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ADAPTING TO CLIMATE CHANGE IMPACTS ON HUMAN HEALTH

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ABSTRACT: This paper provides an examination of the potentially significant impacts of climate change on human health and well-being in Canada. Some key concerns include an increase in illness and premature deaths from temperature stress, air pollution, and increases in the emergence and persistence of infectious diseases. The effects of climate-related natural hazards and extreme events on both physical safety and mental health are another concern. Although there will likely be some benefits to climate change, such as a decrease in cold-weather mortality, negative impacts are expected to prevail. Adaptation will be necessary to reduce health-related vulnerabilities to climate change. Some adaptation initiatives include the development of vaccines for emerging diseases, public education programs aimed at reducing disease exposure and transmission, and improved disaster management plans. The implementation of early warning systems for extreme heat is another effective adaptation strategy. The paper concludes that successful adaptation to climate change will require coordinated efforts among different groups and the consideration of climate change in health care decision-making.

Keywords: climate change, adaptation, human health

1. Introduction

Good health, which requires physical, mental and social well-being, is a key determinant of quality of life. As a result, health and health services are extremely important to Canadians. The health care and social services sector employs more than 1.5 million Canadians, and over CAN$102 billion per year is spent on health services.(CIHI, 2002) This spending on health care accounts for about 9.3 percent of the total annual value of goods and services produced in Canada (Gross Domestic Product). This represents an average of approximately CAN$3,300 per person per year. At a very basic level, the relationship between health and climate in Canada is demonstrated by the strong seasonal variability in the incidence of infectious diseases (Li, 2000) and the persistent seasonal pattern in mortality (see Figure 1). The monthly number of deaths tends to reach a low in August, then rises to a peak in January and declines again during the spring and summer months. Many of the winter deaths result from pneumonia (Trudeau, 1997), suggesting that

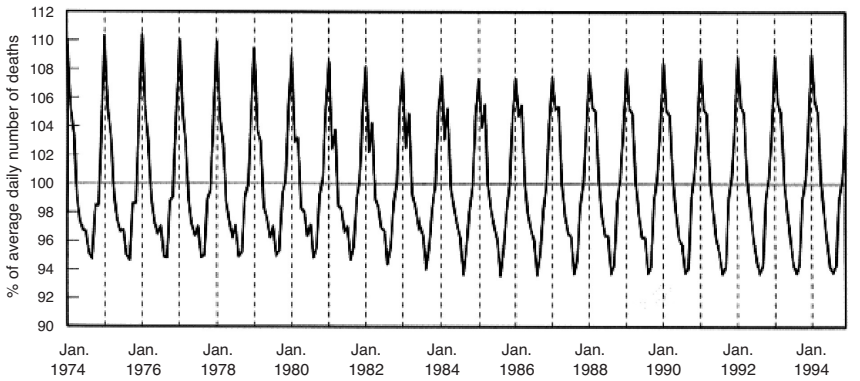

FIGURE 1

Seasonality of Deaths in Canada, 1974-1994. *Source: Statistics Canada, 1997.*

seasonal changes in weather and climatic conditions influence respiratory infections. Deaths from heart attacks and strokes likewise show strong seasonal fluctuations, with peaks in both summer and winter.

Another strong linkage between climate and human health is seen in the impacts of extreme climate events and weather disasters. Flooding, drought, severe storms and other climate-related natural hazards can damage health and social well-being by leading to an increased risk of injury, illness, stress-related disorders and death. In recent years, this has been dramatically demonstrated by the effects of the 1996 flood in the Saguenay region of Quebec (Brooks and Lawrence, 1998), the 1997 Red River flood in Manitoba (International Red River Basin Task Force, 2000), and the 1998 ice storm in eastern Ontario, southern Quebec and parts of the Maritime Provinces (Hartling et al., 1999; Slinger et al., 1999).

Trends in illnesses and deaths associated with air pollution, extreme weather events, allergies, respiratory diseases, and vector-, food- and water-borne diseases all illustrate that weather and climatic factors influence health and well-being. Therefore, there is concern that climate change of the magnitude projected for the present century by the Intergovernmental Panel on Climate Change (1.4–5.8°C increase in mean global temperature; reference 13) may have significant consequences for health and the health care sector in Canada.

Table 1 Possible health impacts from climate change and variability in Canada	
HEALTH CONCERNS	EXAMPLES OF HEALTH VULNERABILITIES
Temperature-related morbidity and mortality	• Cold- and heat-related illnesses • Respiratory and cardiovascular illnesses • Increased occupational health risks
Health effects of extreme weather events	• Damaged public health infrastructure • Injuries and illnesses • Social and mental health stress due to disasters • Occupational health hazards • Population displacement
Health effects related to air pollution	• Changed exposure to outdoor and indoor air pollutants and allergens • Asthma and other respiratory diseases • Heart attacks, strokes and other cardiovascular diseases • Cancer
Health effects of water- and food-borne contamination	• Enteric diseases and poisoning caused by chemical and biological contaminants
Vector-borne and zoonotic diseases	• Changed patterns of diseases caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks and other vectors
Health effects of exposure to ultraviolet rays	• Skin damage and skin cancer • Cataracts • Disturbed immune function
Population vulnerabilities in rural and urban communities	• Seniors • Children • Chronically ill people • Low-income and homeless people • Northern residents • Disabled people • People living off the land
Socio-economic impacts on community health and well-being	• Loss of income and productivity • Social disruption • Diminished quality of life • Increased costs to health care • Health effects of mitigation technologies • Lack of institutional capacity to deal with disasters

Indeed, results of climate modelling exercises, assessments of regional environmental and resource vulnerabilities, and climate abnormalities experienced across the country in recent years all indicate that changes in climate could make it more difficult to maintain our health and well-being in the future. The potential impacts of climate change are classified as either direct (e.g., changes in temperature-related morbidity and mortality) or

indirect (e.g., shifts in vector- and rodent-borne diseases) (McMichael et al, 2001). Of particular concern are the effects on more vulnerable population groups, including the elderly, the infirm, the poor and children. Rural residents, who may have to travel farther for health care, and those relying directly on natural resources for their livelihood (e.g., some aboriginal communities), are also considered to be potentially more vulnerable. Overall, health effects will be a function of the nature of climatic changes, exposure to changes, and our ability to mitigate exposure. Although most of the literature focuses on the negative impacts of climate change on human health, certain benefits, such as decreases in illness and mortality related to extreme cold, are also expected (Duncan et al., 1997). Some of the key issues related to health and climate change in Canada are listed in Table 1.

This paper presents an overview of the major potential impacts of climate change on human health and well-being, and highlights some initiatives that have already been undertaken to better understand the impacts on Canadians and help provide information for the development of adaptation strategies.

2. Previous Canadian Studies on the Health Impacts of Climate Change

In their summary of research as part of the Canada Country Study, Duncan et al. (1997) identified a range of health-related climate change impacts, and discussed the role of potential adaptation strategies. Key concerns included the effects of climate change on heat- and cold-related mortality, a possible northward expansion of vector-borne diseases, an increase in food-borne diseases, changes in the amounts and quality of available water resources, and weaknesses in the public health infrastructure.

Particular attention was paid to the effects of high temperature combined with poor air quality in large southern Canadian cities. It was concluded that, in cities such as Toronto, Ottawa and Montréal, the degree of warming projected over the next few decades could lead to a significant increase in the number of deaths during severe heat waves, particularly among the elderly and the infirm.

The Canada Country Study also drew attention to potential increases in disease transmission and bacterial contamination due to climate change. For

example, heavy rainfalls could increase outbreaks of infectious diseases such as cryptosporidiosis and giardiasis ('beaver fever'). Warmer temperatures would generally favour the survival of cholera bacteria, as well as the growth of certain algae that release toxins that can accumulate in fish or shellfish. A warmer environment resulting from climate change could also enhance the prevalence of food-borne diseases from enteric bacteria and viruses, favour the northward spread of mosquitoes and ticks capable of transmitting disease (e.g., dengue fever, yellow fever and malaria), and increase the number of disease-carrying rodents and their contact with humans.

Duncan et al. (1997) also discussed the need for both short- and long-term adaptations that would reduce the health impacts of climate change. Such adaptation measures include introducing weather-watch warning systems, assisting acclimatization to extreme heat, and improving public outreach and education. The need for increased research, including interdisciplinary studies, was also stressed.

3. The Health Effects of Climate Change and Climate Variability

Our health and well-being are strongly influenced by weather and extreme events. A changing climate would affect mortality and injury rates, illnesses and mental health. These impacts would result from changes in factors such as temperature extremes, air quality, water- and vector-borne diseases, and extreme weather events. The impacts would vary across the country, with different regions facing different priority issues.

3.1 Temperature Stress

Climate change is projected to cause milder winters and warmer summers. People will largely be able to adapt to gradual changes in average temperatures through normal acclimatization. However, higher air temperatures are also expected to increase the frequency and intensity of heat waves (McMichael et al, 2001). Heat waves can exceed the physiologic adaptive capacity of vulnerable groups, such as infants, the elderly and those with pre-existing health conditions. The impacts of heat waves tend to be greater in urban, rather than suburban or rural areas, likely owing to both the 'heat island' effect and higher levels of air pollution. Studies have suggested that an increase in the number of days of extreme heat (above 30°C) over this

century, would result in greater heat-related mortality in some urban centres in southern Canada (Chiotti et al, 2002; Last and Chiotti, 2001). However, it should be noted that seasonal acclimatization and appropriate adaptation measures, such as access to air conditioning and necessary medical care, could reduce the number of deaths (Davis et al., 2002).

Research suggests that the timing and characteristics of heat waves may influence the degree of health impacts. For example, heat waves that occur earlier in the summer tend to result in more deaths than those that occur later in the season, as people have not yet acclimatized to warmer weather (Sheridan et al, 2002). In addition, current warming trends show that night-time minimum temperatures are increasing more rapidly than daytime maximum temperatures, and climate models suggest that this trend will continue (Dhakhwa and Campbell, 1998). This means that, during future heat waves, there would be less relief due to night-time cooling than there is at present, and this would further increase temperature stress (Epstein, 2000).

As well as affecting mortality rates, extreme high temperatures would also influence a range of heat-related illnesses. Direct impacts of extreme heat include heat fatigue, exhaustion, heat rash, cramps and edema, as well as heat stroke and sunstroke. Indirect impacts, such as pre-existing health conditions exacerbated by extreme heat, cover a wide range of circulatory, respiratory and nervous system problems (Thompson et al., 2001). Factors that increase the risk of heat-related illnesses include old age, medication use (especially anticholinergic and psychotropic medications), obesity, previous heat injury and skin disorders (Cooper, 1997). Heat-related illnesses place additional stress on health infrastructure and can cause significant economic costs. Studies suggest that, although heat-related health effects are reflected in hospital admissions, the relationship can be difficult to quantify because ambulance and hospital admission records are presently not designed to capture such data.

3.2 Air Pollution and Related Diseases

Air quality influences many respiratory ailments. Although the average concentrations of toxic air pollutants in Canada have generally been reduced to fairly low levels, relative to those experienced 50 years ago, the daily and seasonal rises in levels of air pollution are still closely followed by peaks in the number of people admitted to hospitals or dying of respiratory and

circulatory diseases (Goldberg et al., 2001; Cakmak et al., 2002) Air pollution causes and exacerbates acute and chronic illnesses, such as lung disease, and results in increases in health care costs and premature deaths (Health Canada, 2001). Air quality is especially a concern in the most populous regions of Canada, including the Windsor to Québec corridor and the lower Fraser Valley of British Columbia, where summer air pollution levels often reach hazardous levels. Indeed, it is estimated that approximately two-thirds of Canadians live in regions that suffer from high smog levels in the summer (Maarouf and Chiotti, 2001). Children and the elderly are groups considered particularly susceptible to poor air quality.

Climate change could affect both average and peak air pollution levels (Chiotti et al, 2002). For example, background concentrations of ground-level ozone (a pollutant that irritates the lungs and makes breathing difficult) are expected to increase over mid-latitudes due, in part, to higher temperatures (McMichael et al, 2001), whereas intense smog episodes are projected to become more frequent during summer months as a result of climate change (Chiotti et al, 2002). Higher summer temperatures are also likely to increase energy consumption for cooling, thereby adding to pollution emissions (Maarouf and Chiotti, 2001).

Airborne particulates from natural sources, such as forest fires and wind erosion, also have the potential to increase as a result of climate change. During recent drought years, large forest fires have spread smoke across areas covering more than 200,000 square kilometres (Natural Resources Canada, 2003). In July 2002, smoke from large forest fires in Quebec caused New York to issue a statewide alert for people with respiratory and heart conditions to remain indoors. Particulates in forest fire smoke can irritate the respiratory tract when they are inhaled. Forest fires could increase in frequency and severity in some regions of Canada as a result of future climate change. An increase in drought could also lead to increased concentrations of dust in the air due to wind erosion of soils (Maarouf and Chiotti, 2001), particularly on the Canadian Prairies, where dust storms presently represent a significant natural hazard. Alkali dust emissions, resulting from
wind erosion of dried salt lake beds, have caused nasal, throat, respiratory and eye problems for some rural residents on the southern Prairies and could become more common if climate change results in further drying of saline lakes in this region (Wolfe, 2001).

3.3 Waterborne Diseases

Heavier rainfall events and higher temperatures resulting from climate change may increase the occurrence of waterborne diseases, such as giardiasis and cryptosporidiosis. Although such diseases are generally not serious for most of the population, the very young, the elderly and those with compromised immune systems may be vulnerable. Heavy rainfall events and flooding can flush bacteria, sewage, fertilizers and other organic wastes into waterways and aquifers. If not properly treated, such events can lead to the direct contamination of drinking water supplies.

Recent examples of waterborne disease outbreaks related, at least in part, to climatic conditions include those caused by *E. coli* in Walkerton, Ontario (2000); *Cryptosporidium* in Collingwood, Ontario (1996); and Toxoplasma in the greater Victoria area, British Columbia (1995). In Walkerton, expert witnesses testified that the outbreak, which resulted in seven deaths and thousands of illnesses, could be partly attributed to an unusually heavy rainfall event, which followed a period of drought (Last and Chiotti, 2001). Such trends are receiving growing recognition; researchers have determined that more than 50 percent of waterborne disease outbreaks in the United States between 1948 and 1994 were preceded by extreme precipitation events (Curriero et al., 2001). A detailed discussion of the causes and history of infectious diseases associated with contaminated drinking water in Canada is provided by Krewski et al (2002).

Increases in temperature would also exacerbate water contamination, as higher temperatures encourage the growth and subsequent decay of algae, bacteria and other micro-organisms, causing odour and taste problems and, in extreme cases, even rendering the water toxic (Chevalier et al., 2002). In addition, higher water temperatures and storm water runoff, combined with greater use of beaches, have been associated with increases in infectious illnesses in people using recreational waters (City of Toronto, 2001)

3.4 Food-Borne Diseases

An increase in heavy rainfall events and higher temperatures may increase the occurrence of toxic algal outbreaks in marine environments (Weise et al., 2001). Toxic algal blooms can contaminate shellfish, which in turn pose a danger to human health through paralytic shellfish poisoning. Increased problems with contamination of both domestic and imported shellfish are

possible. Food poisoning from contamination of other imported foods may also increase, as rising air temperatures allow microbes to multiply more quickly (Bentham and Langford, 1995).

3. 5 Vector- and Rodent-Borne Diseases

Vector-borne diseases are infections that are transmitted to humans and animals through bloodfeeding arthropods, such as mosquitoes, ticks and fleas. Insect- and tick-borne diseases, such as West Nile virus, Eastern and Western Equine Encephalitis (transmitted by mosquitoes), Lyme disease and Rocky Mountain Spotted Fever (transmitted by ticks),(Morshed, 1999; Morshed et al, 2000) already cause human health problems in some parts of Canada. Rodent-borne viruses, capable of causing illnesses and deaths in humans, are also present in much of southern Canada (Drebot et al., 2000). Hantaviruses, which can cause fatal infections (pulmonary syndrome), are of particular public health concern because the deer mice that carry hantaviruses tend to invade dwellings and are present across Canada as far north as the Yukon Territory and the Northwest Territories (Mills and Childs, 1998; Calisher et al., 1999). Rodents may also carry tick-borne diseases, such as Babesiosis (Jassoum et al., 2000).

There are concerns that future changes in climate could lead to conditions that are more favourable for the establishment and/or proliferation of vector and rodent-borne diseases (Chiotti et al., 2002). The impacts of climate change on these diseases are generally expected to result from the effects of changing temperature, rainfall and humidity on the vector species, although the development rates of the pathogens themselves may also be affected. For example, longer and warmer springs and summers resulting from climate change could increase mosquito reproduction and development, and also increase the tendency of mosquitoes to bite (Epstein, 2000). Mosquitoes would also benefit from warmer winters, as cold temperatures currently reduce mosquito populations by killing mosquito eggs, larvae and adults. Furthermore, increases in extreme weather events, especially those that trigger flooding, could increase breeding areas for mosquitoes by creating more shallow pools of stagnant water.

Observed trends in Lyme disease and West Nile virus illustrate how quickly new and emerging diseases can spread. For example, Lyme disease has extended its range significantly across the United States since the 1980s, and is now considered to be a major public health concern. Although the disease

is still rare in Canada, warmer weather and the northward migration of animals and birds that carry infective ticks could further expand its range (Maarouf and Chiotti, 2001). The recent, extremely rapid spread of West Nile virus across the United States and Canada, although not due to climate change, is another example of how quickly and widely a newly introduced virus can expand its range. Conditions expected to result from climate change could further facilitate the spread of the virus northward.

Another potential future health concern in Canada is the re-emergence of malaria as a result of climate change, increased travel and immigration, and increased drug resistance (Martens, 1998a). Malaria-infected persons exposed to North American mosquitoes capable of transmitting the causative *Plasmodium* parasite can cause localized outbreaks of infections. In addition, new insect vectors, such as the 'tiger mosquito', which has spread across 25 states since its introduction to the US from Asia in 1987 (Moore and Mitchell, 1997), may extend their range to southern Canada if climate conditions become more favourable (Maarouf and Chiotti, 2001). Nevertheless, there remains considerable uncertainty regarding how climate change will affect vector lifecycle and disease incidence of malaria, especially in a North American context.

3.6 Allergens

Changes in temperature, precipitation and length of the growing season would all impact plant growth and pollen production, and ultimately human health by, for example, extending the allergy season (McMichael et al., 2001). Studies have also shown that elevated concentrations of atmospheric carbon dioxide can enhance the growth and pollen production of ragweed, a key allergy-inducing species (Ziska and Caulfield, 2000). Although not all species of allergen-producing plants will necessarily react in a positive manner to changed climate conditions, a more stormy climate may sweep more allergens into the air and lead to more frequent allergy outbreaks (Burch and Levitan, 2002). Stormy winds may also increase airborne concentrations of fungal spores, which have been shown to trigger asthma attacks.(Dales et al., 2003).

3.7 Ultraviolet (UV) Radiation

Exposure to ultraviolet (UV) radiation is expected to rise in future, leading to an increase in temporary skin damage (sunburn), eye damage (e.g., cataracts) and rates of skin cancer (Martens, 1998b; Walter et al., 1999). Increased UV

exposure could result from a number of factors associated with climate change, including stratospheric ozone depletion due to increased concentrations of some greenhouse gases, and increased development of high-altitude clouds (Maarouf and Chiotti, 2001). Longer summer recreational seasons resulting from global warming may also contribute to increased population exposure to solar UV radiation.

3. 8 Effects on Human Behaviour

Climate also has an influence on mental health. This is particularly evident in the case of climate-related natural hazards, where property losses and displacement from residences can cause significant psychological stress, with long-lasting effects on anxiety levels and depression (Klaver et al., 2001). Social disruptions resulting from family and community dislocations due to extreme weather events pose a special stress for children and those of lower socio-economic status. Increased levels of anxiety and depression were seen among farmers experiencing crop failures (Klaver et al., 2001) due to drought and among victims of the 1997 Red River flood (International Red River Basin Task Force, 2000).

Temperature also appears to influence human behaviour. In the Montréal area, researchers found that the number crimes per day tended to increase with daily maximum temperature up to about 30°C (Ouimet and Blais, 2001). Another study found that higher summer temperatures are linked to increases in human aggression (Anderson, 2001). Linkages may also exist between extreme climate events, aggression and crime rates. For instance, increased aggression could result from crowding of disoriented and distressed people in temporary emergency shelters. A recent study examined how the ice storm of 1998 affected crime rates in three regions of Quebec.

4. Adaptation

Canadians escape many climate-related extremes by using a wide range of physical and social adaptation measures. Seasonal changes in our clothing and lifestyles, the design of our buildings and other structures, and behavioural, social and economic adaptations have allowed us to remain generally healthy and comfortable except under the most extreme weather and climate conditions. Nevertheless, the possibility that future climate changes will force Canadians to deal with conditions beyond the range of historical experience suggests that there will be new stresses on the health sector and that additional adaptation will be necessary.

To address population health risks resulting from climate change, a two-step process, in which the risks are managed in a systematic and comprehensive manner, has been recommended (Health Canada, 2000). First, there is a need to assess the vulnerabilities and adaptive capacities of different regions, communities and population groups. The next step would involve identification and selection of the most appropriate response strategies. The linkage between climate change mitigation and adaptation actions is particularly strong in the health sector because of the health benefits derived from reducing greenhouse gas emissions. Assessments must take into account not only the possible impacts of climate change on the health sector, but also the capacity to adapt to those impacts. This process is well suited to being examined as part of an integrated risk-management framework.
Work has also already started on developing vaccines against several viruses and protozoa responsible for emerging infectious diseases prevalent in the tropics, including malaria and West Nile virus (Marshall, 2000; Taubes, 2000). These new vaccines may help to limit the future spread of emerging viral diseases. Monitoring for emerging diseases, and public education programs that provide information on reducing the risk of exposure and transmission, will also serve to limit the threat of infectious diseases. For example, satellite measurements could be used to determine linkages between environmental conditions and the spread of some pathogen vectors (Estrada-Pena, 1998).

As noted previously, health impacts related to an increased frequency of extreme climate events and climate-related natural disasters are a key area of concern. Although many Canadian municipalities have emergency management plans in place, their emergency management capacity tends to vary widely. Communities prone to weather-related hazards, such as avalanches, floods, heat or cold waves, or storm surges, should generally be better prepared to cope with increased frequencies of such extreme events than communities that have rarely experienced them, although other factors are also important. This is exemplified by contrasting emergency response to the 1997 Red River flood in Manitoba, where disaster plans proved effective, with the 1998 ice storm in eastern Ontario and Quebec, where emergency power supplies, food distribution systems and emergency shelter provision were insufficient to deal with the crisis (Last and Chiotti, 2001). Measures have since been taken to strengthen emergency preparedness and response capacity in the region affected by the ice storm.

In addition to emergency management, another key component of responding to extreme climate events is the implementation of early warning systems (McMichael et al., 2001). Such a strategy has been successfully introduced in Toronto to help reduce the health impacts of extreme heat and cold. Other important adaptive measures to reduce the health risks of climate change include land use regulations, such as limiting floodplain development, and upgrading water and wastewater treatment facilities.

Several Canadian cities are promoting longer-term measures aimed at reducing the heat-island effect. Summer temperatures in urban areas tend to reach higher extremes than surrounding rural areas, in part due to the prevalence of infrastructure and surfaces, which act to absorb, rather than reflect, incoming solar radiation. In a Toronto-based study, researchers recommended promotion of cost effective measures, such as the large-scale use of light-coloured, reflective 'cool' surfaces for roofs and pavements, and the strategic placement of vegetation to provide shade (Basrur et al., 2001). These measures are being promoted as 'win-win' adaptation options, as they also serve to reduce energy usage.

Other researchers, however, note that adaptation measures may themselves entail some health and safety risks. For example, green spaces harbour animals, birds and biting insects or ticks, which may serve as reservoirs for infectious diseases such as Lyme disease (Daniels et al., 1997) and the West Nile virus. Therefore, careful planning and testing of proposed adaptation measures, as well as health surveillance after the introduction of adaptation measures, may be needed.

4.1 Facilitating Adaptation

A study of the health infrastructure in the Toronto-Niagara region revealed several barriers to effective adaptation to climate variability and change (Chiotti et al., 2002). These barriers stem from knowledge gaps, insufficient organization and coordination, and inadequate understanding and communication of climate change and health issues within the health community. If adaptation measures are to be successful, these barriers must be overcome.

Successful adaptation will also depend on Canadians becoming more aware of, and actively engaged in, preparing for the potential health impacts of climate change. Several nongovernmental organizations have begun to draw the attention of their members and the public to the causes and effects of

climate change, and to the need for both mitigation and adaptation measures. Among these are the Canadian Public Health Association and the Canadian Institute of Child Health, which published its assessment of the implications of climate change for the health of Canadian children.

Some key recommendations stemming from these initiatives include:

- increasing the capacity of the health sector to manage the risk to human health and well-being from climate change, particularly for the most vulnerable population groups, including children, the elderly, and disabled persons; and
- managing population health risks in a systematic and comprehensive manner, so that climate change is integrated into existing frameworks, rather than being addressed as a separate issue.

5. Conclusion

Climate change has the potential to significantly affect human health and well-being in Canada. Some key concerns include an increase in illness and premature deaths from temperature stress, air pollution, and increases in the emergence and persistence of infectious diseases. The effects of climate-related natural hazards and extreme events on both physical safety and mental health are another concern. Communities in northern Canada will face additional issues resulting from the impacts of climate change on ecosystems. Although there will likely be some benefits, such as a decrease in cold-weather mortality, negative impacts are expected to prevail. The impacts will be greatest on the more vulnerable population groups, such as the elderly, children, the infirm and the poor.

Adaptation will be necessary to reduce health-related vulnerabilities to climate change. Some adaptation initiatives include the development of vaccines for emerging diseases, public education programs aimed at reducing disease exposure and transmission, and improved disaster management plans. The implementation of early warning systems for extreme heat is another effective adaptation strategy. Successful adaptation will require coordinated efforts among different groups and the consideration of climate change in health care decision making.

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