation.

Did you know?

In 1992, Environment Canada scientists developed a method to predict the strength of the sun's UV rays based on day-to-day changes in the ozone layer. In the same year, Canada became the first country to issue nation-wide daily predictions of UV radiation levels. The UV rating is now a common feature of daily weather forecasts.[219]

What You Can Do

The cosmetic appeal of suntans has endured through the 20th century. However, there is no such thing as a healthy tan. Tans are the body's way of protecting itself from too much UV radiation. While some exposure to UV rays is inevitable, there are a number of things you can do to avoid overexposure[216,218]:

- Avoid prolonged exposure to the sun, particularly between 10 a.m. and 4 p.m.
- Wear protective clothing, such as a wide-brimmed hat, tightly woven clothing, a long-sleeved shirt and long pants, when you have to spend long periods in the sun.
- Protect your eyes by wearing sunglasses that filter out UV rays.
- If you cannot cover up, use a sunscreen or sunblock lotion with a sun protection factor (SPF) of 15 or higher that offers both UV-A and UV-B protection. Reapply every two hours, as well as after swimming and exercising.
- Avoid using sun lamps and tanning salons. The extra UV radiation from these sources adds to your cumulative exposure and increases the risk of premature wrinkling and other health effects, such as skin cancer.
- Remember that water, ice, snow, sand and concrete reflect UV rays and can increase your exposure. For every rise of 300 m above sea level, you increase your exposure to UV-B and UV-A radiation by 4% and 1%, respectively.
- If you have fair skin and light-coloured eyes and sunburn easily, you should take extra precautions to avoid UV rays.
- Avoid direct sunlight when taking medications such as tetracycline, which can increase your sensitivity to UV radiation.
- Examine your skin regularly for changes in moles, freckles or skin discolorations. Report any changes to a doctor. Early detection of skin cancer increases the chance of successful treatment.

Emerging Issues

Global Warming/ Climate Change

Current evidence suggests that the Earth's climate is warming. Since 1895, average global temperatures have increased by approximately 0.5°C, while Canada's average temperature rose by 1.1°C during the same period. The 11 warmest years since records began in 1854 have all occurred since 1976. Assuming that current social trends continue, climate models predict that the Earth's average temperature will increase further by about 0.3°C *per decade* over the next 100 years—approximately six times the increase over the past 100 years.[220,221]

A warming of this magnitude could cause profound environmental and health effects, including widespread coastal flooding as a result of the melting of polar ice caps, an increase in severe weather events, such as tropical storms, and the emergence of "tropical" diseases in temperate climates, such as Canada's. Most climate experts blame the global warming trend on "greenhouse gases," such as carbon dioxide and methane. These naturally occurring gases help to regulate our climate by trapping solar radiation in the form of heat. Although some scientists believe global warming may just be a part of the normal variability in climatic cycles, atmospheric levels of greenhouse gases have risen steadily since the 1800s, owing to increased emissions from human activity.[30,220,221]

Carbon Dioxide

Did you know?

The average car generates 4.72 t of carbon dioxide per year (based on a total distance of 20 000 km travelled per year at a fuel consumption rate of 10 km/L).[222] Studies show that more than 50% of all car trips involve a journey of less than 3 km.

Carbon dioxide is a colourless, odourless gas released naturally from decaying organic material, volcanoes and forest and grass fires and in the air exhaled by people and animals. Carbon dioxide is also released by the combustion of fossil fuels used in motor vehicles and to generate electricity and heat. Carbon dioxide accounts for about 0.03% of our atmosphere, although concentrations of this gas have increased by 28% in the last 200 years and are expected to double in the next 40 years.[221] In Canada, fuel consumption—and hence carbon dioxide emissions—has declined on a per-vehicle basis in recent years. However, total carbon dioxide emissions are increasing steadily, partly because of a rise in the number of automobiles on Canadian roads.[172,221]

Methane

Methane is a colourless, odourless, flammable gas released naturally from decaying organic material, volcanoes, marshes and rice paddies. Methane is also a by-product of the digestive tracts of cattle and other grazing livestock.[223] In Canada, other significant sources of methane include oil wells, coal mines and landfill gas. Global concentrations of methane increased by 5.6% between 1984 and 1993.[221]

Landfill gas—a mixture of methane (40–50%), carbon dioxide (35–50%) and other gases—is generated by the breakdown of municipal organic wastes, such as paper, food and wood, in landfill sites.[224] The uncontrolled generation and emission of landfill gas may pose immediate health and safety hazards to people in the area (e.g. fires or explosions caused by migrating gas), either at the landfill or in adjacent properties. Landfill gas also poses a risk of asphyxiation if it enters an enclosed space or structure that is poorly ventilated. Other health concerns are associated with the presence of organic and inorganic compounds found in landfill gas. Moreover, the odour from raw landfill gas is a potential nuisance to people living near the landfill site.[224]

Reducing Emissions of Greenhouse Gases

In Canada, a variety of public and private sector organizations are actively working to slow the pace of climate change. Some initiatives include:

- the National Action Program on Climate Change, launched in February 1995 by Canada's environment and energy ministers, which is designed to help Canada stabilize greenhouse gas emissions by the year 2000;

- the Voluntary Challenge and Registry Program, which encourages Canadian companies and organizations to develop action plans to limit emissions of greenhouse gases. So far, businesses and industries representing 70% of our total national emissions have joined the program;
- the Program of Energy Research and Development, under which Natural Resources Canada is co-ordinating research on electric vehicles, high energy efficiency cooling and heating systems, low-emission vehicles and the role of oceans in climate change[221]; and
- the "FCM 20% Club," sponsored by the Federation of Canadian Municipalities (FCM), which encourages municipal governments to work together to reduce greenhouse gas emissions.[225]

What You Can Do

Here are some steps you can take to reduce your own contribution to global warming:

- Walk, cycle or take the bus more often.
- Ensure that your car is properly maintained. A well-tuned engine can reduce your fuel consumption (and carbon dioxide emissions) by up to 10%.[222]
- Turn off your vehicle's air conditioner. Air conditioners can decrease fuel economy by up to 26% during stop-and-go driving.[222]
- Plant some trees. The average tree absorbs 4 kg of carbon dioxide per year.[229]

Incineration

Many Canadian municipalities are producing garbage at an increasing rate, filling existing landfill sites to capacity. In the Metropolitan Halifax area, for example, the amount of solid waste generated each year grew by 75% between 1978 and 1989, from 152 550 t to 267 119 t, although the region's waste output has stabilized since then.[231] To reduce the amount of waste they produce, some urban areas have installed municipal

Global Warming and Severe Weather

Global climate models predict that the Earth's average temperature will increase by about 3°C over the next 100 years. Among other things, this global warming trend may bring an increase in weather extremes, such as heat waves, droughts, floods, tropical storms and snowstorms.[221] Indeed, a growing number of climatologists believe that global warming has already begun.[226] Consider some recent events:

- In the summer of 1995, Canadians sweated through the warmest June and July in the past century, while the British endured the third hottest spell since 1659 and the driest in the last 200 years. More than 800 people died during a heat wave in the United States.[226]
- Also in 1995, Ottawa and Montreal experienced the coldest and snowiest November and December on record.[226]
- In July 1996, 7 people were killed and 12 000 people were left homeless when the banks of the Saguenay River overflowed in Quebec. It was one of the worst floods in Canadian history.[227,228]
- Also in 1996, a fierce rainstorm in the Ottawa–Hull region flooded 1500 homes, hailstorms in Winnipeg and Calgary caused more than $250 million in damage, Nova Scotia was hit by Hurricane Hortense—the largest in Canada in 21 years[228] —and residents of Vancouver and Victoria lived through one of the whitest Christmas seasons in decades.
- In the spring of 1997, the Red River overflowed its banks, causing the worst flooding of southern Manitoba this century.

Global Warming and the Spread of Tropical Diseases

Infectious diseases such as malaria, tuberculosis and cholera are the leading cause of death and disability around the world, particularly in developing countries.[229] Many scientists believe that global warming could promote the spread of "tropical" diseases into new areas, such as North America and Europe, by extending the range of disease-carrying mosquitoes and other hosts.[30,229] Indeed, this may be occurring already. In 1995, rising temperatures helped the Aedes mosquito, which carries dengue fever, cross the coastal mountain range of Costa Rica and invade the rest of the country. The mosquito also spread northwards, reaching the Texas border.[230] In the early 1990s, the Asian tiger mosquito landed in Texas via Japan, in a load of used tires. Since then, the tiger mosquito, which can carry at least 15 different viruses, has extended its range to Illinois.[229]

incinerators, whereas others are examining this option. A modern incinerator can reduce wastes by as much as 90% by volume and 75% by weight, while generating heat energy in the process.[232]

However, incinerators are expensive to build and operate and pose a number of potential environmental and human health risks. For example, municipal incinerators are the largest source of chlorinated dioxins and furans in Canada. Incinerators can also release particulates, acid aerosols, metals and PAHs into the environment. The fly ash recovered from incinerator stacks usually contains very high levels of lead and cadmium, which should be disposed of safely.[232]

Under the National Incinerator Testing and Evaluation Program, Environment Canada has shown that incinerator emissions from both old and new installations can be controlled to acceptable levels, if modern emission control technologies are applied.[232]

Major Initiatives to Protect Our Health

In Canada, there are a variety of public and private sector programs and initiatives that aim to reduce the human health risks posed by air pollutants. Some examples are briefly described below.

Research

For more than a decade, Health Canada has investigated the relationship between air quality and human health. Current research areas include:

- inhalation toxicity studies in which animals are exposed to airborne contaminants;
- human clinical studies, under controlled laboratory conditions, to identify the adverse health effects of single air pollutants and pollutant mixtures;
- exposure monitoring of sensitive individuals, such as people with asthma, to determine the pollutant levels to which people are exposed on a daily basis; and
- monitoring of population exposure patterns and public health trends associated with various airborne contaminants, such as airborne particles, acid aerosols and ground-level ozone.[169]

In one study, for example, scientists are investigating whether the breakdown of aspirin and aspirin-like substances in the blood can serve as a simple indicator of exposure to ozone and related compounds.[233] In a second study, scientists are investigating the relationship between sulphate levels and deaths due to cardiorespiratory disease in southwestern Ontario to estimate the number of years of life lost as a result of particulate pollution in Canada. Another study involves an analysis of data from 16 Canadian cities to determine the link between several common air pollutants and mortality and hospitalization rates. A fourth study is examining the relationship between air pollution and emergency department visits in Saint John, New Brunswick, with a particular focus on the broader health, quality of life and economic impacts of cardiorespiratory disease episodes caused by air pollution.

Air Pollution Monitoring

In 1969, the federal and provincial governments launched the National Air Pollution Surveillance (NAPS) Network to monitor and assess the quality of outdoor air in Canadian towns and cities. The NAPS Network provides important information on concentrations of common air pollutants, including carbon monoxide, sulphur dioxide, ozone, total suspended particulates and nitrogen dioxide. In addition, the provinces and some municipalities operate air monitoring networks to measure air quality at the community level and identify source-specific problems.[102]

Ambient Air Quality Objectives

In the early 1970s, the National Ambient Air Quality Objectives were established to protect the Canadian environment and human health from excessive exposure to common air pollutants found in outdoor air.[235] For each pollutant, the objectives take into account both the levels and the duration of exposure at which adverse effects may occur. Although the objectives are not mandatory, Canada's provinces and territories use them as the basis for setting air quality regulations and standards. Under this

National Pollutant Release Inventory (NPRI)[234]

The National Pollutant Release Inventory (NPRI) provides information on the amounts of pollutants that are released or transferred to waste disposal sites by public and private sector organizations in Canada. Launched by Environment Canada, the NPRI is designed to help Canadians develop a better understanding of the nature and quantity of specified substances released into our environment. Under the NPRI, organizations that manufacture, process or otherwise use at least 1 of 178 NPRI-listed substances in quantities of 10 t or more per year and that employ at least 10 people are required to report pollution emissions or transfers to Environment Canada. The NPRI collects data on a variety of hazardous substances, including metals, polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs), such as benzene.

program, Health Canada is responsible for establishing health-based guidelines for each pollutant, whereas Environment Canada is responsible for establishing environmental guidelines. Air quality objectives are then based on the lower of the two guidelines.

To date, air quality objectives have been established for seven substances: sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone, suspended particulates, hydrogen fluoride and hydrogen sulphide. Under this program, Canada's air quality objectives are reviewed on a continuous basis by scientists from the environment and health departments of federal, provincial and territorial governments. For example, the current objectives for suspended airborne particulates may soon be replaced by objectives for inhalable particulates—small particles of less than 10 µm in diameter (PM_{10}) that are a particular health concern because they can travel deep into human lungs.[87,132]

Residential Air Quality Guidelines

In 1987, Canada became one of the first countries in the world to develop guidelines for residential air, with the publication of *Exposure Guidelines for Residential Indoor Air Quality*. These guidelines define maximum acceptable ranges for 10 pollutants present in indoor environments, including aldehydes, carbon dioxide, carbon monoxide, nitrogen dioxide, ozone, particulate matter, sulphur dioxide and water vapour.[133] They also provide information on how to reduce exposure to indoor air pollutants. An additional air quality guideline for radon was published in 1988 by Health and Welfare Canada.

Accelerated Reduction and Elimination of Toxics

The Accelerated Reduction and Elimination of Toxics (ARET) program is a voluntary initiative involving Canadian industry, the federal, provincial and territorial governments and various health and academic organizations. The goal of the ARET program is to reduce the potential risks posed by toxic substances by accelerating the reduction or elimination of selected industrial emissions. The ARET program provides an opportunity for industry to take the lead in establishing and achieving environmental goals rather than simply responding to new regulatory requirements. Since the program was launched in 1993, over 270 participating organizations have reduced their total emissions of ARET substances by more than 10 500 t, while committing themselves to further reductions by the year 2000.[236] Some of the substances targeted for emission reductions under the ARET program include metals, such as cadmium, cobalt, copper, lead, mercury and nickel; and volatile organic compounds (VOCs), such as trichloroethylene, tetrachloroethylene and methylene chloride.[236]

Legislation

In 1988, the Government of Canada established CEPA to provide an effective way of identifying, evaluating and subsequently managing the risks posed by toxic substances in our environment. Under CEPA, federal guidelines and regulations have been established to reduce environmental levels of airborne substances, such as lead, nitrogen oxides and sulphur dioxide.[168] In addition, action plans are being developed to reduce the health and environmental risks associated with 26 substances that were deemed "toxic" under CEPA, including benzene, cadmium, chromium, nickel, PAHs, trichloroethylene, tetrachloroethylene and methylene chloride. Other relevant federal legislation includes the *Motor Vehicle Safety Act*, administered by Transport Canada, which regulates tailpipe emissions of carbon monoxide, nitrogen oxides, hydrocarbons and diesel particulates from new motor vehicles.

International Initiatives

Canada is an active participant in global efforts to control transboundary air pollution, including these initiatives:

- the 1979 United Nations Economic Commission for Europe Convention on Long-Range Transboundary Air Pollution. Under this Convention, Canada has signed international protocols to reduce sulphur dioxide emissions and stabilize nitrogen oxide emissions and has helped to draft protocols to control heavy metals and persistent organic pollutants, such as PAHs[166];
- the 1987 Montreal Protocol and subsequent amendments, which set timetables for phasing out the consumption of major ozone-depleting substances, such as CFCs. Under the influence of the Protocol, new Canadian supplies of ozone-depleting substances fell from 27.8 kt in 1987 to 5.8 kt in 1993[237]; and
- the 1991 Canada–U.S. Air Quality Agreement, which commits both countries to reduce sulphur dioxide and nitrogen oxide emissions.[168]

What You Can Do

Here are some simple steps you can take to minimize your contribution to air pollution and reduce your exposure to outdoor and indoor air contaminants:

- Pay attention to the air quality index or smog advisories, if they are reported in your area.
- Whenever possible, use public transportation instead of your car, and walk or ride your bicycle when smog levels are not elevated.
- Whenever possible, avoid or limit the use of other gasoline-powered vehicles and equipment, such as motorbikes, motorboats and gas lawn mowers.
- Use fuel-efficient cars and maintain them well.[30]
- Turn off your car engine when waiting at car washes, stores, railway crossings and fast food outlets.[153]
- When air pollution levels are high, avoid strenuous outdoor activity.
- If you have heart or lung problems, follow your doctor's advice on how to manage your condition during air pollution episodes.
- When using solvent-based products such as gasoline or mineral spirits, handle and dispose of them with care.
- When doing yardwork, do not burn leaves, grass clippings or branches. Recycle or compost waste organic materials.[30]
- Wear sunscreen and protective clothing and eyewear, even in the winter, while out in the sun.
- Ensure adequate indoor ventilation, and take other measures to reduce levels of indoor air contaminants.[109]

For more information about indoor air quality, consult the following Health Canada publications:

- *Exposure Guidelines for Residential Indoor Air Quality*;
- *Indoor Air Quality and You*;
- *Office Air: A Worker's Guide to Air Quality in Offices, Schools and Hospitals*; and
- *Indoor Air Quality in Office Buildings: A Technical Guide.*

Additional resources include CMHC and Natural Resources Canada, creator of the R-2000 Home, one of the first model homes to combine an environmentally friendly and healthy building design.[30]