Chapter 8

Vulnerabilities, Adaptation and Adaptive Capacity in Canada

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8.1 INTRODUCTION

Global climate change is one of many large-scale environmental changes that reflect the increasing impacts of human activities on the environment. Other large-scale changes include stratospheric ozone depletion, biodiversity loss, worldwide land degradation, freshwater depletion and the global dissemination of persistent organic pollutants. Combined, they have important consequences for the sustainability of ecological systems, food production, economic activities and human population health (McMichael et al., 2003).[1]

According to the Intergovernmental Panel on Climate Change (IPCC), "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level" (IPCC, 2007b, p. 5). The rate of climatic change and its impacts will likely create new stresses on individual and community health and well-being, and increase vulnerability to already existing environmental and social pressures. The health effects of climate change are diverse and of varying importance but according to the IPCC "... are projected to progressively increase in all countries and regions" (IPCC, 2007a, p. 393). There is substantial evidence worldwide on the association between specific climate conditions and mortality, illnesses and discomfort (McMichael et al., 2003; Riedel, 2004; IPCC, 2007a). Previous chapters in this Assessment documented the health risks many Canadians and communities face across the country and how these may evolve as the climate changes. These include illnesses and deaths related to poor air quality, heat waves, water- and food-borne contamination, changing patterns of diseases spread by animals, ticks, and insects, and extreme weather events. Key segments of our population such as seniors and children, are often more vulnerable because of specific physiological sensitivities and reduced ability to cope by themselves with climate-related risks.

The extent to which climate change will disrupt society, affect the economy and reduce Canadians' quality of life and health will largely depend on the strength of existing systems to protect people from hazards, the willingness to adapt to short- and long-term changes and existing capacity to increase our efforts to adapt. Canadians identify climate change as an important threat to health; 81% of people surveyed in 2007 were concerned about climate change risks to health (Canadian Medical Association (CMA), 2007). This awareness is important for successfully implementing adaptation measures at the individual and institutional level.

Climate change may bring some benefits to the health and well-being of Canadians through reduced cold snaps (Gosselin, 2004; Riedel, 2004; Stern, 2006); however, Chapter 6, Health Impacts of Climate Change in Quebec, suggests that such benefits might be limited given that

1 The World Economic Forum ranked climate change to be the highest global environmental risk on the basis of severity of economic losses and number of possible deaths (World Economic Forum, 2007).

people in that province are generally already well adapted to cold conditions. Potentially longer growing seasons for agriculture might also benefit Canadians economically, although this will depend on many factors, including future levels of heat stress, water availability and pest problems (Lemmen et al., 2008; IPCC, 2007a).

Adaptation[2] is not a new concept; many actions are being taken in Canada to reduce the health risks associated with weather extremes and longer-term climate variability. Health authorities within all levels of government, voluntary organizations and private organizations are responsible for a range of functions and services that may be affected by climate change. However, the existing systems vary in their effectiveness, and may not be fully protecting the populations most at risk. Severe weather-related hazards may be so overwhelming that current risk management efforts to protect human health and well-being may not be adequate or effective. And if newly developed policies and plans do not take into account the hazards associated with future climate change and the increased risks to human health and well-being, people will not be adequately protected.

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Kelowna, British Columbia, 2003

The public health community advocates for preventative interventions to manage risks related to climate variability and change (Kovats et al., 2003). However, preventing the onset of disease before it occurs requires an adequate knowledge of potential impacts and existing vulnerabilities, as well as sufficient capacity to act so that the necessary interventions can be developed. The capacity of individuals, governments and communities in Canada to adapt to the health risks associated with current climate variability and future climate change has rarely been subjected to rigorous analysis. Sparse information exists about individual adaptations and the effectiveness of protective measures used by Canadians and their communities; consequently, our understanding of vulnerabilities is incomplete.

This chapter examines the capacity of governments and communities to respond to climate change through an assessment of measures and systems that are in place to manage current climate-related health risks. It reviews results from new research, findings from other chapters of this Assessment and literature to draw conclusions about the sensitivity and exposure of Canadians to climate-related risks, and ultimately to provide insights about vulnerability. To support future adaptation efforts, it identifies current roles and responsibilities for managing climate-related health risks and provides an adaptation framework that offers guidance for developing needed measures to protect Canadians. It concludes by suggesting areas where adaptation efforts should focus and potential options for consideration by public health and emergency management officials.

2 "Adapting" means changing individual behaviours, and government policies and programs to help avoid the negative impacts of climate change, and to position Canadians to exploit its opportunities (Health Canada, 2005a). See section 8.10 for a more detailed discussion.

8.2 VULNERABILITY

There are many different definitions of vulnerability that arise from the use of this term in the natural hazards, risk management, poverty, public health and development literatures (Downing and Patwardhan, 2005). In the climate change impacts and adaptation field, vulnerability refers to "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2007a, p. 21). The vulnerability of a population or region to the impacts of climate change is a function of (IPCC, 2001; Smit and Wandel, 2006):

1. Exposure to climate hazards
2. Sensitivity to those impacts
3. Adaptive capacity

For any given social and economic system, exposure is the probability of the occurrence of an ecosystem impact or effect (e.g. extreme weather event, emerging disease, smog episode) whose influence extends over a particular area (Adger, 2003). For human health, exposure refers to "the amount of a factor to which a group or individual was exposed; sometimes contrasted with dose, the amount that enters or interacts with the organism" (McMichael et al., 2003, p. 291).

Sensitivity is the "degree to which a system is affected, either adversely or beneficially, by climate-related stimuli" (Adger et al., 2003, p. 28). Sensitivity of individuals and populations can be influenced by a range of important determinants of health, such as socio-economic status, biology and genetic endowment, availability of health services, gender and personal health practices. Sensitivity to the impacts of current climate change and variability is also directly related to the effectiveness of current adaptations or measures to reduce the exposure to the impacts or mitigate the health risks.

Definition of adaptive capacity

Adaptive capacity is the "ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences."

Source: IPCC, 2007a, p. 21.

Adaptive capacity provides an indication of the ability of a system to manage change successfully. Levels of adaptive capacity among individuals, communities and governments are often linked (Smit and Wandel, 2006). Individuals are better able to safeguard their own health when they reside in communities that possess high adaptive capacity, and communities benefit from comprehensive plans and responses put in place by regional and national governments. This chapter focuses on adaptive capacity as a key component of vulnerability.

It should be noted that "vulnerability" is used somewhat differently by emergency management practitioners and researchers. It is defined by this community in terms of "...conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. It is a measure of how well prepared and equipped a community is to minimize the impact of or cope with hazards" (Public Safety and Emergency Preparedness Canada (PSEPC), n.d. p.12). The level of vulnerability is not directly associated with the potential hazard; it is associated with other factors such as a person's age, education, income, disability, or a community's level of disaster preparedness.

Significant differences in vulnerability to the impacts of climate change exist among countries, particularly between developed and developing ones (McMichael et al., 2003). Developed countries have a significantly higher capacity to prepare for and respond to weather extremes and health emergencies. For example, between 1994 and 2003, 40,981 people in high human development countries were killed by hydro-meteorological disasters whereas 293,345 people in low human development countries were killed (International Federation of Red Cross and Red Crescent Societies, 2004).[3] It should be noted that an estimated 33,000 of the deaths in high human development countries are accounted for by a single event, the extreme heat wave in Europe in 2003. The importance of strong public health systems is also demonstrated by the striking contrast in disease incidence among some neighbouring countries. From 1980 to 1999, there were 64 reported cases of dengue fever in Texas but 62,514 cases over this same time period in three bordering states in Mexico (U.S. Department of State, 2002).

Differences in vulnerability also occur within countries because of disparities in resources. For example, some remote communities in Canada's North currently face greater adaptation challenges to climate change than most of their southern counterparts. Rapidly melting permafrost, which is used as the base for ice roads, makes it difficult to resupply communities such as Tuktoyaktuk with food, medicines and other necessities (Munro, 2006). This is occurring at the same time that changes in the health of animals (e.g. caribou) and in their migration routes and distribution are occurring. Consequently, several communities no longer have safe or consistent access to country foods for long periods (Nickels et al., 2006). As well, gaps in some public health services and systems exist in many northern communities.

3 The classification of countries as high, medium or low human development in *World Disasters Report 2004: Focus on Community Resilience* is based on the United Nations Development Programme's 2003 Human Development Index (International Federation of Red Cross and Red Crescent Societies, 2004).

8.3 VULNERABILITY ASSESSMENT APPROACH

The main objective of vulnerability assessments is to identify feasible adaptation options to reduce the effects of climate change (Smit and Wandel, 2006). An initial assessment of the vulnerability of a population or community can be made without detailed information about how the climate will change in the future. Such analysis draws from information about the sensitivity and exposure of populations to past climate variability, as well as from information about the current capacity of systems to adapt to changing conditions (Lemmen and Warren, 2004).

Current levels of vulnerability are related to the adaptive measures in place and the effectiveness of a range of traditional public health activities (IPCC, 2007a). Existing measures for reducing climate-related health risks and emergencies may increase or decrease future vulnerability; this information can be used to identify gaps that need to be addressed.

Several conceptual and analytical frameworks for assessing vulnerability and adaptive capacity related to climate change have been developed and published (Smit and Pilifisova, 2001; Downing and Patwardhan, 2005; Ford and Smit, 2005). As discussed in Chapter 2, Assessment Methods, the best guidance document for the assessment of adaptation to climate change, in relation to human health, has been identified by Füssel and Klein (2004) as *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* (Kovats et al., 2003). However, this document provides limited guidance for the exploration and assessment of adaptive capacity as a key factor in determining vulnerability. For this reason, the approach followed here also draws upon the *Framework for Assessing Vulnerability for Climate Adaptation* developed by Downing and Patwardhan (2005). This framework emphasizes key activities, including assessing the exposure to climate hazards, particularly for vulnerable populations; assessing sensitivity; gauging adaptive capacity; examining future vulnerability; and linking the vulnerability assessment outputs with adaptation policy options.

The approach used here to examine adaptive capacity in Canada therefore included the following steps:

- Identify determinants of adaptive capacity to guide analysis.
- Identify concerns about current adaptation efforts and the capacity of public health and emergency management systems to reduce health risks, based on analysis of current adaptations and measures.
- Integrate information about sensitivity and exposure of Canadians to hazards associated with climate variability and change to provide preliminary insights about the vulnerability of Canadians.
- Identify roles and responsibilities, and current adaptations in Canada for safeguarding human health and well-being.
- Identify possible adaptation measures that can be employed to reduce risks to health and to build adaptive capacity and reduce vulnerabilities.

8.4 METHODS

Adaptation options and the capacity of Canadian communities and governments to address climate-related health risks were investigated according to the key health issues that are the focus of this Assessment.[4] It should be noted that the analysis of adaptive capacity is not specific to any province or region of Canada, unless so indicated. For this reason, estimates are not provided on relative levels of existing capacity among specific regions or communities. The adaptive capacity of communities in northern Canada and in the province of Quebec is discussed in Chapter 7, Health Impacts of Climate Change in Canada's North and Chapter 6, Health Impacts of Climate Change in Quebec, respectively.[5] The analysis in this chapter also focuses on the capacity of existing institutions and organizations to adapt rather than the capacity of individual Canadians.

Various sources of data were used for analysis in this chapter. Information on roles and responsibilities for adaptation was obtained through the Internet: websites of government and non-governmental sources, and in particular, the websites of the agencies responsible for the provision of health care, public health, safe drinking water and emergency management services. The inventory is not comprehensive but, for the purpose of examining adaptive capacity in Canada, it provides a synopsis of the key differences in responsibilities among jurisdictions and organizations.

A literature review and expert informant interviews with public health and emergency management officials were used to identify existing concerns about the capacity of governments and communities to address the health risks related to climate variability, including those expected to increase because of climate change. The literature review used information available from international agencies (e.g. World Health Organization (WHO)) and from national, regional and local authorities (e.g. Health Canada). Some information on the capacity of public health systems to plan for and respond to health emergencies is available because of recent events such as the severe acute respiratory syndrome (SARS) outbreak in Toronto, and the illnesses and deaths in Walkerton, Ontario, caused by the contamination of the water supply by *E. coli 0157:H7* and *Campylobacter jejuni.* Analysis of these events provided information about levels of capacity for protecting Canadians during public health emergencies. It also provided information about measures to strengthen public health systems—measures that could be applied to better protect the health of Canadians under conditions of climate change. This information, along with recent actions to improve capacity, such as creation of the Public Health Agency of Canada in 2004 and the position of Chief Public Health Officer for Canada, is drawn upon for the analysis in this chapter.

There is a paucity of peer-reviewed studies on climate change and health adaptation and adaptive capacity in Canada. Therefore, this chapter partially draws upon the grey literature, including unpublished workshop reports and working papers, memoranda, public health protection procedures, and guidelines from health and emergency management agencies and other relevant sources. Inferences made from the international literature, which has grown substantially over the last few years, are presented with care and in a manner that respects the specific circumstances of Canadian governments and communities.

4 Adaptation measures and adaptive capacity related to risks from increased exposure to ultraviolet radiation due to stratospheric ozone depletion are not examined in this chapter.

5 See Chapter 2, Assessment Methods, for the rationale for including these regions in this Assessment.

Health and emergency management experts and practitioners from academia, government and non-governmental organizations at municipal, provincial and federal levels were consulted through health emergency management simulation exercises (i.e. a heat wave in Montreal and two storm surge simulations in Atlantic Canada) and through surveys. Workshops organized by Health Canada were also held to obtain information on current adaptations and key determinants of adaptive capacity. These consultations highlighted the need to examine the capacity of a wide range of decision makers and organizations (such as governmental authorities and practitioners), and the need to examine both current and future vulnerabilities (Health Canada, 2003a).

Calls being made during storm surge table-top simulation exercise in Port-aux-Basques, Newfoundland and Labrador, 2005

Relatively few climate change and health assessments have been conducted, and few of these include systematic and comprehensive assessments of adaptation measures and adaptive capacity. Approaches and methods for assessing adaptive capacity and vulnerability are still being refined. Conceptual frameworks and methods do not exist to allow for precise quantification of existing adaptive capacity, including that of decision makers within non-governmental and governmental organizations. As well, uncertainty about future changes in risks and the diversity of health impacts across areas and regions are key challenges faced by such assessments (Füssel and Klein, 2004; Lemmen and Warren, 2004). For these reasons, this chapter constructs a snapshot of current adaptations in Canada, and identifies key concerns and trends regarding current adaptive capacity from a variety of available sources. Health and emergency management officials routinely make decisions under conditions of uncertainty about how to best address threats to public health by using risk-based approaches that are designed for this purpose (Health Canada, 2000). It is therefore expected that the findings of this chapter will be useful in deliberations about how to most effectively address future health risks associated with climate change.

8.5 ASSESSING ADAPTIVE CAPACITY

Adaptive capacity is generally assessed by examining the current state of the system or region, and its ability to deal with current stresses, such as climate variability. A measure of the effectiveness of current policies and programs is key to understanding existing capacity (Spanger-Siegfried and Dougherty, 2003). Well documented research on the key determinants of capacity and the existing levels of capacity to adapt to health risks related to climate change in Canada is lacking. In support of this Assessment, Health Canada consulted with experts and practitioners to identify determinants important for managing health risks and contributing to adaptive capacity (Health Canada, 2003a). The determinants

that were highlighted correspond to those identified by WHO, which are described in the following text. These included access to material resources (i.e. economic wealth), technology, information and skills, institutional arrangements, public health infrastructure, equity and the existing burden of disease (Grambsch and Menne, 2003).

Economic resources

Wealthy nations and wealthy communities within nations are better able to adapt because they have the economic resources to invest and to offset the costs of adaptation. For example, over the past decade, disasters in developed countries resulted in an average of 44 deaths per event whereas disasters in less developed countries killed an average of 300 people per event (International Federation of Red Cross and Red Crescent Societies, 2004).

Technology

Access to technology in key sectors and settings (e.g. agriculture, water resources, health care, urban design) is an important determinant of adaptive capacity. Many adaptive strategies, such as the development of vaccines to combat infectious diseases, involve new technological developments. Storm prediction and warning services by Doppler radar and communications systems (e.g. television, weather radio) are technologies that are important for warning citizens and preparing communities for threats from extreme weather events.

Information and skills

Information sharing and awareness-raising activities are important for communicating health risks associated with climate variability and change, and the adaptive actions that can be taken to protect people (WHO, 2005). Countries with more "human capital" or knowledge also have greater adaptive capacity. As well, health systems are labour-intensive, and require skilled and experienced staff such as those trained in the operation, quality control and maintenance of public health infrastructure.

Institutions

Strong and effective institutional arrangements are an important determinant of adaptive capacity (Grambsch and Menne, 2003). Ineffective or maladaptive public health policies and programs, and a lack of collaboration among relevant agencies and organizations can create an inability to meet health needs. Collaboration between public and private sectors, such as the Ouranos Consortium in Quebec or the Prairie Adaptation Research Collaborative in Alberta, can greatly facilitate research on climate change impacts and the development of the needed adaptations to address health risks.

Infrastructure

Roads, railways, bridges, water systems, power plants, telecommunications facilities, mass transit, ports and airports are all fundamental for maintaining the quality of life and health of people living in a community. Infrastructure specifically designed to increase resiliency and reduce risks

Photo Credits: Alberta Government

from climate extremes (e.g. flood control structures, air conditioning, building insulation), and general public health infrastructure (e.g. sanitation facilities, wastewater treatment systems, laboratory buildings) reduce vulnerability by enhancing adaptive capacity (Grambsch and Menne, 2003).

Equity

Adaptive capacity is likely to be greater when access to resources within a community, nation or the world is equitably distributed. Under-resourced populations and jurisdictions may lack the means to plan for climate change impacts.[6]

Existing burden of disease

Population health and well-being is an important determinant of adaptive capacity (McMichael et al., 2003; IPCC, 2007a) because it contributes to the ability to regain a state of physical, mental and social well-being in the face of significant challenges and changes (e.g. loss of a job for an individual or loss of an industry for a community). Some populations and regions in Canada have significantly lower health status than others (e.g. the North),[7] and therefore may be more vulnerable to the health impacts of climate change and have less capacity to adapt.

There is no guiding framework or consensus on the criteria required for evaluating the determinants of adaptive capacity and on the indicators that should be used (Lemmen et al., 2008). Few of the proposed methods and procedures for assessing the adaptive capacity of communities clearly identify specific measures for gauging the ability to address expected impacts. Using indicators to measure adaptive capacity also presents significant challenges; this is because indicators say little about the processes that make systems and populations vulnerable and that determine whether these systems and populations can adapt to new climate hazards (Brooks and Adger, 2004). Therefore, this chapter does not develop and use indicators to measure capacity. Rather, it highlights key concerns about the capacity of governments and communities in Canada to address climate-related health risks that have been raised in recent reports, audits, research projects, expert interviews, workshops and surveys during this study. These concerns are based on important findings about limitations in the effectiveness of current adaptations that are aimed at reducing climate-related health risks.

6 Internationally, the obligation of developed countries to provide assistance to less developed ones for their adaptation efforts is included in the United Nations Framework Convention on Climate Change.

7 Detailed discussion of the adaptive capacity of Canada's northern communities can be found in Chapter 7, Health Impacts of Climate Change in Canada's North.

8.6 ADAPTIVE CAPACITY IN CANADA

Our ability to adapt to the health impacts of climate change depends on the rate and magnitude of the changes in the future (U.S. Department of State, 2002). More rapid climate change or warming, creating greater ecosystem changes and extreme weather events, could result in health risks that would increasingly challenge our existing capacity to respond. The cumulative impacts of a number of extreme events or health emergencies test the capacity of a community or region to respond as well as their resiliency (i.e. ability to return to normal) (Smit and Wandel, 2006). For example, many Prairie communities, particularly those located in river valleys and along floodplains, are subject to cumulative natural and other hazards. These include floods, droughts, heat waves, hailstorms, blizzards, tornadoes, chemical spills during transport and power outages (Haque, 2002). If these were to occur in quick succession, health and social service providers could be overwhelmed.

Extreme weather events are incurring increasing economic costs to individuals, communities, businesses and governments in Canada. Between 1900 and 1970 the estimated direct damage costs of weather-related disasters in Canada was $4.8 billion while from 1990 to 2000 the estimated cost was $13.7 billion (PSEPC, 2005). Significant numbers of Canadians have concerns about the ability of their governments to deal with health emergencies. A survey in 2006 revealed that 39% of Canadians and 34% of doctors feel that the health care system is not well prepared for a public health emergency, such as flooding or a disease outbreak (e.g. SARS). Only 6% of Canadians think the health system is "very prepared" (POLLARA, 2006).

Current adaptations may not be sufficient to reduce exposures and address sensitivities to protect Canadians from the more severe hazards (e.g. more intense extreme weather events) and longer-term changes expected with climate change (Lemmen et al., 2008; Health Canada, 2005a; Roberts et al., 2006). As indicated in other chapters of this Assessment, risks to human health and well-being will likely increase, particularly as the rate of change quickens. Projections of increased risks related to climate change suggest that greater adaptation efforts and enhanced capacity in Canada will be required to prepare and plan for the expected climate-related hazards (Chiotti et al., 2002). A key step in enhancing our efforts to protect Canadians from climate-related health risks is to gain understanding of the effectiveness of current adaptations and of areas where gaps exist in adaptive capacity (Kovats et al., 2003). Such information can inform future adaptations and help decision makers track progress toward strengthening institutions, programs, policies and human resources to protect health from the effects of climate change.

Canadians have engaged in a wide range of activities aimed at enhancing health and well-being in the face of weather patterns and extremes associated with the Canadian climate (Riedel, 2004). The scope of public health interventions that could be classified as adaptations to climate-related health risks is enormous. A formal cataloguing of current activities in Canada was therefore not conducted in this chapter. The following sections discuss key adaptations in Canada and concerns that have been identified regarding such measures and our current capacity to cope with climate-related hazards and associated health risks. The discussion is organized according to health issue and includes information on recent actions by federal, provincial and municipal governments to enhance capacity.

8.6.1 Adapting to Health Risks from Natural Hazards

IPCC indicates that the rate of climate warming will increase over the coming decades and that it is very likely that heat waves and heavy precipitation events will become more frequent (IPCC, 2007b). It is also likely that tropical cyclones (i.e. hurricanes) will become more intense (IPCC, 2007b).

Past adaptation efforts in Canada have limited to a large extent the impacts of natural disasters and other health emergencies. Disaster trends in developed countries, such as Canada, show a decline in fatalities during this century due to factors such as improved warning systems, building codes and safety knowledge (Kovacs, 2006). Among the current measures to reduce risks to human health and personal property from extreme weather, the Meteorological Service at Environment Canada issues over 30 types of weather alerts, including weather watches, warnings and special statements.[8] Approximately 14,000 severe weather warnings are issued to communities across Canada annually (Environment Canada, 2003). As well, some communities have built specially designed infrastructures (e.g. Winnipeg floodway) to reduce risks from natural hazards.

Photo Credits: Environment Canada – Canadian Hurricane Centre

Hurricane Juan damage at Prospect, Nova Scotia, 2003

However, weather-related disasters such as prolonged droughts, floods, hurricanes and wildfires continue to pose health risks for Canadians. For example, Hurricane Juan,[9] which was a Category 2 hurricane that hit Nova Scotia on September 29, 2003, resulted in extensive damage to central Nova Scotia and Prince Edward Island, and was responsible for eight deaths. More than 300,000 people were without power for up to a week and a half and it was the most costly hurricane in Canadian history (McBean, 2006).[10] In addition, such events may have significant long-term psycho-social health impacts on individuals, such as depression, post-traumatic stress disorder and anxiety. Currently, there is little information about the prevalence of such impacts associated with past weather-related emergencies and disasters in Canada (Hutton, 2005), but it is generally acknowledged that they are significant (Gutman, 2007).

Critics have suggested that current capacity to respond to health emergencies in Canada is limited (Street et al., 2005). Recent reports and audits conducted in response to a number of emergencies in Canada (e.g. floods in Manitoba; 1998 Ice Storm in eastern Canada; wildfires in British Columbia; water safety issues in Walkerton, Ontario, and Battleford, Saskatchewan; SARS; Creutzfelt-Jacob disease; 2003 Ontario blackout) have examined the ability of the health sector and others to respond to unpredictable events and other emergencies.

8 See Annex 1 for a list of the different types of weather alerts issued by Environment Canada.

9 See Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, for detailed information on the impacts of Hurricane Juan and the community response.

10 Other recent weather events in Canada have seriously impacted individuals and disrupted communities. For example, the 1998 Ice Storm caused massive power outages that affected 4.7 million people in eastern Ontario, Quebec and New Brunswick. Over 600,000 had to be evacuated, and 28 deaths and 945 injuries occurred. Total damages were estimated at $5.4 billion (Public Safety and Emergency Preparedness Canada (PSEPC), 2007a). In July 2000, a tornado hit Pine Lake, Alberta, causing 27 deaths and 600 injuries, and displaced close to 1,700 people (PSC, 2007c). See Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, for a more detailed discussion of such impacts.

8.6.1.1 Emergency management

There is broad recognition in Canada that there is a need to enhance our efforts to plan, prepare for and mitigate the more frequent and intense extreme weather events that are projected to occur because of climate change (Health Canada, 2001; Lemmen and Warren, 2004; The Conference Board of Canada, 2007). A recent parliamentary review of emergency preparedness in Canada (Standing Senate Committee on National Security and Defence, 2004) identified a number of concerns that need to be addressed to ensure Canadians are adequately prepared to face future hazards and extremes. Recommendations in the report called for several measures such as:

- improved leadership and coordination by the federal government on emergency preparedness matters;
- improved funding assistance mechanisms that allow provinces and municipalities to undertake preparedness activities;
- improved communications and coordination among response agencies, communications with the public, access to critical supplies and training;
- improved information about emergency health stockpiles and access to them for municipalities;
- more capacity within the Canadian Forces to provide support to municipalities in large emergencies; and
- improved linkages on emergency preparedness matters among municipal, provincial and federal governments.

> "....accumulating risks associated with factors such as increased urbanization, critical infrastructure dependencies and interdependencies, terrorism, climate variability and change, animal and human health diseases and the heightened movement of people and goods around the world have increased the potential for various types of catastrophes. Such events could transcend geographic boundaries to challenge FPT emergency management, including response" (PSEPC, n.d., p. 3).

The need to make Canadian communities safer in the face of increasing emergencies and disasters has also been recognized as a federal/provincial/territorial priority in both the public health and health emergency management sectors in Canada (Federal/Provincial/Territorial (F/P/T) Network for Emergency Preparedness and Response, 2004).

National voluntary organizations with their networks, experience and expertise are well positioned to play an effective role in assisting communities to prepare for and respond to the challenges of climate change. However, with certain exceptions, neither government agencies nor voluntary organizations have the mature systems, plans or networks required to facilitate voluntary sector involvement in activities related to adaptation to the health risks associated with climate change. A recent survey conducted by the Canadian Red Cross (2005) indicated that 64% of voluntary sector organizations with a specific mandate in emergency preparedness did not have a service continuity plan. The same survey revealed that over 75% of responding organizations without a clear mandate in emergency preparedness, but willing to mobilize their volunteer resources on this issue, did not have an up-to-date service continuity plan. Consequently, the voluntary sector may have difficulty responding to increasing pressures to aid in preparing for and responding to greater risks to Canadians from climate-related hazards.

Case study: Storm surge simulations in Atlantic Canada

In 2005, two coastal communities in Atlantic Canada, Shediac–Cap–Pelé, New Brunswick, and Channel-Port aux Basques, Newfoundland and Labrador, tested their emergency response plans to better prepare for storm surges, which are expected to become more frequent and intense due to climate change. Representatives of municipalities, police and fire departments, health centres, hospitals, provincial governments, federal government and non-profit organizations actively participated in the simulation exercises. The exercises proved to be an effective research method to identify capacity and gaps. They also met training objectives by enabling participants to better understand the potential impacts of such an event, identify the vulnerable geographical areas and populations, identify shortcomings in the emergency management plans and improve future collaboration among stakeholders.

Several recommendations, which correspond closely to determinants of capacity analyzed in this chapter, were proposed to enhance the effectiveness of response capabilities and protect the communities. These include (Health Canada, 2006b):

Institutions

- Ensure an annual update of emergency response plans (e.g. names, telephones, procedures).
- Coordinate actions within the municipal emergency plan with the needs of surrounding communities.
- Establish a coordination process between municipal emergency planners and other organizations involved (e.g. hospitals, community services, coast guard, provincial ministries).
- Update emergency response plans for local health services.
- Ensure coordination between local health centres and community organizations.
- Include procedures to follow in case of a sudden, severe outbreak of a disease (epidemic) and/or terrorism act in the municipal emergency plans.
- Be prepared for the possibility of multiple and simultaneous public health crises (e.g. storm surges, epidemics).

Information sharing and skills

- Clearly define the criteria for declaring a state of emergency.
- Better define roles and responsibilities of people involved in response.
- Identify communication alternatives (e.g. satellite phone, very high frequency (VHF) radio).
- Offer training in emergency response for key municipal personnel.
- Include community organizations (e.g. Red Cross, churches, Salvation Army, seniors' clubs) in all emergency planning steps.
- Create a regional list of public health services available in an emergency situation.
- Make available an emergency medical telephone line to the public.

Infrastructure

- Identify needed human resources and equipment (e.g. generators) locally and regionally available.
- Ensure the municipality has the necessary tools to facilitate the exchange of information during an emergency (e.g. meeting room, maps, boards for logistic information such as weather conditions, record of decisions, contact information).
- Do not depend extensively on regional resources (human and equipment) because they are often solicited by all affected communities in an emergency.

8.6.1.2 Research, education and training

The increasingly "risky" environment faced by municipalities, including the potential impacts of climate change, has demanded more risk assessments, a more rigorous approach to the development of emergency management plans, and more training for emergency services personnel and public health officials. Several municipalities and senior-level government departments have undertaken risk analyses to support their emergency planning, but these have been done mostly on an informal and ad hoc basis. Except in a few cases, these analyses have not factored in climate change within a systematic risk management approach. A divergence between emergency management and adaptation to climate change exists across all levels of government in Canada (Noble et al., 2005).

As well, Canada significantly lags behind countries such as Australia and the United States in establishing emergency management education programs, and consequently suffers from a lack of educated professionals and researchers working in this field (Bruce et al., 2005). There is a shortage of qualified Canadian educators to develop and deliver courses, to supervise post-graduate students and to conduct research (Bellisario et al., 2007). As well, few provinces require certification for emergency management professionals in Canada (Bruce et al., 2005). However, significant strides have recently been made in the development of Canadian course materials and programs for practitioners, and the development of certificate programs across the country is well underway (Bellisario et al., 2007).

A key informant survey of public health officials in cities of various sizes across Canada revealed a broad awareness of climate change and related health issues. All respondents indicated that weather and climate do have a significant impact on health and most (76%) stated that climate change will increase risks to health in their respective jurisdictions (Health Canada, 2006d).[11] However, more than half of those in the survey indicated that climate change had not been identified as a priority public health issue in their geographic jurisdictions; the reasons most often cited were a lack of funding and, particularly, a lack of information or understanding of whether, and why, climate change is a pertinent issue for the public health sector (Health Canada, 2006d). Respondents who did report that climate change was considered an important public health issue in their jurisdiction also indicated that it was not considered a high priority (Health Canada, 2006d). The need for better understanding of health risks associated with climate change is reflected in a resolution passed by the Canadian Public Health Association in 2001 calling for more research into the health impacts of climate change (Canadian Public Health Association (CPHA), 2001b).

8.6.1.3 Critical infrastructure

> "Extreme events such as floods, droughts and heat waves are likely to increase under global warming and will challenge our ability to manage health risks and test the resilience of our infrastructures in many areas, including health service delivery." (Kovats and Haines, 2005, p. 501)

Physical infrastructure plays a vital role in sustaining the health of Canadians. Weather extremes and events can debilitate key infrastructure, posing significant direct (e.g. drownings) and indirect (e.g. mental stress from economic dislocation) health impacts.[12] Public capital investment to maintain and improve infrastructure in Canada has not kept pace with the growing economy and the demands of its population (Harchaoui et al., 2003). Much of Canada's infrastructure is nearing the end of its designated life (Haque, 2002). Almost 30% of the nation's public infrastructure is over 80 years old; only 40% is under 40 years old. Canadians have used on

11 Results of a survey of public health and municipal decision makers, as discussed in Chapter 6, Health Impacts of Climate Change in Quebec, also revealed a high level of awareness about potential risks to health from climate change. As well, a resolution from the Ontario Public Health Association in 2004 recommended the development of programs to address the health impacts of extreme weather events related to climate change (Ontario Public Health Association, 2004).

12 For example, Hurricane Juan (2003) and the Ice Storm (1998).

average almost 80% of the useful life of all public infrastructure in the country (Zuker, 2004).[13] While a recent report shows that the average age of some categories of infrastructure has decreased, overall significant challenges remain and require sustained action (Statistics Canada, 2008). Definitions of public infrastructure vary, as do estimates regarding the extent of infrastructure needs. There is however, consensus on the need to take action.

The current state of infrastructure in Canada could make Canadians more vulnerable to future weather extremes and hazards because the capacity to withstand extreme environmental events is reduced (Haque, 2002; Office of the Auditor General of Canada (OAG), 2006). Damage to buildings from weather can be caused by storm winds, rain penetration, poor durability of construction materials, flood damage, coastal erosion and foundation movement (City of Hamilton, 2006). Extreme weather events associated with climate change are of concern because even small increases in weather and climate extremes have the potential to bring large increases in damage to existing infrastructure. As Auld and MacIver stated, "the damage from extreme weather events tends to increase dramatically above critical thresholds—the high impact storms associated with damages may not be much more severe than the type of storm intensity that occurs regularly each year" (Infrastructure Canada, 2006, p.1). In response, disaster mitigation, including climate change adaptation, has been incorporated into recent federal infrastructure programming as an eligible funding category and climate change impacts are examined during the project assessment process.

A 1995 survey by the Federation of Canadian Municipalities (FCM) found that 59% of the water distribution networks in Canada and 43% of water supply systems were in unsatisfactory condition. Breaks and leaks plague the water mains in older cities, and over 50% of water distribution networks were noted to perform unsatisfactorily. It was also found that 68% of sanitary and combined sewers, 58% of sewage treatment systems and 53% of storm sewers did not operate at an acceptable level and needed some type of repair. The FCM survey also noted that wastewater treatment and conveyance crises have emerged in communities of all sizes throughout Canada (Infrastructure Canada, 2003).

Greater action is needed to implement adaptation measures to make Canada's infrastructure more resilient and to facilitate adaptation in other jurisdictions (OAG, 2006). More resilient infrastructure means lower health risks through reduced risk of structural failure that can accompany extreme events. Recent impacts of climatic events on key infrastructures in Canadian communities demonstrate the need to develop new infrastructure designs that can resist larger and potentially more damaging events expected under climate change (City of Hamilton, 2006). As current infrastructures are upgraded and replaced, engineers need new and updated design values, revised codes and standards, and new methodologies to incorporate climate change considerations into engineering procedures (McBean and Henstra, 2003; Infrastructure Canada, 2006).

Infrastructure failure in Toronto

A severe thunderstorm event with rainfall intensity greater than that experienced during Hurricane Hazel (1954) hit northern Toronto on August 19, 2005. It resulted in the failure of a culvert under Finch Avenue. The entire roadbed of Finch Avenue West at Black Creek was washed away affecting all of the city and utility infrastructure within the road allowance. The storm cost $500 million in insured losses due to flooding, collapsed roadways and lost "buried" infrastructure. It also resulted in significant traffic disruptions caused by the loss of the roadbed.

Source: Infrastructure Canada, 2006.

13 The expected life cycle of bridges, housing, commercial buildings, seaports and rail infrastructure is 50 to 100 years; that of dams, water supply infrastructure, sewers and airports is 50 years; and that of roads and waste management facilities is 20 to 30 years (Infrastructure Canada, 2006).

Infrastructure that provides health services to a population needs to have the capacity to cope with extreme weather events (IPCC, 2007a). Hospitals are key to Canada's health services infrastructure. An emergency that cripples a community or region's hospital services can become a disaster claiming hundreds of lives and affecting thousands of people. Improved emergency management measures for Canada's hospitals are needed. Important shortcomings have been identified in emergency communications strategies in general hospitals (Ferrier, 2002). Many hospitals require better plans for acquiring surge capacity during times of emergencies (e.g. sharing of staff). Limited coordination between hospital plans and those of the community, and limited testing of emergency protocols (e.g. evacuation procedures) have been identified as factors that increase the vulnerability of these institutions, and of patients, to the impacts of emergencies and disasters. Finally, there is a lack of training of those responsible for emergency planning in hospitals. Only 37% of officials had completed an emergency preparedness course in a recent survey of Canadian hospitals (Ferrier, 2002).

8.6.1.4 Rural–urban divide

An examination of emergency preparedness in Canada revealed differences in capacities between cities and smaller communities, or rural areas of Canada, to plan and prepare for emergencies and disasters. Small communities and rural areas[14] are less prepared than large cities (Haque, 2002). Communities not served by adequate transportation or communications infrastructures may be isolated for extended periods of time, compounding hardship. A key informant survey of community emergency preparedness officials found that smaller centres face significant problems with emergency planning and preparedness functions (e.g. training and testing plans) because of insufficient financial and human resources. Most of these smaller centres did not employ specialized emergency planners. In comparison, almost all medium and large communities had designated a full-time official to be responsible for emergency preparedness and coordination (Egener, 2005). Another study (Haque, 2002) comparing rural and urban communities identified the following key challenges facing rural communities in their efforts to improve preparedness:

- reliance on volunteers for emergency personnel;
- lack of economic resources to cope with hazards;
- an underestimation of the frequency of events and hazards because of a lack of knowledge and risk assessments; and
- inadequately trained or organized emergency personnel.

14 Rural communities are defined here as communities with fewer than 1,000 inhabitants. This is consistent with the definition used by Statistics Canada.

Costs to Canadian municipalities are of particular concern. Costs for security and emergency management are increasing rapidly because of many factors, such as increasing urbanization and concentration of populations and increasing climate variability (Egener, 2005). In addition, assistance with emergency preparedness training has been reduced by federal and, in some cases, provincial governments, leaving municipalities to develop and deliver this training or else contract it out. Ultimately, less than half of the smaller centres indicated that their response in the event of an emergency would be effective (Egener, 2005).

Important differences between rural and urban communities concerning their ability to implement a range of programs exist. A survey of public health officials in cities of different sizes across Canada revealed that although most communities consider climate-related information in planning and program development (e.g. air and water quality advisories), the largest cities have the broadest range of initiatives to protect health from weather- and climate-related hazards (e.g. monitoring of West Nile virus and/or Lyme disease, air quality levels, ultraviolet (UV) levels, water quality). They also engage in more research on the health impacts of air pollution, issue extreme weather warnings, and have action or outreach plans on climate change (CPHA, 2006).

8.6.1.5 Risk perception and attitudes of individual Canadians

A primary responsibility for preparing for extreme weather events and reducing the risks they pose to protect health and well-being falls to individual Canadians and households (Murphy et al., 2005; Remedios, 2005). Public Safety and Emergency Preparedness Canada (2007b) advises that Canadians should know what disaster risks they face, develop an emergency plan, have a kit on hand that provides provisions to last three days and know what to do in the event of an emergency. Actions to prepare for emergencies could also include doing home repairs to reduce hazards, purchasing disaster insurance and obtaining first aid training (Murphy et al., 2005).

Many residents in the North, a region in Canada currently experiencing particularly severe impacts from climate change,[15] are changing their behaviours to adapt to weather-related risks. For example, communities in Nain, Labrador, are taking many actions to minimize the dangers associated with unpredictable weather. This includes performing ice-track tests before travelling, notifying people about the safety of travel routes and forming search-and-rescue teams (Furgal, 2002).

> "Experience has shown us that household emergency preparedness is one of the most effective means of mitigating the personal effects of a disaster. By preparing emergency provisions, members of a household can turn what could be a life-threatening situation into a manageable problem" (Falkiner, n.d. p. 14).

However, most individuals are largely unprepared for emergencies (Murphy, 2004). Citizens generally plan only for the immediate future, overestimate their ability to cope when disaster strikes and rely heavily on emergency relief (Tierney et al., 2001). A survey of 576 households was conducted in Kingston, Ontario, in 2001 to determine levels of emergency preparedness for extended winter power outages, fires and medical emergencies. It indicated a generally low level of preparedness among respondents and highlighted a number of areas where improvement was necessary (Falkiner, n.d.). Many Canadians do not view themselves as being at risk from extreme weather. A national survey of Canadians in 2001 found that 60% of Canadians either somewhat disagreed (34%) or strongly disagreed (26%) with the statement that extreme weather in their area posed a risk to themselves, their family or their property (Ipsos-Reid Corporation, 2001).

15 See Chapter 7, Health Impacts of Climate Change in Canada's North, for more information.

8.6.1.6 Recent actions to improve adaptive capacity

In recent years, considerable progress has been achieved towards developing a more integrated and robust emergency preparedness and response capacity in the health sector (Health Canada, 2005a). Many provinces have taken actions to strengthen emergency planning in their respective jurisdictions. Several now require that municipalities conduct hazard assessments and have emergency preparedness plans (McBean and Henstra, 2003; Egener, 2005). For example, Ontario's *Emergency Management and Civil Protection Act* (2006) requires communities and the provincial government to establish emergency management programs, based on hazards and risks that the people of Ontario may face. The Act provides emergency powers to the premier and to the lieutenant governor-in-council to ensure that the provincial government has the necessary power to react quickly to an emergency (e.g. evacuations, closing public places, disposing of environmental or animal waste) (Government of Ontario, 2006). In October 2006, Emergency Management Ontario launched a one-year all-hazards warning system pilot that warns citizens of imminent threats to life and property from man-made and natural hazardous events such as floods, forest fires, unsafe drinking water or chemical spills. Public safety warnings are broadcast across two cable channels, The Weather Network and its French counterpart, MétéoMédia (Ontario Ministry of Community Safety and Correctional Services, 2006).

Following the 1998 Ice Storm that debilitated Quebec, eastern Ontario, New Brunswick and Nova Scotia for a number of weeks, the province of Quebec took important steps to strengthen emergency preparedness and response capacity; the province is now much better able to cope with future extreme events (Lemmen et al., 2008). For example, during the crisis it purchased 57,000 cots and blankets from the Red Cross; this has provided the province with the ability to open many more emergency shelters if confronted with other large-scale disasters (D. Shropshire, pers. comm., October 15, 2005). The province also created Ouranos, a consortium initiative of Hydro-Quebec, the Quebec Government and other partners, to build an understanding of regional climate change and its environmental, social and economic impacts. The Ouranos Consortium is developing the research tools necessary to provide decision makers with detailed climate change scenarios on a regional scale. In fall 2006, the Consortium adopted a research component on climate change impacts on human health.

Health measures under Quebec's climate change action plan

- Setting up an alert system for intense heat and for monitoring, in real time, related health problems in all regions of Quebec likely to be affected.
- Supporting health services building managers in analysis of the ventilation/air conditioning/dehumidification needs of care institutions, taking into account climate change.
- Improving systems for monitoring infectious diseases to allow for quickly detecting pathogens and diseases whose development is accelerated by climate change.
- Developing training, to be offered to workers in the public health, clinical services and civil protection sectors, on diseases and emerging health problems related to climate change and their treatment.
- Introducing a short- and long-term epidemiological monitoring system for physical and psychological health problems related to extreme climate events.
- Financial support for the creation of cool areas (e.g. tree planting, creation of parks, installation of municipal pools) in urban communities and cooling for strategic infrastructures (e.g. hospitals, homes for the elderly, schools) to mitigate the impact of summer heat waves on the population.

Source: Government of Quebec, 2006.

National Framework for Health Emergency Management

In 2001, the federal, provincial and territorial Ministers of Health acknowledged the need for a comprehensive, integrated and coordinated strategic plan for managing health emergencies in Canada (Health Canada, 2005a). In response, the National Framework for Health Emergency Management was developed to provide a consistent, inter-operational approach to health emergencies at a pan-Canadian level (F/P/T Network for Emergency Preparedness and Response, 2004). This framework aims to enhance the capacity of local, provincial and federal authorities to prepare for and respond to emergencies by fostering operational bridges based on shared principles, guidelines and operating procedures. Key principles of the National Framework include an all-hazards and consequences approach, resiliency and sustainability of programs and planning, and comprehensive management practices that balance mitigation, preparedness, response and recovery. This all-hazards approach examines the full range of threats and their implications for Canadians—in terms of their individual and public health impacts, as well as community and societal effects. Although controlling infectious diseases and other health emergencies continues to be a priority, this new approach begins to bridge the gap between climate change and health emergency management policy and decision making (Health Canada, 2005a).

8.6.2 Adapting to Health Risks from Water-, Food-, Vector- and Rodent-Borne Diseases

To prepare for the expected health impacts of climate change, WHO has advocated for a general strengthening of public health and health care services. In particular, "The maintenance of national public health infrastructure is a crucial element in determining levels of vulnerability and adaptive capacity" (McMichael et al., 2003, p. 14). Public health authorities play a critical role in monitoring and taking action to maintain health and well-being within the whole community. This is accomplished by the following three primary activities (Carty et al., 2004):

- health protection—reducing or preventing risks through a variety of activities (e.g. food and water safety, immunization, handling of toxins);
- health screening and surveillance—the early detection of disease to facilitate treatment; and
- health promotion—education and outreach activities on a variety of issues to reduce or prevent risks (e.g. smoking, injury prevention, nutrition, reproductive health).

Among other activities, local, provincial and federal health departments in Canada maintain registries of health data on certain diseases, infections, hospitalizations and injuries; WHO monitors similar data at a global level. These data, which are collected by recording events as they occur, contribute to passive surveillance and may be enhanced by active surveillance programs that obtain data on particular health problems (e.g. emerging infections) (Pinner et al., 2003). The national *Notifiable Diseases On-Line* and *Canada Communicable Disease Report* allow access to information on case reports and surveillance results of infectious diseases.

The effectiveness of policies and programs for responding to disease outbreaks and emergencies in Canada has recently been examined following outbreaks and other events that have taken place during the past decade. These outbreaks and events have tested the capacity of public health and emergency systems. Several of the key areas for improvement highlighted in these reports are discussed in sections 8.6.2.1 to 8.6.2.5.

8.6.2.1 Institutional coordination and planning

A common gap in dealing with health emergencies and infectious disease outbreaks at a pan-Canadian level was the absence of a common approach to provide consistent and inter-operational procedures. A national legislative and policy framework for a measured, harmonized and unified response to pan-Canadian health emergencies was highlighted as a critical need (Health Canada, 2003b; F/P/T Network for Emergency Preparedness and Response, 2004). More generally, population health strategies that address the health outcomes of the full range of determinants of health—encompassing social, environmental, cultural and economic factors—have been called for (Standing Senate Committee on Social Affairs, Science and Technology, 2003). This includes programs and services that recognize different health care needs of men and women, visible minorities, people with disabilities and new Canadians (Commission on the Future of Health Care in Canada, 2002).

8.6.2.2 Health system and public health resources

Past funding levels for health system and public health functions, including those dedicated to the prevention and control of infectious diseases, have been identified as insufficient to meet existing service needs (Commission on the Future of Health Care in Canada, 2002). Other studies highlighted the need to bolster public health infrastructure (CPHA, 2001a; Health Canada, 2003b) and ensure that emergency departments have the physical facilities and equipment to achieve minimal facility standards for emergency situations. Capacity is needed to ensure that hospitals that serve as regional centres can be equipped with the appropriate infrastructure to allow their participation in surveillance networks—including the receipt of necessary national and international alerts (Health Canada, 2003b). Greater resources are required to support provincial, territorial and regional capacity for infectious disease surveillance, outbreak management and related infection control activities (Health Canada, 2003b).

8.6.2.3 Information sharing and exchange

The ability of Canadian health officials to exchange and share data and information on disease outbreaks and emergencies in a timely and accurate manner across jurisdictions is critical to their ability to respond effectively and adapt to new situations (e.g. inter-provincial surveillance reporting). Several studies have reported a need to improve the ability of officials to share information (CPHA, 2001a, 2001b; Health Canada, 2003b; Standing Senate Committee on Social Affairs, Science and Technology, 2003). A report by Health Canada in 1999 found that some of the information about the health of Canadians is not organized to meet the needs of health professionals and policy makers (Health Canada, 1999). To address these concerns, more timely access to laboratory testing and results, using common technology platforms and typing procedures, has been recommended, as well as the development of management protocols for infectious disease outbreaks (Health Canada, 2003b; Standing Senate Committee on Social Affairs, Science and Technology, 2003).

8.6.2.4 Human resource planning and training

Several studies have recommended that greater attention needs to be paid to human resource planning and training to buttress the ability of communities to respond to infectious disease outbreaks and public health emergencies, particularly at a time when many health service facilities are overtaxed. Health care delivery services in Canada currently experience high demand. Although 87.7% of Canadians had a regular family physician in 2001 (Health Canada, 2002b) and, in 2003, 84.9% of Canadians were satisfied with the health services they received (Health Canada, 2004b), one in 10 Canadians reported unmet needs for health care in 2003 and 32% of those named waiting for care as a barrier (Canadian Institute for Health Information (CIHI), 2006b). As well, in 2004, 48% of Canadians reported waiting more than two hours to be treated in an emergency room (CIHI, 2005).

Improved human resource planning is needed to create a reserve or "surge" capacity to deal with public health emergencies (CPHA, 2001a, 2001b; Commission on the Future of Health Care in Canada, 2002; Health Canada, 2003b; Senate Standing Committee on Social Affairs, Science and Technology, 2003). A recent survey of health practitioners in Ottawa indicated that family physicians in that city perceive their offices as unprepared to address serious health crises (Hogg et al., 2006). Only 18% thought their offices were prepared to respond to a serious respiratory epidemic and 50% believed they were not prepared (Hogg et al., 2006).

Several studies recommended a comprehensive plan be developed for addressing issues related to supply, distribution, education and training, remuneration, skills, and patterns of practice for health professionals in this country (CPHA, 2001a, 2001b; Commission on the Future of Health Care in Canada 2002; Health Canada, 2003b; Standing Senate Committee on Social Affairs, Science and Technology, 2003). Improving surge capacity to protect health in times of emergency is particularly important given that Canadians are at increased risk to the health impacts from more frequent and intense extreme weather events.[16] Improving crisis communication activities has also been identified as a pressing need; further training of health professionals to facilitate the sharing of information with the public during health emergencies is required (Health Canada, 2003b).

8.6.2.5 Recent actions to improve adaptive capacity

In the wake of the SARS outbreak in 2003 and the many calls to bolster the public health system, a new Public Health Agency of Canada (PHAC) and the position of a Chief Public Health Officer for the country were created in 2004. Increased investments in public health functions created and strengthened a variety of programs: the International Centre for Infectious Diseases, which focuses on research, training, commercialization and innovation in addressing the threat and impacts of infectious diseases; a Skills Enhancement for Public Health program; a Pan-Canadian Framework for Public Health Human Resources Planning; and a Public Health Scholarship and Fellowship Grant Program. Increased investments have also targeted the development or application of leading-edge technologies, such as the Public Health Map Generator that PHAC makes available to public health professionals across Canada. This program enables them to quickly and easily visualize their local health data by using web-based map applications (PHAC, 2006). PHAC is also contributing to the building of an International Vaccine Centre at the University of Saskatchewan. This facility will be the first of its kind in the world, unique in its focus on vaccine development for both animal and human pathogens. It will be a level three high-containment testing facility that will develop vaccines to stop the spread of infections such as West Nile virus, Creutzfelt-Jacob disease and SARS (PHAC, 2007a).

16 See Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, for more information.

The capacity of health officials to undertake needed surveillance activities to detect and then effectively manage a host of risks to human health has been enhanced in Canada. Infectious diseases, including those that pose increased risks to Canadians and people worldwide due to climate change, require rapid and early detection. Early detection of outbreaks provides public health officials in Canada, other countries and international bodies, such as WHO, early warnings for preventative and remedial actions. PHAC operates the Global Public Health Intelligence Network, an Internet-based early warning system. The system gathers preliminary reports of public health significance from around the world 24 hours a day, seven days a week, and disseminates relevant information on disease outbreaks and other public health events to users in the public health community within and outside of Canada (PHAC, 2004). This system has been credited with recognizing the outbreak of SARS in China in 2002 and contributing to limiting the spread of the disease (Sommer, 2006). Additionally, the Canadian Integrated Public Health Surveillance program at PHAC provides an integrated suite of computer and database tools to Canadian public health professionals to support needed surveillance activities (PHAC, 2007b).

The contamination of drinking water with *E. coli 0157:H7* and *Campylobacter jejuni* in Walkerton in 2000—the most serious water-borne disease outbreak in Canadian history (seven deaths and 2,300 illnesses)—initiated a review and improvement of water supply regulation in Canada. After this event, many provinces revised their standards to align with the Canadian Drinking Water Quality Guidelines developed by Health Canada. To support provincial and territorial partners in efforts to protect the health of Canadians from health risks associated with contaminated drinking water supplies, Health Canada and PHAC are undertaking a number of actions. These include the development of a web-based system designed to report boil water advisories and notify stakeholders across Canada, the development of the technical document *From Source to Tap: Guidance on the Multi-barrier Approach to Safe Drinking Water,* and facilitating the sharing of information through the Federal/Provincial/Territorial Committee on Drinking Water.

Efforts are also being made under the First Nations Water Management Strategy to ensure that clean and safe drinking water is accessible in First Nations communities in Canada. In May 2003, the federal government announced $600 million in new funding under this strategy to improve the delivery of clean and safe water, as well as wastewater treatment services, to First Nations communities.

New water treatment facility for Walpole Island First Nation

In November 2005, the federal government committed $10 million to replace the current water treatment facility at Walpole Island First Nation. Walpole Island First Nation has an on-reserve population of 2,200 and it is located near Wallaceburg, Ontario. There are approximately 650 homes on-reserve at Walpole Island, most of which are serviced by the community's current water treatment facility. The existing facility, which operates at full capacity, will be replaced by a new water treatment plant in 2008. Through the First Nations Water Management Strategy, a total of $67.2 million has been provided since 2003 for 54 major plant upgrades or replacements. These projects which are currently under design, construction or have been completed, will improve water quality in 45 First Nations communities in Ontario.

Source: Indian and Northern Affairs Canada (INAC), 2007.

8.6.3 Adapting to Health Risks from Air Pollution and Heat Waves

It is widely accepted that current global warming trends will continue and that excess mortality is associated with extreme temperatures and heat waves (IPCC, 2007a).[17] Increasing temperatures can also affect the chemical reactions involved in the creation of air pollution. Concern over the health risks associated with heat waves and increased smog levels has precipitated calls for the development of warning and protection systems in Canada (Cheng et al., 2005).

8.6.3.1 Air quality indices

Timely information about the risks to health from air pollution can play an important role in changing personal behaviours to minimize these risks. Smog advisories are the first line of defence in terms of protecting the health of Canadians from exposure to air pollution. Integral to these advisories is the Air Quality Index that provides information on a daily basis about local air pollution conditions. Currently, there is no standard air quality index used across Canada. All provinces except Saskatchewan (and no territories) and, in some cases, municipalities (e.g. Montreal) have developed their own indexes. They have done so with support from the federal government in the form of scientific, monitoring and technical assistance. There is also a lack of consistency in the way that air quality is calculated and reported, and in the use of health-based messages (Environics Research Group, 2005). As well, a recent survey of physicians in Canada found that almost none of those surveyed provide information to their patients about air quality and health as a regular part of their interactions with patients, although all believe that outdoor air quality has a negative impact on health and many feel the impact is significant. The physicians identified a lack of time, a lack of information and an insufficient understanding of the topic as barriers to addressing the health implications of poor air quality with patients (Environics Research Group, 2006).

Despite the relative success of the air quality indices, various groups have expressed concerns about fundamental flaws in the assumptions used in their calculations. These concerns are largely health-based, reflecting that there are no known thresholds for ozone and fine particulate matter, that the air standards upon which the index is based are outdated, and that the majority of health effects occur outside smog advisory periods (Chiotti, 2006). As well, the current Air Quality Index may be less effective at changing individual behaviour than desired. Individuals tend to disassociate air quality health risks from their own situation, either by underestimating their own exposure or assuming the risks apply primarily to other people they believe are most vulnerable (e.g. seniors). Most Canadians know that air quality indexes or advisories are provided in their area. But this information is having a limited impact in attracting attention and prompting actions to reduce personal exposure, even during poor air quality events (Health Canada, 2005a). Also problematic is that there is no central registry in Canada recording smog advisories on a national basis, although there are websites that provide provincial or regional air quality data in varying degrees of detail (Chiotti, 2006).

8.6.3.2 Smog response plans

Municipal smog response plans generally consist of a communications plan, a communications network and operational actions to reduce emissions of harmful air contaminants. The plans typically involve four central activities (Chiotti, 2006):

- educating the community about the health effects of air pollution;
- documenting, monitoring and reporting on local air quality;
- developing a management strategy to reduce local emissions contributing to air pollution; and
- preparing the community to respond appropriately to smog events.

17 The IPCC stated, "It is more likely than not that anthropogenic forcing through emissions of greenhouse gases has increased the risk of heat waves" (IPCC, 2007b, p.10) and that "it is *very likely* that hot extremes, heat waves and heavy precipitation events will continue to become more frequent." (IPCC, 2007b, p.15).

Many municipalities in south-central Canada have developed long-term clean air plans, and most of them have included a smog response plan component. However, there is a spatial disconnect in smog response plans vis-à-vis regions that use an air quality index, which could emerge as a serious health problem. Few, if any, municipalities outside of south-central Canada have smog response plans in place, although several communities across Canada experience air pollution episodes that pose risks to health. Many of these communities have developed air management strategies and/or are taking actions to reduce GHGs (Chiotti, 2006). While the current number and distribution of smog advisories suggests that this is not yet a serious problem, smog conditions could change significantly under climate change (Chiotti, 2006).[18]

8.6.3.3 Other actions

Although adaptive actions are important for reducing an individual's exposure to both air pollution and extreme temperatures, mitigation actions to reduce emissions of air pollutants are required to further lessen the health risks associated with such atmospheric conditions (Health Canada, 2005b). Measures to reduce the emissions of GHGs can have immediate health benefits by directly reducing the emission of chemical airborne pollutants. Mitigation actions to reduce both air pollutants and GHGs are in line with the preventative approach to climate change advocated by the public health community (CPHA, 2001c). The capacity of individuals, communities and governments to reduce air pollutants and GHG emissions is an important complement to adaptive actions, but is not investigated in this chapter.

8.6.3.4 Heat alert systems

Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, demonstrates that robust emergency management policies and programs, including early warning systems and emergency response plans, constitute key adaptation measures for lowering the risks to human health from extreme weather events and other natural disasters. Analysis of the health impacts of the 2003 heat wave in Europe underscores the importance of these, and other, risk management policies and the high costs of not being prepared (WHO, 2005).

Heat alert systems can be effective in reducing heat-related illnesses and deaths (Smoyer-Tomic and Rainham, 2001; Kovats and Jendritzky, 2006; United States Environmental Protection Agency (U.S. EPA) et al., 2006). There are several known approaches to determining the threshold for triggering an alert. To be effective, accurate predictive capabilities must inform adequate communication and warning strategies and timely response measures (Ebi, 2005). The widespread introduction of air conditioning, improved emergency and health care services, improved weather forecasting, and the introduction of heat alert and response systems in large cities such as Toronto have helped to keep the number of heat wave-related deaths and illnesses in Canada low (Clean Air Partnership (CAP), 2004; Dolney and Sheridan, 2005). In the eastern U.S., especially in its southern areas, excess deaths from high summer temperatures have declined significantly from the 1960s to the 1990s, apparently for reasons similar to those in Canada (Davis et al., 2002).

Heat alert systems rely upon communication activities and networks as important components of a response plan. Municipal actions are largely undertaken by community-based partners, in terms of outreach to vulnerable groups. Few communities in Canada have developed full heat alert and response plans. Given the relationship between extreme heat and mortality (McGeehin and Mirabelli, 2001; Basu and Samet, 2002; Kovats and Ebi, 2006; Ebi, 2007), this may constitute a public health concern. The distribution of heat alert systems

18 See Chapter 4, Air Quality, Climate Change and Health, for more information.

in Canada is largely limited to Ontario and Quebec. A small number of communities in other regions engage in some sort of awareness-raising, such as the posting of heat-health information on community websites (Paszkowski, 2007).[19] Heat alert systems follow a similar protocol that has been developed for smog response plans. Advice is generally directed at individuals to help them reduce their exposure to heat stress. The following are the components of most systems currently in place in south-central Canada (Chiotti, 2006):

- *Monitoring*—Health department staff monitor the weather information posted by Environment Canada, usually from May 15 to September 30 each year.
- *Notification*—Health department staff are provided an advance five-day weather forecast from Environment Canada, or information regarding humidex advisories.
- *Consultation*—When necessary, Health department staff consult with the local weather office to discuss region-specific forecasts with a trained meteorologist.
- *Decision*—Based on the weather sources and conditions, the month, the heat pattern at the particular time of the season, health surveillance information and an assessment of the capacity of the system to react, the Medical Officer of Health will determine if the Region will issue a heat alert to the community (T. Kosatsky, pers. comm., November 26, 2005).
- *Activation*—If a heat alert is declared, Health Department staff will send notification to the media and community stakeholders that may be affected by extreme temperatures. Identified stakeholders, including long-term care facilities and hospitals, local shelters, municipal employees and child care centres, receive the heat alert notice. Each agency is then responsible for internal notification of its staff. Heat alert information is sent to the internal communications website contacts for posting on municipality websites. Other measures include:
  - bottled water is distributed to vulnerable people at places where they are likely to gather;
  - shelters are asked to ease their curfew rules;
  - cooling centres are opened in central locations;
  - transit tickets are issued to the homeless so they can reach cooling centres; and
  - a 12-hour heat information line is activated to answer heat-related questions.
- *Public education*—Messages to the general public reinforce individual responsibility as well as educate people. The public is encouraged to look in on vulnerable neighbours (e.g. seniors living alone) and are given information about how to provide support for hot weather illness. People without shelter and those without air conditioning are encouraged to go to air-conditioned public facilities, such as malls and libraries. Public education occurs in a variety of ways:

  - information is obtained by calling the municipality or visiting the website;
  - agencies post information on bulletin boards and are prepared to answer questions; and
  - information is provided through the media.
- *Termination*—When hot weather is no longer a health threat, the Medical Officer of Health ends the heat alert by notifying the media and participating agencies.

19 See Annex 2 for examples of municipalities and industries with heat alert systems.

- *Evaluation*—An evaluation component to the heat alert system is necessary to determine changes or additions to the plan for subsequent years.

There are different approaches worldwide and within Canada to setting thresholds for taking action on heat. For example, Toronto uses a synoptic air masses approach. This approach considers the health risks posed by a combination of several weather variables, including air temperature, dew point temperature, visibility, total cloud cover, sea level air pressure, wind speed and wind direction, in determining when to issue alerts (Angus, 2006).

Table 8.1 Number of alerts issued by Toronto Public Health, 2001–05

Year	Alerts Issued by Toronto Public Health
2001	9
2002	16
2003	6
2004	2
2005	26

Source: Angus, 2006.

In contrast, Montreal's Heat Watch Warning System is based on minimum and maximum temperature thresholds defined on the basis of temperature-related mortality for the region. Alerts are issued when both maximum temperatures are greater than 33°C and minimum temperatures are greater than 20°C, for three consecutive days (Angus, 2006). Smaller municipalities tend to rely on temperature thresholds set for larger centres or rely on Environment Canada's humidex advisories to provide additional advice to the population or trigger their respective response plan.[20]

In part, the implementation of response systems in Canada has been influenced by heat-related deaths caused by well-publicized heat waves in the U.S. (e.g. Chicago in 1995) and Western Europe (e.g. France, Italy, Germany and England in 2003). However, public health officials in some Canadian cities have examined temperature-related mortality in their own jurisdiction and identified vulnerable populations in light of future climate projections. Their concerns are also supported by a number of statistical studies demonstrating that vulnerable populations are sensitive to different temperatures and associated weather conditions (Smoyer et al., 1999, 2000). Greater understanding of temperature and health thresholds is required to inform the development of future heat alert systems to meet the needs of communities of different sizes and locations, and characterized by different vulnerable populations. The effectiveness of current heat alert systems needs to be evaluated to ensure maximum protection of populations and guide the decisions of communities in setting up appropriate systems (Angus, 2006). Key knowledge gaps exist about optimal public health interventions for reducing deaths and illnesses associated with extreme heat events (Ebi, 2005).

Current responses to increased health risks from extreme heat events have placed emphasis on adaptation measures that reduce the exposure of vulnerable populations to heat. As an adaptation option, relying exclusively on air conditioning to cope with heat waves could be risky. Any large-scale power failure, such as that of August 2003 that hit several U.S. states and much of Ontario, could leave many people physically unable to cope with unmitigated heat stress. Furthermore, the "reliance on energy-intensive technologies such as air conditioning is unsustainable and can be considered a maladaptation" (WHO, 2005).

20 A humidex advisory is issued when temperatures are expected to reach or exceed 30°C and the humidex values are expected to reach or exceed 40°C. Humidex values are intended to represent the effect that high humidity and high temperatures have on the human body. Comfort levels for humidex readings are: 20–29 (comfortable), 30–39 (varying degrees of discomfort), 40–45 (almost everyone is uncomfortable), and +45 (many types of work and exercise should be restricted) (Environment Canada, 2006). Although there is no formal definition of a heat wave, Environment Canada considers one to occur when there are three consecutive days when the maximum temperature is 32°C or higher.

Photo Credits: City of Toronto

Example of a sign indicating that a cooling shelter has been opened during an extreme heat event.

Less common in Canada are actions explicitly aimed at reducing the heat island effect (Chiotti, 2006; Paszkowski, 2007). This effect is caused by large surface areas of materials that absorb heat from the sun, such as asphalt, in combination with little vegetation to provide shade and cool the air. The urban heat island effect is responsible for making the temperature in cities 4 to 7°C higher than surrounding areas (City of Hamilton, 2006). Many measures that have been introduced to reduce the heat island effect have been driven by the need to reduce energy use in large urban centres. More recently, it is understood that these measures can offer important health benefits by reducing thermal radiation and ambient temperature in the city and offering cool shelters during extreme heat events. Such actions include planting shade trees, installing reflective roofs, optimum planning of roadways and buildings, and urban reforestation (City of Hamilton, 2006). The Green Roofs and Evergreen projects in Canada and the Cool Cities program in the U.S. indicate that the application of these measures is beginning to take place (City of Toronto, 2007; Evergreen Canada, 2007).

Case study: Heat wave simulation in Montreal

A heat wave simulation in Montreal was conducted in 2005 to test a new emergency preparedness plan. It also gauged the usefulness of such exercises in identifying gaps in preparedness and response activities related to extreme heat events. The city demonstrated an advanced level of preparedness to manage the health impacts of heat waves, and the simulation confirmed that major strides have been made in recent years in emergency planning for such events. The introduction of other events that would simulate the occurrence of cumulative impacts on the systems under evaluation was critical to this exercise. Several aspects of adaptive capacity were reviewed as part of the simulation and recommendations for improvement of current systems were made in order to further enhance the effectiveness of the plan (Rousseau, 2005).

Based upon this and other studies, actions required to ensure that plans are effective are highlighted below:

Institutions

- Heat wave emergency response plans should be well integrated with the emergency plans of the city's emergency preparedness centre and the provincial health agency.
- Community and volunteer organizations' roles should be well articulated in emergency response plans.
- A procedure to limit access to drinking water from the aqueduct in the event of water contamination (e.g. public drinking fountains) and to supply residents with drinking water should be in place.

Information sharing and skills

- It is important that the roles and responsibilities of communications officials within the city and relevant agencies are clearly articulated and that mechanisms are in place to ensure open communication between organizations at all levels (e.g. emergency preparedness centre, department of public health, provincial health agency, community organizations, Meteorological Service of Canada).

Infrastructure

- Lists of emergency shelters must be adapted to extended heat wave events and up-to-date.
- Vulnerability of the city's infrastructure critical to public health during an extended heat wave must be understood and potential failures addressed ahead of time.

8.6.3.5 Recent actions to improve adaptive capacity

To enhance our ability to reduce the health risks from air pollution, Health Canada, Environment Canada and a variety of stakeholders have been engaged in a process since 2001 to improve the Air Quality Index. A new health risk-based Air Quality Health Index has been developed. It is designed to make use of a formula that represents the combined effects of the air pollution mixture rather than using the concentration of a single pollutant as an indicator of air quality. It therefore better reflects the overall cumulative health risks associated with a more comprehensive range of air pollutants. The new index also provides explicit health messages tailored for the general population and populations at higher risk (people with pre-existing cardiovascular and respiratory disease, children, seniors). Individuals can use these messages to decide how to adapt their activities to reduce their exposure to harmful air pollution levels. Messages also include actions to reduce air pollution on both an individual and society-wide basis (Health Canada, 2006a).

Ontario recently passed legislation on a new Clean Air Plan, which establishes new targets for sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from most industrial sectors by 2015, the introduction of 40 new air standards, and the implementation of a risk assessment approach to setting standards. Ontario has also made a commitment to close its coal-fired electricity generation plants; Lakeview, located just west of Toronto, was recently closed. These initiatives to reduce levels of air pollution are complemented by other actions being implemented at the regional and municipal levels, most notably the Greater Toronto Area (Canzi, 2007) and the Greater Vancouver Area (The Sustainable Region Initiative, 2005).

The Green Municipal Funds, which are managed by the Federation of Canadian Municipalities (FCM), have stimulated municipal investments in innovative environmental infrastructure projects and practices to promote cleaner air and protect the global climate. Also, 151 Canadian communities participate in the Partners for Climate Protection Program (FCM, 2007). Participants include all major urban centres across Canada that have committed to reducing GHGs and acting on climate change.

Health Canada's 'Building Heat Resilient Individuals and Communities in Canada' Initiative

In 2007 Health Canada initiated a multi-year project to reduce risks to the health of Canadians from extreme heat events. In collaboration with provincial and municipal partners, best practice guidelines for heat and response systems are being developed along with clinical guidelines for managing heat-related illnesses. Activities will be targeted at ensuring that populations most vulnerable to extreme heat events such as seniors, children, those with pre-existing diseases and the socially disadvantaged are protected.

Most major cities across Canada have developed or are developing their own climate change plans. These plans usually contain objectives and targets for GHG emission reductions for municipal corporations and the community as a whole (typically a 20 and 6% reduction, respectively, below 1990 levels by 2010). Actions are primarily transportation oriented (e.g. alternative fuels, more efficient driving practices), but also involve community plans (e.g. increased funding for cycling and pedestrian infrastructure), waste management plans (e.g. landfill recovery and cogeneration) and energy plans (e.g. greater use of renewables and improved energy efficiency). To the extent that these initiatives reduce air pollution in the affected communities and regions, they could act to offset projected future deterioration in air quality due to rising temperatures associated with climate change.[21]

21 See Chapter 4, Air Quality, Climate Change and Health, for more information, and Annex 3 for a list of Canadian municipalities with climate change programs.

In addition, in response to new research showing that vulnerable populations are sensitive to different temperatures and associated weather systems, some municipalities in central Canada (Kingston, Toronto, Region of Peel, Hamilton, Montreal, Ottawa, Region of Waterloo, Regional Municipality of Halton) have established or are considering their own heat alert systems (Chiotti, 2006).

8.6.4 Cross-Cutting Capacity to Adapt to Climate Change Health Risks

In 2005, a federal/provincial/territorial adaptation working group agreed on a National Climate Change Adaptation Framework. The Framework presents areas of potential collaboration among jurisdictions to increase Canada's capacity to adapt to climate change impacts, to recognize and reduce risks, and to identify and pursue opportunities (Natural Resources Canada (NRCan), 2005). As well, several provinces and territories have made commitments to address climate change impacts by developing climate change action plans. A number of these, including Quebec, Yukon, Ontario, Newfoundland and Labrador, and British Columbia, highlight potential health risks associated with climate change. Those developed by Quebec, Newfoundland and Labrador, and British Columbia set out specific actions to prepare for actual or expected health risks through adaptation (Government of British Columbia, 2004; Government of Newfoundland and Labrador, 2005; Government of Quebec, 2006) At the time of writing, Nunavut and Saskatchewan were developing their respective plans, both of which are expected to include a human health component. Such plans are necessary for providing the institutional foundation and policy focus, along with access to funding and partnership development, to facilitate efforts to address climate change and health risks.

The Canadian Climate Impacts and Adaptation Program, sponsored by the Government of Canada, has funded climate change adaptation research in public and private sectors and provided information to individuals, businesses and communities to assist them in making appropriate decisions about climate change adaptation (Lemmen and Warren, 2004). Several federal departments have supported research on adaptation and have participated in national impacts and adaptation assessments. Results from health research have been used to inform adaptation initiatives; for example, in the development of the health component of the Quebec climate change action plan (Government of Quebec, 2006). The health care sector is well organized with respect to the sharing of climate change adaptation information (e.g. Canadian Climate Impacts and Adaptation Research Network (C-CIARN) Health Sector) as well as internationally (collaboration of Le Centre Hospitalier universitaire de Québec with WHO) (Gosselin, 2004), in part, due to these investments.

Over the past several years, the Government of Canada has worked to enhance partnerships with national voluntary organizations through increased outreach, engagement, collaboration and capacity building. The voluntary sector is a key partner in strengthening the health of Canadians and their communities (Health Canada, 2005a). Voluntary organizations play an important role through health promotion, the development of social capital by empowering people and communities to take action, and through the provision of extensive networks of service at the community level. Organizations such as the Canadian Red Cross and the Salvation Army provide a wide range of social services to Canadians. These services are a vital component of adaptive capacity in this country. In 2003, approximately 161,000 non-profit and voluntary organizations were operating across the country. Approximately 17% of voluntary organizations were in the health and social services sectors (Statistics Canada, 2003b). In the event of a disaster, relief organizations provide emergency social services such as clothing, shelter, tracing and reunification services, and emotional support for affected individuals and communities. During heat alerts, public health officials can work with many different community-based groups (e.g. Red Cross, Salvation Army) that reach out to vulnerable populations. In Toronto, for example, more than 1,100 community agencies working with vulnerable populations are advised during a heat alert (Chiotti, 2006).

In 2005, a national collaboration among the Canadian Red Cross, the Salvation Army, St. John Ambulance and other key organizations developed a voluntary sector framework for health emergencies and a model for developing and sustaining episodic volunteers. This collaboration of key partners in the voluntary and non-governmental sectors provides opportunities for voluntary organizations to engage effectively with all levels of government on matters related to climate change and the needs of communities and vulnerable populations. This successful model is now being used to increase broader voluntary sector involvement in health emergencies related to climate change (Canadian Red Cross et al., n.d.(a), n.d.(b)).

Despite efforts in many areas to improve adaptive capacity, the 2006 report of the Commissioner of the Environment and Sustainable Development noted the absence of overall strategies and plans in federal departments to guide their work on adaptation to the effects of climate change (OAG, 2006). It found that the federal government has made limited progress in organizing its activities to obtain the information needed to identify potential impacts and address vulnerabilities. A report by The Conference Board of Canada (2007) called for a greater federal role in adaptation by:

- funding direct physical and economic research on adaptation measures;
- facilitating partnerships with other governments;
- improving data collection about the state of natural capital (e.g. forest cover, water resources) to determine the magnitude and extent of local impacts; and
- collaborating with provincial governments to review regulatory structures and to ensure that regulators pay attention to adaptation considerations.

8.6.5 Key Findings

Governments and communities in Canada have taken many actions to adapt to health risks associated with extreme weather and climate variability.

Analysis in this section demonstrates that many actions have been taken in the past to protect Canadians from health risks associated with extreme weather and climate variability, water- and food-borne contamination, air pollution and heat waves. Such actions have contributed to limiting the number of deaths from weather extremes and other health emergencies in Canada. However, the economic costs of extreme events in this country are increasing rapidly (Etkin et al., 2004), and such events continue to pose significant risks to the health and well-being of Canadians and their communities. Climate change knowledge needs to be integrated into current planning activities to adapt our current systems to the changes ahead.

Concerns exist about the effectiveness of current adaptations to health risks from current climate variability.

Gaps have been reported in measures and systems in Canada that can reduce climate-related health risks. Parliamentary reviews and other reports have raised concerns about emergency management systems which relate to government leadership, funding arrangements, communications and coordination, and information-sharing initiatives. The age of infrastructure integral to the protection of human health—such as roads, sewage treatment, storm sewers, and water distribution networks—also contributes to the vulnerability of Canadians to a range of climate-related hazards but its renewal presents opportunities to effectively reduce future risks. The ability to respond to disease outbreaks and public health emergencies in Canada is highly influenced by funding for a number of public health functions, the ability to exchange and share surveillance and monitoring data, and the state of human resource planning and training. Current efforts to protect Canadians from health risks associated with extreme heat events are hampered by limited knowledge of effective heat alert and response systems for the different types of communities in Canada. In addition, measures to mitigate the urban heat island effect are limited in Canadian communities.

This analysis also found that capacity is not evenly distributed among communities in Canada. Disparities exist in the ability to plan and prepare for emergencies among cities and smaller communities and rural areas. Smaller communities and rural areas are generally engaged in fewer activities and have less capacity to adopt needed measures. This may translate into significantly less protection from disasters and public health emergencies for people living in these communities.

Recent initiatives and activities have improved the ability of governments and communities to reduce risks to health from current climate variability.
The ability of governments and communities to mitigate, prepare for and respond to a number of public health emergencies and other risks to health (e.g. smog episodes) has been improved. This improvement has taken place in response to calls to strengthen the capacity to address risks to health from environmental threats. Investments have been made from national to local levels in a range of public health activities, and government and non-governmental partners are working to improve coordination, collaboration and information sharing to provide more effective management of a variety of risks to health.

The creation of PHAC and related investments in several public health functions and services in Canada has begun to address a number of the identified concerns regarding existing capacity for addressing public health emergencies. In addition, the new National Framework for Health Emergency Management and the Voluntary Sector Framework for Health Emergencies have enhanced adaptive capacity by providing needed coordinating structures to facilitate emergency planning and response activities within and outside of government.

Although knowledge gaps about risks and vulnerabilities remain, investment in impacts and adaptation research by all levels of government and partners has built a foundation of knowledge that is now available to public health decision makers for the development of adaptation strategies. The health care sector is well organized with respect to the sharing of climate change adaptation information, but research funding and researchers dedicated to this issue are limited.

Most provinces and territories have either developed a climate change action plan that includes adaptation, or are in the process of doing so. Quebec is particularly well advanced, and has developed a slate of activities to address the health risks associated with climate change. Many provinces and territories have taken important actions to enhance emergency preparedness in communities, and have strengthened regulations governing drinking water quality. At the community level, many local authorities have developed climate change or clean air plans that support and direct programs for reducing air pollution and associated risks to health.

Presently, it is not possible to estimate the extent to which recent improvements in public health and emergency management services have protected the health of Canadians from climate-related impacts. Many of the initiatives have only recently been launched, and the very broad scope of activities makes such analysis prohibitive.

Existing gaps in public health and emergency management activities that are not addressed in the future have the potential to significantly affect the ability of Canadians to plan for and respond to climate change impacts in Canada.
Gaps in current adaptations and existing capacity to protect people from the health risks related to climate change in Canada are of particular concern if there is wide exposure to such risks or if exposure increases significantly. High exposure in this context suggests greater vulnerability of individuals and communities and requires increased adaptive efforts to reduce the health risks related to climate change. Street et al. (2005, p. 173) suggested that "the fact that most public health systems are currently taxed to their maximum and struggling to deal with emerging health problems limits their capacity to deal with the added health impacts of extreme weather and climate events." The more complex cumulative and long-term effects need to be considered as well. There is a pressing need for research related to these types of health effects, because many are indirectly induced or triggered by a number of climatic factors.

8.7 EXPOSURE TO CLIMATE-RELATED HEALTH RISKS

The following sections summarize information from previous chapters of this Assessment and other sources to document the potential direct and indirect exposure of Canadians to a range of climate-related risks. Information is also provided on how exposure might increase with climate change, where data permit. A wide range of environmental and social factors may influence human exposures and sensitivities to climate change health risks (Smit and Wandel, 2006). Many of these factors differ from region to region and even community to community. Therefore, vulnerability assessments at these levels will be required to obtain information needed to more accurately identify priority health risks and effective adaptations.

People are exposed to a range of climate-related risks

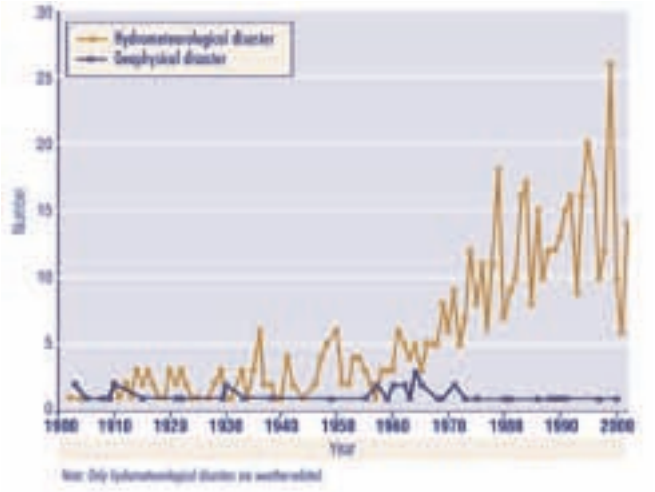
"Climate change currently contributes to the global burden of disease and premature deaths (very high confidence). Human beings are exposed to climate change through changing weather patterns (for example, more intense and frequent extreme events) and indirectly through changes in water, air, food quality and quantity, ecosystems, agriculture and economy. At this early stage the effects are small, but are projected to progressively increase in all countries and regions."

(IPCC, 2007a, p. 43).

8.7.1 Natural Hazards

Many Canadians have been exposed to natural hazards and have suffered effects on their health (e.g. dislocation). The total number of Canadians affected by natural disasters increased from 79,066 between 1984 and 1993, to 578,238 between 1994 and 2003. Single events can expose very large numbers of people to hazards. For example, the 1998 Ice Storm resulted in 4,826,586 people, or 66.9% of the general population of Quebec, being impacted by the storm (Gutman, 2007). The total number of people affected was 1,243,335 in the Montérégie region alone, the area most severely affected, and of these, 128,960 or 10.3% were people over 65 years of age (Gutman, 2007). Figure 8.1 shows the rise in the number of natural disasters in Canada over the last century.

Figure 8.1 Frequency of Natural Disasters in Canada, 1900–2002



Source: Etkin et al., 2004.

Certain areas of Canada experience specific weather events and hazards much more frequently than others. Potential exposure to individual hazards therefore varies significantly across Canada, as one would expect given the size of the country and associated variations in weather patterns, ecosystem characteristics and physical features. Table 8.2 identifies the regions in Canada most affected by specific natural hazards and weather-related extreme events.

Table 8.2 Regions in Canada affected by natural hazards

Hazard	Most Affected Areas
Avalanches, Rock- Mud- and Landslides, Debris Flows	All regions of Canada—particularly Rocky Mountains in Alberta, British Columbia, Yukon, southern and northeastern Quebec and Labrador, Atlantic coastline, Great Lakes, St. Lawrence shorelines
Heat Waves	All regions of Canada—particularly Windsor to Quebec corridor, along Lake Erie, Lake Ontario and St. Lawrence River, Prairies, Atlantic Canada, British Columbia
Cold Snaps	All regions of Canada
Drought	Prairie provinces most affected Other areas of southern Canada can be at risk
Wildfires and Forest Fires	Most provinces and territories of Canada-particularly Ontario, Quebec, Manitoba, Saskatchewan, British Columbia, Northwest Territories, Yukon
Thunderstorms, Lightning, Hail, Tornadoes, Hurricanes	Thunderstorms: Many regions of Canada Lightning: Low-lying areas in southern Canada Tornadoes: Nova Scotia, Ontario, Quebec, Alberta, Saskatchewan, Manitoba Hurricanes: Eastern Canada-particularly Atlantic Canada Hailstorms: Southern Saskatchewan, southern and northwestern Alberta, southwestern interior British Columbia, less frequently in Ontario and Quebec
Floods	Large parts of Canada's inhabited areas-particularly New Brunswick, southern Ontario, southern Quebec, Manitoba

Note: Information for this table is drawn from Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, which analyzed information from the Canadian Disaster Database. The table includes information from the database to highlight where most of these events have occurred in the past. Risks to health from natural hazards may exist in regions where "disasters" have not occurred, so this table likely underestimates current exposure by Canadians across the country to these types of events.

This table illustrates that all provinces and territories in Canada have been affected by hazards in the past. Some hazards, such as flooding or cold waves, have affected people in communities across Canada whereas others, such as hurricanes, are a threat in only a few regions. Some hazards, such as heat waves, have been identified as particular threats for highly populated urban centres (e.g. Toronto, Montreal) whereas others, such as forest fires and avalanches, tend to affect communities that are more remote and less densely populated—although the impact of forest fires on air quality is known to be far reaching. It is also important to note that some regions and communities can be threatened by more than one hazard. Individuals living in Prairie communities are potentially exposed to heat waves, cold waves, flooding, drought, thunderstorms, hailstorms and tornadoes. This is important from a public health perspective, given the possibility of cumulative risks to health from extreme weather events that can occur in quick succession. The exposure of Canadians to climate-related hazards from a regional and population basis is currently high.

Intense rainstorms in British Columbia

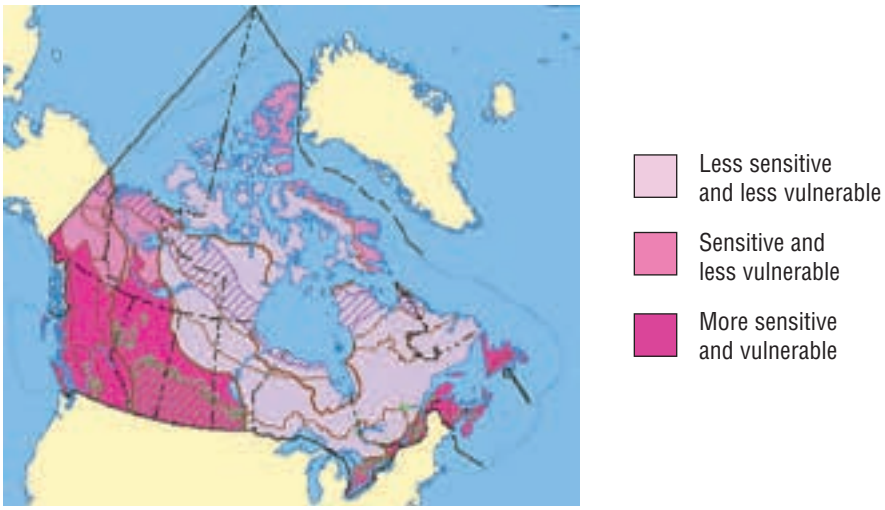
In November 2006, British Columbia experienced a number of intense rainstorms. So much rain fell that rivers in the Lower Mainland, the south coast and the southern half of Vancouver Island rose close to flood levels. Intense rains triggered mudslides, washouts and flooding. Eight communities and 200,000 people were left without power when transmission lines were damaged by a storm. The mudslides triggered by the intense rainfall contaminated drinking water sources forcing two million residents to boil their water—the widest warning in Canadian history. The warning remained in effect for 10 days for nearly one million people (Environment Canada, 2007a).

Climate change is projected to increase the frequency and intensity of specific natural hazards in Canada. More frequent extreme weather events that threaten communities with limited experience with such events in the past (e.g. greater number of heat waves) will mean increased exposure to potential health risks in the absence of effective adaptations (e.g. flood mitigation measures, urban heat island mitigation measures, further reductions in the release of air pollutants). To illustrate how the exposure of Canadians might change in the future, projections of increased flooding and forest fires under climate change conditions are described in sections 8.7.1.1 and 8.7.1.2, respectively.

8.7.1.1 Flooding

Floods have been the most commonly reported disasters in Canada (Tudor, 1997). With climate change, it is very likely that heavy participation events will become more frequent. It is also likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and greater amounts of precipitation (IPCC, 2007b). Increased frequency and magnitude of flood flows will increase the hazard to structures, buildings and humans (NRCan, 2000). Figure 8.2 highlights the regional sensitivity of rivers to predicted climate change in Canada. The most sensitive regions include the Atlantic coast and the Great Lakes and St. Lawrence Valley regions. This is a result of the shift from snowmelt to more intense rainstorms as the main source of flooding. Small streams in urban areas may pose particular hazards for people and their communities. Flows are also likely to increase in the southern Cordillera and eastern slopes of the Rocky Mountains. This will affect large Prairie streams, whereas smaller Prairie streams risk flooding from increases in thunderstorm activity (Atlas of Canada, 2007b).

Figure 8.2 Sensitivity of river regions to climate change

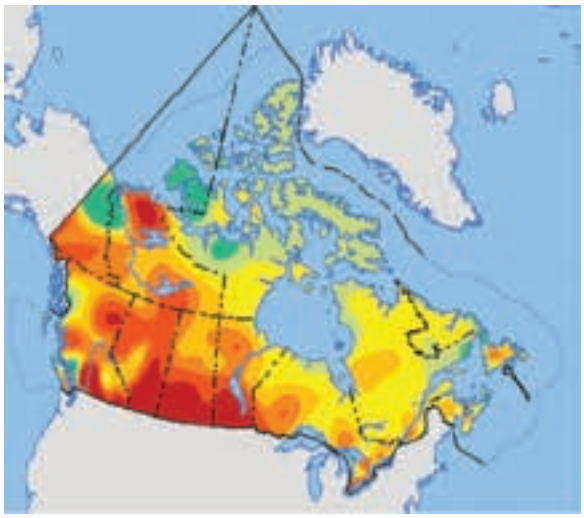


Source: Atlas of Canada, 2007b.

8.7.1.2 Forest fires

There are about 9,000 forest fires recorded annually in Canada. An average of 2.1 million hectares are burned every year, the majority being boreal forests (Nugent, 2002). Using four General Circulation Models (GCMs) to project forest fire danger levels in Canada under a warming climate, large increases in the extent of extreme fire danger and a lengthening of the fire season were found (NRCan, 2000). Figure 8.3 shows projected seasonal severity ratings across Canada in the period 2050 to 2059, based on a climate with doubled carbon dioxide (CO_2) concentrations (based on the Canadian GCM). Areas with high severity ratings are projected to expand into the central and northern parts of the Prairies, north-eastern British Columbia and south-central Yukon (Atlas of Canada, 2007a).

Figure 8.3 Projected forest fire severity level, 2050 to 2059



Note: the Seasonal Severity Rating, which is a measure of fire danger conditions over a complete fire season, has a relative scale with values above 6 being extreme.

Source: Atlas of Canada, 2007a.

8.7.2 Water-, Food-, Vector- and Rodent-Borne Diseases

Canadians are currently exposed to a range of climate-sensitive infectious diseases. For example, Chapter 5, Impacts of Climate Change on Water-, Food-, Vector- and Rodent-Borne Diseases, revealed that many Canadians, particularly the young and seniors, are affected by gastrointestinal disease each year in Canada. This burden of disease is partly attributable to water sources, but it is not yet possible to determine to what extent (Charron et al., 2005). Water-borne disease outbreaks have been associated with *E. coli* O157: H7, *Campylobacter,* occasionally *Shigella* and other pathogens (Levy et al., 1998; Lee et al., 2002; Oliver et al., 2003; Charron et al., 2004; Schuster et al., 2005). *E. coli, Campylobacter* and *Salmonella* constitute the most common food-borne pathogens in Canada (PHAC, 2003).

West Nile virus, a mosquito-borne illness, was first documented in Canadian birds in 2001 (Pepperell et al., 2003). Since then, it has spread rapidly, and has been documented in all Canadian provinces and territories, except for British Columbia, Newfoundland and Labrador, Yukon, Nunavut and the Northwest Territories. Over 1,800 human cases were reported in Canada from 2002 to 2005; 46 were fatal. Cases have been concentrated in a number of urban and semi-urban areas of southern Quebec, southern Ontario and in rural populations in the Prairies (Pepperell et al., 2003; Gaulin et al., 2004).

Lyme disease currently does not affect many Canadians, although the vector *Ixodes pacificus* is widespread in British Columbia. As well, populations of *I. scapularis* can be found in southeastern Nova Scotia, southern Ontario and southeastern Manitoba (Barker and Lindsay, 2000; Ogden et al., 2005).

Hantavirus pulmonary syndrome is a rare disease in Canada, with only 36 cases being reported between 1989 and 2001 (Drebot et al., 2000). Cases have been confined to the western Canadian provinces—British Columbia, Alberta, Saskatchewan and Manitoba, with only one case being reported in Quebec (Weir, 2005). However, the presence of infected mice throughout Canada suggests that the potential for exposure to this disease exists across the country (Drebot et al., 2000).

Climate change is expected to increase the exposure of Canadians to a number of climate-sensitive water-, food-, vector- and rodent-borne diseases. Weather has been linked to a number of reported water-borne disease outbreaks in Canada.[22] Climate change may also heighten vector-borne disease risks through a variety of mechanisms, such as the development of new habitats that can support the establishment of vectors where they could not survive before, and changes in lifestyles and activities of Canadians altering their exposure to vectors (e.g. camping more often). For example, climate change may bring about higher ambient temperatures that will shorten tick life cycles, create more favourable conditions for host-seeking activity and increase tick survival (Ogden et al., 2004, 2005); this in turn would increase the risk of Lyme disease in Canada.

Climate change-related alterations in the worldwide distribution and intensity of various diseases could increase the exposure of Canadian travellers to these diseases. Global increases in endemic malaria, increased resistance to anti-malarial drug therapy, and a significant increase in global travel have resulted in thousands of cases of malaria transported into Europe and North America annually, with a few giving rise to transmission by indigenous mosquitos (Fayer, 2000). Several hundred cases of malaria are imported into Canada each year (MacLean et al., 2004).

8.7.3 Air Pollution and Extreme Heat Events

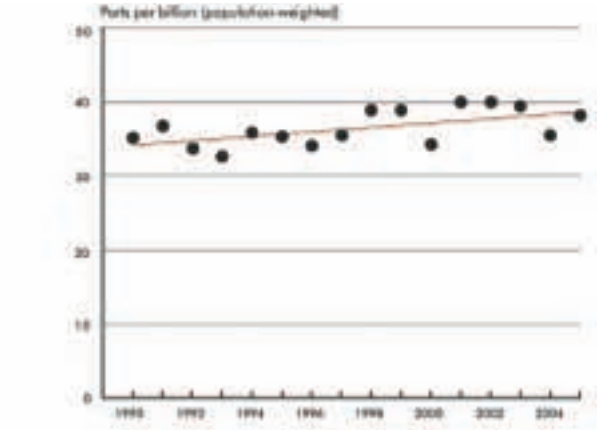
8.7.3.1 Air pollution

Many Canadians are exposed to air pollution, particularly smog. The Government of Canada estimated in 2005 that air pollution causes 5,900 premature deaths in eight Canadian cities each year (Health Canada, 2005b). The Ontario Medical Association provided similar mortality estimates, but additionally estimated that air pollution is associated with approximately 17,000 hospital admissions and 60,000 emergency room visits in Ontario every year (Ontario Medical Association, 2005). Illnesses caused or exacerbated by air pollution, such as respiratory and cardiovascular disease, will increase in prevalence as the Canadian population ages (Health Canada, 2005b). Individuals with diabetes, asthma, emphysema, heart disease and circulatory disease are at greater risk on days when air pollution is high (Health Canada, 2005b). Therefore, as the number of Canadians with pre-existing conditions increases, it can be expected that more air pollution-related deaths, hospitalizations and emergency room visits will occur. Three regions in Canada experience more episodes of elevated levels of smog than others: the southern Atlantic region, the Windsor to Quebec corridor and the Lower Fraser Valley in British Columbia (Nugent, 2002). Current exposure to smog is significant; these are highly populated regions and make up a substantial portion of Canada's total population.

Figure 8.4 shows the increase in the national seasonal average of ground-level ozone between 1990 and 2005. There is regional variation; the highest levels and most consistent increases have occurred in southern Ontario. This region, which is home to 30% of Canadians, had an increase in ozone concentrations of 17% from 1990 to 2005. Southern Quebec and Alberta also had higher ozone concentrations. Concentrations in southern Quebec increased by 15% over this time period (Government of Canada, 2007). Between 1990 and 2004, NOx and volatile organic compound (VOC) levels in urban areas decreased, likely because of improvements in fuel quality and emission control technologies for on-road vehicles (Government of Canada, 2006).

22 See Chapter 5, Impacts of Climate Change on Water-, Food-, Vector- and Rodent-Borne Diseases, for more information.

Figure 8.4 Ground-level ozone exposure indicator, Canada, 1990–2005

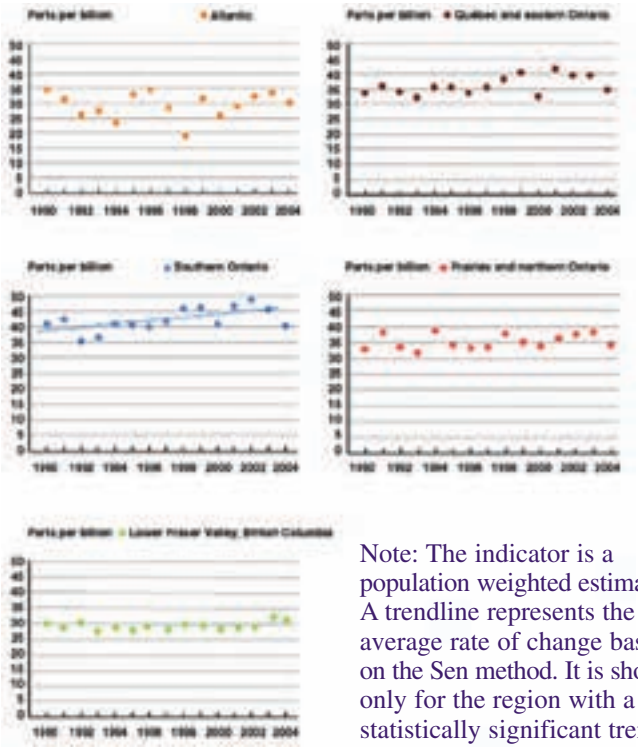


Note: The trend line represents an average rate of change of 0.8% per year. From 1990 to 2005, the indicator shows a statistically significant increase of 12% (plus or minus 10 percentage points, resulting in a possible increase ranging from 2 to 22% at a 90% confidence level). Ambient data collected from 76 monitoring stations.

Source: Government of Canada, 2007.

Warming of the global atmosphere will likely lead to regional and global changes in precipitation, cloud cover, water vapour, wind direction and wind speed, which in turn could influence the formation of air pollutants in the atmosphere.[23] The IPCC (2007a) has reported that concentrations of ground-level ozone are projected to increase over North America. Modelling results presented in Chapter 4, Air Quality, Climate Change and Health suggest that a warming of 4°C associated with climate change, without other changes in the climate or in emissions, would result in increased ozone concentrations and resulting health effects. Larger increases would be observed in the Windsor to Quebec corridor, and in the Calgary, Edmonton, Fort McMurray and Vancouver areas. Figure 8.5 shows the current regional variations in ozone trends.

Figure 8.5 Ground-level ozone indicator by region, 1990–2004



Note: The indicator is a population weighted estimate. A trendline represents the average rate of change based on the Sen method. It is shown only for the region with a statistically significant trend.

Source: Government of Canada, 2006.

23 See Chapter 4, Air Quality, Climate Change and Health, for more information.

8.7.3.2 Extreme heat events

Although heat-related hospital admissions and deaths have not been much studied in Canada, in recent years there have been frequent news reports of people suffering from heat waves and smog in cities in southern Canada. This was the case during the summer of 2005 (Canadian Broadcasting Corporation (CBC) News, 2005). Based on historical records, "hot days" (temperatures equal to or above 30°C) occur with some regularity in most parts of southern Canada. On a regional basis, the highest number of hot days tends to occur in southern Ontario and southern Quebec, although such events can also occur in Prairie cities and interior British Columbia. Table 8.3 illustrates the regional pattern of hot days and the significant increase in observed temperatures in 2002 compared with the historical norm (1961–91). In early August 2002, a hot spell broke all records across the eastern Prairies; Winnipeg had 10 hot days, including seven in a row; Regina had 11 in a row; and Val Marie had 16 consecutive days above 30°C.

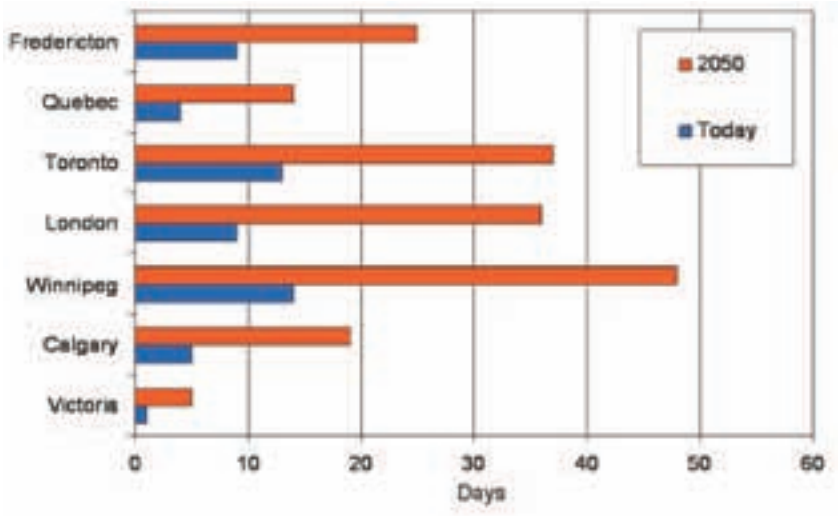
Table 8.3 Observed number of above normal "hot days" (temperatures equal to or above 30°C) for selected cities across Canada, 2002

Location	Observed	Normal
Vancouver	0	N/A
Calgary	10	5
Saskatoon	17	12
London	23	9
Toronto	34	14
Ottawa	20	11
Montreal	14	10
Moncton	7	5

Source: Environment Canada, 2002.

Although there are uncertainties associated with climate change scenarios, there is a fairly high confidence level regarding temperature projections. IPCC indicates that it is very likely that hot extremes and heat waves will continue to become more frequent (IPCC, 2007b). A recent study by Cheng et al. (2005) estimated that the number of days in south-central Canada with 3:00 p.m. temperatures ≥30°C could more than double by 2050 and triple (in some cases even quadruple) by 2080. Even larger increases have been estimated for other cities across the country by 2050. Figure 8.6 shows the current and projected number of hot days above 30°C for selected cities across Canada. Exposure to extreme heat events associated with climate change is expected to grow considerably in the future, entailing greater health risks for large numbers of Canadians living in major urban centres.

Figure 8.6 Current and projected number of hot days above 30°C for selected cities across Canada

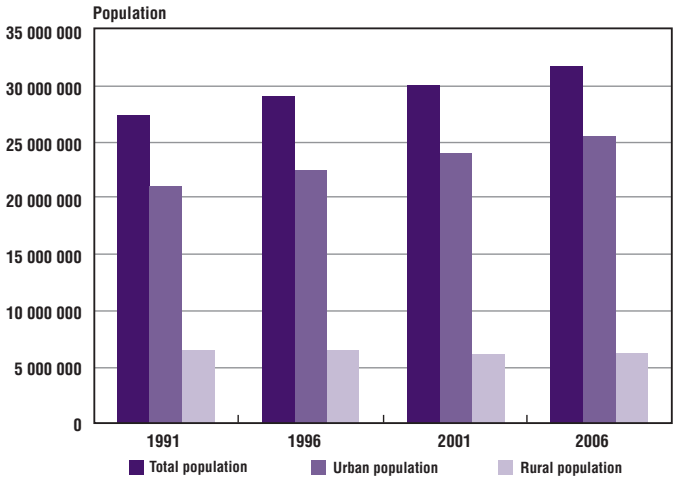


Source: Hengeveld et al., 2005.

8.7.4 Increasing Population

In the absence of increased adaptation actions, exposure to climate-related health risks will increase as Canada's population grows over the next 50 years. The population of Canada in 2004 was just under 32 million people, with almost 80% of Canadians living in urban communities (Statistics Canada, 2006). From 1991 to 2006 urban populations increased by 21% in Canada, while rural populations decreased by 2% (Government of Canada, 2007). Figure 8.7 shows the change in rural and urban populations in Canada from 1991 to 2006.

Figure 8.7 Total, urban and rural population, Canada, 1991 to 2006



Source: Government of Canada, 2007.

Under a medium-growth scenario, the population could exceed 40 million by the late 2030s, with the trend toward greater urbanization continuing. In this scenario, it would rise to 39 million in 2031 and around 42.5 million by 2056 (Statistics Canada, 2005c). More people living in large urban centres could increase exposure to specific risks to health, such as those related to more intense urban heat.

8.8 POPULATION SENSITIVITY

Gaps in the capacity to protect human health from climate change are also of concern if large segments of the population display high sensitivity to these impacts. High sensitivity implies a greater vulnerability of individuals and communities to the impacts of climate change on health. Increased adaptive efforts to reduce health risks are required in this context.

All Canadians display sensitivity to some health impacts arising from climate change. Natural disasters, extreme heat, air pollution, and water-, food-, vector- and rodent-borne diseases, all of which can be exacerbated by climate change, can affect the health of every Canadian and people living in all regions of the country. However, specific population groups, such as infants and children, seniors and those with pre-existing health conditions, can be more severely affected because of their particular physiological characteristics (Health Canada, 2005a). Sensitivity also depends on the magnitude of the threat posed by the environmental change. Some people may not be sensitive to mild changes in the environment, but are very sensitive to severe and repetitive climatic events (Health Canada, 2005a). Sensitivity is also closely related to exposure; if an individual is frequently exposed, his or her underlying sensitivity may be exacerbated. This section reviews evidence of the sensitivity of key groups within our population and examines projections of increases in these population groups, where data permit.[24] The distribution of these populations throughout Canada, along with the various attributes that underlie vulnerability, can vary widely. Future investigation of the distribution and characteristics of highly sensitive populations at regional and community levels will help to reduce climate-related health risks across Canada.

8.8.1 Seniors

Populations considered highly sensitive to climate change health impacts currently make up a significant portion of the Canadian population. Canadian seniors (age 65 and over) constituted 13% of the total population in 2005 (Statistics Canada, 2007). This group has been shown to be more sensitive than the general population to vector-borne diseases (Health Canada, 2005a), water- and food-borne contamination (Health Canada, 2005b), air pollution (Health Canada, 2003b) and heat waves (Kovats and Jendritzky, 2006; IPCC, 2007a). Many of the factors that increase sensitivity to heat waves are more pronounced in this population cohort. Risk factors for heat-related deaths and illnesses relate to (Kovats and Koppe, 2005):

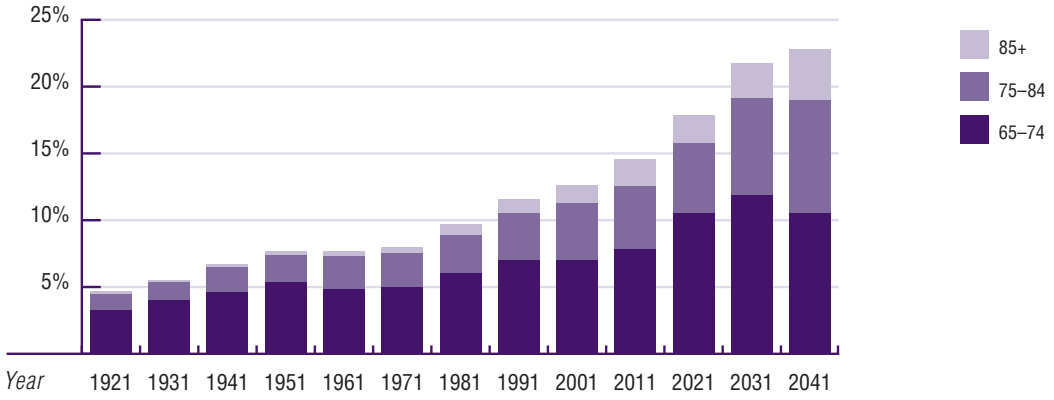
- age;
- pre-existing disease—primarily chronic respiratory or cardiovascular disease;
- social factors (e.g. living alone);
- use of certain drugs (e.g. phenothiazines, antidepressants, alcohol, diuretics);
- impaired cognition (e.g. dementia);
- housing (e.g. building type, living on high floors);
- presence and use of air conditioning in the home or residential institution; and
- physical activity—over-exertion or inactivity.

During the 2003 extreme heat event in Europe, 70% of the 14,800 excess deaths in France were persons over 75 years of age (International Federation of Red Cross and Red Crescent Societies, 2004).

24 See Chapter 7, Health Impacts of Climate Change in Canada's North, for a discussion of factors underlying the sensitivity and vulnerability of Aboriginal Canadians living in the North to the health impacts of climate change. Analysis of socially disadvantaged, disabled and immigrant populations in Canada was not conducted in this chapter and is left to further assessments.

Seniors constitute the fastest growing population group in Canada. Population projections show that population aging, which has already begun, will accelerate in 2011 when the first baby-boom cohort (born in 1946) reaches the age of 65. This rapid aging is projected to last until 2031, when seniors would account for between 23 and 25% of the total population—between 8.9 and 9.4 million people (Statistics Canada, 2007). Figure 8.8 shows the senior population by age groups, as a percentage of the total population in Canada, 1921–2041. The fastest growth is occurring among the oldest Canadians. In 2001, over 430,000 Canadians were 85 years of age or older—more than twice as many as in 1981 and more than 20 times as many as in 1921 (Health Canada, 2002a). The number of Canadians aged 85 plus will nearly double from 500,000 in 2006 to approximately 900,000 in 2026 (Statistics Canada, 2007).

Figure 8.8 Seniors by age groups, as % of the total population, Canada 1921–2041



Source: Government of Canada, 2002.

In 2003, Canadians made over 14 million visits to emergency departments in Canada. Such visits were highest for the very young and for the very old; for those over 85 years of age, 44% visited an emergency department in Ontario in 2003–04 (CIHI, 2005). In 2003, seniors accounted for a third of all acute care hospitalizations and almost 50% of all hospital days (Rotermann, 2006). Expected increases in illnesses and deaths due to the effects of climate change will place increasing pressure on the capacity of current facilities, such as hospitals, shelters and care facilities (Institute for Population Health, 2002; Carty et al., 2004; Riedel, 2004). For example, in the U.S., even with heat alert systems in place, more frequent extreme heat events are expected to increase the demand for emergency medical services and visits to emergency room facilities (U.S. EPA et al., 2006). Given projections for increased extreme heat events in Canadian cities, similar pressures on health and emergency services in Canadian communities can be expected as well.

8.8.2 Children

The environmental health field usually considers "children" to cover the period from the time of conception up to 19 years of age. This period includes defined stages during which key vulnerabilities and sensitivities are related to developmental and/or behavioural stages. Young children and developing fetuses display higher sensitivity to the many health impacts of climate variability and change (e.g. heat stress, respiratory illnesses from air pollution, water-borne diseases) because of their hand-to-mouth behaviour, proximity to the ground (where dirt and pathogens are concentrated), relatively high intake of air, water and certain foods, high surface area-to-body mass ratio, and the potential for high cumulative exposures

over their long life expectancy (Carty et al., 2004; Health Canada, 2005b). Children age 4 and under constituted 5.3% of the Canadian population in 2005, or almost 1.8 million people (Statistics Canada, 2005c). However, by 2031 children under 4 years old are expected to decrease to 4.6% of the population (Statistics Canada, 2005c). It is also important to note that the proportion of children can vary significantly in different population groups. For example, children under 14 years old represent one third of the Aboriginal population compared to 19% in the non-Aboriginal population (Statistics Canada, 2003a). This can influence the type and delivery of programs that may be needed to protect children from climate-related hazards.

It is important to identify how childhood exposures can affect adult health; some effects may not be immediate and may manifest themselves only later in life. For example, the effect of exposure to UV radiation is cumulative; studies indicate that people who have suffered severe and frequent sunburns during childhood are at greater risk of developing melanoma later in life (Health Canada, 2006c). Prevention of children's exposure to climate-related environmental hazards may help alleviate future health care costs for adult and aging populations.

Children often depend on societal measures and parental protection to prevent exposure to climate risks. Because children, and infants in particular, must rely on the protection of parents and/or caregivers, the latter must be aware of the health risks and measures available to reduce them. Older children must also be made aware of appropriate protective practices so that they can protect themselves.

8.8.3 People with Pre-existing Illnesses

People who are chronically ill may be more sensitive to water-, food-, vector-, and rodent-borne diseases, smog and extreme heat events (Health Canada, 2005a). Chronic diseases that increase the sensitivity of individuals include cancer, cardiovascular disease (heart disease and stroke), mental illness, diabetes, asthma and chronic obstructive lung disease.

Chronic diseases are among the most common and costly health problems facing Canadians (PHAC, 2007c). In 2003, 5.7% of all Canadian adults, and nearly one in four people over 70 years of age, reported having heart problems (Heart and Stroke Foundation of Canada, 2003). The prevalence of diabetes among adult Canadians in 2000 was 5.1% (Health Canada, 2003c). In 2001, 5 serious respiratory diseases (asthma, chronic obstructive pulmonary disease, lung cancer, tuberculosis and cystic fibrosis) affected approximately 3 million Canadians, or 10% of the population (CIHI, 2006a). Asthma alone afflicted 8.5% of Canadians 12 years of age and over in 2003 (Statistics Canada, 2005a). Many chronic diseases are more prevalent in people age 65 and older in Canada, and a number of Canadians may suffer from more than one chronic disease at a time.

However, younger Canadians also suffer from chronic diseases which contributes to the number of individuals sensitive to the impacts of climate variability and change. For example, while 13% of seniors (65 years and older) had diabetes in 2000, 9% of people 55 to 64 years of age and 4% of people 45 to 54 years of age also had this disease (Statistics Canada, 2007).

Since many respiratory diseases affect adults over the age of 65, the number of people with these conditions will increase as the population ages. The prevalence of self-reported asthma is increasing (Statistics Canada, 2007). The number of deaths and, by proxy, the number of Canadians with cardiovascular disease, will also likely increase as the population ages. Canadians run a high risk of developing cardiovascular diseases: 8 out of 10 individuals have at least one of the following risk factors: smoking, physical inactivity, being overweight, high blood pressure or diabetes.[25] One in 10 has three or more. Thus, the burden of cardiovascular disease will continue for many more years.

Cancer is expected to be the leading cause of death in Canada in the next several years. The number of people to be diagnosed with cancer is expected to double between 2004 and 2020 as Canada's population grows and ages (Health Canada, 2004c). The reduction in smoking among Canadians over the last quarter century has resulted in important reductions in lung cancer in men, but insignificant time has elapsed for lung cancer rates to begin to decline in women. An improvement in dietary behaviours—Canadians are eating more fruits and vegetables—may have led to a decrease in cancers of the gastrointestinal tract. However, rates of obesity are increasing among Canadians (Statistics Canada, 2007) and this is contributing to increases in other cancers (Health Canada, 2004c).

The impact of extreme weather and climate variability on the quality of life of people living with chronic diseases is not yet well defined. Research is needed to better understand the effects of climate change on some of these diseases and the public health measures and medical treatments that are available to reduce the impacts on health. Decision makers responsible for setting standards and practices in care facilities and hospitals will not only have to plan for demographic changes and the incidence of these diseases, but also account for climatic factors that may exacerbate symptoms or even cause illnesses within populations.

25 A recent study of diabetes rates in Ontario suggested that the percentage of people with this disease is growing more rapidly than expected. About 8.8% of Ontarians over age 20 had diabetes in 2005-above the rate of 8.4% that the WHO forecasted for 2030 in industrialized countries such as Canada (CBC News, 2007).

8.9 KEY FINDINGS: THE VULNERABILITY OF CANADIANS

Canadians are currently vulnerable to climate-related health risks.
The analysis in this chapter suggests that Canadians are vulnerable to climate-related health risks. This is due to the sensitivity of groups within the population, widespread exposure to climate-related hazards, and gaps in existing adaptations and abilities to cope with the risks. With respect to natural hazards, Canada has become more vulnerable because of population growth, urbanization, an aging population and infrastructure, increasing environmental degradation and over-reliance on technologies (Environment Canada, 2003). As Etkin et al. (2004, p. i) pointed out, "Canadians are more vulnerable to natural disasters than they could or should be."

The combined effects of projected health, demographic and climate trends in Canada are expected to increase the vulnerability of Canadians in the future to climate-related health risks in the absence of effective adaptations.
As Canada's population grows and as climate change expands the geographical range, frequency and intensity of weather and climate-related hazards, individuals will increasingly be exposed to heat waves, smog episodes, storms, floods, and water-, food-, vector- and rodent-borne diseases. In addition, expected population growth and chronic disease trends indicate that the proportion of Canadians highly sensitive to the health risks of climate change will grow over the coming decades, although this may vary according to region. The number of Canadian seniors is growing dramatically. This population cohort is expected to almost double in size by 2031. The number of Canadians suffering from chronic illnesses such as heart disease, cancer and respiratory diseases is also on the rise. Consequently, more illnesses and deaths related to climate change can be expected in the absence of expanded and improved adaptations.

Climate change impacts on the health of Canadians will increase pressures on health and social services if effective adaptations are not developed and implemented.
Climate change impacts that arise out of existing vulnerabilities are expected to test the complex of infrastructures underpinning the delivery of health care and public health services in Canada (Institute for Population Health, 2002; Lemmen and Warren, 2004; Carty et al., 2004). Without effective adaptations, the costs of climate change will extend beyond the direct health impacts (e.g. increased incidence of illness, injury, and death) to include economic costs to health care and social systems (Institute for Population Health, 2002).[26]

26 In 2003, total health expenditure in Canada was $123 billion (current dollars) or $3,884 per Canadian (Statistics Canada, 2005b).

8.10 ADDRESSING CLIMATE CHANGE HEALTH RISKS AND VULNERABILITIES

> "Without adaptation, a wide range of health impacts can be expected with the projected changes in temperature and precipitation, including deaths, diseases, and injuries caused by changes in the distribution of disease vectors and possible increases in extreme weather events such as droughts and cyclones" (Pachauri, 2005, p. xxii).

The primary objective of adaptation in the public health context is to reduce the burden of disease, injuries, disabilities, suffering and deaths (Grambsch and Menne, 2003). The preferred measures for adapting to impacts on health will be based on recognized public health strategies (Gosselin, 2004). Canada is already engaged in many adaptive actions to reduce the risks associated with current climate variability and extremes, some with greater success than others.

To a great extent, protecting Canadians from climate change will not entail the development of new programs. It will require revising, reorienting or strengthening current public health policies and practices to make them more effective and to target particularly vulnerable populations (McMichael et. al., 2003). Many of the actions that are being taken now to protect Canadians from health risks associated with air pollution (e.g. smog alerts), poor water quality (e.g. boil water advisories), infectious diseases (e.g. monitoring and surveillance), extreme weather events (e.g. preparedness and planning) and heat waves (e.g. "cooling off" locations) provide the basis for planning for climate change (Berry, 2005).

Adaptation strategies to reduce the health risks associated with climate change can have significant near- and long-term "co-benefits." Many adaptation actions reduce risks to Canadians posed by air and water pollution, infectious disease outbreaks and disasters that are not related to climate change and climate variability. In this sense, they can be considered "no-regrets" actions (Scheraga et al., 2003). For example, improved emergency management at the community level by using an all-hazards approach could help reduce health risks from toxic spills, terrorist attacks and earthquakes, in addition to those associated with extreme weather events. Similarly, preventative health measures to reduce respiratory illnesses associated with air pollution by using traffic restrictions and the development of active transportation infrastructure (e.g. bicycle paths, walking paths) can convey substantial health benefits to citizens due to less traffic congestion, more physically fit individuals and improved quality of life (Health Canada, 2005b). It is also generally acknowledged that specific adaptation measures may ultimately provide significant economic benefits for communities and governments. Relatively modest investments in disaster mitigation activities (e.g. warning systems) can help prevent deaths, widespread suffering, and the huge economic costs associated with disaster response and relief operations (International Federation of Red Cross and Red Crescent Societies, 2002).

On the other hand, current or planned policies and programs to reduce risks related to climate change may be "maladaptive" when they fail to reduce targeted risks or when they create new risks. For example, during the 1998 Ice Storm in eastern Canada, only four of a total of 28 deaths were from hypothermia; the other 24 were from carbon monoxide poisoning or injuries related to the indoor use of open flames, barbecues, or propane or kerosene heaters. Current policies could be contributing to increasing risks because they are not designed to deal with changing conditions and circumstances brought about by climate change (Barg and Swanson, 2005). It is important to gauge the effectiveness of current measures and identify where risks can arise from maladaptation.

Adaptation strategies may complement existing efforts to reduce GHG emissions aimed at addressing climate change (IPCC, 2007a). For example, changes in urban planning and building design to reduce the urban heat island effect (e.g. planting of trees, arcades and narrow streets) can prevent buildings from warming up and contribute to comfortable indoor living environments while simultaneously lowering GHG emissions through the reduced need for air conditioning (Koppe et al., 2004). Conversely, ancillary environmental and human health benefits, such as reduced local air pollution (especially fine particulate matter) and corresponding decreases in respiratory illnesses can arise from appropriately planned GHG reduction measures (Adger et al., 2005).[27] Both adaptation and GHG mitigation actions need to be employed to address climate change impacts (European Environment Agency, 2006; IPCC, 2007a).

8.10.1 Proactive Adaptation

Planning for the unexpected is one of the largest challenges posed by climate change. Adaptation to climate change health risks needs to be proactive and not reactive to prevent the largest potential impacts (WHO, 2002; Gosselin, 2004; IPCC, 2007a). The most effective and cost-efficient adaptation responses will generally be planned ahead of time rather than developed on an ad hoc basis without an integrated and comprehensive approach (Roberts et al., 2006). The precautionary principle (Lambert et al., 2003) should be used to guide the development of vulnerability assessments and adaptive public health strategies.[28] The implementation of early warning systems in anticipation of increased risks to human health from climate-related hazards is an example of application of the precautionary principle (Ebi, 2005).

There is general agreement among researchers about the types of measures needed to either improve the way current risks to health are addressed, or to plan for what a changing climate may bring. These types of measures are targeted toward both governmental and non-governmental organizations. Practical experience has shown that a combination of primary, secondary and tertiary preventative public health measures is needed to deal effectively with climate-related health risks. Types of measures include:

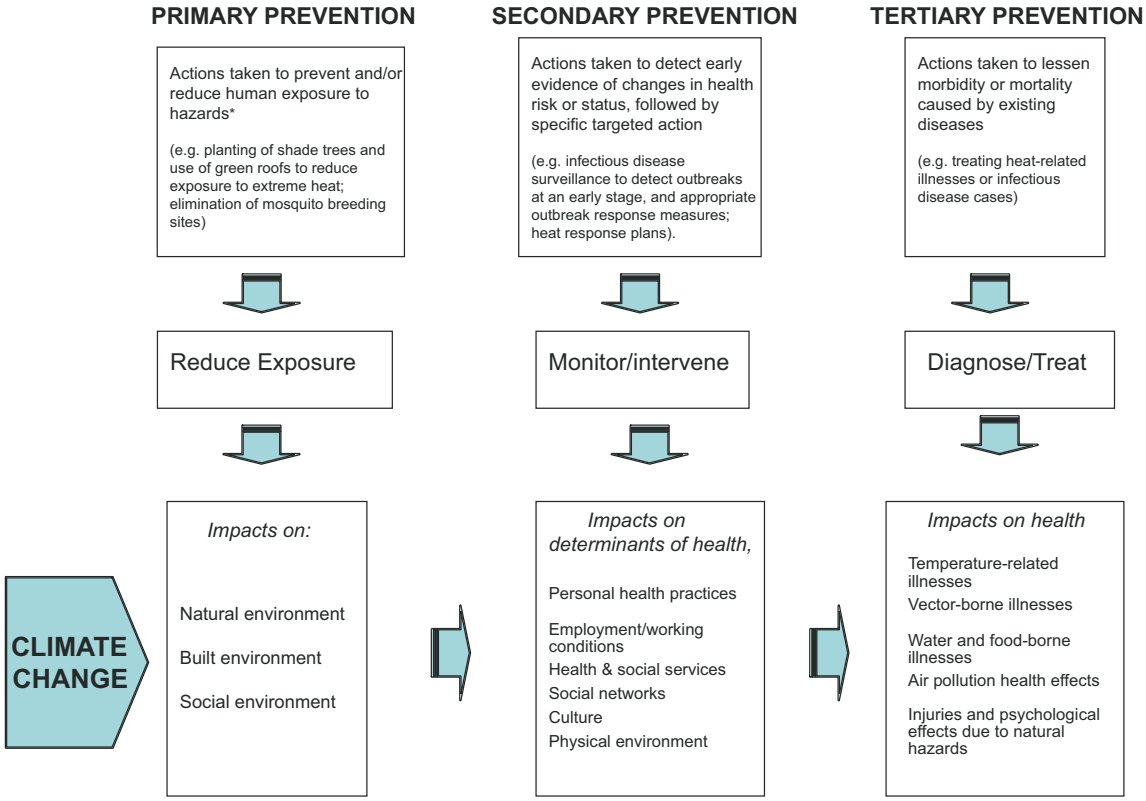
- surveillance and monitoring
- public education and outreach
- legislation
- infrastructure development
- technological and engineering innovations
- medical interventions

All types of preventative measures are needed to effectively reduce the health risks associated with climate change. However, secondary and tertiary prevention measures are both, in general, less effective than primary prevention measures and can be more expensive in the long-term (Kovats et al., 2003; The Sheltair Group, 2003).

27 The Canadian Public Health Association has called for measures to reduce GHG emissions and to address the health impacts of current energy use in Canada (CPHA, 2001c).

28 Health Canada defines the precautionary principle as "Where there are reasonable grounds to believe that exposure to an agent may cause serious or irreversible damage to human health, take cost-effective precautionary measures, even if some cause and effect relationships are not fully established scientifically. Where possible, strive to anticipate and prevent health risks rather than merely to control those that already exist" (Health Canada, 2000, p. 8).

Figure 8.9 Preventive approach to adaptation



*reduction of GHG levels (mitigation) has also been termed "primordial prevention", or eliminating the risk itself, whereas primary prevention reduces exposure to the risk

Source: Adapted from Séguin et al. 2005.

A preventative approach (Figure 8.9) requires a sound understanding of the health risks associated with the physical and ecosystem changes related to climate change. It also requires risk-based decision support tools, a clear understanding of roles and responsibilities for adaptation, and an understanding of possible adaptation measures. Communities and regions will need to conduct their own investigations of existing vulnerabilities to health risks to identify where additional capacity is needed.[29] Vulnerability is often context specific as the conditions that interact to shape exposures, sensitivities and adaptive capacities vary among communities (Smit and Wandel, 2006). Regions and communities in Canada may have significant differences with respect to the location and size of vulnerable groups. For example, effective emergency management requires that officials have updated information about the location and number of vulnerable populations—children, seniors, people with disabilities and chronic illnesses, the socially disadvantaged—within their communities, along with knowledge of their special needs and priorities (Murphy et al., 2005).

29 Some communities or provinces have undertaken, or are in the process of undertaking, climate change impacts and adaptation assessments that include discussion about risks to human health. For example, an assessment has been conducted for Nova Scotia (DeRomilly and DeRomilly Limited et al., 2005), British Columbia (B.C. Ministry of Water, Land and Air Protection, 2002), the City of Vancouver (The Sheltair Group, 2003), the City of Hamilton (Ormond, 2004) and the City of Toronto (Ligeti et al., 2006). Most of the reports focus more on expected impacts and provide a less detailed analysis of vulnerabilities resulting from limits to adaptive capacity.

Authorities in the health and emergency management sectors would greatly benefit from information derived from regional- and community-level assessments of vulnerability. These assessments would identify the effectiveness of key adaptation efforts currently in place in their jurisdictions. Such assessments should examine existing socio-economic and climate conditions, and those projected in the future, and develop linkages to current health impacts from which to develop adaptation strategies. They would also identify gaps that need to be addressed. Participatory impact and adaptation assessment approaches are useful for these purposes (Kovats et al., 2003; Brooks and Adger, 2004).[30] To support such activities, the next sections identify current roles and responsibilities for managing climate-related health risks in Canada and provide a list of possible adaptation options for public health officials to use to address existing health vulnerabilities to climate change.

Photo Credits: City of Winnipeg, Manitoba

Filling sandbags to combat Winnipeg's Red River Flood, 1997

8.10.2 Roles and Responsibilities for Adaptation in Canada

Many climate impact and vulnerability studies highlight lists of adaptation options but fail to investigate key decision-making processes. An important element of these processes is defining roles and responsibilities for adaptation (Grambsch and Menne, 2003). In Canada, different levels of government, including federal, provincial, territorial and municipal authorities, share the responsibility for the delivery of public health, health care and emergency social services. The allocation of responsibility for specific issues can differ significantly from one region or province/territory in Canada to another.

Municipal-level governments play a central role in reducing climate-related health risks, given their roles in providing police services, fire and ambulance services, local public health and social services, and community emergency preparedness and planning. Most emergencies in Canada are local in nature and are managed by the municipalities, or at the provincial or territorial level (PSEPC, 2006). Many municipalities are expanding their roles in these areas; however, some adaptations, such as emergency management initiatives, require that municipalities be provided with financial support, information and technical support from higher levels of government (Institute for Catastrophic Loss Reduction (ICLR) and Emergency Preparedness Canada (EPC), 1998).

Table 8.4 summarizes the key activities performed by various organizations and governments in relation to climate change health issues. Significant differences exist regarding the division of responsibilities among the federal government, provinces, territories and municipalities, so the table is illustrative in nature; some jurisdictions may not be responsible for all, or even many, of the activities listed under each health issue.[31]

30 See *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* (Kovats et al., 2003) for guidance on conducting assessments. Also see Chapter 2, Assessment Methods, for more information about the strengths and limitations of the methods and tools used in this Assessment.

31 For a more detailed listing of roles and responsibilities between provinces and municipalities with regard to infectious diseases, food safety and drinking water issues, see Health Canada, 2006d.

Table 8.4 Roles and responsibilities for health adaptation in Canada

Health Issue	Jurisdiction	Role
Drinking Water Quality	Municipalities	• Operation and safety of city water supplies including water testing, water treatment, water delivery and storm-water management • Drinking water quality standards and drinking water quality objectives • Sewer systems • Publish educational and advisory information on water quality • Advise on issuing boil water advisories
	Provinces/Territories	• Develop and enforce all legislation pertaining to municipal and public water supplies, including their construction and operation • Advise on policies, regulations and protocols regarding water quality inspections • Conduct inspections of municipal drinking water systems and laboratories that test drinking water • Water quality testing laboratories • Draft emergency response planning regarding water supplies • Water quality standards and watershed management • Approving designated areas for water treatment plants • Well water safety • Implementation of national guidelines for drinking water safety
	Federal Government	• Research on threats to drinking water and development of a recommended set of national guidelines for drinking water safety
Food Safety	Municipalities	• Public health inspections of food preparation and serving premises including food-processing plants, special events, retail food stores, mobile canteens • Investigate food-borne illness outbreaks • Issue permits to all food-handling establishments • Enforcement and education and training of food-handling staff • Respond to complaints made by the public • Review and approve building plans for new food-service establishments • Engage in food safety awareness activities to reduce health risks from food-borne diseases
	Provinces/Territories	• Food and safety quality regulations and legislation to ensure safety of food (e.g. toxic substances) including apiculture (bees and pollination), farming, livestock, pesticides, pest management and plant health • Register, licence and/or issue permits to food-handling establishments • Food protection, preparation and distribution programs • Animal health programs • Inspect food-processing establishments and milk plants • Education and training of food-handling staff and industry associations • Investigate and respond to complaints made by the public • Review and approve building plans for new food-service establishments • Investigate food-borne illnesses and outbreaks • Provide food safety information to the public • Note: Some provinces, such as Nova Scotia, Prince Edward Island and Newfoundland and Labrador, assume responsibility for all aspects for food safety and employ public health inspectors in this regard

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Health Issue	Jurisdiction	Role
	Federal Government	• Protect human health and the environment by minimizing the risks associated with pest control products • Set the safe residue levels for pesticides in food • Establish policies and set standards regarding the safety and nutritional value of food • Evaluate the safety, quality and effectiveness of veterinary drugs • Promote the nutritional health and well-being of Canadians • Protect the food supply from food contamination
Infectious Diseases	Municipalities	• Surveillance of communicable disease transmission at the community level • Disease prevention and control • Hospital treatment • Community-based residential, home health and public health services related to infectious disease control • Public education and awareness (e.g. West Nile virus, Lyme disease) • Public health interventions such as vaccination and screening programs, travel health • Emergency or pandemic planning
	Provinces/Territories	• Regional disease monitoring and surveillance activities through public health laboratories • Notifiable disease management guidelines • Collect, compile, analyze and publish statistics on disease incidence • Inspect waste management facilities, accommodations, workplaces, food-processing plants and various public areas • Laboratory services for detection and assessment of illness • Prevention and control • Nursing certification • Public and clinical education
	Federal Government	• Research and disease surveillance activities • Outreach and coordination with international partners (e.g. World Health Organization) • Quarantine, travel medicine and migration health programs
Air Pollution and Heat Waves	Municipalities	• Smog advisory systems and heat alert systems* • Long-term clean air and/or climate change plans that are aimed at reducing air pollution and emissions of GHGs
	Provinces/Territories	• Air quality monitoring and forecasting (e.g. air quality indices) to inform city health officials and Canadians • Temperature forecasts • Home, community and residential care for seniors who are particularly vulnerable to health risks from heat waves • Initiatives, including regulations, to improve air quality from both domestic and trans-boundary sources, such as transportation (e.g. vehicle inspection and maintenance programs), electricity generation and industrial point sources

Health Issue	Jurisdiction	Role
	Federal Government	• Scientific monitoring and technical advice for development of air quality indices and heat advisories • Air quality and temperature forecasting for smog episodes and heat alerts (e.g. humidex advisories)† • Initiatives, including regulations, to improve air quality from both domestic and trans-boundary sources, such as transportation, electricity generation and industrial point sources (e.g. low sulphur in gasoline and diesel fuels, Canada-United States Air Quality Agreement) • Pollution prevention plans for major emitters (e.g. base-metal smelters)
Natural Hazards	Municipalities	• Prepare and implement community emergency management plans including hazard identification and risk assessment • Health emergency services including expert medical and public health advice, management of actual or potential communicable disease outbreaks, monitoring of evacuation centres, maintaining food safety and sanitation for the community, offering counselling for stress and coping problems, assisting with emergency dental treatment, helping people with special needs, and checking the environment to make sure the air, soil and water is safe • Community design activities (e.g. land-use planning and zoning) to reduce vulnerability to hazards
	Provinces/Territories	• Emergency management legislation that supports local authorities in developing comprehensive emergency management systems that include prevention and mitigation, preparedness, response and recovery activities. It also gives local authorities special powers to prevent or limit loss of life and damage to property or the environment during a state of local emergency • Conduct environmental assessments, environmental protection and management, infrastructure upgrading and community growth management
	Federal Government	• Forecast trends in natural hazard frequency • Monitor outbreaks and global disease events • Assess public health risks during emergencies • Work toward enhancing public safety and security for Canadians in collaboration with other levels of government, community organizations and international health and security agencies • Implement federal public health rules governing laboratory safety and security, quarantine and similar issues • Bioterrorism detection, emergency health services and emergency response • Develop and implement federal and national emergency management policies, response systems and standards, including alerting the public in cooperation with provinces and territories • Work with provincial and territorial emergency management organizations to provide first responders with funds, tools and training

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Health Issue	Jurisdiction	Role
Cross-Cutting	Municipalities	• Health promotion activities that contribute to reducing health risks from climate variability and change (e.g. safe living environments, immunization information, safe food preparation, active living, etc) • Undertake, or provide support for, continued training and education of health professionals • Initiatives to reduce GHGs
	Provinces/Territories	• Facilitate local and municipal strategies to improve the health and well-being of Canadians living in their respective jurisdictions • Develop policies and strategies to focus on priority health areas of concern (e.g. water quality) • Deliver health care services • Health promotion activities that contribute to reducing health risks from climate variability and change (e.g. safe living environments, immunization information, safe food preparation, active living, etc) • Undertake, or provide support for, continued training and education of health professionals • Initiatives to reduce GHGs
	Federal Government	• National leadership for many important health issues (e.g. West Nile virus) and collaboration with international partners in efforts to protect the health of Canadians • Facilitate the development and implementation of federal/provincial initiatives (e.g. health emergency management) • Conduct intramural research and analysis about health risks and trends (e.g. human health risk assessments), develop and publish health indicators (e.g. economic burden of illness in Canada) and provide scientific and technical expertise to provinces, municipalities and health professionals (e.g. air pollution health effects) • Existing collaborative arrangements, such as the federal/provincial/territorial Committee on Health and the Environment, enhance coordination among all levels of government, ensure optimal knowledge transfer and systematic flow of scientific and policy information that cascades from federal to provincial to local government levels • Health promotion activities that can contribute to reducing health risks from climate variability and change (e.g. safe living environments, immunization information, safe food preparation, active living, etc) • Undertake, or provide support for, continued training and education of health professionals • Initiatives to reduce GHGs

Health Issue	Jurisdiction	Role
Non-Governmental Organizations		• Provide a wide range of health and social services to Canadians • Emergency management programs which provide information and emergency social services, such as clothing, shelter, tracing and reunification services, and emotional support for affected communities • Disaster relief and mitigation through information exchange and public awareness to change behaviour, education and training, access to health care delivery and personal support, research and policy development, and data collection for operational and policy planning • Help people with special needs access health services, such as dialysis, chemotherapy and respiratory aids, street youth services, assistance for homeless individuals, palliative care, services for the mentally and physically challenged, safe houses for women and children, meal services for seniors and community health centres (provide primary and health promotion services in communities)
Individuals		• Preventative measures to reduce the health risks from climate extremes and change (e.g. personal health practices such as reducing exposure to UV radiation, safe food preparation, correct hand washing, safe-driving practices, emergency preparedness plans and kits, etc) • Stay informed of important risks to health (e.g. severe weather warnings) and of measures that should be taken to protect health • Reduce GHG emissions • Testing of water quality in wells and private systems
Other Sectors		• Initiatives and programs to adapt to climate change impacts that directly or indirectly impinge on the health and well-being of a population (e.g. transportation, agriculture, industry, tourism, forestry, urban planning, insurance, etc) • Reduce GHG emissions

Notes: Responsibility for a number of public health issues in many provinces is delegated to regional-level authorities or groups that often service more that one community. For example, the province of Ontario had 36 public health units and the province of Alberta had nine regional health authorities at the time of writing. Roles and responsibilities of this kind are covered under "Municipalities" in the "Jurisdiction" column of the table.

* Some communities in Canada have undertaken such activities, although they have no formal mandate to do so.

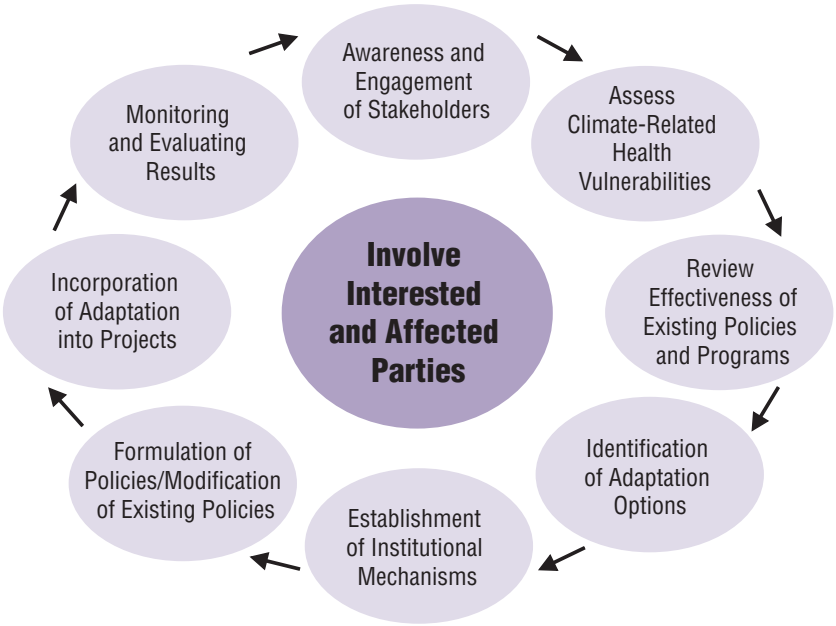
† Environment Canada issues humidex advisories not as weather warnings but as "Special Weather Statements" (Environment Canada, 2006).

Source: Adapted from Philpot, 2006.

8.10.3 Adaptation Strategy Development and Implementation

Knowledge about processes of adaptation from the fields of risk management, natural hazards research, and resource development and planning is available to inform adaptation planning and vulnerability reduction (Smit and Pilifosova, 2001). Researchers have developed numerous tools and approaches for assessing adaptation options. Some Canadian communities have also developed general adaptation guides (Halifax Regional Municipality, 2006; Mehdi et al., 2006). The Government of Canada, through Public Safety and Emergency Preparedness Canada, has developed a tool, *Community-wide Vulnerability and Capacity Assessment,* for carrying out a vulnerability and capacity assessment at the community level (Kuban and MacKenzie-Carey, 2001). Figure 8.10 presents a framework for describing the process of developing an adaptation strategy to reduce climate-related health risks.

Figure 8.10 Framework for adaptation development and implementation in the health sector



Source: Adapted from Penney and Wieditz, 2007.

The framework corresponds broadly to the key steps of standard risk management frameworks that are employed in the health sector.[32] Basic steps include early engagement of stakeholders, assessing risks to health, identifying and implementing adaptation options, and monitoring and evaluating the results. A number of important considerations that are described below need to be taken into account when implementing this framework to develop effective adaptation measures to protect populations from health risks related to climate change.

8.10.3.1 Considerations for strategy development and implementation

Local and regional approaches

Smit and Wandel (2006, p. 283) indicated, "Practical initiatives that tangibly address and improve societal adaptive capacity, thereby reducing vulnerability, are commonly expected to be evident at the community scale." Therefore, efforts to develop needed adaptations to health risks associated with climate change must be tailored to the specific needs of a community or region to be successful in reducing existing vulnerabilities. In this regard, considerations of how quickly the risk must be addressed, the expected costs of adaptations, risks versus benefits of actions, and the perceptions, concerns and values of interested and affected parties (Health Canada, 2000) need to be addressed by decision makers.

Initiatives to reduce risks in urban communities (e.g. heat alerts) may not be effective public health interventions for protecting people who live in rural communities. For example, many rural communities in Canada do not have public transportation to allow people to easily get to cooling centres (if they exist) to escape extreme heat. These communities also often have a much smaller infrastructure of helping agencies (e.g. food banks) to provide assistance during extreme events (A. Berry, pers. comm., November 15, 2006).

Smaller communities may face specific challenges in preparing for and managing emergencies. Training and certification of community officials can be problematic if they are required to travel to colleges in distant large urban centres at their own personal cost. As well, many rural

32 See, for example, *Health Canada Decision-making Framework for Identifying, Assessing and Managing Health Risks* (Health Canada, 2000).

communities in some parts of Canada have become popular tourist destinations during the summer season, leading to a large influx of people at these times. For example, the community of Bayfield, Ontario, can see its population increase tenfold during the summer months from a permanent residency of 900 people. Emergencies during this period have the potential to overwhelm health and social services, creating significant planning challenges (A. Berry, pers. comm., November 15, 2006).

Multi-sectoral approach

The development of effective adaptations to climate change health risks often requires a multi-sectoral approach to planning and policy development. Protecting the health of Canadians requires effective adaptations by a range of sectors such as transportation, tourism and recreation, fisheries, forestry, agriculture, industry and energy, and municipalities. "Education and engagement of stakeholders has a primary role to play in establishing a foundation to build equitable and sustainable strategies for adapting to climate change" (European Environment Agency, 2006, p. 28). Maladaptation, or a lack of any adaptive actions at all, within any of these sectors could produce significant health risks that would need to be managed. Consequently, the health sector should aim to build close working relationships with officials in other sectors to promote awareness of the need for proactive adaptations.

The insurance industry has become active in promoting natural hazard mitigation measures; these involve actions to reduce, as much as possible, the actual physical impacts of a hazard (e.g. dams, culverts, building codes) (Murphy et al., 2005). In Canada, these activities have been promoted by the industry-funded Institute for Catastrophic Loss Reduction, created in 1997, which facilitates the development and dissemination of disaster prevention knowledge. The framework for developing adaptive strategies to reduce health risks related to climate change includes involving officials and experts from other relevant sectors in broad engagement processes; these processes require input and participation at every stage from all interested and affected parties.[33]

Mainstreaming adaptation

The adaptation literature increasingly focuses on the importance of "mainstreaming" climate change mitigation and adaptation considerations and information into existing decision-making processes, rather than creating new policies or policy instruments. This has been driven by the recognition that most adaptations are not likely to be taken because of concerns over climate change impacts alone (Smit and Wandel, 2006). The concept of mainstreaming risks related to climate change describes processes that would bring explicit consideration of climate change into current decision-making processes (Dougherty and Elasha, 2004).

In the health sector, mainstreaming entails incorporating information about climate-related health risks into existing risk management activities, and integrating efforts among different health sector partners to develop coordinated responses to these risks. Hazard assessments that take into account projected climate change impacts should be integrated into community official plans; for example, development plans could be checked against known or expected hazards to reduce risks to people and their property (McBean and Henstra, 2003). The framework for developing adaptive strategies to reduce health risks related to climate change presented earlier supports the concept of mainstreaming by highlighting the need to establish institutional mechanisms for adaptation development, and to explicitly incorporate adaptation and climate change considerations into policies and programs designed to reduce health risks. Identification of needed adaptation options to reduce health risks becomes a routine part of policy development once such considerations are mainstreamed in current activities. Table 8.5 summarizes possible adaptation measures to manage health risks related to climate change that are highlighted in the literature.

33 See *Air Quality and Climate Change Corporate Strategic Plan* (City of Hamilton, 2006) for an example of a partnership approach to address climate change impacts and adaptation issues at the community level.

Table 8.5 Possible adaptation measures to manage health risks related to climate change

	Heat Stress	Extreme Weather Events	Infectious Diseases	Water- and Food-borne Diseases	Air Pollution
Surveillance and Monitoring	Prepare registries of vulnerable individuals (e.g. seniors) that require assistance Establish hot weather response plans and early warning systems	Prepare registries of vulnerable individuals (e.g., seniors) that require assistance Early monitoring of health outcomes from extreme weather events Enhance quantitative data on short-term and longer-term health impacts of extreme weather events	Identify most vulnerable populations Surveillance of vector populations Monitor and reporting of disease incidence	Identify most vulnerable populations Surveillance of water- and food-borne diseases Monitor and reporting of disease incidence	Identify most vulnerable populations Establish air quality monitoring systems Establish systems for reporting the impact of vehicles and other polluting sources on air quality
Public Education and Communication	Early warning systems Provide information about the health risks of heat stress and actions to protect health Provide information about measures to reduce temperatures in and around homes (e.g., planting bushes and trees)	Early warning systems Provide information about the risks of natural disasters in specific communities Provide information about actions that would reduce exposure before, during and after extreme weather events Provide information about actions to take in preparation for and during extreme weather events (e.g. stockpiling non-perishable food)	Early warning system for health professionals Provide information to residents, travellers and vulnerable populations that takes into account changes in epidemiology of infectious diseases Provide information on precautions to take to avert risks (correct hand washing, immunization)	Early warning system for health professionals Provide information to residents, travellers and vulnerable populations that takes into account changes in epidemiology of water- and food-borne diseases Provide information on precautions to take to avert risks (boiling water, safe food handling procedures)	Issue Air Quality Health Index daily to the public Provide information about actions to take to reduce exposure to air pollutants, for vulnerable groups in particular (e.g. reduce exertion levels and energy consumption, stay indoors, car pool)
Legislative	Building guidelines that make buildings more heat resistant Requirements for smart urban planning to reduce urban heat island effect	Improve land-use planning (e.g. limit development in high-risk areas such as floodplains or coasts) Foster environmental management (e.g. defensive structures to minimize flash floods, water conservation) Building guidelines to account for increasing weather severity	Quarantine laws Travel and importation of goods laws	Watershed protection laws Water quality regulations	Reduce emissions from fossil-fuel power generating stations Traffic restrictions Determine new air quality guidelines and standards to protect human health

	Heat Stress	Extreme Weather Events	Infectious Diseases	Water- and Food-borne Diseases	Air Pollution
Infrastructure Development	Provide accessible air-conditioned public facilities and shelters Provide accessible drinking fountains in outdoor public places Extend hours of cooling facilities	Identify critical and hazardous infrastructure Develop cost sharing mechanisms (e.g. insurance) for compensation to reduce post-event mental and economic stresses Improve infrastructure for effective interventions (e.g. emergency rooms and stockpiles); maintain and test public shelters and evacuation plans Maintain dams, floodplains, and storm runoff capabilities	Laboratory facilities for rapid detection of pathogens Improve infrastructure for effective interventions (e.g. emergency rooms, stockpiles)	Laboratory facilities for rapid detection of disease pathogens Upgrade water treatment, sewage and sanitation facilities to deal with more severe extreme weather Improve infrastructure for effective interventions (e.g. emergency rooms, stockpiles)	Improve public transit systems and bicycle lanes to reduce traffic-related pollution levels Incentive programs for citizens, households, communities and corporations to reduce emissions and energy consumption
Technology and Engineering	Improve urban design to reduce heat island effect (e.g. planting trees, increasing green spaces, shading conditions along streets and parking lots, pattern of subdivisions and shape, size and orientation of building lots)	Strengthen and enforce building codes and standards Develop and implement protective technologies: hard (sea walls, dams, dykes) and soft (marshes, wet lands, natural buffers, etc) to reduce the potential for floods Increase redundancy, efficiency and resilience of power supply grids	Vector control measures (e.g. reduce breeding grounds for mosquitoes and other vectors)	Disease prevention measures reflecting the latest information from Canadian and international surveillance and research organizations New technologies to improve water treatment, sewage and sanitation facilities	Promote and encourage use of alternative (clean) fuels and zero-emission vehicles
Medical Interventions	Intervention activities (e.g. “heatline”) to provide information to vulnerable populations “Buddy system” to check on neighbours) Include climate change projections in health planning	Provide training to medical and emergency staff; enlist and train volunteers to be recruited during an emergency Maintain disaster management programs, including tools for local public health facilities to provide rapid health needs Include climate change projections in health planning	Develop and make available new drugs and vaccines Public immunization programs Include climate change projections in health planning	Develop and make available new drugs and other treatments Include climate change projections in health planning	Increase public health staff with a mandate to provide information on air quality health effects Include climate change projections in health planning

Source: Adapted from Chiotti et al., 2002. Includes measures from Health Canada, 2001; IPCC, 2001, 2007a.

8.10.4 Barriers to Adaptation

Many decision makers in the health sector do not yet consider adaptation to the impacts of climate change a priority issue requiring immediate attention. The fact that most Canadians are not well informed about the likely health risks associated with climate change (Carty et al., 2004) may contribute to the current approach by health officials. As well, funding for adaptation-related initiatives in Canada has been overshadowed by efforts to reduce GHGs, and has been inadequate to address existing risks (The Conference Board of Canada, 2006). Therefore, health officials may find that they must compete for resources for adaptation or share such resources with others seeking to address a variety of other public health problems.

Actions for adapting to climate-related health risks have also been hampered by an incomplete understanding of climate processes, the interacting socio-economic variables that influence climate change, and future societal responses to the expected impacts. These gaps make it difficult to project specific impacts using future climate scenarios, including the associated risks to human health. Ebi (2005, p. 49) suggested, "...there is high uncertainty about the rate and intensity of any changes in climate variability in a particular location over a specified time period, but high certainty that without adequate preparation, extreme events will lead to increased morbidity and mortality." Consequently, determining effective climate change adaptation strategies to reduce health risks can be a difficult and complex task. For example, rising sea levels and an increasing frequency of storm surges are expected to pose significant risks to property and people living in some communities of British Columbia, such as the City of Richmond. At the time of writing, that city was in the process of updating its system of dykes to accommodate changes in weather and rising sea levels. However, uncertainty about the severity of future sea level rise is making a cost-benefit analysis, as part of the efforts to update dykes in that city, difficult (Ballard and Lidster, 2006).

Scheraga et al. (2003) identified the following possible explanations for the failure to adapt effectively to health risks associated with climate variability under current climate conditions:

- failure to identify and understand factors that affect the risk and the ability of society and individuals to respond;
- limited resources available for adaptation;
- conscious decision by society not to invest scarce resources in adaptive responses; and
- perceived lack of vulnerability or perceived elimination of the threat.

Barriers to adaptation can also exist when proposed measures are either not technically feasible or their effectiveness has not been demonstrated. For example, more research needs to be conducted on the effectiveness of different response plans to manage the health risks from heat waves so that appropriate systems that respond to local needs can be developed. There may also be changes that cannot be anticipated, and adaptations to these cannot be made in advance of their occurrence. As IPCC suggests, the magnitude and timing of climate change impacts will vary with the amount and timing of climate change, and unmitigated climate change would, in the long-term, likely exceed the capacity of natural, managed and human systems to adapt (IPCC, 2007a).

Climate change is expected to affect Canada in specific geographic areas or distinct ecosystems; its impacts will not follow traditional provincial or territorial boundaries. Because provinces and territories are responsible for many aspects of environmental and health management, governments and agencies will need to collaborate when addressing vulnerabilities and developing adaptive strategies. This collaboration is needed to prevent duplication and to use resources efficiently; separate adaptive strategies may not be needed for each jurisdiction.

8.10.5 Opportunities for Future Actions

Even in the face of the many challenges to adaptation, important opportunities exist for making progress in efforts to reduce health risks associated with climate change. Although significant gaps remain with respect to knowledge about existing vulnerabilities to the impacts, including those related to human health, research on impacts and adaptation in Canada is yielding results. A knowledge base is being developed as a result of many studies that address regional and sectoral issues, and by connecting researchers with decision makers who need to manage future risks related to climate change (OAG, 2006). Understanding of basic concerns related to health and a changing climate has increased through recent studies,[34] and this Assessment will contribute to this body of evidence.

The public health and emergency management communities can benefit from recent increases in the ability to forecast extreme weather events which have taken place over the past 30 years as more has been learned about the climate system. Environment Canada is recognized as an international leader in global climate modelling (OAG, 2006) and therefore constitutes an important source of information for future climate change adaptation work. In addition, the health care sector in Canada is well organized with respect to sharing information about climate change adaptation, both at home and internationally.

The public health field has many years of experience in reducing risks to health from environmental hazards; this experience can be drawn upon to meet the challenges posed by climate change (Ebi et al., 2005). It demonstrates that vulnerability to climate-related health risks can be reduced through appropriate adaptive actions (e.g. heat alerts, disease surveillance, health promotion activities to reduce poor health) and through efforts to build adaptive capacity.

A high level of awareness exists among public health officials in Canada about the impacts of weather and climate on human health and well-being, and about potential future risks to Canadians. This provides a strong basis for moving forward with actions to address these risks. Interest in adaptation is growing with a greater acceptance of scientific findings on climate change; reports on recent extreme weather events that have significantly impacted communities within and outside of Canada also contribute to this interest (Penney and Wieditz, 2007). Individual Canadians are capable of shifting their behavioural and architectural practices to suit climatic conditions, even as the number and geographical extent of climate-related hazards increase as the climate changes.

Canadian Red Cross: Expect the Unexpected Program

In response to the Saguenay floods of 1996, the Canadian Red Cross developed the school-based Expect the Unexpected Program. It is an example of health promotion activities carried out by a voluntary organization to reduce health risks related to natural disasters. Since 1997, this program has delivered learning activities on natural disasters and extreme weather events to over 750,000 students in 11 provinces and territories in Canada (Canadian Red Cross, 2005).

Ultimately, the opportunity to address key barriers to adaptation exists. Public health and emergency management officials and their partners can build on their past experience in addressing these types of issues through effective interventions. They can draw from the growing knowledge of health risks related to climate change and the increasing awareness of Canadians about the issues.

34 See *Climate Change and Health: Research Report* (Health Canada, 2004a).

8.11 KNOWLEDGE GAPS AND RESEARCH NEEDS

Successfully managing the health risks to Canadians arising from climate change will require more detailed assessments of vulnerabilities to existing climate variability as well as to future changes in climate. These need to take place at regional and community levels, given the broad scope of potential impacts and of possible public health responses. A number of research gaps that need to be addressed to improve adaptation development and reduce health risks have been identified in the literature (McMichael et al., 2003; Riedel, 2004). The lack of research findings related to climate change and health adaptation and adaptive capacity in Canada was a major obstacle for the assessment of capacity conducted in this chapter.

Future assessments and current efforts to manage climate-related health risks would benefit from research to improve knowledge in the areas listed below.[35]

Climate Projections

- Improved climate models and scenarios, particularly at the regional scale, to reduce the high level of uncertainty regarding possible future exposures to hazards for specific populations.
- Greater understanding of the regional distribution of health risks associated with climate change in Canada as well as differences in existing capacity to adapt (e.g. between northern and southern communities) to the future changes.

Regional and Local Assessment of Vulnerabilities

- Regional- and community-level exposure to current and future climate-related hazards that pose health risks.
- Location and attributes (e.g. perceptions and behaviours) of highly sensitive populations.
- Evaluation of emergency management plans in regions and communities that take into account climate events, climate effects and multiple stressors (e.g. cumulative impacts).
- Ability to plan for and respond to disease outbreaks and public health emergencies.
- Integrated activities to protect vulnerable populations from health risks associated with air pollution and heat waves, including efforts that may be required to take preventative measures to mitigate the health impacts of heat waves by reducing the urban heat island effect.
- Extent to which adaptive capacity is unevenly distributed among communities within regions or populations within communities. Disparities between cities and smaller communities and rural areas with respect to the ability to plan and prepare for emergencies can be significant.

35 No attempt has been made to prioritize the knowledge gaps identified here.

Adaptation Strategies and Measures

- Economic costs of the projected health impacts related to climate change.
- Economic costs of adaptation strategies (e.g. heat alert systems).
- "Best practice" adaptation measures (e.g. outreach activities, assistance to vulnerable populations, monitoring of health impacts).
- Current extent of maladaptations and their contribution to health risks from current climate variability.

- New infrastructure designs which include standards that take into account larger and potentially more damaging events expected under climate change; as current infrastructures are upgraded and replaced, engineers need new and updated climatic design values, revised codes and standards, and new methodologies to incorporate climate change considerations into engineering procedures.
- Processes and drivers of adaptation decision making and how climate change considerations can be integrated or "mainstreamed" into current health risk management practices and frameworks; level of certainty needed for public health decision makers to act; tools needed for effectively communicating this to decision makers.
- Factors that affect our current capacity to adapt at the individual, community and institutional levels, including the cumulative impacts of repeated extreme events; conditions that stimulate or act as a barrier to adaptation (e.g. institutional coordination, risk communication, participatory processes).
- Monitoring of extreme heat events, heat alerts and heat-related illnesses and deaths per year in Canadian communities.

Vulnerable Populations

- Characteristics or qualities that make specific populations more vulnerable to health risks related to climate change and the distribution of such vulnerable groups in Canada.
- Risk perception related to climate change health impacts among individual Canadians that influences capacity to adapt.
- Communications and outreach strategies for changing individual behaviours to reduce health risks (e.g. appropriate messaging during heat and smog alerts) and interventions by public health officials.

8.12 CONCLUSIONS AND RECOMMENDATIONS

8.12.1 Conclusions

This review of climate-related hazards in Canada, the exposure of people to these hazards, and the existing capacity to manage health risks reveals that Canadians are vulnerable to climate variability and weather extremes.

In the past century, we have succeeded in reducing mortality from weather extremes and other public health emergencies in Canada. However, the economic costs of extreme events in this country are rapidly increasing, as is the number of people affected by natural disasters. The fullness of the health impacts from such events is not well understood. Such events and other climate-related hazards (e.g. smog, food-, water-, vector- and rodent-borne diseases) continue to pose significant short- and long-term risks to the health and well-being of Canadians and their communities. Gaps in the adaptive capacity of governments and communities in Canada to address climate-related health risks exist. In some circumstances existing systems and measures may not be sufficient to deal with unforeseen events or to respond to the cumulative stresses arising from many events occurring simultaneously, or in rapid succession. Findings from this first assessment of adaptive capacity can inform our future research and program and policy development to enhance our current capacity to adapt to climate change.

Several factors influence the vulnerability of the Canadian population to current and future climate-related health risks:

About our population:

- All Canadians are exposed to climate-related hazards but to varying degrees. Many are at increased risk of health effects because of a greater frequency and magnitude of these hazards or due to inadequate protection or coping mechanisms.
- Health and demographic trends will increase the proportion of the population that is sensitive to the health risks associated with climate change. The proportion of seniors in Canada will grow from 13 to 25% of the population by 2031.
- Individuals play an important role in protecting themselves by responding to a range of climate-related health risks. But Canadians often do not perceive a threat from natural disasters and are generally unprepared for health emergencies.

About systems and measures in place:

- Many sectors in our society have a role to play in reducing vulnerabilities to health risks. The extent to which human health considerations are not incorporated into land-use planning, infrastructure development, emergency preparedness and mitigation, environmental management, and transportation planning increases vulnerability to climate change health impacts.
- Response systems, infrastructure and risk management approaches have been designed to respond to discrete health risks or climatic events based on past climate trends. Climate change is very likely to bring pressures that will test or exceed the limitations of these systems.

- The likelihood of cumulative impacts and the possibility of irreversible (in human-time scales) environmental changes related to climate change (e.g. loss of glaciers, desertification) suggests that there will be limits to adaptation and unavoidable impacts on health.

About our capacity to adapt:

- Public health sector and emergency management officials display concern about risks to populations from climate change but are generally not mobilized around this issue and have not accorded it sufficient attention.
- Competing budgetary priorities make it difficult to allocate sufficient resources for adaptation and preventative measures. The lack of resources is a particular constraint for small cities and communities.
- Leadership is a necessary ingredient to mobilize officials and individual Canadians to take the needed actions to protect health; many await such leadership to pave the way for future adaptations through the conduct of research and the development of needed policies and programs.

Actions to reduce the vulnerability of Canadians to current climate-related health risks are needed. Significant capacity resides in existing institutions and programs, physical infrastructures and human and financial resources that can be dedicated to protecting health and well-being. Efforts taken now to reduce risks will significantly reduce our vulnerability to the health impacts of future climate change. Well-designed adaptation strategies can have significant near- and long-term ancillary benefits, such as reduced risks to Canadians posed by air and water pollution, infectious disease outbreaks and disasters. As well, adaptation strategies (e.g. mitigation of the urban heat island effect) may support existing efforts to reduce emissions of GHGs; such measures can have significant benefits to health. Both adaptation and GHG mitigation actions need to be employed to address climate change impacts. Whether Canadians adapt successfully depends on whether existing knowledge, economic resources, skills and other resources are employed fully and effectively.

8.12.2 Recommendations

A recent review of current adaptation initiatives in select urban centres in Canada and internationally reveals that while many cities have taken action to reduce vulnerabilities to natural hazards, few have taken into account the additional pressures that climate change will create (Penney and Wieditz, 2007). This concurs with the findings of this chapter, and therefore the following recommendations are made:

Governments, communities and individuals should maintain and enhance current measures and programs to protect health from climate-related risks and incorporate climate change information into existing activities.

Sustained initiatives and activities are needed to build adaptive capacity in the health and emergency management sectors. Some systems (emergency management, public health, infrastructure, etc.) should strengthen the ability to cope with existing stresses. Many lessons have been learned from recent events in Canada that can inform the adaptation process. In addition, gaps in current adaptive capacity identified in this chapter can provide direction to decision makers for future actions.

Although the costs of adaptation can be high, the costs to health and well-being and the quality of life of Canadians will be higher if planning and implementation of adaptive responses to climate-related health risks does not occur (Health Canada, 2005a; Street et al., 2005). Experience has shown that it is less costly to invest in shoring up capacity than to repair damages from a disaster. Addressing the existing gaps in public health and emergency management activities has the potential to significantly improve the ability of Canadians to reduce health threats from future climate change in Canada.

Governments, communities and individuals should identify future vulnerabilities and plan new adaptations to increase the capacity required to manage emerging risks.
Efforts are needed to act proactively and initiate new adaptive strategies and partnerships to build the capacity to adapt that will be needed in the future. The overview of roles and responsibilities for adaptation provided in this chapter suggests that areas of responsibilities are generally well defined, although some gaps may exist for specific issues. New collaborations are required to address increases in climate-related hazards that do not respect political boundaries and that lead to events that are potentially much larger and more frequent than in the past.

Regional- and community-level assessments of health vulnerabilities are needed to identify, at the local level, where current public health and emergency management activities and those of other sectors need to be augmented to reduce risks to health. A number of approaches for conducting vulnerability assessments and for assessing adaptation options are available to public health and emergency management officials in Canada. Local and regional studies are necessary to fully understand the factors that create vulnerabilities and to guide the choice and implementation of effective risk management measures. Priority avenues of inquiry for such assessments are detailed in section 8.11 Knowledge Gaps and Research Needs of this chapter.

Health care and social services authorities need to plan for the impacts to individual and community health expected under climate change.
Health care and social services authorities in Canada should prepare for increased pressures that are expected from climate-related health risks. Demographic trends suggest that the projected increase in Canada's population and, in particular, the increase in the size of the cohort of seniors could contribute to these pressures. The health sector needs to proactively address health risks associated with climate change through its central roles in risk assessment and adaptation development (e.g. disease surveillance activities). The convergence of increased workloads and more frequent emergencies from natural hazards related to climate change may reduce the ability of the health system to protect individuals and their families (McBean and Henstra, 2003). Developing the appropriate capacity to manage the additional stress of climate change is essential for protecting the future health of Canadians.

In conclusion, opportunities exist in Canada to protect the health and well-being of Canadians from current climate variability and future climate change. Our ability to make progress depends on our willingness and determination to plan for short- and long-term changes, and fully utilize existing capacity to reduce health risks. All levels of government need to work together, and with interested parties such as professional associations, community leaders, businesses, voluntary sector organizations and public health practitioners, to address the impacts of climate change on health. Future partnerships will benefit from the growing knowledge about the health risks related to climate change that Canadians face, and from previous public health experience in addressing environmental health issues with effective interventions. Early results can be achieved and supported by increasing awareness among Canadians of health risks related to a changing climate.

8.13 ANNEXES

Annex 1: Types of Weather Alerts Issued by Environment Canada

Severe Thunderstorm	Tropical Storm	Rainfall	Wind	Blizzard
Tornado	Hurricane	Freezing Rain	Les Suetes	Blowing Snow
Funnel Cloud	Storm Surge	Freezing Drizzle	Wreckhouse Wind	Snowfall
Cold-Core Funnel	High Heat and Humidity	Flash Freeze	Marine Wind	Snow Squall
Landspout	Heat Wave		Dust Storm	Winter Storm
Waterspout	Humidex			Wind Chill
				Cold Wave
				Arctic Outflow
				Frost
				Multiple Weather
				Fog-Smoke
				UV
				Air Quality

Source: Adapted from Environment Canada, 2007b.

Annex 2: Heat Alert Response Plans in Canada

Municipalities		Industry
Capitale national (Quebec)	Laurentides	The Construction Safety Association of Ontario (Heat Response Plan)
Chaudières-Appalaches	Lanaudière	Occupational Health Clinics for Ontario Workers Inc. (Humidex Based Heat Response Plan)
City of Brampton	Laval	Occupational Health and Safety Division, Workers Compensation Board of Prince Edward Island (Guide to Heat Stress)
City of Burlington	Mauricie-Bois-Francs	Ontario Forestry Safe Workplace Association (Heat Response Plan)
City of Hamilton	Montérégie	
City of Kingston	Montreal	
City of London	Outaouais	
City of Mississauga	Region of Peel	
City of Ottawa	Regional Municipality of Halton	
City of Sudbury	Region of Waterloo	
City of Toronto	Town of Markham	
Estrie	Town of Oakville	

Annex 3: Examples of Municipal Climate Change Programs in Canada

- City of Calgary
- City of Edmonton
- City of Halifax
- City of Ottawa
- City of Sudbury
- City of Toronto
- City of Vancouver
- City of Winnipeg
- Montreal

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