Chapter 6

Health Impacts of Climate Change in Quebec

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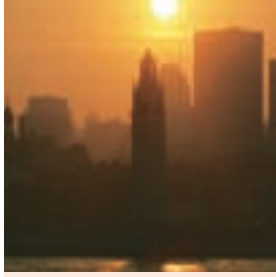

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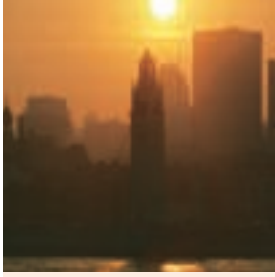


6.1 INTRODUCTION

When Health Canada decided to launch *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity* in 2003, several factors contributed to the development of a more detailed regional component that addressed Quebec.

Research projects on the health impacts of climate change have been underway since 1999. They have addressed several themes (northern environments, airborne organic particulates such as pollen, crime, the effects of heat waves), with the support of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN), Health Canada, the *Ministère de la Santé et des Services sociaux* (Quebec department of health and social services) (MSSS) and the Ouranos Consortium (Ouranos).[1] In addition, these partners discussed other initiatives—in particular, adaptation to climate change by the public and related public services, and modelling of climate change on a finer scale than global climate models to predict future health impacts, along with several other projects. This research was intended to foster a better understanding of public health adaptation measures in the near future and to facilitate their implementation.

The severe European heat wave in summer 2003 was a pivotal incentive to further action by these partners, and prompted a more detailed look at Quebec. This extreme climate event (ECE) joined others that had deeply affected Canadians in the past decade: the 1996 floods in Saguenay and the 1998 Ice Storm that primarily affected the region south of Montreal. These events cost taxpayers and organizations several billion dollars, and there were other non-monetary costs that perhaps were longer lasting. The number of Quebeckers (currently 90%) in favour of international commitments to greenhouse gas (GHG) reduction (Centre de recherche sur l'opinion publique (CROP), 2002) was also a determining factor in going ahead with this research on adaptation to the health-related effects of climate change in Quebec.

In fall 2003, MSSS formed a five-year partnership with Ouranos. In the beginning of 2004, the ministry formally asked eight regional public health departments to implement, no later than 2007, emergency intervention plans in case of severe heat waves. At the same time, the Institut national de santé publique du Québec (Quebec national institute of public health) (INSPQ) was asked to conduct several research projects on impacts and adaptations in cooperation with Ouranos, and to coordinate the related research with the public health network, universities and Health Canada.

It was possible to launch such an assessment for Quebec because of the well-developed governance for public health interventions already active on climate change. The presence of Ouranos, and its multi- and interdisciplinary approach linking the climate sciences and research on adaptations, enabled the mobilization of resources and competencies in this area.

1 Ouranos is a research consortium created in 2001; it studies regional climatology and adaptation to climate change, focusing primarily on Quebec, but it is also active nationally and internationally (Ouranos, 2004)

In addition, recent Quebec reforms in health surveillance and emergency management, as well as an existing public health network active at the sub-regional level on climate change issues, are all underlying reasons for this more detailed regional approach.

There are seven sections in this chapter, including the introduction. Section 6.2 presents contextual data to describe some of the province's basic geographic, socio-economic, administrative and health characteristics to provide some background for the sections that follow. The next sections address research that was conducted for this chapter. Section 6.3 is an overview of the useful public health adaptation activities that already exist. Section 6.4 reports some of the results of a modelling of historic mortality for the period from 1981 to 2001, with future simulations for 2020, 2050 and 2080, using two climatic scenarios. Section 6.5 refers to investigations into climate change-related perceptions and adaptations among Quebeckers, and Section 6.6 to those among municipal and health managers. Section 6.7 presents a synthesis of the current situation, a summary of the key findings, and recommendations or suggestions for future steps for public health adaptation to climate change.

Note that northern Quebec (located above the 50th parallel), which includes the vast James Bay, Hudson Bay and Ungava regions (Figure 6.1), is not discussed in this chapter because the impact assessment for northern Quebec appears in Chapter 7, Health Impacts of Climate Change in Canada's North.

6.2 A BRIEF LOOK AT QUEBEC

6.2.1 Geography

Quebec is one of 10 Canadian provinces. It is 1,667,441 km^2 in size, and is located between 45° and 62° latitude north and between 57° and 79° longitude west. More than 99% of Quebeckers live south of the 50th parallel (Government of Quebec, 2006d). The province is bounded by the Arctic Ocean to the north, the United States (U.S.) and the province of New Brunswick to the south, James and Hudson Bays and Ontario to the west, and by the Atlantic Ocean and Labrador to the east. The topography is rather flat and there is a very well-developed highway network. The area includes 3% of the earth's freshwater reserves (Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP), 2002b). The 3,058-km-long St. Lawrence River is the most important waterway in Quebec. More than 80% of the population lives along its shores or those of its tributaries, and more than 50% of Quebeckers draw their drinking water from this river.

Quebec has a diverse climate with four distinct seasons. Depending on the latitude, average temperatures in summer vary between 5 and 20°C and in winter from -25 to -10°C. Total annual precipitation (rain and snow) also varies depending on the region, with accumulation from 500 to 1,200 mm. There are four main types of climate in Quebec: a temperate humid continental climate south of the 50th parallel, a sub-arctic climate characterized by colder temperatures and less precipitation in the North, an arctic climate in the far North and a maritime climate in the Gulf of St. Lawrence region.

The diverse climate supports several types of vegetation, from deciduous forest in the south and, progressing northward, a mixed forest zone, a boreal forest zone, taiga forest and then tundra in the far North. Forests cover more than half the province; the population is concentrated in the deciduous and mixed forest zones.

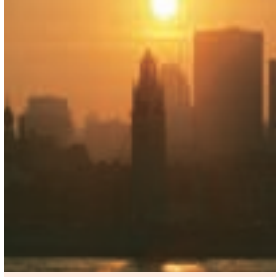


Figure 6.1 Quebec

Note: The 50th parallel is located between Sept-Iles and Matagami.

6.2.2 Basic Socio-Economic Data

6.2.2.1 Population and demography

In 2006, the population of Quebec was 7.6 million, 3.6 million of whom live in the Greater Montreal area. This region has an area of approximately 4,000 km^2 and its municipalities are distributed over five administrative regions (Ville de Montréal, 2005; Institut de la statistique du Québec (ISQ), 2006f). Overall demographic density is very low, with 5.8 inhabitants per km^2, but the density is 36 inhabitants per km^2 for permanently inhabited areas. In addition to a Francophone majority (82%), there is an Anglophone community of approximately 590,000 people, close to 600,000 recently arrived allophones and approximately 80,000 Aboriginal people (Amerindian and Inuit).The Aboriginal population generally lives on reserves or in settlements administered by a band council. Inuit people inhabit the far North and live in villages directed by a mayor and councillors. Ethnic communities, other than French or English, represent approximately 18% of the Quebec population (ISQ, 2003b). Quebec receives some 40,000 immigrants annually; in 2001, these were mainly European (40.3%), Asian (26.9%), African (11.5%) and American (11.2%).

The territory is divided into 17 administrative regions, 103 regional county municipalities, 1,264 municipalities and 78 Amerindian territories. Nine municipalities (Montreal, Quebec, Longueuil, Laval, Gatineau, Sherbrooke, Saguenay, Lévis and Trois-Rivières) have more

than 100,000 inhabitants. Migration to the Montreal region and its bordering regions and the Outaouais has begun and is expected to continue for the next 20 years. The Montreal Census Metropolitan Area has the greatest linguistic and ethnic diversity, with 67% speaking French as their first language and 12% speaking English (ISQ, 2006e). The non-official languages most frequently spoken in Quebec are Spanish (3.2%), Italian (2.7%) and Arabic (1.6%) (Canadian Heritage, 2006).

As in most industrialized countries, Quebec's population is aging, with an average age of 39.3 years in 2004. Demographic trends (fertility, mortality, migration) indicate that the population will become one of the oldest in the world in approximately 40 years. In 1986, there were seven people between the ages of 15 and 64 for each person 65 years and older; projections for 2031 indicate there will be only 2.2 (ISQ, 2003a; Government of Quebec, 2006c).

6.2.2.2 Economy

Quebec had a gross domestic product (GDP) of more than C$250 billion in chained (2002) dollars in December 2005, or approximately 20% of the total Canadian GDP (ISQ, 2006b). Almost three quarters of this comes from the service sector. Quebec's GDP ranks it alongside the 20 most industrialized member countries in the Organisation for Economic Co-operation and Development (OECD). The Quebec per-person GDP may be compared with that of England and Japan; it is almost 5% greater than that of the 20 most industrialized OECD countries. However, disposable income[2] per person is still about 8 to 10% lower than the Canadian average, based on historic data. It was estimated at C$23,240 per person in 2006 (ISQ, 2006a).

Each of Quebec's administrative regions has strong economies in the science and technology sector (aerospace, information technology, biotechnology, ground transportation materials, forest products, pharmaceuticals) and in tourism; 27.5 million tourists visit Quebec annually and close to 130,000 people work in some 30,000 tourism-related businesses. Natural resources (forestry and mining) and energy resources are also at the heart of the Quebec economy. Hydroelectricity accounts for 96% of electricity production. This high percentage occurs only rarely elsewhere in the world (Manitoba, 99%; Norway, more than 99%) (Energy Information Administration, 2002; Manitoba Energy, Science and Technology, 2003). Peak demand is in winter, and a great many homes use electric heat. Quebec mineral resources rank it among the world's 10 major mining producers. There is currently an increase in exports as a result of international trade agreements and the North American Free Trade Agreement, which have increased Quebec's ability to compete on the international market. The U.S. is Quebec's principal economic partner (88% of exports). Total exports from Quebec in 2006 were valued at C$150 billion, or approximately 54% of its GDP (Ministère du Développement économique, de l'Innovation et de l'Exportation, 2007).

6.2.3 Health Administration Organization

Health and social services are combined under one administration, the MSSS, and are divided into central, regional and local levels (Figure 6.2). Quebec has 18 socio-health regions governed by the *Agences de la santé et des services sociaux* (health and social services agencies), within which are the *Directions de santé publique* (public health branches). These regions are the same as the governmental administrative regions, with the exception of Mauricie and Centre du Québec, which form one socio-health region, and the northern Quebec administrative region, which is divided into three parts (Nunavik, Terres-Cries-de-la-Baie-James and Nord-du-Québec) mainly because of the size of the territory and the ethnocultural characteristics of the population.

2 Disposable income is defined as the balance of personal income after direct individual income tax and various other fees, licences and permits, including hospital and health insurance premiums, and excluding indirect taxes. Disposable income is more discretionary than personal income (Eco-Santé, 2005b).

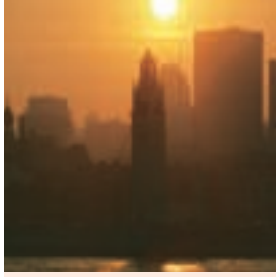
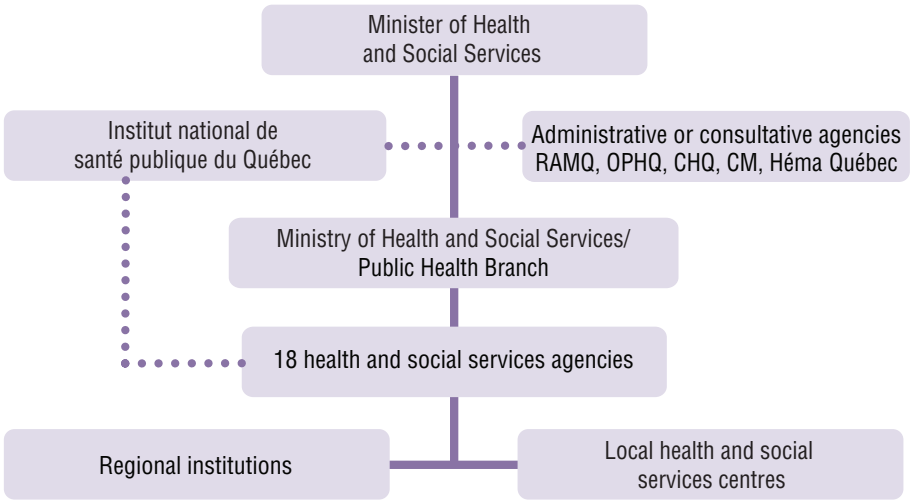


Figure 6.2 Public health within the Quebec health and social services system



RAMQ: Régie de l'Assurance-maladie du Québec (Quebec health insurance board)
OPHQ: Office des personnes handicapées du Québec (Quebec office for the disabled)
CHQ: Corporation d'hébergement du Québec (Quebec accommodations corporation)
CM: Conseil du medicament (medication board)

Source: MSSS, 2005.

At the provincial level, MSSS establishes the general direction and allocates budget resources. At the regional level, the *Agences de la santé et des services sociaux* are responsible for regional planning and resource management, as well as budget allocations to institutions. At the local level, the 95 *Centres de santé et de services sociaux* (CSSSs) (health and social services centres) and other stakeholders share responsibility for the local population through a clinical and organizational project. A regional public health branch within each agency coordinates regional public health program activities, in cooperation with the CSSSs and other partners outside the health network. The regional director of public health is directly appointed by the minister on the recommendation of the regional agency, and has a great deal of professional latitude within the legislative framework.

The public health network also relies on INSPQ and its mandate to improve the population's health and well-being (INSPQ, 2006c). INSPQ has more than 500 employees and provides MSSS and the regional agencies with support in the form of expertise, research, laboratories, training and international affairs. For 20 some years, roundtables on public health, occupational health, environmental health, infectious diseases, health surveillance and health promotion have helped to coordinate the various public health sector stakeholders. A permanent secretariat periodically assembles representatives from the 18 regions, from INSPQ and MSSS, as well as several guests, depending on the files, for the roundtables. These meetings help to coordinate, plan, transfer knowledge and share resources.

In December 2005, the Quebec health and social services network included 315 institutions, 199 of which were public. These include health and social services centres (acute hospital services, home care, social services), university hospitals, youth centres, rehabilitation centres, long-term hospitalization centres and nursing homes. The remaining 116 institutions are privately owned and are almost exclusively long-term care facilities. There are also approximately 1,500 private medical clinics and 4,000 community organizations active in health and community services. Almost 7% of the Quebec labour force (approximately 250,000 people) work in health and social services. Each of the 18 socio-health regions includes one or more CSSS, hospitals, rehabilitation centres, and child and youth protection centres.

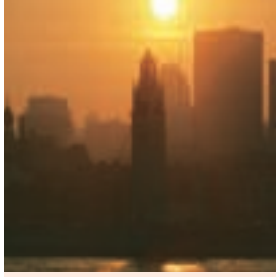
6.2.4 Public Health Goals and Programs of Interest

The *Loi sur la santé publique* (Quebec public health act), which came into effect in December 2001, is intended to protect and maintain public health through a provincial health program, regional action plans and increased health surveillance. In 2003, the *Programme national de santé publique (2003–2012)* (provincial public health program) was launched. Its general objective is to improve determinants of health and well-being by reducing health and psychosocial problems and trauma. In the context of climate change, the maintenance of air quality, surveillance of infectious diseases and reduction of poverty are very relevant. These issues are addressed specifically through research and innovation as well as through environmental health intervention (MSSS, 2003b). INSPQ is involved in research, which includes working on climate change, training researchers and publishing their work (INSPQ, 2006a).

6.2.5 Other Provincial and Municipal Policies

Various governmental policies on social housing, emergency preparedness, water management and sustainable development complement the above-mentioned public health programs in being able to implement steps that are needed to address climate change. The Société d'habitation du Québec (SHQ) (Quebec housing corporation) administers several programs to improve the supply and quality of social housing in Quebec (SHQ, 2006). Since 2001, the *Civil Protection Act* has defined areas of organization and action for organizations and agencies responsible for civil protection, as well as their responsibilities, such as those of municipalities in implementing their emergency plans (Ministère de la Sécurité publique (MSP), 2005). Section 16 of the Act obliges municipalities to define their objectives for reducing vulnerability to risks associated with major disasters, and to identify actions required to achieve these objectives. This change focuses on prevention versus reaction (i.e. reacting to disasters).

In 2002, the *Ministère du Développement durable de l'Environnement et des Parcs* (MDDEP) adopted the water policy (*Politique nationale de l'eau*), which is a comprehensive synthesis of water issues in Quebec (MDDEP, 2002c). As a result of this policy, changes were made to regulations on the quality of drinking water to ensure that small distribution networks provided quality drinking water and that water treatment plant employees were appropriately trained (MDDEP, 2005b). An international agreement on sustainable water resources in the Great Lakes-St. Lawrence River Basin was signed by two Canadian provinces (one of which was Quebec) and eight U.S. states (MDDEP, 2005c). The purpose of the recent *Loi sur le développement durable* (sustainable development act) is to guide sustainable development in Quebec; it is a first step toward a sustainable development policy (MDDEP, 2006a). The most recent Policy on Health and Well-Being dates back to 1992 and does not include measures to address climate change (MSSS, 1992). However, public health measures are outlined in the Government of Quebec Climate Change Action Plan 2006–2012, announced at the end of June 2006 (Government of Quebec, 2006e), and are discussed in the following two sections.



Certain municipal initiatives should also be recognized. Because of their responsibilities in land use and urban planning, municipalities are responsible for zoning. Many are currently revising urban boundaries within which future construction of all types will be permitted. The use of new flood-risk area maps will also be considered more frequently over the next few years. The *Union des municipalités du Québec* (UMQ) (association of Quebec municipalities) has also adopted a number of policies and programs on climate change. The *GES-Énergie municipalités* (GHG-municipal energy) program aims to reduce municipal GHG emissions. More than 200 municipalities already participate in the program (UMQ, 2006). For example, in 2004, Quebec City adopted a plan to reduce GHG emissions by 22% by 2010 (Ville de Québec, 2004). This plan has already begun to yield results (Ville de Québec, 2006). The key roles that municipalities play in developing and implementing recycling, transportation and environmental policies, as well as in the leadership of emergency preparedness plans, make them key players in adapting to climate change.

6.2.6 Status of Surveillance and Monitoring

The provincial public health program includes a surveillance program to learn about and share information on the status of population health, including the acquisition, production and distribution of data (MSSS, 2003b). The current surveillance program tracks more than 150 indicators (mortality, morbidity, health determinants, services, etc.), and will develop several dozen more over the next five years. The program could be adapted for the surveillance of health issues related to climate change because of its flexibility in analyzing priority or emerging issues, and its capability for prospective analyses (simulations) targeting certain health issues.

In 2004, INSPQ's *Infocentre de santé publique* (public health information centre) centralized data acquisition and implemented provincial surveillance tools—an essential step to understanding health problems on a large scale. All large databanks are now, or will be, hosted by INSPQ (or accessible under agreements with INSPQ), including data on meteorology, climate simulations, environmental pollution, etc.. The current plan provides for the development of indicators related to climate change within the *Infocentre de santé publique.* These will include a component that incorporates spatial and temporal analyses related to climate for some notifiable diseases, the implementation of a system for the surveillance of physical and mental health during ECEs, and improvements to the alert system for heat waves for a coordinated, real-time follow-up. INSPQ is also participating in the development of an Internet atlas of public health vulnerability to climate change (Gosselin, 2005). All these recent initiatives will be implemented between 2006 and 2012.

6.2.7 Ouranos Consortium and Public Health

The Ouranos Consortium is a multidisciplinary research and development (R&D) organization that studies climate change and adaptation; it includes some 250 scientists from 10 provincial ministries, one federal department, a Crown corporation (Hydro-Québec) and four universities. MSSS became a formal member in 2004, although it had been involved in joint health projects since 2002. Research activities include 10 programs and approximately 60 projects, 10 of which are part of the 2006–2009 health plan adopted in March 2006. MSSS has mandated INSPQ to coordinate and conduct part of the research on the health effects of climate change and required adaptations, in cooperation with regions, Ouranos partners and Health Canada.

6.3 STATUS OF CLIMATE CHANGE ADAPTATION INITIATIVES, 2004–07

6.3.1 Context

Climate change will have diverse effects. According to international authorities (World Health Organization (WHO), 2003; United Nations, 2007a, 2007b) and several multinational corporations (Earth Institute, 2007), proactive solutions to create measures to adapt to and mitigate the impacts must be implemented immediately. National and international health authorities have targeted six areas essential to human health: heat waves and urban heat islands; preparation for extreme climatic events (ECEs); water and food; vector-borne and zoonotic diseases (WHO, 2003; Warren et al., 2004; Menne and Ebi, 2006); exposure to ultraviolet (UV) rays; and air quality. MSSS, INSPQ and Ouranos are addressing these areas on a regional scale in Quebec. This section provides an overview of the efforts that are starting or underway to prevent or mitigate the negative health effects associated with climate change.

6.3.2 Methodology

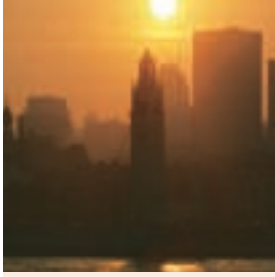
Literature review and semi-structured telephone interviews provided the information on current adaptation initiatives in each of the six targeted areas. The literature review (of scientific and government documents) was conducted using general (Google) and specialized (e.g. Medline, Web of Science) search engines, and from sources published either in French or English between 1995 and 2005 that were applicable to Quebec. Semi-structured telephone interviews, averaging approximately 15 minutes each, were conducted with key informants from public and private institutions (e.g. health care, occupational health and safety, air quality protection, urban climates, land management and environmental measures, air conditioning technology, environmental law and public safety). These key informants were from the 15 administrative regions in southern Quebec; the northern regions are addressed in Chapter 7, Health Impacts of Climate Change in Canada's North.

The initiatives identified for the period 2004–07 were assessed by comparing them with Canadian, American or international recommendations from various organizations such as the Government of France, U.S. Environmental Protection Agency (USEPA), U.S. Centers for Disease Control, the World Meteorological Organization, the World Health Organization and Health Canada. Emphasis was on the following subjects: heat waves and urban heat islands; preparation for ECEs; water and food; and vector-borne and zoonotic diseases. National and international health recommendations were compared with current adaptation initiatives in Quebec to address issues related to the various themes studied, and a synthesis of the required adaptations was prepared. The results of these overviews were recently published (Giguère and Gosselin, 2006a, 2006b, 2006c, 2006d). Two other areas, UV rays and air pollution, have not yet been investigated in depth because of limited available resources. The relationship between air quality and climate change in Canada is reviewed in Chapter 4, Air Quality, Climate Change and Health.

6.3.3 Heat Waves and Urban Heat Islands

6.3.3.1 Context

In southern Quebec, global climate models predict that by the end of the century, average temperatures will increase by an additional 2 to 3°C in the summer (Ouranos, 2004). This would likely be accompanied by an increase in the frequency and intensity of heat waves (Warren et al., 2004). The definition of a heat wave varies a great deal from one location to another (Institut de veille sanitaire (InVS), 2003b). For Quebec, a heat wave warning is currently issued when the Environment Canada forecast for a period indicates

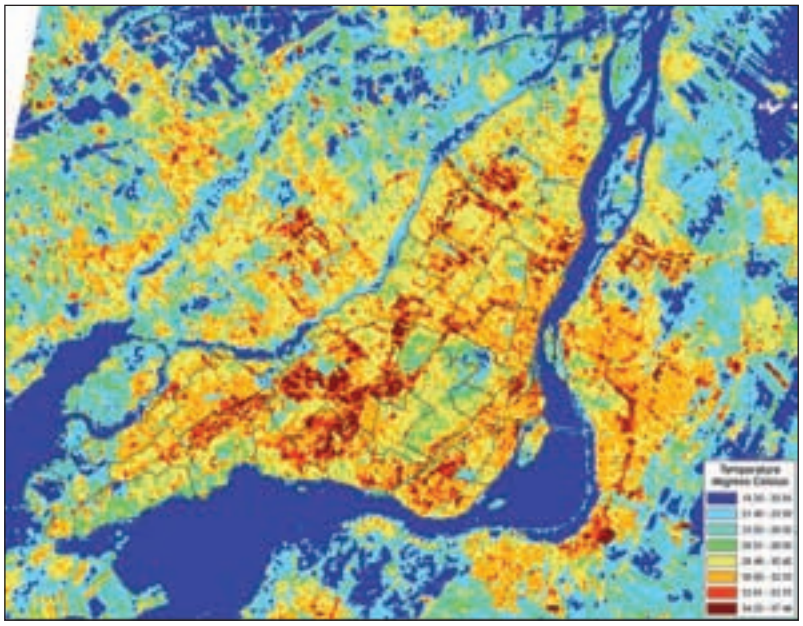


no less than three consecutive days during which daytime outdoor air temperatures are greater than 33°C and the minimum nighttime temperatures are 20°C or greater, or two nights during which the temperature remains at 25°C or more (Direction de santé publique (DSP) de Montréal, 2004, 2006).

The urban heat island effect (UHIE) is generated by asphalt surfaces and various infrastructure materials that absorb heat, thereby increasing the outdoor air temperature by 0.5 to 5.6°C (Oke, 1982) (Figure 6.3). This phenomenon affects a significant proportion of the population, especially socio-economically disadvantaged individuals living in urban areas and people with chronic illnesses or cardio-respiratory diseases (including children and seniors) (Patz et al., 2000; Michelozzi et al., 2005; Haines et al., 2006).

A general provincial plan is not in place for adaptation measures to address heat waves and UHIEs. However, MSSS has stipulated that, for 2007, public health units in the seven socio-health regions in southern Quebec are to include specific intervention strategies for periods of extreme heat in their emergency measures plans (MSSS, 2006a). Initiatives also include various brochures and training programs related to the risk of heat waves to the general population and certain vulnerable groups, such as seniors or certain groups of workers (Commision de la santé et de la sécurité du travail (CSST), 2004; MSSS, 2004).

Figure 6.3 Example of heat islands in the Montreal region, summer 2001



Source: Courtesy of F. Guay, Ouranos Consortium.

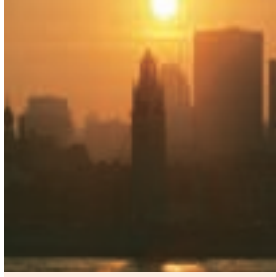
6.3.3.2 Current adaptations

In 2004–05, heat wave warning systems were prepared for nine cities with more than 100,000 inhabitants. As yet, none of the cities has had to deal with a long-lasting heat wave. However, some of the initial steps before a full alert have been successfully implemented in real-life situations. A simulation in Montreal (Health Canada, 2005) also identified some improvements that could be made to existing plans. In addition, Ouranos is currently planning or conducting research projects on heat waves and UHIEs (Table 6.1).

Table 6.1 Projects under the Ouranos health program, 2006–09

Theme	Title
Heat Waves and Climate Warming	1. Additional historical analyses of hospital morbidity, emergency room visits and general mortality as a function of historic temperatures and simulated analyses for the 2020, 2050 and 2080 horizons. 2. Implementation of roundtables to assess the measures required for adaptation to climate change: institutional and clinical components. 3. Identification of sectors vulnerable to intense heat in a Canadian metropolis for intervention and research on public health.
Other Extreme Climate Events	4. Feasibility study for the development of real- and non-real time tools for surveillance of the health effects of extreme climate events.
Air Quality	5. Estimation of future smog levels with the Unified Regional Air-quality Modelling System (AURAMS) and the Canadian Regional Climate Model (CRCM). 6. Fine spatial variations in mortality and hospitalization with extreme climate events in urban environments.
Water Quality	7. Feasibility study of water management projects using current Ouranos water projects. 8. Incidence and distribution of gastrointestinal illnesses among populations at risk and the risk factors associated with climate and agricultural practices.
Integration, Communication and Strategic Support	9. Development of an interactive atlas on health vulnerabilities associated with climatic change. 10. Integration, dissemination and transfer of knowledge and support for Ouranos activities by the Quebec MSSS and its networks, Health Canada and the World Health Organization.

Various initiatives (using pamphlets and other communication tools to address the risks associated with extreme heat) have been put in place to inform the general public and some of the more vulnerable clients, such as seniors and their families, and certain groups of workers. A similar awareness-raising initiative was undertaken with health institutions and other groups (e.g. CSST, Réseau public québécois de la santé au travail (Quebec public occupational health network) and organizations (e.g. medical clinics, pharmacies, Fédération des locataires d'habitations à loyer modique (federation of low-cost housing tenants). A recent exploratory study in the Estrie region on medication use during periods of oppressive heat illustrates the importance of cautions by pharmacists (Albert et al., 2006). A significant percentage (30.2%) of people aged 65 and over take a type



of prescription medication whose absorption can be affected by dehydration, or that can impede caloric loss or alter kidney function. Nearly 5% of seniors were taking three or more medications of this type at the same time.

Several municipalities (e.g. Quebec, Gatineau, Montreal, Laval, Saint-Eustache) are increasing tree plantings along streets, improving tree maintenance and making their replacement mandatory. Province-wide standardization of fines for cutting down trees should contribute to their conservation (Government of Quebec, 2005a). The increasing interest in green roof systems and high-albedo roofs[3] that lower the absorption of solar energy, and increasing use and availability of public transportation in some regions help to reduce the UHIE (Ducas, 2004; Ville de Montréal, 2005).

6.3.3.3 Required adaptations

In light of literature reviews and semi-structured telephone interviews (Giguère and Gosselin, 2006d), the following could be developed in Quebec to decrease the negative effects of heat waves and urban heat islands, according to the authors:

- increased training for health professionals;
- popular education pilot projects on personal protection during heat waves and on helping to combat the UHIE;
- economic measures to encourage the implementation of various initiatives to mitigate the effects of heat waves, specifically measures related to better residential insulation;
- improvement of knowledge related to aeration, ventilation and air conditioning for health and long-term care centres;
- new guidelines for the management of health care centres during heat waves; and
- ongoing reinforcement of initiatives that have already been implemented, specifically those addressing real-time monitoring of the effects of heat waves.

A record of existing air conditioning in hospitals and long-term care centres is suggested to ensure knowledge of the resources, target where improvements can be made, and complete the information being collected for current extreme-heat research projects. MSSS is currently implementing such a system. Regulations on energy efficiency in buildings date back to 1983, and are currently being re-evaluated by the government.

6.3.3.4 Synthesis

Current heat wave adaptation efforts appear fragmented. However, although certain key preventative measures are lacking, ongoing and completed research projects (Table 6.2), legislation, heat wave-related emergency plans and surveillance measures represent a very good start for the implementation of adaptation measures. Preventative measures, notably to combat the effects of urban heat islands and to improve the energy efficiency of homes and institutions, in addition to the commitment to increasing air conditioning in care facilities (Government of Quebec, 2006e), are to be implemented, likely in the coming years. To date, the initiatives represent a balanced portfolio of short-term measures as well as long-term preventative ones.

3 High-albedo roofs reflect most of the solar energy away from their surface before it is absorbed and converted into heat energy.

Table 6.2 Other ongoing or completed (C) health projects in Quebec except for northern regions (2002–2008)

Theme	Title
Heat Waves and Climate Warming	1. Awareness of risks encountered by outpatients suffering from chronic pulmonary disease and measures to be taken during periods of intense heat (2008) 2. Historic variability analysis of general mortality (in relation to temperature) and simulations for 2020, 2050 and 2080 with downscaling (C) 3. Survey of personal and family perceptions, vulnerabilities and adaptations (C)
Air Quality	4. Increase in concentrations of organic particulate (pollen) caused by climate change and potential consequence for respiratory disease and vulnerable populations in urban environments (Climate Change Action Fund) (C)
Vector-Borne and Zoonotic Diseases	5. Geosimulation of the progression of West Nile virus infection as a function of climate in Quebec (2007)
Climate Change and Adaptations	6. Survey of health and municipal managers on perceptions, vulnerabilities and adaptations (includes extreme climatic events) (C) 7. Post mortem on adaptations to disasters and catastrophes (including extreme climatic events), for the period between 2004 and 2007 (C) 8. Post mortem on adaptations to vector-borne diseases in Quebec, for the period between 2004 and 2007 (C) 9. Post mortem on adaptations to heat waves and urban heat islands in Quebec, for the period between 2004 and 2007 (C)

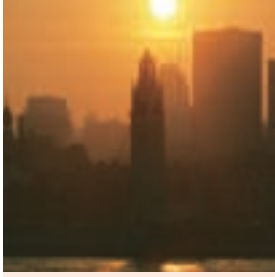
Note: (C) indicates completed projects.

6.3.4 Emergency and Extreme Climate Event Preparedness

6.3.4.1 Context

In Quebec, as elsewhere in the world, climate scenarios predict an increased frequency and intensity of certain ECEs including hurricanes, heat waves and heavy rainfall causing floods (Ouranos, 2004). The ice storm that hit the Montreal region in 1998 was a turning point in Quebec's awareness of civil protection; in 2001, the *Civil Protection Act* reorganized the civil protection system (MSP, 2005).

The consequences of ECEs include damage to physical structures and individuals (both the people who are affected and those who work with them) who experience short- and long-term physical and psychological effects (Maltais et al., 2001a, 2001b; Auger et al., 2003). Displacement of affected populations, the gravity of health effects, insurance coverage and material losses may all lead to psychological sequelae.



6.3.4.2 Current adaptations

Recent changes to provincial legislation have improved civil protection (MSP, 2005) and the linkages among stakeholders appear to have improved. Most of the adaptation initiatives have their roots in the surveillance and monitoring, training and education, and regulation and policy sectors. A storm and flood detection system and real-time surveillance of dams and rivers is in place for the entire province. A new, standardized approach to risk analysis and management in municipalities for 19 risks is being implemented, and is complete for two risks: forest fires (natural) and fires (human-induced) (Table 6.3). The involvement of public health branches, MSSS and INSPQ is planned as part of the implementation of emergency plans and measures. Land use plans for cities and regions intend to include climate change considerations that are consistent with provincial regulations (flood plain management) and advice from public health branches, and MSSS will provide feedback on development plans and urban planning. Ouranos will be undertaking a research project on the ECEs (Table 6.1) that involves assessing the feasibility of developing real- and non-real-time surveillance tools for the health effects of these events.

Table 6.3 Types of natural or human-induced risks that will be included in risk analysis in Quebec municipalities

Risks	
Natural	***Human-induced***
Avalanches	Social disruption
Meteor showers	Buildings and structures collapse
Epidemics, pandemics, infestations	Major fires and conflagrations
Forest fires	Failure, shortages and contamination of goods and services
Floods	Industrial risk
Landslides	Nuclear and radioactive risks
Storm surges	Dam failure
Extreme weather phenomena	Terrorism
Earthquakes	Hazardous material transportation accident
	Accident when transporting people and merchandise

Source: MSP, 2004.

6.3.4.3 Required adaptations

Based on the summary of the adaptations recommended by the various agencies that were consulted, the authors of this study concluded that Quebec should further develop prevention programs or invest in programs to address ECEs (Giguère and Gosselin, 2006b). Investments have increased over the past 10 years, but they have recently declined. The following initiatives for adaptation to ECEs in the context of climate change are encouraged:

- improvement of planning and preventative investment for ECEs, such as the protection of buildings and critical infrastructure (e.g. power supplies, specifically for heating and food storage), and water treatment facilities;
- measurement, modelling and the communication of risks for the various types of ECEs over the short-, medium- and long-term to develop appropriate initiatives;

- research on the short- and long-term effects of ECEs on health and the improvement of emergency health measures; and
- implementation of a system for the surveillance and epidemiological follow-up of health effects (deaths, injuries, infectious diseases, psychosocial effects) of ECEs.

6.3.4.4 Synthesis

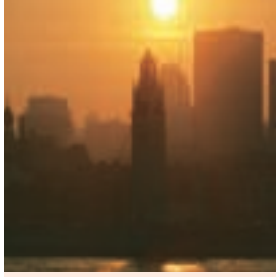
Quebec has one of the most advanced health surveillance and environmental monitoring systems in Canada, as well as a good emergency response system according to the study led by Giguère and Gosselin (2006b). However, none of these health surveillance systems specifically addresses ECEs, a gap the authors recommend to correct. Disaster and ECE adaptation initiatives should be developed by adding a component relating to the effects of climate change, as well as a significant component relating to the prevention of impacts on health. The risk analysis approach used by civil protection stakeholders (implementation is beginning) will play an important role in achieving this. These suggestions have been integrated into the 2006–2012 action plan of the Quebec government (Government of Quebec, 2006e).

6.3.5 Water

6.3.5.1 Context

The current abundance of water resources is reflected in the 326-litre average per capita daily water consumption (Center for Research and Information on Canada (CRIC), n.d.) and the many private swimming pools in Quebec (50% of pools for 23% of the population). The projected effects of climate change include the drop in levels, flow and quality of watercourses; changes in the rainfall regime; and an increase in the salinity of the St. Lawrence River (Environment Canada, 2005b). These changes will have a significant impact because surface water is the source of drinking water for more than 70% of Quebeckers (MDDEP, 2002a). The quality and quantity of current abundant water resources could be compromised. The possible impacts are substantial and briefly described here.

Water-borne diseases can occur when pathogenic microorganisms migrate to underground or surface water sources (Canadian Council of Ministers of the Environment (CCME), 2004, 2005). Phosphorus, nitrogen, sunlight and heat are the primary factors associated with the formation of cyanobacterial water blooms (Magnuson et al., 1997; Giani et al., 2005; Rolland et al., 2005). In Quebec, this phenomenon was reported in 84 lakes and streams between 1999 and 2003 (INSPQ, 2006c), and led to bans on consuming and bathing in the water from these sources, although no cases of human disease have been reported to date. The cyanotoxins produced by cyanobacteria can cause skin irritation, as well as severe liver and nerve damage when contaminated water comes into contact with skin or is ingested (American Water Works Association, 1999; Agriculture and Agri-Food Canada, 2003). Young children, seniors and people with chronic diseases are at higher risk of developing severe symptoms from contaminated water. People who are engaged in water sports are also particularly vulnerable to natural biotoxin contamination (Agence de développement de réseaux locaux de services de santé et de services sociaux, 2003; MDDEP, 2005a). The larger population could be affected both physically and psychologically by water shortages, and families at risk could experience a higher degree of food insecurity if they were required to purchase their water (DSP de la Montérégie, 2004).



6.3.5.2 Current adaptations

Water quality surveillance is generally well organized by MDDEP and the St. Lawrence Centre. Training for regional public health branches on water issues is excellent, and abundant information is available to the public and professionals. Several environmental initiatives to decrease contaminants are underway in cities and industry, including the forestry and agricultural sectors. The recent changes made to water quality (MDDEP, 2005b) and pesticide legislation should have a beneficial effect on water quality by decreasing surface runoff waste.

Surveillance of illness outbreaks associated with water and food is not well developed among the general population but is better established in institutional and commercial settings. Ouranos is planning public health research projects on water quality (Table 6.1).

6.3.5.3 Required adaptations

Comparison of existing adaptations with those recommended (Giguère and Gosselin, 2006a) indicates the following should be developed or more widely applied throughout the province:

- accelerated implementation of various methods for maintaining optimal water quantities to ensure the safety of persons (fire, basic hygiene, food requirements) and quality drinking water (pressure, dilution). These include specifically:
  - optimization and standardization of leak detection for water supply systems
  - education of individuals and businesses about the importance of and methods for conserving drinking water
  - inclusion of low water use techniques in the *Building Code*;
- strict control of water quality surveillance in small drinking water supply systems;
- financial support to implement watershed management, to accelerate implementation and preserve multiple uses;
- development of management policies for cases of conflict over supply; and
- improved epidemiological surveillance of health impacts related to drinking water and recreational water to ensure faster and more sensitive detection of outbreaks by public health authorities.

6.3.5.4 Synthesis

Climate change will likely have a major negative impact on the quality and quantity of water resources in Quebec due to more frequent and severe low-flow and drought periods, as well as diminished flow from Lake Ontario (into the St. Lawrence) and the Ottawa River (Environment Canada, 2002; Croley, 2003; Fagherazzi et al., 2005). Because these sources provide drinking water for the Greater Montreal area, major difficulties in water use management are expected (Vescovi, 2003). Water quality also seems to be affected by climate change, and abundant rainfalls have been associated with increased rates of gastroenteritis in recent studies from the U.S. (Curriero et al., 2001) and Canada (Thomas et al., 2006). The legislative frameworks for drinking water quality, watershed management, and pesticide management are basic tools for adapting to climate change, and have recently been updated significantly. Their implementation has begun, and water resource management practices and water treatment infrastructures should be better coordinated because currently several controversial files affect land management and public health.

6.3.6 Vector-Borne and Zoonotic Diseases

6.3.6.1 Context

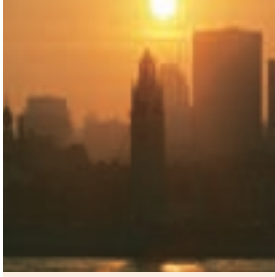
In Quebec, the trend toward warmer temperatures (which has been observed and predicted by climatic scenarios) could encourage the appearance of vector-borne and zoonotic diseases that do not normally occur here, or could increase the range for some diseases currently present. According to models, Lyme disease is expected to appear in southern Quebec within 10 to 20 years (Ogden et al., 2006) (Figure 6.4). Climate influences several aspects of infectious disease cycles, such as the reproduction of animals, insects and ticks; the ease with which insect vectors can transmit the disease; and human behaviour leading to exposure to various vectors (Ontario Forest Research Institute, 2003). Other than the West Nile virus, there are currently no other significant cases of vector-borne diseases; only one isolated case of hantavirus has been reported to this point (Giguère and Gosselin, 2006c).

Figure 6.4 Simulation of changes in the range for Lyme disease, toward 2050

Source: Ogden et al., 2006.

6.3.6.2 Current adaptations

Surveillance of zoonotic and vector-borne diseases is well organized by the various departments involved, in part because the public system subsidizes a portion of the research. Certain diseases require mandatory reporting; this measure helps to limit outbreaks. The Public Health Agency of Canada and MSSS make information about infectious diseases available to the public and professionals. Public health branches distribute pamphlets and provide information on Internet sites to keep the public informed about current infectious diseases. The *Laboratoire de santé publique* (public health laboratory) is very well organized and provides excellent support for any analyses that are required.



West Nile virus was the most closely monitored disease until recently (Gosselin et al., 2005), as sampling campaigns and larvicide control measures ended in 2006. Several research projects have been completed or are underway (Table 6.2). A decision-support tool is being designed for West Nile virus, based on the geosimulation approach and including the climate change context (Bouden et al., 2005). Several very effective zoonotic surveillance networks have been established by the *Ministère de l'Agriculture, des Pêcheries et de l'Alimentation* (MAPAQ) (department of agriculture, fisheries and food) (MAPAQ, 2006) and the *Institut national de santé animale* (national animal health institute). Since 1997, they have regularly collaborated with MSSS and the public health branches on epidemiological research. MAPAQ has also invested heavily in research and laboratories over the last few years (MAPAQ, 2006).

6.3.6.3 Required adaptations

Experts consulted in the Giguère and Gosselin study (2006c) outlined several important steps for improved adaptation to the emergence and increase of zoonotic and vector-borne diseases related to the effects of climate change in Quebec:

- maintain, encourage and implement integrated surveillance systems for zoonotic and vector-borne diseases that may present new risks with climate change;
- include indicators related to the effects of climate change—such as consideration of the epidemiological and ecological changes related to these diseases—in surveillance systems for zoonotic and vector-borne diseases;
- heighten awareness and education initiatives for individuals, farmers, and human and animal health professionals to address emergence, intensification, detection and protection issues as they relate to zoonotic and vector-borne diseases in the context of climate change; and
- continue research into methods for the control of zoonotic and vector-borne diseases; specifically, the implementation of preventative technologies to prevent natural and artificial aquifers from becoming suitable mosquito breeding areas and the inclusion of these technologies in infrastructure construction standards.

6.3.6.4 Synthesis

Considering the several climate change adaptation initiatives underway in this area of public health, it is the area that offers the most extensive coverage of the population. However, Giguère and Gosselin (2006c) note that Quebec has been spared to a great extent from vector-borne health risks until now. In the future, climate change will likely increase the importance of vector-borne diseases in the province. Legislative reform with a view to better control of vector-borne and zoonotic diseases has led to significant investment in monitoring and laboratory testing in the agricultural sector. The importance of food safety in a context of commercial agricultural production has helped to stimulate various adaptation initiatives that are also related to reducing risks associated with vector-borne and zoonotic diseases; the significance accorded to these initiatives by the health sector has increased. However, difficulties exist, such as how to effectively reach the thousands of farmers scattered across the province and how to deal with millions of potential mosquito breeding grounds. Existing vector-borne and zoonotic surveillance systems have not yet been tested in a large scale event in such a way as to demonstrate their capacity to handle a major epidemiological situation affecting humans.

6.3.7 Other Subjects

6.3.7.1 Ultraviolet rays (UV)

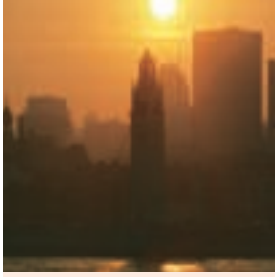
With climate change, it is expected that the warm season will be extended, and public exposure to UV rays will increase (Hill et al., 1992).

The incidence of health problems associated with over-exposure to UV rays, particularly sunburns and skin cancer, could continue to increase at a greater rate than in previous decades. An increase in the number of cataracts can be expected, as well as an immunosuppressant effect that could, for example, have a negative effect on vaccine effectiveness and foster the development of epidemics (WHO, 2003). Despite this fact, there has been very little research into climate change and public exposure to UV rays in Quebec. Furthermore, UV protection is rarely considered in proposed climate change adaptation measures in Quebec despite its priority nationally (Warren et al., 2004). The effects on public health are serious, with more than 80,000 new cases of skin cancer in Canada each year. This is the most common type of cancer (Canadian Cancer Society, 2005). The health effects associated with UV rays are preventable with modified personal protection behaviours and with the creation of shade. Moreover, UV risk-awareness programs are cost effective. For example, in Australia, the prevention of the negative effects of UV rays costs an average of eight cents (US) per capita whereas cancer treatment costs $5.70 (US) per capita (WHO, 2003).

Tools currently available include the UV index issued by Environment Canada, which is widely available to the public. In addition, the National Sun Safety Committee brings together scientists from every Canadian province to encourage cooperation and intersectoral action in reducing the incidence of UV-caused skin cancer (Canadian Strategy for Cancer Control, 2001). Required adaptation measures include increased educational programs about the dangers of UV exposure, research projects to measure the effects of climate change on population behaviour in terms of UV exposure, and measuring the effectiveness of the various adaptation measures designed to decrease UV exposure. Preventative measures for shade creation will also be useful.

6.3.7.2 Air quality

In addition to producing carbon dioxide (CO_2), the burning of fossil fuels affects air quality. Various pollutants and tropospheric ozone precursors, as well as the fine particulates involved in the production of urban smog, have been proven responsible for harmful health effects. More than 80.4% of Quebeckers live in urban areas, and 25% of them live in the Montreal area (ISQ, 2006e, 2006f), which is already greatly affected by poor air quality (ISQ, 2006e, 2006f; INSPQ, 2006c). Climate change will also increase the time periods conducive to smog formation (Warren et al., 2004). Further, climatic warming will have an additional negative impact on air quality because there will be longer growing seasons, causing an increase in concentrations of airborne pollens (Warren et al., 2004; House and Brovkin, 2005).



Climate models predict an increase in the frequency of ECEs, including droughts, wildfires and storms (increased pollen dispersion is among the associated effects), all of which have a negative impact on air quality (Warren et al., 2004; U.K. Department for Environment, Food and Rural Affairs (DEFRA), 2005). In Montreal, links have been established between climate and pollen concentrations, as well as among pollen concentration, visits to the doctor and socio-economic status (Garneau et al., 2005). Poor air quality is responsible for premature deaths among vulnerable populations, such as individuals with respiratory disease, allergies or cardiac disease, in particular children and seniors. The effects of pollen can compound this and are significant in terms of health effects and costs, given the existing high rate of allergies. It is estimated that 10% of the population suffers from respiratory diseases and allergies (Agence de la santé et des services sociaux de la Montérégie (ASSSM), 2002); in Quebec in 1992, the annual direct cost of hay fever amounted to $49 million.

This area of concern is the subject of current research projects (Table 6.1) as well as one recently completed project (Table 6.2). Existing adaptations in place include air quality indices (e.g. InfoSmog) available throughout the year (Environment Canada, 2006b), but their usefulness appears minimal according to recent studies (Bélanger et al., 2006a; Tardif et al., 2006) and they will likely need to be enhanced. The required adaptations include preventative measures to encourage decreased activities during periods of high air pollution, and the promotion of measures to improve air quality, such as using public transportation, travel by bicycle or on foot, and the purchase of smaller vehicles that consume less energy and raw materials to manufacture and operate. Further information and data on the relation between air quality and health should be considered a priority, given the burden that poor air quality imposes on health.

6.3.7.3 Strategic communication and research tools

Climate change adaptation efforts should be conducted in a concerted manner, based on reliable and accessible data, to respond effectively to new demands and to involve all stakeholders. Current initiatives include an atlas of health vulnerabilities, and projects under the Ouranos health program (Table 6.1) and the INSPQ Infocentre (INSPQ, 2006b). However, a permanent knowledge-based distribution and transfer program to address climate change adaptations has yet to be developed and implemented. This program would be intersectoral, given the wide range of adaptations and the various stakeholders involved. This activity is included under the Ouranos health program outlined in Table 6.1.

6.3.8 Synthesis

Currently, several climate change adaptation initiatives are being implemented—a positive indication for the province. These include an integrated and planned research and surveillance effort that addresses the connection between health status and climate; and certain products are being distributed to managers in various provincial departments and the regions and used for policy formulation and program development. The recent implementation of several significant legislative and regulatory tools to protect public health and to implement preventative measures is also a positive element in the context of adaptation to climate change. The excellent history of interministerial and intersectoral cooperation in Quebec will be a considerable asset in the highly complex domain of adaptation. But as yet, there is no integrated public health program that could launch a coordinated charge on the priorities in this area and address the gaps that have been identified (Bélanger et al., 2006a).

In light of the research conducted and experts who were consulted (Giguère and Gosselin, 2006a, 2006b, 2006c, 2006d), the following initiatives in the areas listed here should be developed.

For extreme heat:

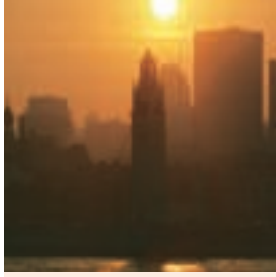
- training for health professionals;
- implementation of popular education pilot projects on personal protection during heat waves and on contributing to controlling the UHIE;
- addition of economic measures to encourage the implementation of initiatives to mitigate extreme heat phenomena, specifically measures related to better housing insulation;
- improvement of knowledge about aeration, ventilation and air conditioning for health care centres and nursing homes;
- new guidelines for the management of health care centres; and
- ongoing reinforcement of initiatives that have already been implemented, particularly with respect to real-time surveillance of the effects of heat waves.

For adapting to ECEs in the context of climate change:

- promotion of a culture of preventative planning for ECEs, such as building protection, critical infrastructure (e.g. transportation, power supply, water treatment plants);
- measurement, modelling and communication of risks of the various types of ECEs in Quebec over the short, medium, and long terms to develop the appropriate initiatives;
- research on the effects of ECEs on health over the short and long terms, in addition to the improvement of emergency health measures; and
- implementation of a surveillance and follow-up system on health effects of ECEs as a function of the climate.

For water resources:

- accelerated implementation of the various methods for the maintenance of optimal water quality to ensure human safety (fire, basic hygiene, food needs) and drinking water quality (pressure, dilution). These include:
  - optimizing and standardizing leak detection in water supply systems
  - educating individuals and businesses on the importance and means of conserving drinking water
  - integrating low-water use techniques into the *Building Code*;
- strict control of water quality surveillance in small drinking water supply networks;



- financial support for watershed management and infrastructure to accelerate its implementation and preserve the multiple uses of the watershed;
- development of management policies for conflicts over supply; and
- improvement of surveillance of health effects related to drinking and recreational water.

For zoonotic and vector-borne diseases:

- implementation and maintenance of integrated surveillance systems for zoonotic and vector-borne diseases that may present new risks with climate change;
- inclusion of indicators related to the effects of climate change—such as consideration of the epidemiological and ecological changes related to these diseases—in surveillance systems for zoonotic and vector-borne diseases;
- intensified awareness and education initiatives for individuals and human and animal health professionals that address emergence, intensification, detection and protection issues as they relate to zoonotic and vector-borne diseases in the context of climate change; and
- continuation of research into methods for the control of zoonotic and vector-borne diseases, specifically the implementation of preventative technologies to prevent natural and artificial aquifers from becoming suitable breeding areas for mosquitoes, and on the inclusion of these technologies in infrastructure construction standards.

For protection against increased exposure to UV rays:

- increase in the visibility of educational programs on the dangers of UV exposure and on effective prevention measures;
- research projects to measure the effects of climate change on population habits in terms of UV exposure and measurement of the effectiveness of the various adaptation measures designed to decrease UV exposure; and
- creation of more shade in urban environments.

For air quality:

- assessment of the usefulness of air quality indices for behavioural changes related to preventative and protective measures;
- implementation of measures to improve air quality, such as the promotion of public transportation, travel by bicycle or on foot, and purchase of smaller, cleaner vehicles; and
- maintenance and development of available knowledge and new data on air quality and health.

6.4 HISTORICAL AND SIMULATED MODELLING OF MORTALITY FOR 2020, 2050 AND 2080

6.4.1 Introduction

In Canada, as in many other countries, climatic warming means an increase in average temperatures and a rise in sea level, as well as a greater probability of ECEs (e.g. periods of intense heat, freezing rain, floods) (Natural Resources Canada (NRCan), 2002). This situation is recognized as a public health concern (WHO, 2000, 2002; Donaldson et al., 2001) because of the effects of climate change on increased mortality and morbidity related to heat stroke, skin cancers, cardiovascular and respiratory diseases (e.g. asthma), vector-borne and zoonotic diseases, kidney disease, liver disease, neurological disease (e.g. epilepsy) and mood disorders (e.g. depression) (McGeehin and Mirabelli, 2001).

Some of the research undertaken for this chapter was to identify and simulate certain future climate-related health effects in Quebec. The first goal was to quantify the relationships among mortality, some morbidities and climate. The second goal was to project future rates of mortality and hospitalization for a given future Quebec climate. Analyses were carried out using mortality (1981–1999) and morbidity data (number of hospitalizations, individuals hospitalized or emergency room visits between 1981 and 2002) in tandem with chronological series on several climatic parameters (e.g. temperature, diurnal range, Humidex) to create statistical models. These models were then paired with regional projections for climatic variables generated by Ouranos to identify variations in mortality and morbidity for simulated future periods.

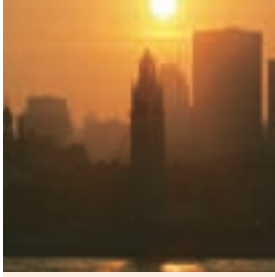
The first part of the results is presented here; this includes selected statistical mortality models for several cities and regions in Quebec, as well as projections associated with these models for three future periods (2020, 2050 and 2080 horizons). The other analyses on hospital morbidity and emergency room visits are underway and will become available in 2008. The main data sources used in this project are presented (under section 6.4.2 Methodology) along with a few details on data processing, as well as the creation of the database. The project methodology and results are then presented and discussed.

6.4.2 Methodology

Health data (deaths, hospitalizations, emergency room visits) are all from MSSS. Only non-traumatic deaths were included (codes 1 to 799 in the International Classification of Diseases (ICD-9)). Deaths for the period between 1981 and 1999 were used for the following two reasons:

- Beginning in 1981, death data were more reliable (before 1981 data were not exhaustive or not collected by area) and the format was easier to use; and
- Until 1999, cause of death was classified according to the ninth revision of the ICD (ICD-9) whereas beginning in 2000 the tenth revision (ICD-10) was used, making comparison more difficult.

Meteorological data were taken in part from Environment Canada airport weather stations. These stations collect by far the most complete data and include a large number of meteorological parameters. The airport station data sets were complemented by data from



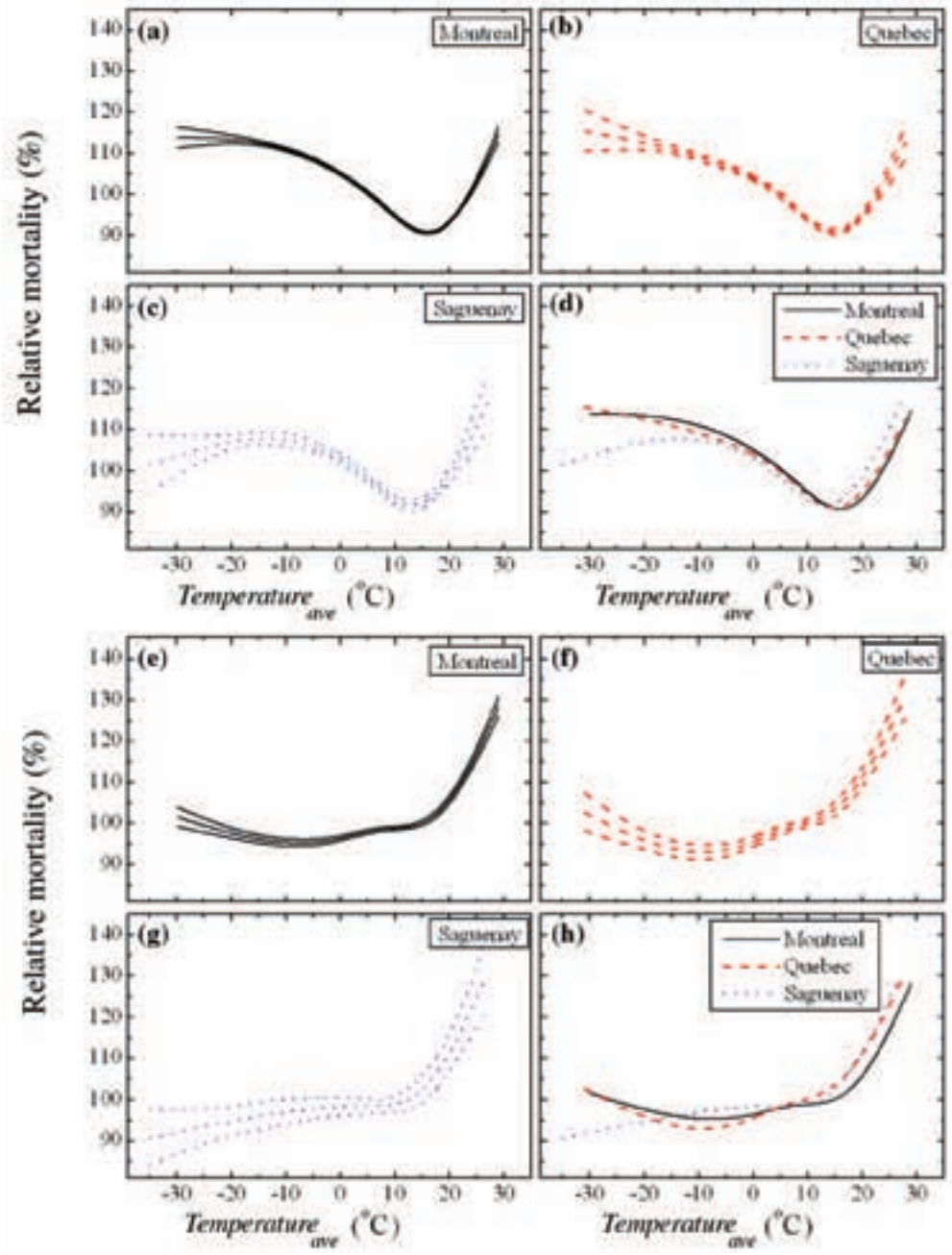
other Environment Canada stations (Environment Canada, 2005a). While the latter are numerous, they produce only temperature and precipitation data. Each truncated postal code was associated with the closest meteorological station. Thus, mortality and morbidity models could be created as a function of the climate for quite a variety of areas. The climate average for a given geographic area was obtained by using all stations associated with the postal codes in this area.

Ouranos provided climate data for future periods. These included daily maximum, minimum and average temperatures for the 2020, 2050 and 2080 horizons. The data are from a specific general circulation model known as the HadCM (Hadley Centre coupled model) (Gordon et al., 2000) paired with scale-reduction techniques (or statistical scaling) (Nguyen et al., 2005). General circulation models are developed on a planetary scale and simulate, among other things, the effects of increases in GHGs for future periods. For this research, two specific emissions scenarios were considered: A2 and B2 (Nakicenovic et al., 2000). These scenarios were established by the Intergovernmental Panel on Climate Change (IPCC), and correspond to various worldwide changes in social, demographic, economic, technological and other domains. It should be noted that the A2 scenario is based on a higher concentration of GHGs (approximately twice the current levels in 2080) than the B2 scenario (IPCC, 2007). Scale-reduction methods make it possible to scale down the simulation results from global models to more local proportions (e.g. town, region). Historic data from weather stations are used to make this change in scale. In the present study, the percentage of explained variance for each predictor-predictand pair is equal to the same order of magnitude (between 65% and 90%) found in the study by Gachon et al. (2005). The predictands considered here are minimum, maximum and average daily temperatures. The various sensitivity analyses carried out to verify the accuracy of the climate models used have shown a high level of reliability—with the exception of the 2020 horizon period, which could be problematic because of the weakness of the expected changes and the lack of statistically significant climate signals (Gachon and Dibike, 2006).

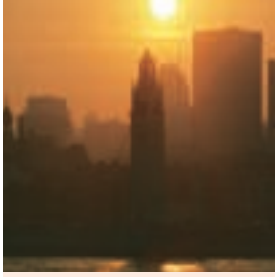
Projections of mortality variations were assessed for certain cities and administrative regions in the province. All cities considered have a weather station close by; this makes it possible to reduce the scale. However, the size of the administrative regions may have reduced the accuracy of projections for these areas. Finally, there are several general circulation models, each of which produces a different version of future climates. The model used here (HadCM3) generates projections close to the average of the other models with the possible exception of winter, where temperature increase projections are below the average (Chaumont, 2005).

Identifying the effect of climate on mortality relies mainly on methods initially developed by Schwartz et al. (1996) for research on the effects of air pollution on health. Use of the Poisson regression made it possible to obtain a statistical relationship between the number of deaths per day and the various meteorological parameters available. More formally, this is a general linear model with specific link functions (McCullagh and Nelder, 1989). A parametric cubic spline function was chosen by the authors of this study (Doyon et al., 2006) to represent the link between deaths and a given climatic parameter. To obtain this relationship, one must control for confounding factors (effects of the day of the week, seasons, long-term mortality trends). As an example, Figure 6.5 presents the relationship between temperature and mortality for three cities in Quebec with and without controlling for confounding factors.

Figure 6.5 Relationship between mortality and average daily temperature for Montreal and Quebec City and the Saguenay Region



Note: Graphs (a), (b) and (c) are taken from the model in which confounding factors are disregarded. Graphs (e), (f) and (g) illustrate those taken from the model in which confounding factors are taken into consideration. Graphs (d) and (h) are overlays of (a), (b), (c) and (e), (f), (g), respectively.



Several meteorological parameters may be included in the mortality model. A first scan was conducted by adding the climatic variables available to the model, one by one. Preliminary analyses were conducted for several cities (Montreal, Quebec, Gatineau, Sherbrooke, Saguenay) for deaths due to all causes, and certain more specific classifications (death due to diseases of the circulatory or respiratory systems). Models have been built that consider various combinations of maximum, minimum and average temperatures and the Humidex. These analyses have made it possible to select only average temperature as the temperature indicator in the model. This variable stood out above others from a statistical point of view. The Akaike (1973) information criterion was used as a performance indicator. The addition of the diurnal range had practically no effect on the model. Nor did dew point, humidity or atmospheric pressure improve residual deviation from the model. Various groupings for time variables were then considered. Once again, the various groupings for time variables were added one by one. For example, the average temperature one to three days prior to death was added to the average temperature model. Another scan was then conducted on all climatic variables in addition to trying various time groupings on each scan. The final model that was selected contained groupings of average temperature up to 14 days prior to death.

This model was then paired with long-term climate simulations to estimate variations in future mortality. The results presented here do not include demographic forecasts; therefore, it is assumed that the size or population of a city or region will not change in the future. This is common practice for these types of simulations, and allows for comparison with the current situation. A detailed discussion of the methodology, sensitivity analyses and a presentation of the selected equations and terms, by city and region is found in Doyon et al., 2006.

6.4.3 Results

6.4.3.1 Historical modelling

One of the project goals was to provide a provincially scaled description of current and future climate effects on the population. First, daily mortality was assessed for several cities in southern Quebec. Statistics by administrative region were added to complement the numbers for cities for which modelling could be problematic; the methodology described in the preceding text may be problematic when death rates are low (<2 deaths/day). The low numbers also prevented modelling age and cause of disease for all cities and regions.

For an in-depth portrait of climate effects on the population, a relationship was established between climate and deaths from all non-traumatic causes for the cities and regions for which the models were significant. Only Montreal was selected for comparison of the effects of heat on causes of death. The causes chosen were deaths due to diseases of the circulatory system (ICD-9, codes 390–459), the respiratory system (ICD-9, codes 460–519) and tumours (ICD-9, codes 140–239).

Figures 6.5 and 6.6 demonstrate the relationship between mortality and average daily temperature for some cities and regions in Quebec. Note that the curves represent relative mortality as a function of temperature. For a specific temperature, the curves compare mortality to the average mortality for all other temperatures, taking into account the seasons, long-term trends and days of the week. (For example, 130% mortality at a given temperature indicates that there were 30% more deaths at this temperature than the average.)

Figure 6.6 Relationship between mortality and average daily temperature for some regions in Quebec

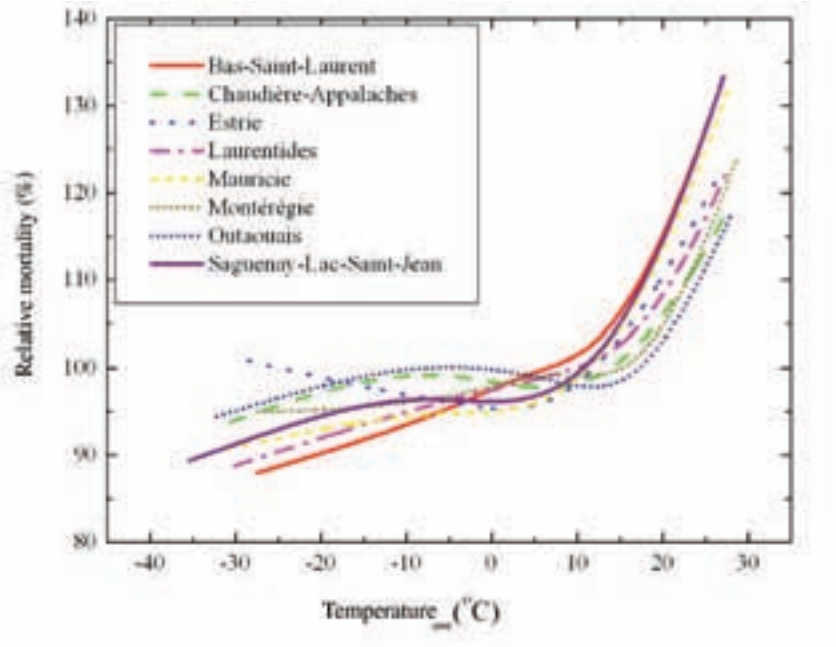


Figure 6.6 makes it possible, on a qualitative basis, to compare the effects of temperature on mortality for each region. The relationship with daily temperature was used because the latter is the climatic variable with the greatest effect on mortality. Generally, for all cities and regions, there seems to be a point beyond which the number of deaths increases almost linearly with temperature. In addition, the slope of the linear portion seems practically identical from one city or region to another. As for the effects of cold, no similar trends could be identified; the effects of cold seem to be more directly related to relative mortality as a function of temperatures in the weeks preceding death.[4]

Despite the size of the administrative regions and the different microclimates of those regions, the same quasi-linear relationship between mortality and temperature can be identified (for the "warm" part of the graph). For the Abitibi-Témiscamingue, North Shore, Lanaudière, Centre-du-Québec, Gaspésie-Îles-de-la Madeleine and Nord du Québec regions, no significant link between the temperature and the number of deaths seems apparent; consequently, these results are not presented. With the exception of Lanaudière and Centre-du-Québec, these regions are sparsely populated and are located in the northern and eastern parts of the province.

6.4.3.2 Estimating mortality for simulated future climates

The HadCM model with scenarios A2 and B2 was used for selected cities and regions to project the variation in mortality due to climate change for different periods. Figures 6.7 and 6.8 show projections for summer and annual mortality, respectively, for several cities. Figures 6.9 and 6.10 illustrate these projections for several administrative regions. Variations in mortality are expressed as a percentage of historic mortality (between 1981 and 1999) and presented for the future periods of 2020, 2050 and 2080. Projections for the summer seasons are presented because variations are most significant during this period. In general, there is a small drop in mortality in winter and a slight increase in spring and fall. Annual variations in mortality are also presented to provide information on a complete year. Because variations in summer mortality are much greater than in other seasons, there is an increase in annual mortality in a warmer future climate.

4 For example, see Figure 7 in Doyon et al. (2006).

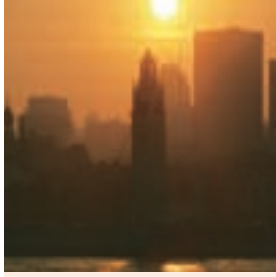
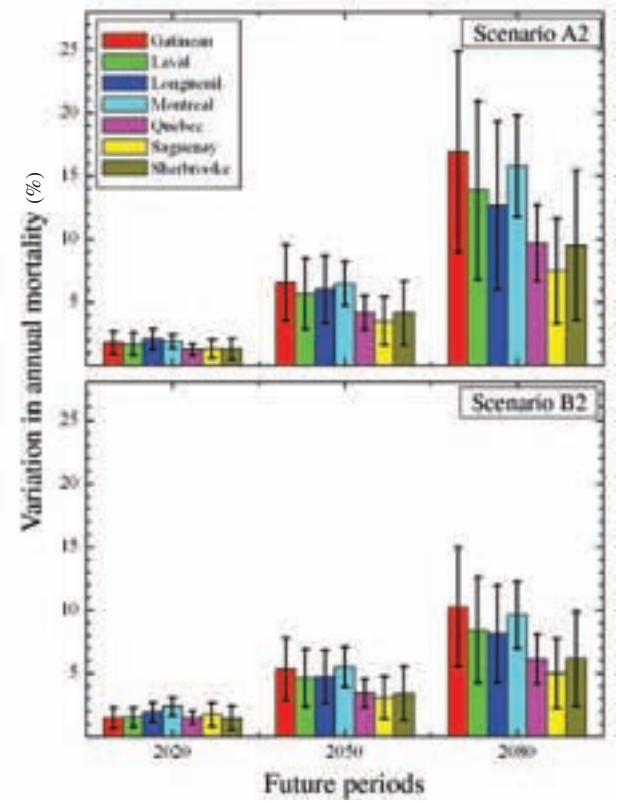
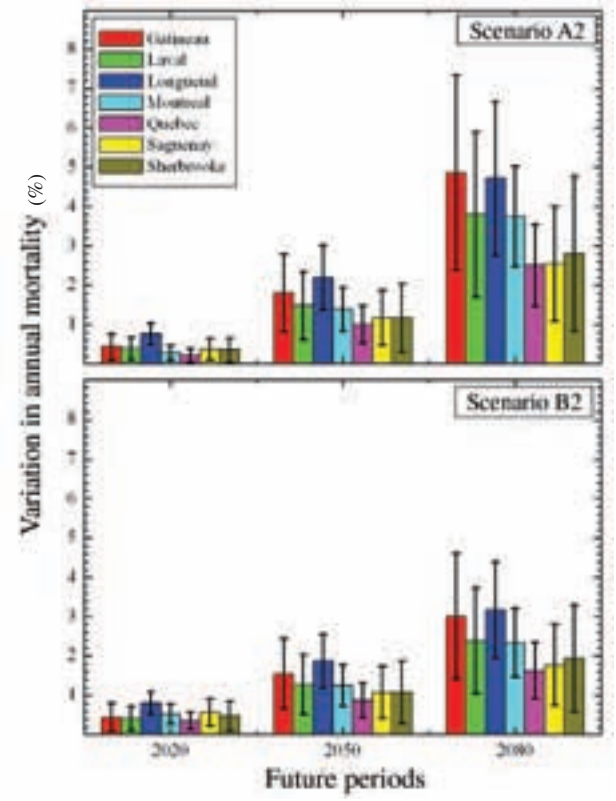


Figure 6.7 Variations in summer mortality for several cities in southern Quebec



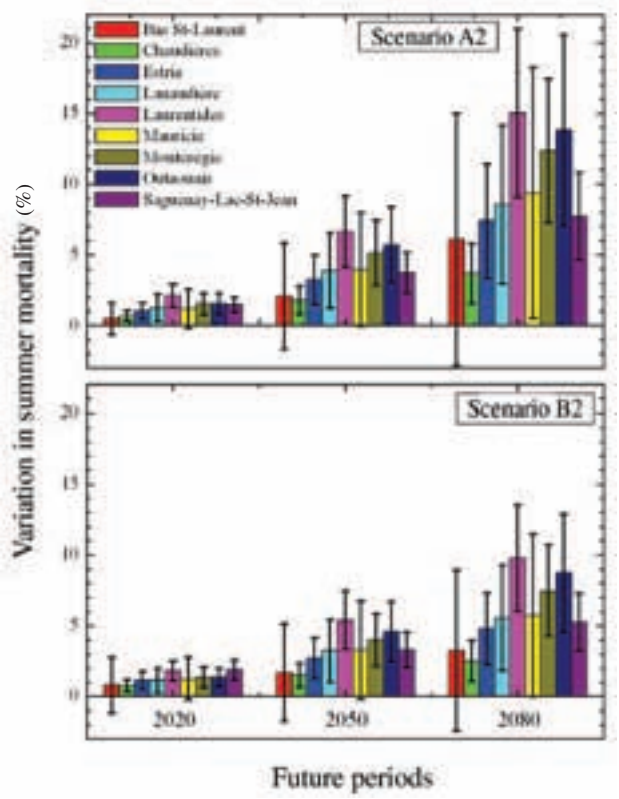
Note: This figure presents expected variations in summer mortality in several cities in Quebec for scenarios A2 and B2. Variations are expressed as a percentage of historic mortality for the period from 1981 to 1999. Black error bars indicate the 95% confidence interval.

Figure 6.8 Variations in annual mortality for several cities in southern Quebec



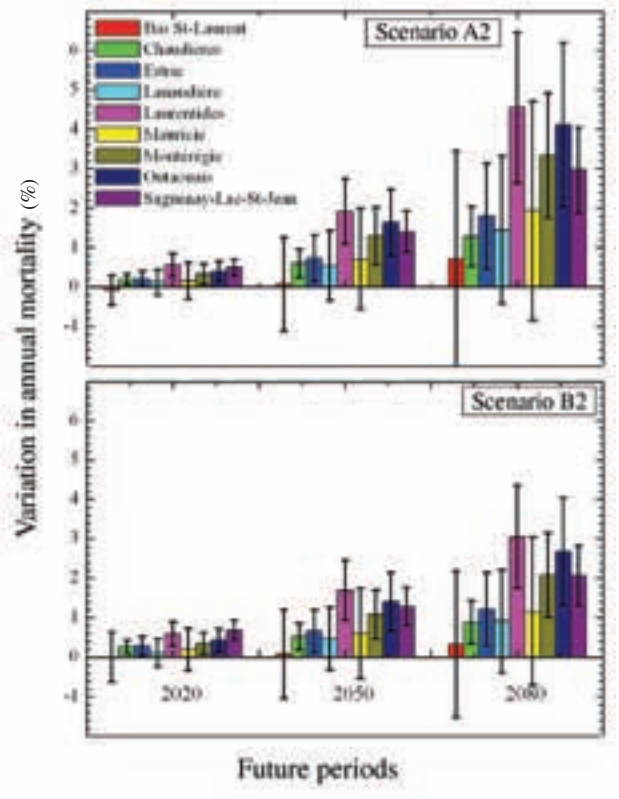
Note: This figure presents expected variations in annual mortality in several cities in Quebec for scenarios A2 and B2. Variations are expressed as a percentage of historic mortality for the period from 1981 to 1999. Black error bars indicate the 95% confidence interval.

Figure 6.9 Variations in summer mortality for several regions in southern Quebec

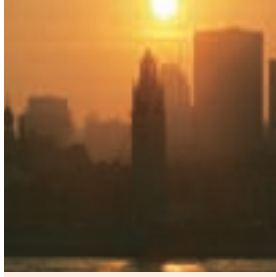


Note: This figure presents expected variations in summer mortality in several of Quebec's administrative regions for scenarios A2 and B2. Variations are expressed as a percentage of historic mortality for the period from 1981 to 1999. Black error bars indicate the 95% confidence interval.

Figure 6.10 Variations in annual mortality for several regions in southern Quebec



Note: This figure presents expected variations in annual mortality in several of Quebec's administrative regions for scenarios A2 and B2. Variations are expressed as a percentage of historic mortality for the period from 1981 to 1999. Black error bars indicate the 95% confidence interval.



The differences in the projections for cities are not significant, but those for the regions are. Regional projections were obtained using the average of monthly forecast temperature anomalies for stations located in or near the region; this crude approximation may explain some of the differences. Also, climatic variability within a single region may have some effect on the statistically established relationship between mortality and temperature. Nevertheless, projections for the Estrie, Outaouais and Saguenay-Lac-St-Jean regions are similar to those of a major city located within each region (Sherbrooke, Gatineau and Saguenay, respectively).

6.4.3.3 Models and projections by age group

For Montreal and Quebec, models were created by age group. Only two groups were considered: 15 to 64 years of age, and 65 years and over.[5] The 15 to 64 age group seems less vulnerable to heat (the slope is less oblique for temperatures greater than 15°C), but seems more vulnerable to cold, especially in Quebec City, where there is a negative slope for temperatures below 10°C. For the summer period, variations in mortality are approximately two to three times more significant for the 65 and over group than for the 15 to 64 age group.

The main results for the simulations are as follows:

- For the A2 scenario, there was an increase in *summer* mortality of approximately 2% for 2020, 6% for 2050 and 10% for 2080, as well as an increase in *annual* mortality of approximately 0.5% for 2020, 1.5% for 2050 and 3% for 2080. In terms of the absolute number of deaths per year[6] for southern Quebec, this would be an increase on the order of 150 deaths annually in 2020, 550 annual deaths in 2050 and 1,400 in 2080. However, the 95% confidence interval for these figures demonstrates a wide range of possible values that also vary with the climatic scenarios used. On the other hand, these data do not reflect the predictable aging of the population, which will likely tend to increase the number of deaths related to warming.
- This increase affects most regions in Quebec (with the exception of Côte-Nord and Gaspésie) and increases in intensity from east to west.
- There does not seem to be any significant difference among the major cities in Quebec with respect to the vulnerability of their populations to climate change.
- Increase in mortality for the population aged 65 and over is approximately two to three times more significant than that for the group between 15 and 64 years of age.
- The effect of temperature on the 15 to 64 age group seems to change over time. This age group is more vulnerable to temperature increases during the 1991 to 1999 period than during the 1981 to 1989 period.[7]

6.4.4 Discussion

Statistical models were developed to establish the relationship between mortality and climate and then predict effects for two scenarios of future climates for Quebec. Projections of mortality were presented for several cities and administrative regions. Projections for the administrative regions had several weaknesses. The development of models required that average temperatures be established for relatively large geographical areas which sometimes included microclimates (such as the Laurentian mountains). In addition, for these large administrative regions, projections for future periods were derived using data from relatively distant stations. Such approximations were not used for cities; therefore, the results for cities were not similarly affected.

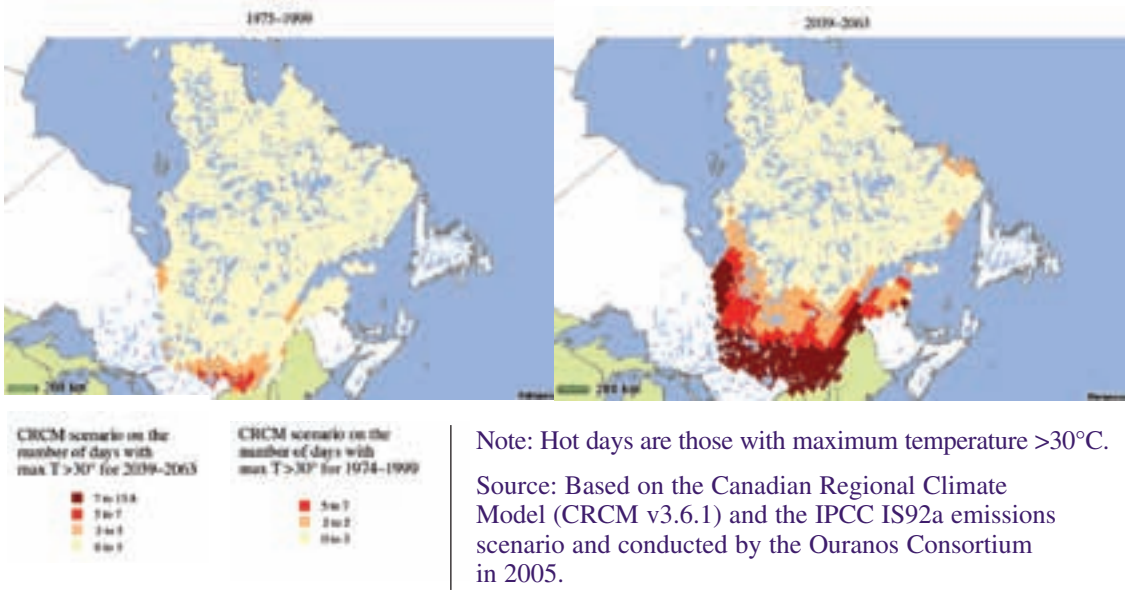
5 Not presented here. See Figure 17 in Doyon et al. (2006).

6 See Tables 3, 4, 5 and 6 in Doyon et al. (2006), for a detailed presentation.

7 Not presented here. See Figure 21 in Doyon et al. (2006).

There is no significant difference among the projections for the various cities. The population density limited the models to regions along the St. Lawrence River, in the Outaouais and in Saguenay-Lac-St-Jean. Projected variations in future climates for this area are very similar and do not show any significant differences in future mortality for the cities considered (Figure 6.11).

Figure 6.11 Current and simulated annual average number of hot days



Note: Hot days are those with maximum temperature >30°C.

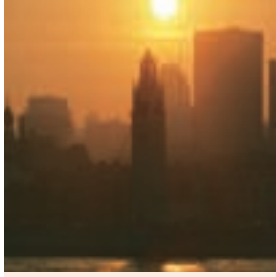
Source: Based on the Canadian Regional Climate Model (CRCM v3.6.1) and the IPCC IS92a emissions scenario and conducted by the Ouranos Consortium in 2005.

In the literature, several publications present projections for variations in mortality for future periods. For example, Donaldson et al. (2001) published projections for the U.K. and several of its large cities predicting annual decreases in mortality. Doyon et al. (2006) obtained the opposite result—an increase in total mortality—for all the cities analyzed. Several factors may explain this difference, such as the ability to adapt to cold and some of the methodology.

As reported by Wilkinson et al. (2001), the excess winter mortality in England between 1986 and 1996 was attributed, among other things, to the absence of central heating and to the high cost of heating. Eventual temperature warming could therefore contribute to decreased winter mortality in this region of Europe. In Quebec, however, the situation is different. In fact, it is unlikely that warming, on average, will affect winter mortality. Over the years, Quebeckers have developed various strategies to adapt to the cold. The *Loi sur l'économie de l'énergie dans le bâtiment* (An act respecting energy efficiency in buildings) (1983), which is intended to ensure minimum performance for heat insulation in walls and ceilings, is an example of an adaptive strategy (*Régie du bâtiment du Québec,* 2006). Furthermore, natural resource endowments in Quebec contribute to the availability of heat at a relatively low cost—one of the lowest of several industrialized countries, including the U.K. (Filion and Lauzier, 2002).

Some methodological differences between the research in this report and that of Donaldson et al. (2001) cannot be ignored. For example, their study did not control for the effect of the seasons. As discussed earlier, controlling for seasons mainly affects the results for the cold portion of the model (Figure 6.6). A model that does not control for this effect will predict fewer winter deaths for future climates. In controlling for the seasonal effect, the increase in summer mortality is not offset by a decrease for the other seasons.[8] The control of seasonal

8 If there is no control for the seasons, the relationship between deaths and cold temperatures seems more significant: the slope of the graph is more significant for cold temperatures when there is no control. If these models are used to predict the variations in winter mortality for future climates (which will be warmer), a significant drop in deaths in the winter is predicted. Inversely, if the seasonal effect is controlled for, the relationship between cold temperatures and mortality decreases, and estimated variations in winter mortality are less significant.



effects is necessary according to Doyon et al. (2006), so that mortality due to climate is not confounded with mortality resulting from seasonal factors (e.g. epidemics). Some other methodological differences also exist in Donaldson et al. (2001). Analyses of Doyon et al. (2006) demonstrate that projections of mortality variations almost double in summer using monthly rather than annual anomalies to derive future temperatures.

A different approach employs air masses in the synoptic scale to establish a relationship between mortality and climate (Kalkstein and Greene, 1997). Using this approach, other researchers have estimated that the number of deaths due to hot days would be approximately three times greater than the decrease in deaths for cold days for several cities in the U.S. This estimate is in line with conclusions by Doyon et al. (2006). It is difficult to compare these results with unpublished work by Kalkstein and Smoyer (1993) cited in Last and Chiotti (2001), who present figures of between 240 to 1,140 additional deaths per year in Montreal; the details of this research (specifically the period for which the projections were made) were not available. Nevertheless, the variations observed for Montreal are within the lower range of those projected for 2050 and in the middle of the range for 2080.[9] More recently, research that was conducted to establish future projections for a few cities in south-central Canada, including climate warming and air pollution levels (Cheng et al., 2005), found the same range of mortality impacts.

With the aging population in Quebec, the percentage of people over 65 will continue to increase. This group grew from 9.7% in 1986 to 12% in 1996 (Pageau et al., 2001) and will reach approximately 28% in 2040 (ISQ, 2000, 2003b). The projections discussed in the preceding text and presented in the related figures were derived for the total population; therefore, these mortality projections can probably be considered as a lower limit that will continue to approach the predictions for a population of 65 years and over, which are two to three times more susceptible to heat-related mortality.

The stability of the model over time is another important methodological issue. It is difficult to anticipate how the population will adapt to climate change. Certain standards may be applied for household air conditioning. Awareness campaigns may have an effect on the vulnerability of individuals most at risk. This issue was addressed briefly, using two models: the first was created with data from the 1981 to 1989 period and the second with data from the 1991 to 1999 period. The idea was to quantify potential changes in the effects of climate on population mortality. For the general population, there were no significant changes in the model and its projections, at least for Montreal and Quebec.[10]

It was noted that the 15 to 64 age group seemed to be more vulnerable to climate change over time. For Montreal, this change was greater for men than for women. An aging population cannot be related to this finding. In the 15 to 64 age group there were more people 50 years and older between 1981 and 1989 than there were between 1991 and 1999. One should therefore expect greater vulnerability to the effects of climate change in this age group in the 1981 to 1989 period than in the 1991 to 1999 period; but the reverse was the case.

This outcome could be attributed to an increase in air pollution that is not taken into account in the models. Because pollution and smog episodes are sometimes correlated with warmer temperatures, the relationship between temperature and mortality obtained by Doyon et al. (2006) could also have been slightly distorted, particularly for the labour force (between 15 and 64 years of age) and more specifically for individuals who work

9 Data not presented here. See Tables 4 and 5 in Doyon et al. (2006).

10 Results not presented here. See Doyon et al. (2006).

outdoors. If air pollution increased significantly between 1981 and 1999, deaths during that period could be statistically attributed to higher temperatures and the conclusion would be that the population is becoming more vulnerable to these temperatures.

It is also possible that this observed difference could be attributed to the small number of deaths, which would modify the stability of the measurement of mortality. On the other hand, average ozone concentrations (ozone being a pollutant associated with an increase in deaths among individuals with chronic pulmonary disease (Lajoie et al., 2003)) in the south of the province continued to increase between 1990 and 2003 (Statistics Canada, 2006). During this period (1990–1999), an increase in deaths from respiratory illnesses, such as obstructive pulmonary disease, specifically among men between 25 and 44 years of age in the Montreal region (Eco-Santé, 2005a), was also noted. Because pollution and smog episodes are sometimes correlated with warmer temperatures, it is possible that certain population groups in the labour force are becoming increasingly vulnerable to higher temperatures (e.g. outdoor workers).

This last hypothesis possibly could be verified by introducing pollution data into the models for Montreal and Quebec. Some authors have already attempted to quantify the significance of temperature effects compared with those for pollution (Kunst et al., 1993; Pattenden et al., 2003; Keatinge and Donaldson, 2006) and agree on the fact that temperature has a much greater effect on mortality than pollution. Recently, other authors have measured this difference for Toronto (Rainham and Smoyer-Tomic, 2003) and reached the same conclusions.[11] Therefore, it is unlikely that the addition of pollution indicators to the models could completely explain the changes in the mortality and temperature relationship for the 15 to 64 age group.

It is important to realize that the models created for this chapter represent the average effect of climate. It is difficult to measure the effect of one heat wave (or other ECE) on death because such events have been historically rare. A binary term has been added to the model to account for heat waves. Between 1981 and 1999, there were heat waves in the province but none were comparable to the one that occurred in France in 2003 (InVS, 2003a).

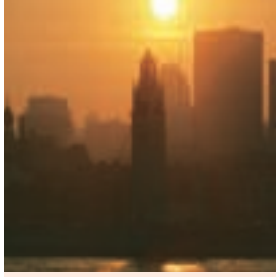
6.4.5 Next Steps

The increases in mortality simulated by the models created for this report nevertheless remain significant from the point of view of public health. These simulations probably represent the lower limit of the increases in mortality, given the currently aging demographic and the possible increase in global emissions of GHGs and global warming. There are many public health programs addressing risk factors that have much less marked effects on mortality and morbidity. Therefore, this information must be incorporated into planning for the prevention of related risk factors and protection of the health of vulnerable populations.

The most populated areas of the province will be the most affected. Issues of warming and heat waves and their related effects are often perceived in Quebec as affecting only the Montreal area. The data here demonstrate a much larger challenge that affects almost everyone in Quebec.

Finally, it will also be useful to pair these simulations with current demographic models to account for changes in the proportion of seniors and in their residential locations. The simultaneous effect of atmospheric pollution should also be subject to additional analyses.

11 The authors demonstrate that the mortality and temperature relationship for men is the one most influenced by controlling for pollution.



6.5 HEAT WAVES AND COLD SNAPS, AND CURRENT AND FUTURE ADAPTATIONS

6.5.1 Introduction

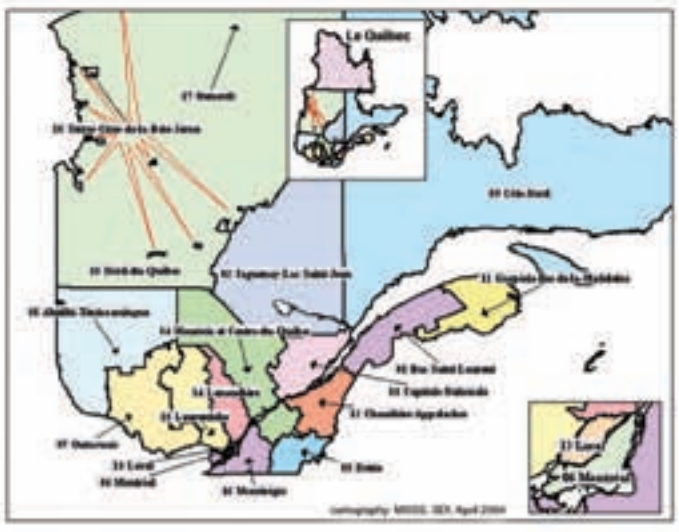
Following on evaluations of the health effects of heat waves and cold snaps, particularly in Europe and North America (Scottish Executive, 2001; Centers for Disease Control and Prevention (CDC), 2004, 2006; WHO, 2005; Centre on Global Change and Health, 2006; InVS, 2006), this section focuses on three studies conducted for this Assessment. These studies examined perceptions and behaviours during heat waves (Bélanger et al., 2006b) and cold snaps (Bélanger et al., 2006c), as well as those concerning the onset of climate change and proposed solutions to alleviate or adapt to it (Bélanger and Gosselin, 2007). Some of the results of a 2005 telephone survey in southern Quebec are summarized and provide an initial response to issues raised by adaptations currently in use for heat waves and cold snaps. Several future adaptation strategies are suggested, a number of which are already the subject of national and international recommendations (e.g. Health Canada, 2001, 2006; Menne and Ebi, 2006). These recommendations include more in-depth research to expand on the investigations that have taken place to date and the implementation of public health measures and public services.

6.5.2 Methodology

6.5.2.1 Research population

The study population was composed of individuals living in southern Quebec (Figure 6.12) and covering 15 of the 18 socio-health regions (SHR), which include more than 99% of the Quebec population (ISQ, 2006f). The health effects of climate change in the three northern regions (Figure 6.12: regions 10, 17 and 18) are discussed and summarized in Chapter 7, Health Impacts of Climate Change in Canada's North.

Figure 6.12 Socio-health regions in Quebec



Source: MSSS, 2004.

6.5.2.2 Sample

The sample, stratified according to socio-health region (SHR), residence and post-stratified for gender (Alavi and Beaumont, 2003), was calculated using 2001 Census data (ISQ, 2005b), with a 95% confidence interval and a precision level of 0.35 (Thompson, 1987). The total sample included 5,080 Quebeckers aged 18 years and over; half were contacted during the spring of 2005 and the other half during the fall of 2005.[12] Sampling was conducted by household, based on a random selection of published residential telephone numbers.

Among the respondents,[13] 5.7% lived in eastern Quebec (Figure 6.12: SHR 01, 03, 11); 5.9% in the north of the province (SHR 02, 08); 14.5% in the Quebec City region (SHR 03, 12); 6.5% in central Quebec (SHR 04); 21.0% and 15.7%, respectively, lived south of Montreal (SHR 05, 16) and north of Montreal (SHR 07, 14, 15); 30.6% lived in Montreal (SHR 06) and Laval (SHR 13).[14] A slight majority of respondents were female (51.5%), and the majority was between 35 and 64 years of age (54.7%; 18–34 years: 29.3%; 65 years and over: 16.0%). French was the first language for 81.3% of respondents, English for 5.8%, a language other than French or English for 10.1%, and English or French plus another language for 2.9%.

6.5.2.3 Data collection

A polling company collected the data by telephone (average interview duration: 20 minutes), seven days a week, between 9:30 a.m. and 9:30 p.m., with a computer system that permitted random redistribution of the order of questions. To minimize any bias due to an association with the outdoor temperature on the day of the interview, two rounds of data collection were conducted. The first (from March 16 to April 19, 2005) was to collect information on adaptations to heat waves; the second (September 15 to October 25, 2005) was to collect information on adaptations to cold snaps. Each respondent was interviewed only once.

6.5.2.4 Questionnaire development

Particular attention was paid to the development of the survey questionnaire. It was prepared as follows: (1) a preliminary questionnaire, based on the literature on health and climate change issues, was developed for the interviews (Presser et al., 2004); (2) exploratory interviews (average duration: 2 hours) were conducted with 21 volunteers (≥18 years of age) to check for the comprehension of certain terms (e.g. chronic illness), identify which measurement scales to use and which questions to exclude; (3) a first draft questionnaire was developed; (4) the first draft questionnaire was tested for telephone use (e.g. clarity and accuracy of questions) with 61 volunteers (≥18 years of age) who were recruited by project researchers and public health practitioners working in the 15 socio-health regions under study; (5) the questionnaire content (English and French versions) was validated by five experts working in the field of health and climate change in Canada; and (6) a polling firm pre-tested the French and English versions of the questionnaire (n=50) at the beginning of each round of data collection.

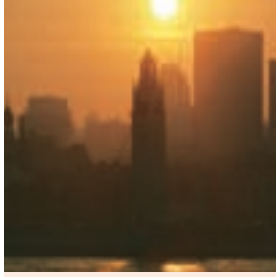
12 For data collected during the spring: 70.2% of those selected (n=3,726) completed the questionnaire; 4.9% were not interviewed because of survey time limits; 6.6% could not be reached; fewer than 1% (n=7) did not complete the interview; 18.2% refused to be interviewed.

For data collected during the fall: 70.0% of those selected (n=3,731) completed the questionnaire, 5.8% were not interviewed because of survey time limits; 7.7% could not be reached; fewer than 1% (n=11) did not complete the interview; and 16,5% refused to be interviewed.

No difference between the percentage of respondents and non-respondents, depending on the SHR of residence, was noted in either data collection ($p \geq 0.4$).

13 With respect to socio-demographic characteristics, no statistical difference was observed between respondents from the first round of data collection (heat waves) and the second (cold snaps).

14 Due to rounding of percentages (to the nearest point), the sum may not total 100%.



6.5.2.5 Information collected

Generally, the information collected from all respondents (first and second rounds of data collection) related to socio-demographic characteristics (e.g. income); health status (e.g. chronic illnesses); housing (e.g. perceived effectiveness of insulation); means of transportation (e.g. use of a car); use of media to obtain weather information (e.g. wind chill index); clothing adaptations as a function of weather; compliance with preventative advisories issued during ECEs; perceptions about the occurrence of climate change (e.g. heat waves); and on current suggested solutions to mitigate or adapt to them.[15] Both the first and second rounds of data collection (heat waves and cold snaps, respectively) addressed ways of cooling (e.g. air conditioning) or heating (e.g. oven) homes, and protection strategies (e.g. toque) for outdoor activities (e.g. running errands) that are used during extreme temperatures.

6.5.2.6 Analysis

The collected data were weighted by calibrating for respondent age and language, on the basis of the 2001 Census data (ISQ, 2005b). The analyses accounted for sampling by socio-health regions. The Rao-Scott likelihood ratio test was used for the bivariate analysis; logistic regression was used for the multivariate analysis (Sautory, 2005).[16] The statistical significance threshold of $\alpha < 0.0001$ was selected because of the high number of respondents.

6.5.3 Heat Waves

6.5.3.1 Current adaptations

Access to and use of air conditioners and fans

Of all respondents, 10.2% had neither a fan nor an air conditioner in their home, 53.9% had only a fan, 26.2% had both a fan and an air conditioner, and 9.6% had only an air conditioner. Almost half of the respondents with an air conditioner (35.8%) had access to a central or wall-based system (a "fixed" versus a "movable" system, such as a window or portable unit).

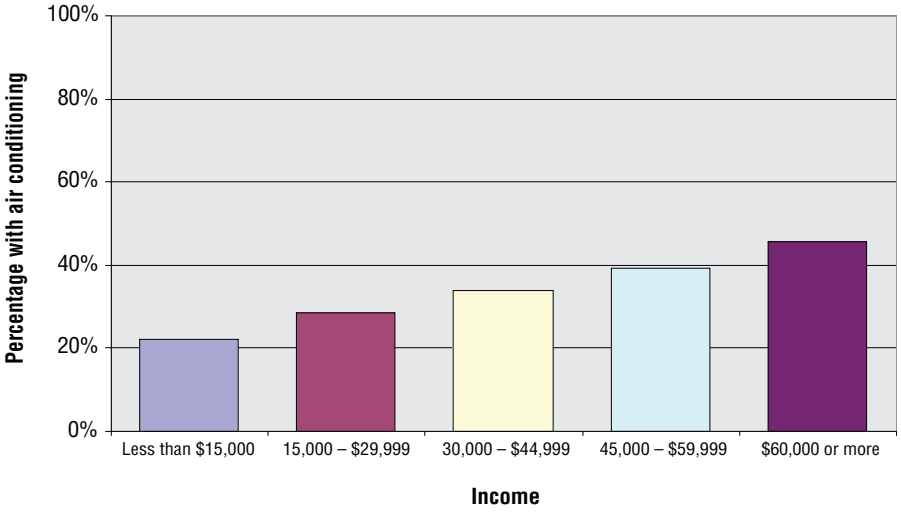
Seniors (41.3%) more often had an air conditioner at home than younger people (35–64 years, 36.9%; 18–34 years, 31.0%). The same is true for respondents who lived with another person (38.4%) compared with respondents who lived alone (26.1%) and for respondents with higher incomes (≥$60,000 before taxes from all sources within the past 12 months[17], 45.5%) compared with those with lower incomes (<$15,000, 22.1%; intermediary strata between $15,000 and $59,999, 28.5% to 39.4%) (Figure 6.13).

15 Perceptions of climate are discussed in section 6.5.5.

16 The results are not presented here. For more information, see Bélanger et al., 2006b, 2006c.

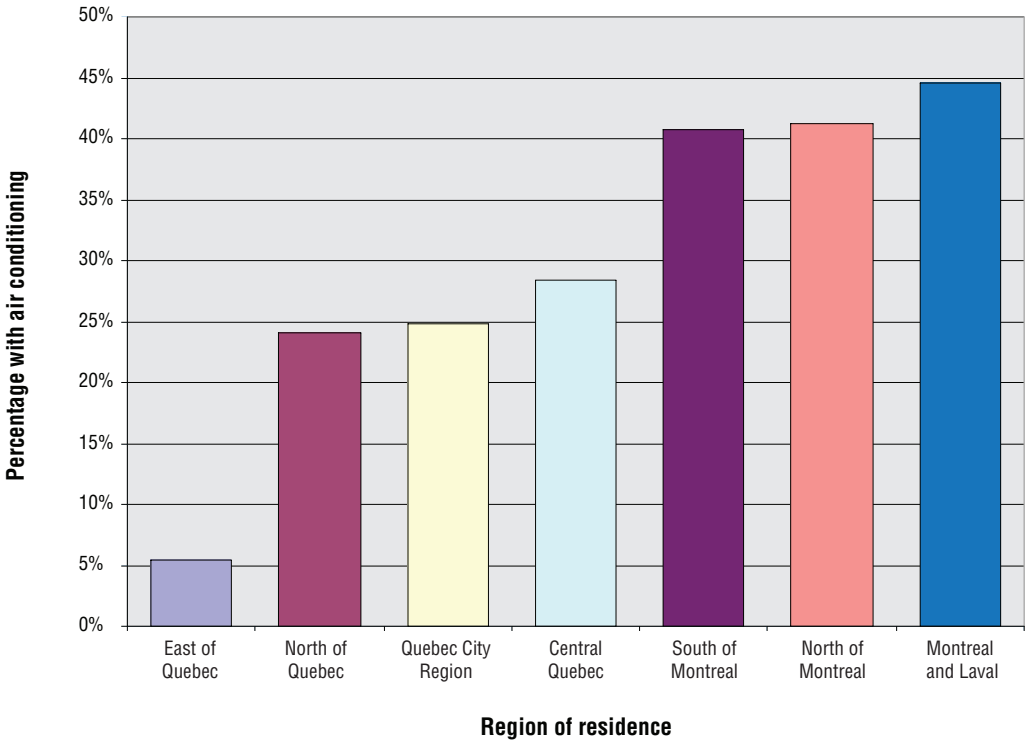
17 All following income figures are before taxes from all sources within the past 12 months.

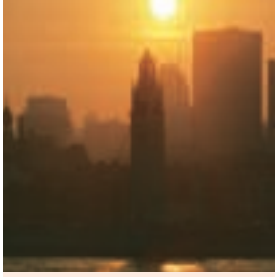
Figure 6.13 Home air conditioning, by income levels



Access to air conditioning also varied by region of residence: 5.4% in eastern Quebec, 24.1% in northern Quebec (south of the 49th parallel), 24.8% in the Quebec region, 28.4% in central Quebec, 40.8% and 41.2% south and north of Montreal, respectively, and 44.6% in Montreal and Laval (Figure 6.14).

Figure 6.14 Home air conditioning, by region of residence





During heat waves, 56.0% of respondents used their air conditioning on a continuous basis (57.6% fixed systems, 42.4% movable systems), 20.1% used it only at night, 21.0% used it only during the day and 1.4% never used it. During heat waves, those who used air conditioning the least during the night were 65 years old and over and had an income of less than $45,000 (58.5%). The second group referred to respondents under 65 years old with approximately the same income (75.5%). Finally, the third and fourth groups included those with better incomes (≥$45,000), first those 65 years and older (79.7%) and then younger (84.8%). Household air conditioning, particularly for fixed systems, was the main reason given by respondents for not opening their windows at night during heat waves.

Four out of five respondents owned at least one fan; 42.8% used them during the day and at night during extreme heat, 31.8% used them only at night, 17.3% used them only during the day and 8.1% never used them. Households with air conditioning showed a lower use of fans at night, which was more common among respondents under 65 years (35–64 years, 76.8%; 18–34 years, 79.6%) than among those 65 years and older (55.7%) and among respondents with chronic neurological disease (61.2% day and night, 16.1% night only, 16.5% day only and 6.2% never) than among respondents with other illnesses (43.0% day and night, 24.9% night only, 22.5% and 9.6% day only) or who were not ill (42.2% day and night, 34.7% night only, 15.6% day only and 7.6% never). Respondents who used fans only at night believed their home insulation was less effective, and opened their windows at night more often than other respondents.

Preferred location to cool down during heat waves by housing type

To cool down during heat waves, 62.3% of respondents preferred to remain at home (30.7% in the home and 31.6% on the balcony or in the yard). Approximately half of the respondents had access to an outdoor pool. Others (37.2%) generally went to public locations outdoors; preferred places included beaches or locations beside other bodies of water (15.7%), gardens or parks (9.6%), outdoor pools (7.4%) and places with air conditioning (9.5%).

Compared to apartment dwellers, respondents who lived in houses most often preferred to remain at home to cool down either inside or by their private pools in equal proportions. They were more likely to be between 35 and 64 years of age, have children less than 18 years of age and incomes of $45,000 or more than apartment dwellers. Home dwellers most often lived in a building that that had been upgraded since its construction—either by adding insulation or by replacing doors or windows—and for which insulation was perceived as very effective in controlling humidity. Almost 40% had an air conditioner (fixed, 23.5%; movable, 15.9%).

There were also substantial differences between apartment dwellers living in small versus large buildings, as shown in Table 6.4.

Table 6.4 Proportions (%) for some characteristics related to residence and behaviour during heat waves

Some characteristics	Home owners	Apartment dwellers (less than 5 floors)	Apartment dwellers (5 floors and more)
Stay home to cool down	69.9	51.2	60.5
Between 35-64 years of age	61.3	44.7	36.8
With children below 18 years of age	36.2	24.3	12.5
No children at all	26.9	49.4	50.7
Incomes over $45,000	50.3	25.4	29.4
Insulation improved since its construction	41.6	26.2	12.1
Doors or windows replaced since construction	65.6	55.7	40.7
Insulation perceived as effective in controlling humidity	40.2	22.4	32.2
Living alone	11.0	35.0	50.4
Access to air conditioning	39.4	28.2	41.5

Source: Bélanger et al. (2006b)

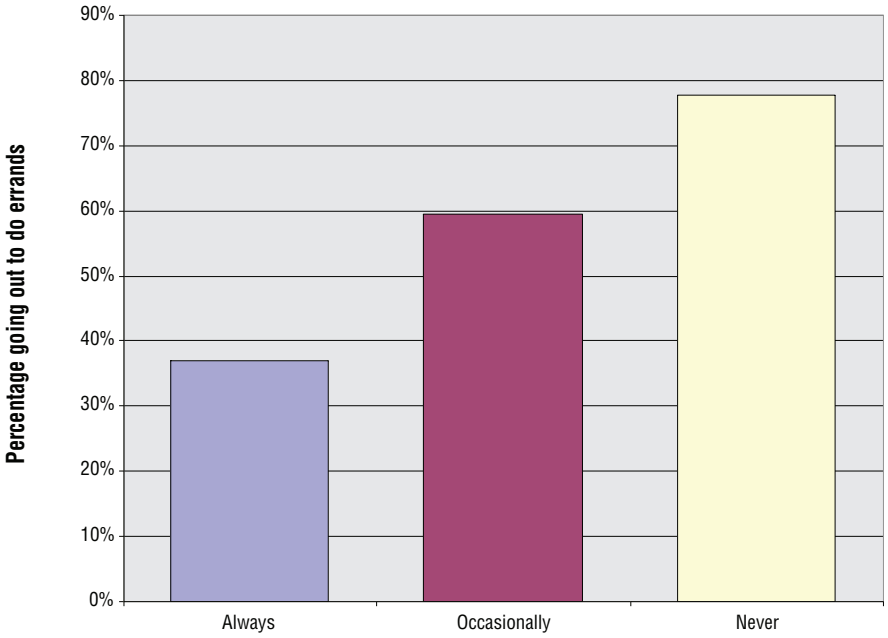
Among residents of apartment buildings with five floors and more, 60.5% remained at home during heat waves and more than half of them stayed inside only; 10.2% went out on their balcony; 25.9% had a pool where they lived. These residents were more likely than other respondents to be 65 and older (37.7%) compared to home owners (14.4%) or dwellers in smaller buildings (15.2%). One in two had no children and lived alone. Compared with all other respondents, they were less likely to live in an apartment that had undergone major repairs. With regard to air conditioning, 19.9% had fixed systems and 21.6% had movable systems, for a total of 41.5%.

Residents of buildings with fewer than five floors were the ones who most often left their homes to cool down during a heat wave (48.7%). They were also more often between 18 and 34 years of age (40.1%) than other respondents and had incomes below $45,000. In addition, they were the respondents most likely to consider that the insulation in their homes was not very effective in controlling humidity and were less likely to have air conditioning (4.3% fixed systems, 23.9% movable systems; total 28.2%).

Running errands or participation in physical activity during a heat wave

Heat waves affected respondents differently with respect to their tendency to go out to do errands (e.g. shop for groceries): 28.7% always went out to do errands during heat waves, 20.2% often, 26.9% occasionally, 15.0% rarely and 8.0% never. Respondents who went out at least occasionally were more often employed (80.0%) than unemployed (74.0%), students (74.4%) or retired (68.3%). Respondents who considered themselves in very good (80.1%) or good (77.0%) health were more likely to go out to do errands during a heat wave than those who considered their health to be average (69.3%) or poor (54.3%). Respondents who did not use a cane, wheelchair or other self-help device (77.8%) were also more likely to go out than those who sometimes (59.4%) or always used them (37.0%) (Figure 6.15).

Figure 6.15 Likelihood of going out to do errands (at least occasionally) during a heat wave in relation to the use of a cane, wheelchair or other self-help device



With regard to more intense outdoor activity (e.g. running, mowing the lawn) during extreme heat, the response was: 14.4% always, 16.4% often, 20% sometimes or rarely, 28.5% never. Men (60.2%) were more likely to do so than women (41.5%). Those 18 to 34 years of age (58.6%) were more likely to do so than those 35 to 64 years of age (49.9%) or those 65 years of age and over (37.2%). Students (68.0%) and workers (58.4%) were also more likely to perform manual work and be exposed to the heat than those with less physical demands: professionals (49.3%), unemployed (48.7%) or retired (40.5%). Respondents who believed that ECEs (such as heat waves) had no effect on their own health (56.9%) were more likely to go out than respondents who believed that ECEs had negative effects (44.8% a little, 44.6% moderately, 30.5% a great deal).

Use of sunscreen, sunglasses and hats during heat waves

When it was sunny, 64.7% of respondents often or always used sunglasses (11.8% sometimes, 23.4% rarely or never), 48.3% used sunscreen (16.5% sometimes, 35.2% rarely or never) and 43.4% used a hat (14.3% sometimes, 42.3% rarely or never). When there was cloud cover, 48.1% used sunglasses (15.0% sometimes, 36.9% rarely or never), 34.2% used sunscreen (15.5% sometimes, 50.3% rarely or never) and 31.0% used a hat (14.7% sometimes, 54.3% rarely or never).

When it was sunny, women (76.1%) used sunscreen more often than men (52.8%). Parents of children <18 years old (74.3%) used it more often than parents of children ≥18 years old (60.6%) or respondents without children (59.9%). Respondents with higher incomes used sunscreen more often than those with lower incomes (72.8% with incomes ≥$60,000, 52.7% with incomes <$15,000, 61.2% to 67.7% intermediary strata). Respondents who often or always followed preventative advice issued during ECEs (such as heat waves) (70.3%) also used sunscreen more often than those who followed preventative advice sometimes (63.9%) or rarely or never (49.4%). Gender (80.7% women, 72.1% men) and compliance with preventative advice (81.0% often or always, 73.7% sometimes, 67.2% rarely or never) were also associated with wearing sunglasses, as with the use of a car (80.8% air conditioned, 75.9% no air conditioning, 64.3% no car).

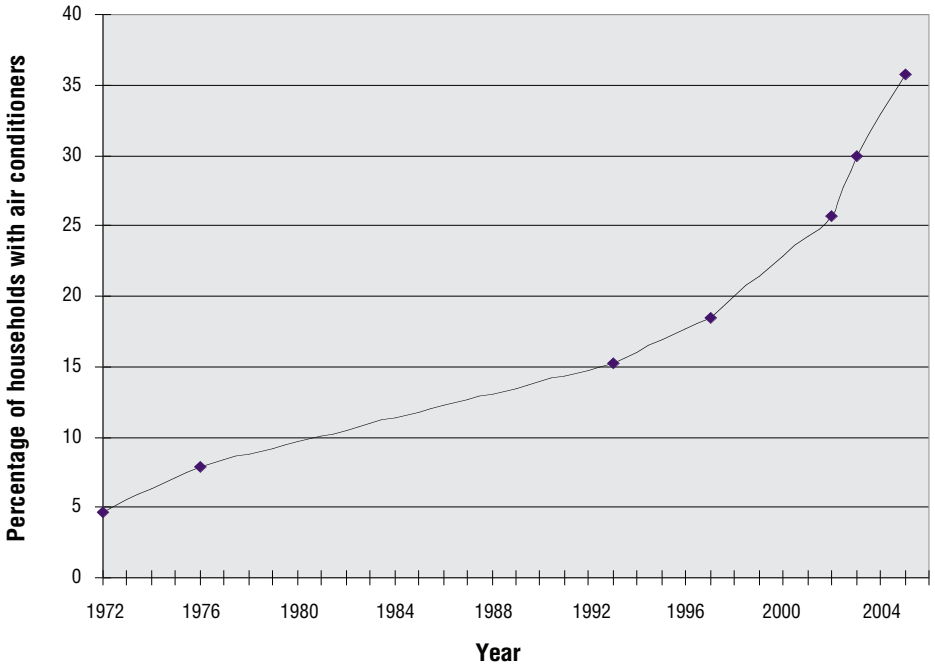
Hats seemed to be worn more by men (66.7%) than women (49.0%) and those over 65 years of age (61.1%) than those 35 to 64 years of age (57.6%) and 18 to 34 years of age (55.7%). It should be noted that some behaviours had become ongoing practices among some respondents; they used sunscreen, sunglasses or a hat even when it was cloudy. There also seems to be a high correlation among these three preventative behaviours relative to their adoption (or not).

6.5.3.2 Suggestions for future adaptations

Air conditioning

The use of air conditioning has been increasing in Quebec for several decades. It has grown from 4.7% of households in 1972 to 15.2% in 1993 to 30% in 2003 (ISQ, 2006c) to 35.8% in 2004 (Figure 6.16).

Figure 6.16 Percent of households with air conditioning in Quebec, 1972 to 2005

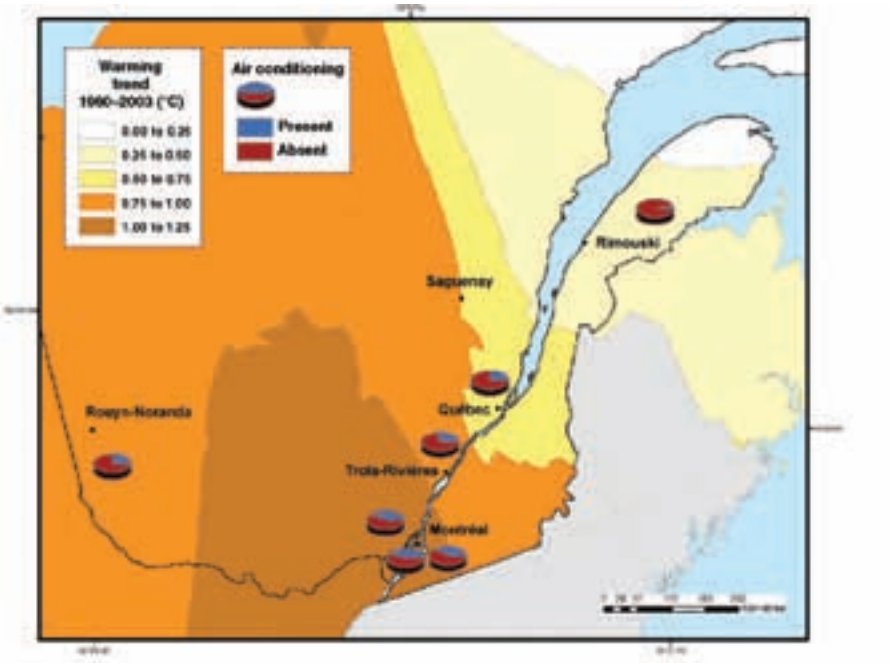


Source: Based on ISQ, 2006c and Bélanger et al., 2006b.

The increase, which appears to have moved from east to west geographically, seems to have started with the temperature warming observed between 1960 and 2003 in southern Quebec (Yagouti et al., 2006) (Figure 6.17). Projected demographic trends for 2026 based on the 2001 census suggest that warming will be more intense in regions where population will grow (ISQ, 2003b). Population increase will inevitably augment the need for air conditioning, particularly because of the increase in urban heat islands associated with greater population densities in southwestern Quebec (Giguère et al., 2006d). As a result, suggestions have been made (Bélanger et al., 2006b) to monitor trends in population growth, heat islands and percent of households with air conditioning to:

- clarify statistics collected on air conditioning (e.g. type of equipment);
- conduct periodic research on temperature changes in correlation with demographic trends; and
- add previous data to an interactive atlas that presents information on maps and graphs, and that is accessible via the Internet to climate change managers and the general public.

Figure 6.17 Percent of household air conditioning in 2005 and increases in average temperatures (1960–2003), southern Quebec



Source: Based on Bélanger et al., 2006b and Yagouti et al., 2006.

Those who are economically disadvantaged were less likely to have air conditioning in their homes. In 2003, 15.8% of households in Quebec with incomes below $20,000 had an air conditioning unit compared with 44.3% of households with incomes of $80,000 and more (ISQ, 2006d). Because those who are economically disadvantaged may be in poorer health (Phipps, 2003), a subsidy program for air conditioning could be considered for homes of the most disadvantaged (including assessment of the space to be air conditioned, purchase, installation and maintenance), especially if health of one of the family members is seriously affected by heat waves according to Bélanger et al. (2006a).

During extreme heat, those 65 years of age and over are one of the most vulnerable groups (InVS, 2004a, 2006). However, although they have air conditioning in the home more often than those who are younger, they use it less frequently at night during heat waves. Identifying the reasons for this would help in the development and assessment of appropriate public health messages and interventions directed at this group.

Respondents who lived in apartments more often had movable air conditioning systems than fixed units; fixed systems are associated with decreases in mortality due to heat (Dixsaut, 2005; Jacques and Kosatsky, 2005) and provide greater comfort than movable units (Vadnais, 2005). An estimate of the number of hours required for movable systems to reach a comfort zone equivalent to that of fixed systems would make an appreciable contribution to public health.

The use of air conditioning in Quebec contributes little to GHGs and air pollution because the power source in Quebec is hydro-electrical. In addition, the power demand for air conditioning occurs during a low energy usage period; peak demand in Quebec is during the winter for residential heating (Hydro-Québec, 2006a). The only other similar situation in North America is in Manitoba; everywhere else, the use of air conditioning generates additional GHGs and air pollutants.

Housing insulation

Several respondents who perceived the insulation in their homes as ineffective in controlling humidity lived in housing built before 1983 and before the adoption of the *Loi sur l'économie de l'énergie dans le bâtiment* (An act respecting the conservation of energy in buildings); this legislation ensures minimum performance for thermal insulation in walls and ceilings (*Régie du Bâtiment,* 2006). More funding for an energy efficiency program—such as that announced in the recent government action plan on climate change (Government of Quebec, 2006e)—should make it possible to improve housing insulation. First priority should be given to economically disadvantaged people, whether they are home owners or tenants, who live in buildings that require major repairs (Bélanger et al., 2006b).

Perceived effectiveness of insulation in controlling humidity was associated with various housing characteristics (e.g. not air conditioned, built before 1983) that may be related in some way to mortality during heat waves (Last and Chiotti, 2001; Auger and Kosatsky, 2002; InVS, 2004a). This perception could be a useful indicator in the area of public health and climate change.

Solutions for cooling homes other than air conditioning and insulation

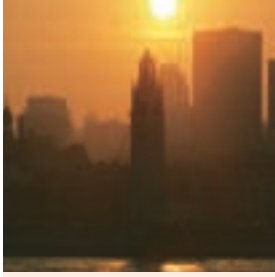
Respondents who had movable air conditioner systems or who did not have air conditioning at all opened their windows at night during heat waves more often than those who had fixed systems. In certain cases, opening windows may be sufficient to cool the home (Dixsaut, 2005) as could other solutions not documented in this research, such as neighbourhood revegetation (Giguère and Gosselin, 2006d) or the use of basements. In the context of sustainable development, the efficiency and effectiveness of these types of solutions should be explored so more diverse options for heat adaptation (versus only air conditioning) could be assessed.

Neurological illnesses

Individuals with chronic neurological disease used fans at night more often during heat waves than other respondents. This result is not surprising because their health may deteriorate irremediably during extreme heat (Semenza et al., 1999; Green et al., 2001; McGeehin and Mirabelli, 2001). Of particular note was the number of respondents in this group who did not have air conditioning at home. The results of this study indicate that socio-economic factors may contribute to this situation. On the other hand, fans may be preferred over air conditioners for health-related reasons. More information on this issue is extremely important, such as identifying the determinants for the use of fans and air conditioners among this group. However, first priority should be given to understanding what makes those with neurological disease so vulnerable to heat. Such research would support the development of better adapted health care and services, guide public health initiatives implemented during episodes of extreme heat, and likely encourage the expansion of medical criteria and increase the lump sum allocated for the purchase and installation of an air conditioner (maximum of $400) under government programs for assistance with the activities of daily living (MSSS, 2003a).

People living alone

Individuals who lived alone and who were 65 years of age and over, economically disadvantaged and/or had a chronic health problem, lived in housing without air conditioning more often than other respondents. Each of these characteristics (including the absence of an air conditioner) has been considered a "risk factor" during heat waves (InVS, 2003b). "Living alone" could be a useful synthetic indicator for population studies on health and climate change; this characteristic may also be available through census data (Pageau et al., 2001).



It would be desirable to examine, in more detail than in this research, the subgroups of individuals who live alone and who are most at risk during extreme heat (Klinenberg, 2002), in addition to identifying the services these subgroups would need to ensure their safety during ECEs. This information could support front-line workers associated with emergency measures, and the implementation and assessment of such measures. In addition, research to understand why "reclusive" people or those who "feel alone" are difficult to reach would be a major asset in identifying appropriate and timely actions to take during ECEs for individuals in this group, whether they live alone or not. It would be important to distinguish between social factors (e.g. support, socialization) and housing factors (e.g. location in the building, such as on the top floor, or in a building with several floors) in relation to their effects on health during extreme heat (Auger and Kosatsky, 2002; InVS, 2004b). The examination of various cultural communities (Klinenberg, 2002) that are often grouped together in certain neighbourhoods (Laverdière, 2001) would also add important information.

Running errands during heat waves

Respondents who usually use canes, wheelchairs or other self-help devices when going out of the home rarely if ever went out to do errands (e.g. groceries) during heat waves, particularly if they were seniors. The reasons they stayed at home were not collected during this research, but it is likely that those in the *Enquête québécoise sur les limitations d'activités* (Quebec survey of activity limitation) (ISQ, 2001) may be applicable—in particular, feeling insecure outside the home, aggravation of health problems, the need for help upon arrival at the destination, the use of non-portable self-help aids, unavailability of an attendant and the lack of adapted public transportation. Such findings are of concern (Bélanger et al., 2006b) because they relate to the additional stresses that may be faced by individuals in this group during heat waves, as well as to the range of services that can be provided for their assistance in the absence of adequate social support. From the point of view of assistance and public health, it would be crucial to collect information on the needs of this group and propose a range of services that respects their physical limitations and attendant fears (e.g. fear of opening the door to a delivery person).

Public places used during heat waves

To cool down during heat waves, people who live in apartments are much more likely to go to public areas than those who live in houses. For this group, the most effective collective actions to address the health effects of extreme heat would be financial support to municipalities and neighbourhood organizations to (1) improve and conserve "free," cool, public areas located in urban environments (e.g. parks and gardens) and (2) implement a support program for municipalities and neighbourhood organizations (Government of Quebec, 2002) to develop the public access network to bodies of water. Over one million Quebeckers participate in swimming and beach-related activities annually (Government of Quebec, 2002). Temperature warming will increase participation in these activities as well as the size of beaches because of drops in water levels (NRCan, 2002). Consequently, better surveillance and vigilance will be needed to protect both the environment (e.g. erosion, pollution) and the population (injuries and drownings.)[18]

Private pools

The number of private pools throughout the province is impressive: 31% of respondents had pools at home compared with 24% in 1997 (NRCan, 1997). An assessment of their effectiveness would be useful; however, filling pools will inevitably become a source of conflict during times of water use restrictions. Regulating the use of water to fill private pools and implementing mechanisms to ensure enforcement would also be potential adaptation strategies (Giguère and Gosselin, 2006d).

18 Drowning was the main cause of death during recreational and sport activities in Canada between 1991 and 2000 (Canadian Red Cross, 2003).

Safety practices for sun exposure during heat waves

The adoption of preventative behaviour to protect against sun exposure (whether or not there is sun) and the close correlation of the use of sunscreen, sunglasses and a hat (Bélanger et al., 2006b) demonstrate the importance of habit in maintaining behaviours (Triandis, 1979; Van der Pols et al., 2005). It also suggests that certain common factors, such as habits, will facilitate the design, short-term adoption and long-term integration of a behaviour into daily life (Ory et al., 2002; Solomon and Kington, 2002; Strecher et al., 2002). Currently, very little is known in the area of the complex interactions among the factors that contribute to certain preventative behaviours (e.g. sequentially, concomitantly). Information on the various factors that contribute to the observance and reinforcement of safe behaviours related to sun exposure could complement public health interventions. Improving knowledge in this little-known area could also significantly improve the understanding of other environment-related behaviours (e.g. recycling, composting, reclamation).

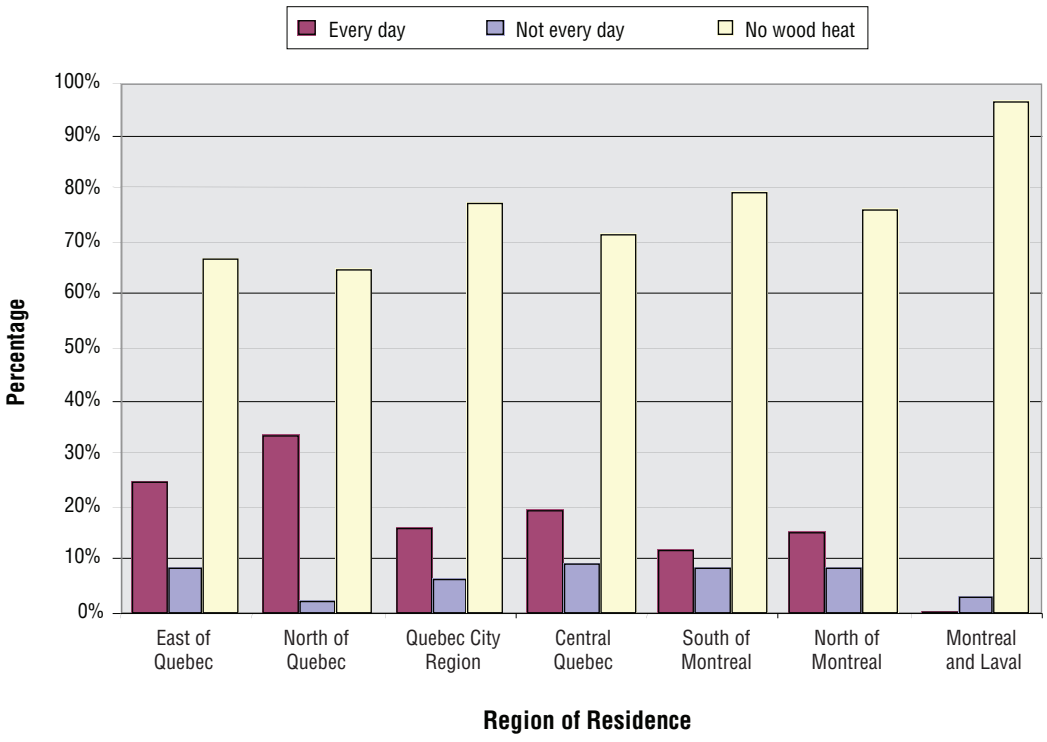
6.5.4 Cold Snaps

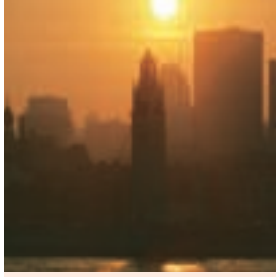
6.5.4.1 Current adaptations

Type of heating used in the winter

More than three quarters of respondents had access to only one source of energy for heating their homes in the winter, primarily electricity (60.8%), while 22.2% combined more than one source, particularly electricity and wood. The prevalence of wood heat (18.5%) was higher among those who lived in houses (28.1%) than apartments (3%) and among those (23.6%) with the highest incomes (≥$45,000) than among those (16.8%) with lower incomes (<$45,000). The use of wood for heat is more frequent outside of Montreal and Laval (Figure 6.18). The use of wood for heat is not affected by smog warnings or by the perception of living in a region subject to winter smog.

Figure 6.18 Percentage and frequency of residences using wood heat, by region of residence

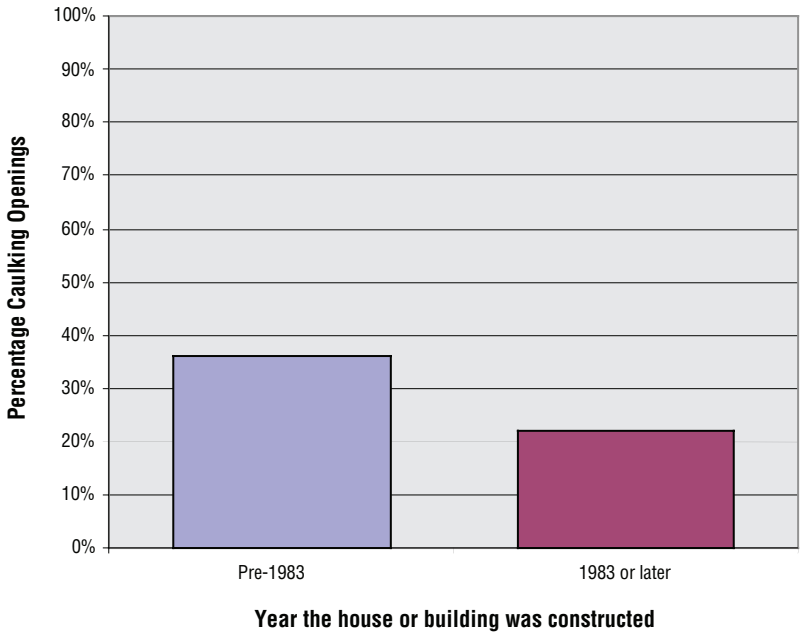




Caulking of openings

In the winter, 12.4% of respondents caulked all windows and doors in their homes and 19.3% caulked some. This strategy was used more often by respondents living in buildings built before 1983 (35.9%) than in or after 1983 (21.8%) (Figure 6.19) as well as by respondents who perceived their home insulation to be ineffective against the cold (55.9% compared to 24.1% when very effective), and ineffective in controlling humidity (49.6% compared to 27.1% when very effective).

Figure 6.19 Prevalence of caulking of openings in houses, by year of construction



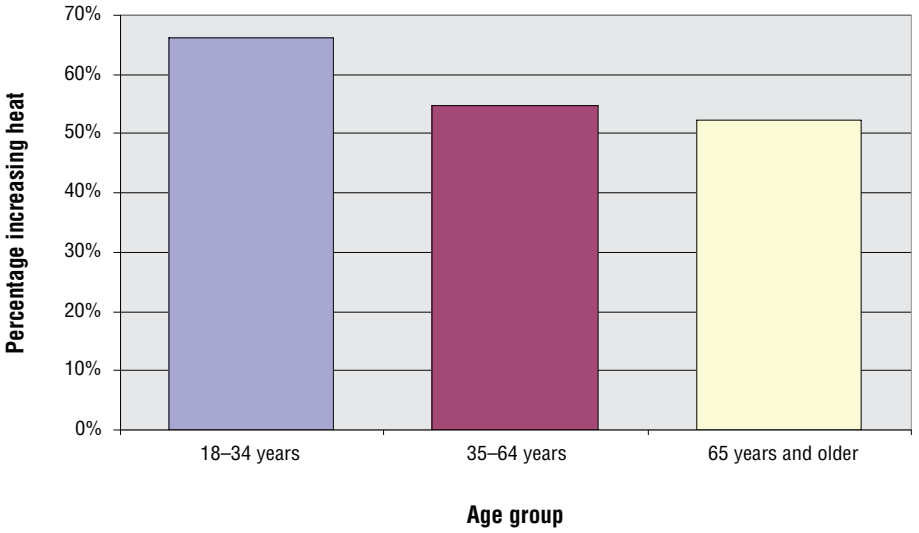
Adaptation strategies for heating homes during cold snaps

During cold snaps, 27.7% of respondents at least occasionally added weather stripping to their windows (e.g. rags) and doors (e.g. carpeting) in their homes. Inefficient home insulation against cold or for controlling humidity seemed to encourage such solutions, particularly among respondents who had never caulked openings in their home.

During periods of intense cold, 23.3% of respondents increased heat during the day, if at home (34.2% sometimes, 42.5% never); 33.8% of respondents at least occasionally increased it at night compared with 67.1% who never did. The tendency to increase heat during the day was greater among men aged 18 to 34 years and women of any age, but particularly among young women (Figure 6.20). At night, it was more common among those aged 18 to 34, allophones and those who had increased it during the day.

More than 10% of respondents used a portable heater during cold snaps: 3% often or always, 8.7% occasionally, 88.6% never. Respondents who used portable heaters most often considered the insulation of their homes to be only somewhat effective, or even ineffective, in fighting the cold. They also most often lived in a home built before 1983.

Figure 6.20 Tendency to increase heat during the day during cold snaps, by age



Twelve percent of respondents used their oven to heat their home during cold snaps: 3.7% often or always, 8.2% occasionally and 88.0% never. These respondents also used various other strategies to adapt, particularly portable heaters.

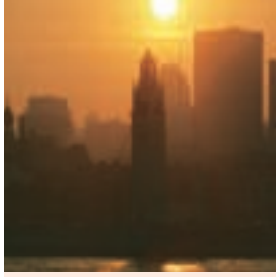
Most respondents (85.9%) opened the draperies or blinds on sunny days during periods of intense cold (6.5% sometimes, 7.6% never), while one-third at least occasionally closed them when it was windy (17.8% often or always, 17.1% sometimes, 65.1% never). Most allophones closed their curtains.

When temperatures dipped below normal, respondents—particularly men aged 18 to 34 and women of all ages, but particularly younger women—used other ways to keep warm at home, including wearing warmer clothes than usual (47.7% often or always, 29.2% sometimes, 20.3% never), using a blanket (e.g. to read or watch television) (39.4% often or always, 30.5% sometimes, 30.0% never), or taking hot showers or baths (10.9% often or always, 28.3% sometimes, 60.7% never).

Finally, 52.7% of respondents reported using at least six coping strategies for keeping warm at home (e.g. using a blanket) or heating their home (e.g. using the oven) during cold snaps, while 37.8% mentioned three to five and 8.7% mentioned one or two (0.8% mentioned none). Five groups of respondents used a higher number of solutions (i.e. women aged 18 to 34, respondents who considered their home insulation to be ineffective in controlling humidity, respondents who did not caulk the windows or doors of their homes, and respondents residing in the socio-health regions covering Montreal, Laval, the Montérégie and the Outaouais).

Outings for shopping or intense physical activity during cold snaps

Approximately 50% of respondents often or always ran errands (e.g. groceries) during abnormally cold temperatures, whereas 28.6% did so occasionally and 19.9% rarely or never did so. Similarly, one third of respondents, or 33%, often or always engaged in intense, physical outdoor activities (e.g. shovelling snow, sports), whereas 26.1% did so sometimes, 18.1% rarely and 21.8% never. Respondents who ran errands or engaged in intense, physical outdoor activities were more often men than women, as well as those who saw themselves as being in good or very good health. In addition, workers and students went shopping more often than people who were unemployed or retired. Those living in houses engaged in intense outdoor physical activities more often than respondents living in apartments.



During such outings, some 75% of respondents always wore warmer clothing than usual. Only 44.4% of respondents always wore warmer footwear than usual. The most popular accessory was gloves (74.3%, always), followed by neck warmers and head coverings (63.5%, always). Face coverings were the least used (25.2%). Generally, those aged 18 to 34 and 35 to 64 (to a lesser degree) used these adaptation strategies more often than older respondents. Use of an automobile also seems to be associated with the greater use of gloves and warmer clothing. No difference was noted in behaviour according to knowledge of the wind chill factor for any type of outing during a cold snap.

Use of a remote car starter in the winter

More than one half of respondents (56.8%) used a car every day, while 27.0% used a car less than once per day and 16.2% never did. The use of a remote starter in the winter was 32.9% among respondents using their car on a daily basis and 27.4% among those using it less frequently. More women (35.3%) than men (27.1%) used a starter. Use of a starter was also more common in the colder regions of southern Quebec. Bélanger et al. (2006c) reported that neither smog warnings nor the perception of living in a region subject to winter smog influenced the use of a remote starter in the winter.

6.5.4.2 Suggestions for future adaptations

Wood heating

In Quebec, residential wood heating increased by approximately 60% from 1987 to 2000 (MDDEP, 2006b), particularly following the 1998 Ice Storm (Télasco, 2004). This trend is worrisome because this type of heat is responsible for half of human-made fine particulates released in Quebec. These particulates, like some gases generated by wood combustion, can affect human health. Two factors should not be underestimated: the increased frequency and intensity of ECEs (NRCan, 2002), which could encourage Quebeckers to burn more wood, and the recent and future increase of the Quebec population in the regions surrounding Montreal (ISQ, 2006f) where the prevalence of wood heating is already relatively high.

With a view to protecting public health, the trend toward heating with wood should be monitored (Bélanger et al., 2006c). Additional information to characterize the exposure and potential risk (e.g. type of equipment, year acquired) would be an asset. At the same time, as suggested in a Canadian Council of Ministers of the Environment feasibility study for a program to raise awareness and replace conventional residential wood heating equipment (Del Matto et al., 2004), it seems important to implement a strategy in stages, with various actions to be taken jointly. These include (1) the adoption of national legislation prohibiting the sale of wood heating equipment not certified by the U.S. Environmental Protection Agency (USEPA, 1988), along with the application of enforcement measures; (2) the implementation of an awareness campaign regarding certified equipment; and (3) the implementation of a long-term national program for replacing conventional equipment, including recycling and promoting various solutions to address the obstacles to using the new wood heating equipment, such as the cost of purchasing and installation. Incentives to replace uncertified wood stoves (set at $320 per stove) seem to be insufficient in some cases (Del Matto et al., 2004). More generous support of low-income households so they can access new, less polluting technology is also suggested (Bélanger et al., 2006c).

Winter adaptation strategies used at home during cold snaps

The combination of certain characteristics of housing and occupant income provides a reasonable basis for identifying certain subgroups of people at high risk during periods of intense cold (Wilkinson et al., 2001). With a view to public health and energy savings, however, it would be best to develop assistance programs for improving home insulation, more suited to the economic reality of less well-off Quebeckers (Hydro-Québec, 2006c), whether owners or tenants (Bélanger et al., 2006c), and to implement attractive incentive programs for energy efficiency.

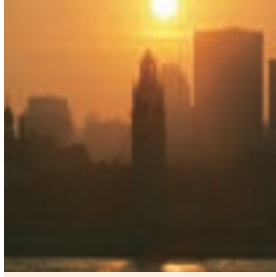
The preventative caulking of doors and windows in the winter—a concrete, cost-effective measure for conserving energy at home (NRCan, 2006c)—could be used more. A study identifying the reasons for the use of caulking would help further messages about conserving energy (Bélanger et al., 2006c).

The parameters of this study did not include identifying physiological and psycho-social factors that affect strategies for keeping warm at home during periods of intense cold (e.g. wearing warmer clothes than usual). From a sustainable development perspective, further examination might be warranted because, although a major decrease in the number of heating degree-days is likely in the future (compared with the period from 1961 to 1990) (Chaumont, 2005), it is also possible that the physiological ability of young people to adapt to the cold could be reduced and in turn this could reduce possible energy savings.

Immigrants, particularly those from tropical regions, must make greater adjustments to extremely low temperatures compared with the residents of colder regions, who are much better adapted to the cold physiologically, socially and culturally (Beaudreau et al., 2004). These immigrants are among the most vulnerable in winter, particularly those of the first generation. Included among their difficulties are language and lack of resources, often including lack of family support; during emergencies, such as a widespread power outage, their abilities to cope are further compromised by these difficulties (Bélanger et al., 2006a). If they have not already done so, emergency measures officials should collaborate with Hydro-Québec, which has already implemented programs aimed at cultural communities in partnership with welcome and integration organizations. These active outreach programs in several languages are aimed at communities of unilingual allophones (Hydro-Québec, 2006c). This approach may be increasingly important if certain ECEs increase in frequency and intensity.

Simultaneous broadcast of wind chill index and clothing recommendations

The study by Bélanger et al. (2006c) did not measure understanding of the wind chill index but documented the absence of behavioural response to it. It appeared that the wind chill index and accompanying Environment Canada recommendations for clothing during intense cold warnings play little or no part in the choice of clothing for outings. This may be because adaptive behaviour depends on many factors (e.g. attitudes, habits, social and cultural influences) other than knowledge (Fishbein et al., 2001; Core Group, 2003). It may also be because the wind chill index is not clearly understood. This index combines two measurements—temperature and wind speed—in a formula that



attempts to quantify a sensation (Tremblay, 2003), and that can vary by gender, age and the body part exposed (Harju, 2002), as well as other factors, such as the state of health (Beaudreau et al., 2004) and the geographic location of residence (Mäkinen et al., 2004). The validity of the wind chill index among the general population had been questioned (Bélanger et al., 2006c) on the basis of its development; just six men and six women, aged 22 to 42, wearing appropriate cold weather clothing were exposed with only the face showing (Environment Canada, 2001). Assessing the understanding of the wind chill index and its impact on the use of appropriate clothing worn outside in the winter is important. It would also be very useful to verify the influence and validity of this index for the general public, including several age groups, socio-economic conditions (e.g. ability to buy thermal clothing) and health conditions (e.g. heart, respiratory), and to identify indicators of compliance with the clothing recommendations issued by Environment Canada during intense cold warnings.

Use of a remote car starter

Four out of five respondents owned a car, and approximately a third used a remote starter in the winter, particularly women (Belanger et al., 2006c). No information helped to identify the reason for this variation by gender, such as a greater perception of cold among the latter (Harju, 2002) or distinct clothing habits (e.g. hats worn by men). There could be other reasons as well (e.g. the habit of idling and the popular belief that "it is good for the engine") (NRCan, 2006b). More specific research into determinants in remote starter use could clarify this matter. The identification of determinants in remote car starter use could be useful in developing initiatives to discourage idling (Bélanger et al., 2006c). Such research is also recommended in terms of public health and environmental protection. Idling contributes to atmospheric pollution which is a major cause of health concerns, given its effects on mortality and morbidity, particularly among children, people with respiratory or cardiovascular illnesses and seniors (Quénel et al., 2003)—all groups deemed to be highly vulnerable during ECEs (MacCracken et al., 2001).

Smog warnings

Info-Smog informs the public of meteorological conditions that are conducive to increased atmospheric pollution. It also gives advice on how to reduce the health effects of smog and sources of pollution, such as automobile combustion and wood heating (Environment Canada, 2006a, 2006b; Health Canada, 2006). This program was created in 1994; a winter component has been included since 2001. The geographic area covered has increased over the years and Info-Smog currently covers almost all of southern Quebec. The new national health risk-based Air Quality Health Index (AQHI) is also planned for demonstration in 2007–2008 (Health Canada, 2006).

Studies indicate that smog warnings do not significantly affect the behaviour of the population where and when they are issued (Bélanger et al., 2006c; Tardif et al., 2006); they have not affected the use of cars, remote car starters or wood heat in winter. A possible explanation is that respondents most frequently using a car or wood heat live in regions where smog warnings have been only recently introduced. However, respondents living in the greater Montreal region act no differently than others and they have had access to the information almost since its inception (in 1994 for summer smog and 2001 for winter smog). Identification of the determinants related to the adoption of advice given in winter smog warnings could improve the Info-Smog program. This being said, it is essential to invest in other concrete measures to reduce atmospheric pollution, such as mass transit infrastructure and the development of cycling paths (Government of Quebec, 2006a). In this regard, the recent announcement in the *Québec and Climate Change, A Challenge for the Future. 2006–2012 Action Plan* is a major signal in this direction (Government of Quebec, 2006e).

6.5.5 Current Perceptions of Climate Change and Future Adaptations

6.5.5.1 Current perceptions

Extreme climate events and smog

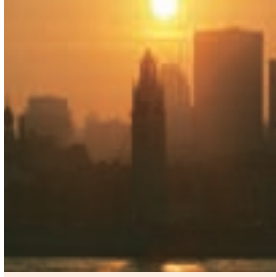
The extreme climate events that were perceived as being the most likely to occur in each study region (Bélanger and Gosselin, 2007) were cold waves (35.1% very likely, 45.1% moderately likely, 15.3% somewhat likely, 3.9% not at all likely) and heat waves (27.4% very likely, 47.9% moderately likely, 18.5% somewhat likely, 6.1% not at all). However, respondents residing in the northernmost portion of southern Quebec viewed their region as far more subject to wildfires than to heat waves. As for other extreme weather events, approximately 60% of respondents considered their region to be very or moderately subject to storms; 50% to ice storms; 40% to droughts; 20% to floods or wildfires; and fewer than 10% to tornadoes, landslides or avalanches. Finally, 20% of respondents thought their region of residence was very likely to experience smog in summer (27.5% moderately likely, 27.4% somewhat likely, 25.3% not at all), whereas 7.6% thought their region was very likely to experience smog in winter (20.8% moderately likely, 28.1% somewhat likely, 40.0% not at all); this was particularly true of Montreal and Laval residents.

Strategies to reduce greenhouse gases and adapt to climate change

Most respondents "agreed completely" with many of the 32 strategies (Table 6.5) put forward to reduce GHGs, adapt to climate change and reduce the harmful effects of these changes on population health and well-being (Bélanger and Gosselin, 2007).

Table 6.5 Greenhouse gas and climate change adaptation strategies

Business and industry
• increase monitoring of commercial and/or industrial pollution • increase monitoring of forestry practices • increase monitoring of agricultural pollution • ban construction of oil- and gas-fired power plants
Land use
• plant trees in recreational areas and schoolyards • plant trees in city centres • turn vacant lots and public lands into parks and gardens • rehabilitate beaches and river banks • prevent construction of houses, cottages and other residences in risk zones (e.g. flood zones) • plant trees in large outdoor parking lots
Infrastructures
• increase recycling in all municipalities • repair and improve water supply systems and aqueducts • rebuild roads to make them more resistant to freeze-thaw cycles and erosion • increase the number of municipal pools and parks with fountains • introduce a consumption tax on drinking water
Buildings
• install air conditioning in homes for sick persons and seniors • install air conditioning in hospitals • improve insulation standards for residences and rental housing • subsidize home air conditioning for seniors and low-income people • subsidize air conditioning for daycare centres • ban wood burning in the winter when smog is severe

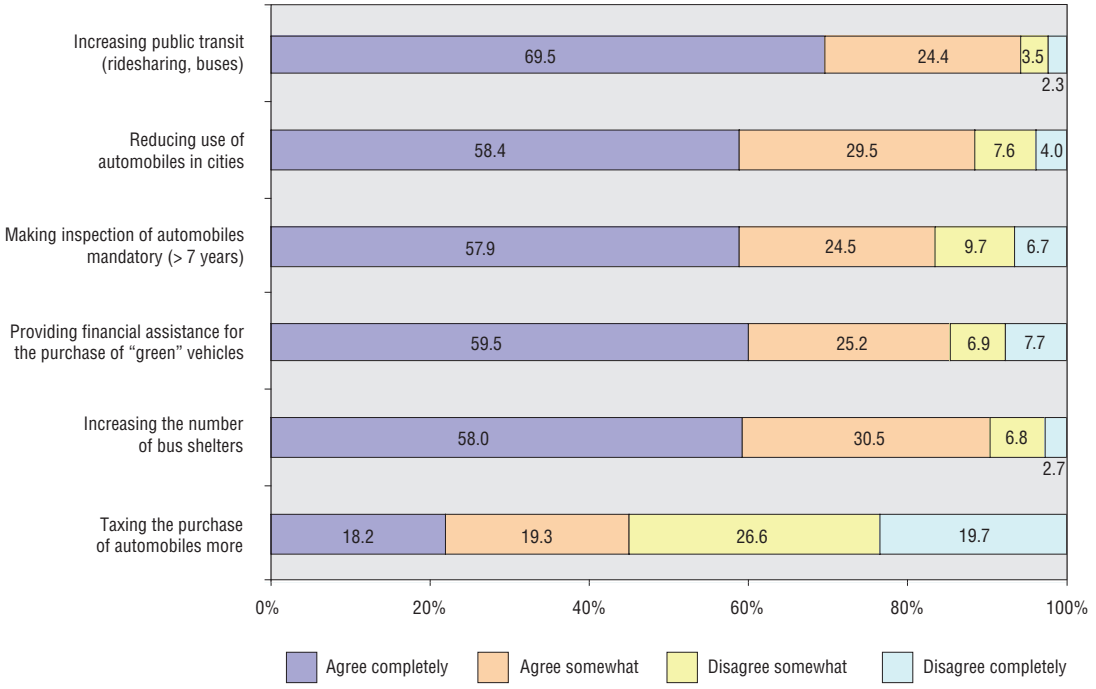


Transportation
• increase public transportation (car pooling, buses) • implement financial incentives for the purchase of "green" vehicles • reduce the use of cars in large urban centres • increase the number of transit shelters • make vehicle inspections mandatory (seven years and older) • expand air conditioning on buses • make air conditioning a standard feature in new vehicles • increase the sales tax on new vehicles
Social measures and research
• expand home care services for sick persons and seniors on low incomes • increase the number of homeless shelters • increase funding for health and climate change research

Source: Bélanger and Gosselin, 2007.

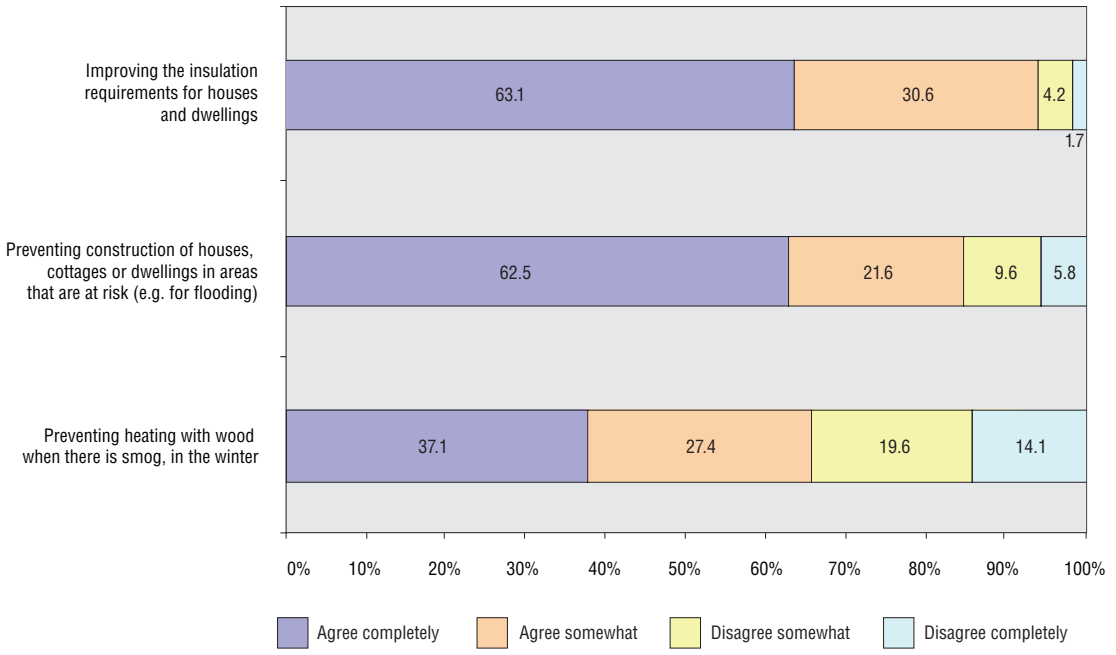
On average, respondents agreed with 19 strategies; 4.2% with fewer than five strategies, 7.6% with five to nine strategies, 13.0% with 10 to 14 strategies, 21.4% with 15 to 19 strategies, 29.1% with 20 to 24 strategies, and 24.6% with 25 to 32 strategies. Some results are presented for transportation (Figure 6.21) and housing (Figure 6.22).

Figure 6.21 Transportation: Solutions to reduce the harmful effects of climate change



Source: Bélanger and Gosselin, 2007.

Figure 6.22 Housing: Solutions to reduce the harmful effects of climate change



Source: Bélanger and Gosselin, 2007.

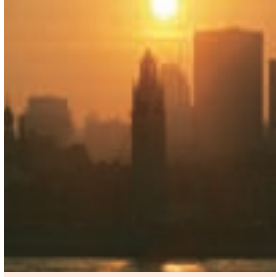
Almost 67% of respondents were in favour of at least three of the four strategies relating to business and industry. Some 82% were in favour of increased monitoring of commercial and industrial pollution, 78% were in favour of stricter controls over forestry practices, 67% were in favour of increased monitoring of agricultural pollution and 53% were in favour of banning the construction of oil- and gas-fired power plants.

Some 66.9% were in favour of at least four of the six land use strategies. Approximately 75% of respondents wanted trees planted in recreational areas, schoolyards and city centres. Some 66% of respondents were in favour of creating beaches (including along rivers) and transforming vacant lots and public lands into parks and gardens. Slightly more than 60% were in favour of planting trees in large outdoor parking lots in cities and also banning residential construction in risk zones.

A little over 70% of respondents were in favour of at least three of the strategies pertaining to infrastructures. Specifically, 83% of respondents wanted more recycling; 76% were in favour of rebuilding roads to make them more resistant to freeze-thaw cycles and erosion, as well as repairing and improving drinking water supply systems; 43% were in favour of increasing the number of municipal pools and the number of parks with fountains; and 32% were in favour of a consumption tax on drinking water.

Half of the respondents were in favour of at least four of the six building-related strategies. Fully 66% approved of air conditioning in hospitals and homes for sick persons and seniors; 63% were in favour of improving residential insulation standards; 52 and 45% were in favour of subsidizing home air conditioning for seniors and low-income people, as well as for daycare centres, respectively; and 37% were in favour of banning wood burning at times when smog is severe.

Close to 60% of respondents agreed with at least four of the eight transportation strategies. Some 70% were in favour of increasing public transportation; 60% approved of financial incentives for the purchase of "green" vehicles; 58% approved of reducing the use of cars in large urban centres, as well as increasing the number of transit shelters and introducing mandatory inspections for vehicles seven years old and older. Finally, 36% favoured air conditioning for buses, 29% wanted air conditioning as a standard feature in new vehicles and 18% favoured higher sales taxes on new vehicles.



6.5.5.2 Suggestions for future adaptations

Extreme climate events and smog

Perceptions of ECEs demonstrate that some events (e.g. such as cold snaps) are of concern to everyone to some degree whereas others (e.g. wildfires) are contingent upon regional geophysical and geomorphological characteristics. Overall, these perceptions also appear to reflect reality (Klaassen et al., 2003; Warren et al., 2004; Yagouti et al., 2006). It is of note that respondents did not mention flooding more often than other extreme events, given that it is of concern for 80% of shoreline municipalities (NRCan, 2006a). Municipal and public health officials have classified flooding as one of the three primary environmental vulnerabilities of southern Quebec (Bélanger et al., 2006a). It is also of note that respondents residing south of Montreal and in Montérégie in particular did not view their region as highly vulnerable to smog, when atmospheric emissions from the two primary sources of pollution—transportation and industry—are higher there than in Montreal itself (INSPQ, 2006a, 2006c). A better understanding of the processes that influence the perceptions of ECEs and smog would be an asset to managers who deal with these issues.

Greenhouse gas reduction and climate change adaptation strategies

Strategies related to business and industry

Implementation of the provincial government's 2006–2012 Action Plan should make it possible to positively address the concerns of the Quebec population, particularly through the consolidation of climate monitoring systems (Government of Quebec, 2006e). The systematic monitoring of environmental indicators (such as atmospheric emissions of primary pollutants) and their effects on health (INSPQ, 2006c, 2006d) is also a step in the right direction. Similar to the existing health-monitoring measures and the associated reporting required under the *Public Health Act* (Éditeur officiel du Québec, 2006c), the Ministère du Développement durable, de l'Environnement et des Parcs (Ministry of Sustainable Development, Environment and Parks) should improve current monitoring practices with respect to the state of the environment and its determinants to gain a better understanding of unfolding trends, as well as to support informed decision making at the local, regional and provincial levels (Bélanger and Gosselin, 2007). Various criteria for monitoring and reporting could be used, such as a five-year profile of environmental trends in Quebec and thematic overviews (e.g., water, air, soil) that could be updated annually. Monitoring data (e.g. health data, environmental data) should be mapped, and the maps made available on the Internet.

Land use strategies

Land use regulations related to flood plains were tightened in 2005 through the *Politique de protection des rives, du littoral et des plaines inondables* (policy on shorelines, coasts and flood plains) (Éditeur officiel du Québec, 2005b) and through the requirement to integrate risk maps into the *Municipalités régionales de comtés* (regional county municipalities) development plans under the *Loi sur l'aménagement et l'urbanisme* (Act respecting land use planning and development) (Ministère des Affaires municipales et des Régions, 2006b). The implementation of these measures—including the development of geomatics at the municipal level and the application of research findings on climate change impacts and adaptations, particularly with regard to drainage in Quebec's urban centres (Mailhot et al., 2007)—will help to characterize and reduce regional vulnerabilities. Moreover, the increased attention being paid to revegetation in urban centres and the various measures taken in this direction in recent years (e.g. inventories of municipal tree stands and various regulations) will likely bring about improvements in the management of urban forestry assets (Giguère and Gosselin, 2006d). These measures are considered as adaptations to reduce urban heat island effects. Efforts to preserve, restore or transform natural sites (e.g. beaches), as well as managed sites (e.g. parks), appear to be crucial in terms of quality of life, particularly for apartment dwellers. Apartment dwellers are more likely to seek out public places for respite during heat waves than house dwellers (Bélanger et al., 2006b).

Strategies related to infrastructures

Quebec's waste management policy for 1998 to 2008 targeted a recovery and reclamation rate of 65% (MDDEP, 1998); by 2004, a rate of 49% had already been achieved (Recyc-Québec, 2004). This environmentally sound management approach is in line with expectations in the area of recycling, and contributes to the reduction of greenhouse gases. Moreover, the initiation of a major investment cycle targeting Quebec's aging public infrastructures (e.g. viaducts, roads, water supply systems) provides an excellent opportunity to establish standards and practices that reflect the potential impacts of climate change (Bélanger et al., 2006a). Steps in this direction will generate benefits for the next 50 years, particularly in the areas of health and road safety (Canadian Automobile Association, 2006). However, far less consensus exists for other strategies, such as increasing the number of municipal pools and the number of parks with fountains, or introducing a consumption tax on water. It would seem that the first of these strategies is aimed at apartment dwellers, the underprivileged, non-drivers, and in short those least likely to have a home pool or the means to travel to recreational areas during heat waves (Bélanger et al., 2006b). A consumption tax on water finds greater acceptance among those whose ability to pay is greater (Villemaire, 1998) and among those from more populated areas where they are more likely to have been exposed to various proposals for taxing potable water.

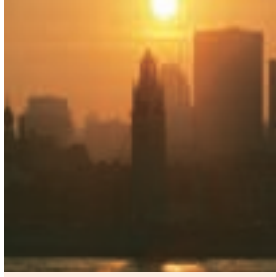
Strategies related to buildings

In the study by Bélanger and Gosselin (2007), the majority of respondents agreed on the need for air conditioning in hospitals and homes for sick persons and seniors—two groups at high risk during periods of extreme heat (Doyon et al., 2006; InVS, 2006). According to some researchers (Giguère and Gosselin, 2006d), Quebec data on air conditioning in health facilities are incomplete. Addressing this gap (including the condition of existing air conditioning and ventilation systems) would be desirable for health protection and public safety.

Those most in favour of subsidizing home air conditioning for seniors, people on low incomes and daycare centres were among the more disadvantaged respondents (many of whom lived in apartment buildings)—in other words, they were the least likely to have home air conditioning (Bélanger et al., 2006b). In 2003, for example, 15.8% of Quebec households with an income below $20,000 had air conditioning, whereas this proportion rose to 44.3% among those who had incomes of $80,000 or more (ISQ, 2006d). Such statistics argue in favour of initiatives (such as air conditioning) directed at those who are economically disadvantaged, some or many of whom are at risk of experiencing serious health problems due to extreme heat. Also, among those most in favour of air conditioning were allophones; related housing and socio-economic conditions may be an explanation (Citizenship and Immigration Canada, 2005; Leloup, 2005). Studies examining the heat adaptation strategies of various ethnic communities would be helpful to increase knowledge about health and climate change, and to optimize the support given to these communities.

The implementation of a more attractive incentive program for energy efficiency, similar to that announced in the provincial government's recent action plan on climate change (Government of Quebec, 2006e), would help to improve home insulation and facilitate adaptations to heat waves. It is hoped that measures will be introduced for persons whose dwellings require major repairs, the case for 7.8% of all private dwellings in Quebec in 2001 (INSPQ, 2006d).

The number of households that use wood burning equipment has now reached 20% (Bélanger et al., 2006c); the number of households using this form of heating increased by approximately 60% between 1987 and 2000 (MDDEP, 2006b). These are worrisome statistics from the standpoint of air quality and public health (MSSS, 2006b), particularly because close to two thirds of respondents in the study saw no reason to prohibit this type of heating during severe winter smog. Closer monitoring of residential wood burning trends and their impact on human health is in order (Bélanger et al., 2006c). Moreover, the determinants of burning wood for heat need to be identified so public awareness campaigns can be improved.



Strategies related to transportation

It is reassuring to note that the majority of respondents were in favour of measures to reduce carbon emissions, including the use of eco-friendly transportation options, the acquisition of energy-efficient cars and various other positive practices. This support should facilitate government efforts to reduce or eliminate transportation-related GHGs (Government of Quebec, 2006e), which accounted for 37.4% of all emissions in Quebec in 2003 and contributed to a host of other negative impacts, including human health impacts (Judek et al., 2005; Ontario Medical Association, 2005). Increasing public awareness of adaptation strategies to climate change constitutes a crucial step. It is very likely that those who drive a car every day will be less enthusiastic about these kinds of transportation strategies than non-drivers or occasional drivers. To optimize awareness efforts, initiatives should be undertaken to identify the primary determinants of transportation choices; to estimate the air pollution associated with each of these choices; and to evaluate people's knowledge of the link between air pollution and their transportation choices (Aubin, 2002). Few respondents were in favour of making air conditioning a standard feature in new cars. This is an encouraging sign because air conditioning consumes gas and therefore contributes to pollution (Environment Canada, 2002). Still, motor vehicle air conditioning trends should be monitored, particularly in light of the observation that people will probably travel more as the cold season grows shorter and may increase their use of air conditioning due to rising temperatures (Lafrance and Desjarlais, 2006). Only one third of respondents were in favour of air conditioning on buses. A study to elucidate the reasons for this response would be useful in developing marketing approaches to promote greater use of public transportation.

Strategies related to social measures and research

Fully 77% of respondents were in favour of providing more home services for seniors and persons with low incomes; 62% were in favour of increasing the number of homeless shelters; and 56% wanted to see more funding for research related to health and extreme climate events. In addition, 60% were in favour of adopting at least two of these three strategies—particularly women, seniors, allophones, the unemployed, the economically disadvantaged, those living alone, apartment dwellers, persons with chronic diseases and those who report their health status as poor. These are the social subgroups most likely to experience social or economic conditions that make it difficult to adapt to heat waves and extreme weather (Bélanger et al., 2006b, 2006c; InVS, 2006). Relocation is not an option for many of these people; therefore, concrete interventions should be incorporated into action plans, particularly in certain urban neighbourhoods (Laverdière, 2001).

6.5.6 Conclusion

From the community to the individual

Based on the study by Bélanger and Gosselin (2007), GHG reduction strategies that call on governments, municipalities and institutions to take action tend to find more support than those directly aimed at individuals. There may be many reasons for this. Some authors contend that the public feels powerless in the face of a global problem of this magnitude and therefore expects government and industry to find appropriate solutions (Dotto, 2000). Consequently, people feel less involved and less inclined to change their behaviour. It would seem that most people are prepared to support national and international initiatives as long as they themselves

are not required to make significant changes in their lives (Bord and O'Connor, 1997), sacrifice their comfort for the greater good (Leiss et al., 2001), or incur costs. Finally, most people are strongly attached to the status quo, and will often do more to maintain it than they will to improve things (Rachlinski, 2000).

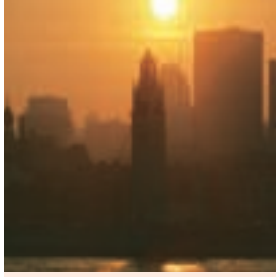
In fact, little is actually known about the cognitive processes that underlie the adoption of adaptive behaviours in social and environmental contexts that are multifaceted (everything from droughts to floods), multidimensional (from the local to the international), and characterized by multiple vulnerabilities (affecting individuals, communities and institutions). Similarly unknown is the nature of groups who prefer to maintain the status quo and of those who are unwilling to pay to effect change (Gelbspan, 2000; Sandalow and Bowles, 2001). Finding answers to these questions would surely help to advance knowledge in the area of climate change. That being said, researchers are not starting from scratch. For example, it is known that individual adaptation measures must be joined by societal and institutional changes to be effective (O'Brien et al., 2004); that sustained Canadian leadership is needed and expected to ensure that everyone is playing according to the same rules (Office of the Auditor General of Canada, 2006); and that individual contributions (e.g. behaviour, responsibility) to climate change received too little coverage in the Canadian media between 1990 and 2004 (Bouchard et al., 2005).

Because the media reinforce and amplify individual representations, Bélanger and Gosselin (2007) recommend that non-governmental organizations, researchers, journalists, municipal and public health managers—all those who have a key role to play—refocus the climate change debate on consequences, including direct and indirect costs (particularly health sector costs) (Crawford and Williams, 2006; Rittmaster et al., 2006). Such education and communication efforts could potentially generate rapid results (Kempton, 1993). In the study by Bélanger and Gosselin (2007), the respondents who were most accepting of the idea of anthropogenic causes were also more likely to support a larger number of GHG reduction and climate change adaptation strategies. Indeed, 70.4% of the respondents who felt that at least 30 of the 32 proposed strategies should be implemented also believed that human activities were causing climate change, whereas this proportion was only 28.8% among respondents who supported at most four strategies.

6.5.7 Synthesis

In industrialized countries, the heat waves of recent decades, particularly those that occurred in Chicago in 1995 and in Europe in 2003, have provided the impetus for a range of publications that have identified the segments of society most at risk in situations of extreme heat. This chapter examined how Quebeckers are adapting to heat waves. Because climate change does not necessarily occur in a linear fashion, it is important to bear in mind that Quebec will still experience very cold winters. For this reason, studies commissioned for this Assessment also examined adaptations to intense cold. Some adaptations to extreme heat and cold are designed to protect the health of the population, while others appear less effective in the long term. Many of the adaptations, some of which are both possible and desirable, are already well accepted by society while others continue to be poorly understood in terms of their link to climate change or may be unacceptable for reasons that have yet to be elucidated.

Based on the results of this study and the literature on climate change, much remains to be done to protect public health and the environment from the effects of ECEs that are likely to become more frequent and more severe. It is important to continue to monitor both impacts and better understand adaptations. The adaptation strategies proposed in this report are a step in the right direction.



6.6 PERCEPTIONS OF MUNICIPAL AND PUBLIC HEALTH MANAGERS

6.6.1 Introduction

By the end of the 1990s, municipal managers in Canada had indicated their concerns about climatic changes (Municipalities Issue Table (MIT), 1998) and proposed measures to reduce GHG emissions in partnership with all levels of government, the private sector and volunteer organizations (MIT, 1998). The following sectors of concern were identified: water supply, waste management, transport, operation of municipal equipment and facilities (e.g. recreational equipment, social housing), energy consumption and GHG emissions (e.g. municipal regulations, urban planning, zoning standards, public relations). Between 100 and 200 of the approximately 4,000 incorporated Canadian municipalities (in about the year 2000) were able to respond to ECE events (MIT, 1998). The Green Municipal Fund, created by the federal government and managed by the Federation of Canadian Municipalities, has supported some 350 projects[19] since 2000 (Federation of Canadian Municipalities, 2006), whereas there are currently 3,700 municipalities across the country according to the Federation. Findings in Quebec are similar; only 93 of 1,110 municipalities[20] (Ministère des Affaires municipales et des Régions (MAMR), 2005c) are registered with the GES Énergie program (Government of Quebec, 2000, 2005b).

In terms of public health, the Climate Change and Impacts Adaptation Programme has funded only 13 research projects relating to health impacts and human adaptation since 1998 (Government of Canada, 2005). In Quebec, MSSS did not join the Ouranos Consortium until 2004. In 2002, very few public health professionals were concerned with climate change (Bélanger et al., 2002). In southern Quebec, interest was piqued by the 2003 heat wave in France, essentially to implement emergency measures for extreme heat (Giguère, 2005).

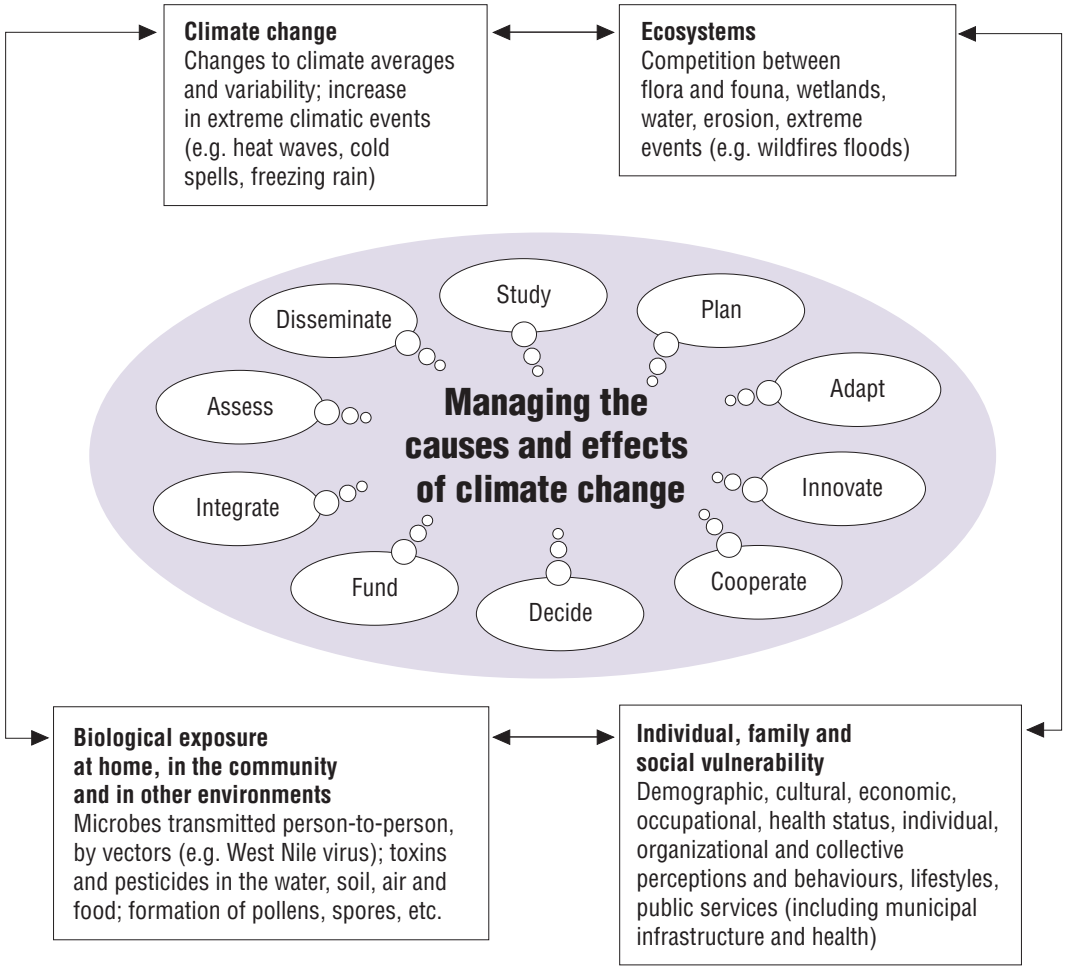
It is unlikely that the lack of awareness of the issue or general information is a key factor in the reluctance of municipal and public health managers to be involved in climate change issues. In fact, the media have widely broadcasted climate change information in recent years, particularly because of the Kyoto Protocol. Several synthesis documents (including some available on the Internet) have also been developed for managers (Isuma, 2001; Auger and Kosatsky, 2002; Gosselin and Grondin, 2002; Ouranos, 2004) and are widely available in various publications and on Quebec and Canadian government web sites. Consequently, other factors more incisive than awareness and general knowledge of climate change would influence public managers in their decisions whether or not to act on this issue, such as the degree of concern regarding such occurrences in their areas, various conditions facilitating or hindering action (MIT, 1998; Canadian Public Health Association (CPHA), 2001), as well as the degree of involvement by partners (Azzah et al., 2002; Wittrock et al., 2001) and the community (MIT, 1999; CPHA, 2001). To facilitate communication and collaboration in Quebec between municipal and public health managers, both of whom are involved in managing the causes and effects of climate change, a better understanding of their respective perceptions was deemed necessary.

Highlights of a study conducted in 2005 among municipal and public health managers in southern Quebec are presented here. The study investigated the relationship between managers' concerns about climate change and its effects and their perceptions of the importance of planning mitigation and/or adaptation measures to be taken over the next 10 or 20 years (Bélanger et al., 2006a) (Figure 6.23).

19 Examples: feasibility studies, pilot projects, field tests.

20 As of January 1, 2005, prior to reconstitution and pursuant to the decree of December 2004, there were 1,110 municipalities in Quebec, excluding Aboriginal reserves, federal land, unorganized territories and Inuit land. That number increased to 1,141 as of January 1, 2006, with reconstitution.

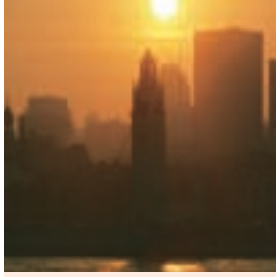
Figure 6.23 Managing the causes and effects of climate change



Source: Adapted from models presented by WHO and the National Institutes of Health (NIH) Committee on Climate, Ecosystems, Infectious Diseases and Human Health, 2001; WHO, 2001; WHO and European Environment Agency, 2002).

In the context of organizational learning theory (Tebourbi, 2000; Berkhout et al., 2004), the study findings provided some answers to the following questions:

- What socio-economic groups of people in their cities, municipalities or socio-health regions do managers see as most vulnerable to climate change, in terms of health and the environment?
- How do managers perceive the frequency and severity of climate change in their regions and in the province? Are they concerned?
- What regional effects of climate change are of concern to managers, particularly in terms of health, civil security, the built or natural environment, infrastructure and the economy?
- How do managers perceive the need to implement, in their respective regions, specific programs in relation to climate change? Why are these programs necessary?
- What actions do they feel have already been taken in their regions to deal with climate change? What key stakeholders are currently involved in this area—locally, regionally and/or nationally—or could possibly be involved?



6.6.2 Methodology

The study (Bélanger et al., 2006a) dealt with municipal and public health managers in southern Quebec, representing more than 99% of the Quebec population (ISQ, 2000). It dealt particularly with 15 of the 18 socio-health regions (Figure 6.12: excluding regions 10, 17 and 18). Each of these health regions is served by a regional health and social services agency which has been responsible for ensuring the delivery of local services since 2003 (Éditeur officiel du Québec, 2005a). Each regional agency has a public health director—who works in close cooperation with other institutional partners in the region (e.g. hospitals)—as well as emergency measures, occupational health, environmental health and infectious disease officials. Each of these professional groups plays a key role in the climate change file (Cassel, 1990; Royal Society of Canada, 1995; Patz et al., 2000; Warren et al., 2004), due to the diversity of clients that may be affected by climate change (e.g. seniors or the chronically ill) and the scope of these health effects (e.g. social and mental stresses caused by catastrophes, heat stroke in workers, water and food contamination) (Warren et al., 2004).

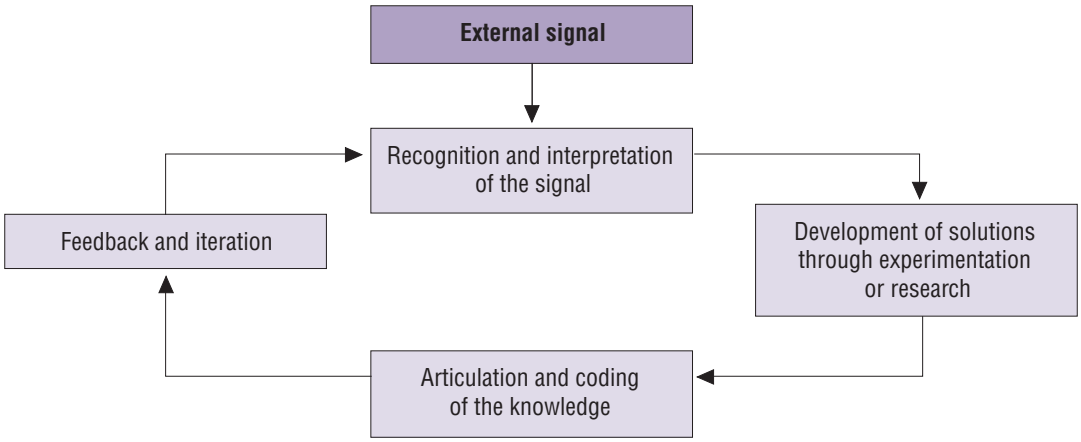
In 2005, there were 86 municipalités régionales de comté (MRC) (regional municipalities) in Quebec, as well as 14 cities (including nine with more than 100,000 residents) that were not in a regional municipality but exercised some of their authority (MAMR, 2005c). Forty municipalities were used for the study. This choice was made to reflect the variability of weather in southern Quebec, in coastal regions (e.g. sea level rises), agricultural regions (e.g. drought), forests (e.g. wildfires), tourist areas (e.g. erosion of beaches, less snow and skiing) and urban areas (e.g. heat islands) (Warren et al., 2004). All of the municipalities managed files related to the effects of climate change, in particular those relating to development, urban planning and agricultural land (e.g. plans, regulations); civil security; services and infrastructure (e.g. housing, roads, mass transit, waterworks, sewers); culture, recreation and tourism; communications and public relations; and administration (e.g. economic development).

A total of 70 health managers and 84 municipal managers were asked to take part in the study. The response rate was 84.4% (58 health managers, 72 municipal managers); more than two thirds of the respondents had at least 10 years of experience as managers. The interview questionnaire was based on health and climate change literature (MIT, 1998; CPHA 2001; Fishbein et al., 2001; Wittrock et al., 2001; Federation of Canadian Municipalities, 2002; Academy for Educational Development, 2003). To better examine the perceptions of managers, these key variables referred to various psycho-social theories rather than a single one. The contents and validation procedures are set forth in Bélanger et al. (2006a).

Three interviewers conducted the data collection by telephone (39 minutes average duration, by appointment) from May 16 to July 8, 2005. The content of the interviews was coded using N'Vivo software (Gibbs, 2002; Quality Systems Registrars, 2005). Two-way interaction between the coder and the researchers or interviewers allowed progressive validation of grouping the data into intermediate response categories (e.g. water management: potable water, wastewater, recreational water) and preliminary descriptive generalizations (Huberman and Miles, 1991; Erlandson et al., 1993). Finally, the thematic content (Paillé and Mucchielli, 2003) was analyzed based on the following five criteria: internal homogeneity (consistent within a single category), external heterogeneity (mutually exclusive or clearly different categories), relevance and comprehensiveness of data, and explanatory productivity (construction of a logical chain of indications and evidence to support the result observed) (Patton, 1990).

The second stage of the analysis was based on a theoretical organizational learning cycle (Tebourbi, 2000; Berkhout et al., 2004) (Figure 6.24). The learning cycle outlines the processes that can help an organization learn from its experiences, guide its objectives and select the relevant information (including the consideration of social, political and structural factors) needed to resolve its problems (Tebourbi, 2000). The processes assist in the interpretation and communication of decision-making knowledge, including the formal and informal mechanisms, used in management and planning.

Figure 6.24 Learning cycle



Source: Adapted from Tebourbi, 2000 (Figure 8, p. 71) and Berkhout et al., 2004 (Figure 1, p. 9).

6.6.3 Results

All respondents (municipal and health managers) perceived vulnerabilities in their regions, whether environmental, socio-economic or health-related. All also reported regional impacts, as a result of climate change, on the general population or more vulnerable subgroups, on natural or built environments, on recreational, sporting or tourism activities, and on the economy (Table 6.6).

Table 6.6 Distribution of managers, by number and percent, and the impacts of climate change on public health in their regions, by category

Impacts of climate change	Health managers	Municipal managers	Number of respondents interviewed
Total number of respondents interviewed regarding climate change impacts on public health	51 (100%)	69 (100%)	120 (100%)
Negative impacts on public health in general	*48 (94%)*	*62 (90%)*	*110 (92%)*
Negative impacts on general health	47 (92%)	57 (83%)	104 (87%)
Negative impacts on physical health	38 (75%)	33 (48%)	71 (59%)
Respiratory and allergies	17 (33%)	16 (23%)	33 (28%)
Infectious diseases	16 (31%)	6 (9%)	22 (18%)
Water-borne diseases	15 (29%)	6 (9%)	21 (18%)
Enteric diseases	9 (18%)	1 (1%)	10 (8%)
Cancers	4	6	10 (8%)
Deaths	5	4	9 (8%)
Other impacts on physical health[i]	7	4	11
Impacts on mental health	13 (25%)	16 (23%)	29 (24%)
Moral	3 (6%)	7 (10%)	10 (8%)
Stress	2	5	7 (6%)

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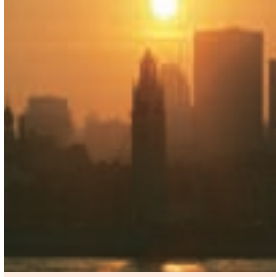

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Impacts of climate change	Health managers	Municipal managers	Number of respondents interviewed
Increased vulnerability	2	3	5 (4%)
Other mental health problems[ii]	7	6	13
Causes of impacts on health	*27 (53%)*	*24 (35%)*	*51 (43%)*
Heat/smog	15 (29%)	11 (16%)	26 (22%)
Water quality	11 (22%)	6 (9%)	17 (14%)
Floods and landslides	2	3	5 (4%)
Other causes[iii]	3	8	11
Variable impact	*2 (4%)*	*5 (7%)*	*7 (6%)*
Little impact on general population	*4 (8%)*	*3 (4%)*	*7 (6%)*
Other (habits and quality of life)	7 (14%)	3 (4%)	10 (8%)
Positive impacts	2	2	4 (3%)
Unknown	2	1	3 (3%)
No impact on public health in general	*5 (10%)*	*12 (17%)*	*17 (14%)*

Notes: As one respondent may identify more than one impact, the total number of respondents does not correspond to the total respondents by category or subcategory.

i Other impacts on physical health: obstacles to physical activity, dehydration/heat stroke, accidents, high blood pressure and cardiac problems, chilblains, illnesses of unknown origin, respiratory problems.

ii Other mental health problems : poverty, depression, passive-aggressive behaviour, post-traumatic stress, suicide.

iii Other causes: pollution, tornadoes, winter temperature fluctuations, snowstorms, forest fires, acclimitization, cold, lack of information.

Source: Bélanger et al., 2006a.

At the regional level, most managers felt that average annual temperatures had risen noticeably over the past few years. They also felt that winters were not as harsh as they were in the past, winter rains and fluctuations in temperature were more common, and snowstorms and the amount of snow on the ground had decreased. Increases in the frequency and violence of climatic events were more commonly noted than rises in temperature. Reference was often made to events that occurred during the summer and winter, particularly heat waves and cold snaps, heavy rainfalls or freezing rain (including their effects, such as flooding), and large variations in temperature. At the provincial level, perceptions of these climatic events were generally the same as those regionally. A majority of respondents felt that climatic events could be accelerated by certain human activities, though not all were convinced that the climatic events they perceived were due to climate change, nor did they did directly relate their observations to ECEs that had occurred in recent decades in their regions or in the province.

Most municipal and health managers were concerned about the regional and provincial impacts of climate change over periods of 10 and 20 years. Similarly, most managers identified the need over the next decade to implement intervention programs related to the effects of climate change. However, regional emergency measures aimed at adapting to these effects have been relatively modest to date, are not uniform provincially, and mostly deal with heat waves. Some respondents noted that the responsibility for and the management of climate change files should rest primarily with regional municipal health officials rather than with various organizational levels, as is the current situation.

The following obstacles to facilitating the implementation of intervention strategies were noted:

- ambiguous messages from upper levels of government decision makers;
- lack of a mandate defining the respective responsibilities and roles of decision makers; and
- lack of financial and technical support, particularly for small and medium-sized municipalities, to implement measures for mitigating and adapting to the effects of climate change.

6.6.4 Discussion

6.6.4.1 Rising average temperature in winter

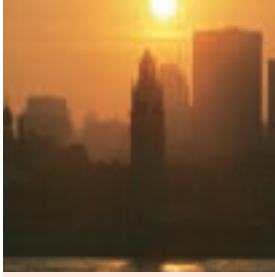
The perception of municipal and health managers that average annual temperatures had not risen noticeably over the last few decades on a regional basis and, to an even lesser degree provincially, may be due to the microclimates of southern Quebec. These microclimates may contribute to a reduced ability to detect "annual" variations that have fluctuated from only 0.5 to 1.2°C between 1960 and 2003 on an east-west trajectory (Yagouti et al., 2006). Furthermore, warming is not necessarily linear (MacCracken et al., 2001). Compared with annual warming, the average rise in temperature in the winter, which is corroborated in the literature (Warren et al., 2004), was most often reported by managers.

6.6.4.2 Increased extreme climate events in summer and winter

The increased frequency and violence of climatic events had more consensus than increased average temperatures, both regionally and provincially. No region was exempt: only the type of events differed, based on the geomorphic characteristics of the area (e.g. strong winds and erosion of shores in the east of the province, tornadoes and violent storms in the west). Some climatic events were mentioned more frequently, such as heat waves, major fluctuations in temperature, heavy rainfalls causing floods and ice storms. Overall, the incidence of these events worries much of the Quebec population, particularly the many summer floods that have affected more than 80% of shoreline communities (NRCan, 2006a). The public has also been affected by ECEs covered widely by the media, including heat waves and various catastrophes over the last 10 years, in particular the Saguenay flood in 1996 (Warren et al., 2004), the Ice Storm in 1998 and the numerous wildfires caused by lightning in the summer of 2002 (NRCan, 2002).

6.6.4.3 Contribution of human-made causes to climate change

Recent global warming of 0.5°C can be partially attributed to GHG emissions generated by human activity (IPCC, 2007). Many managers seemed to be fully convinced of this, some agreed but were not fully convinced of a direct connection, and some did not agree at all. Some respondents appeared to have been influenced by the controversial media coverage of this issue over the last few years (Villeneuve and Richard, 2001). The lack of clarity in the debate on the causes of climate change is not without consequence; first, because decreasing the emission of GHGs associated with human activities is important in reducing the rate and extent of climate change (Warren et al., 2004); second, because this lack of clarity can affect the decision-making process (Prochaska et al., 1995) by influencing the pace at which changes in managers' behaviour take place—from denying the contribution of human-made causes, to "reacting" to climatic events when they occur and, then, to being "proactive" with regards to both GHG emissions and the development of adaptation measures.



6.6.4.4 Certainty about the reality of climate change

Not all managers were certain that they were observing a period of climatic change. It is difficult to categorically state that changes already exist, and the controversy surrounding the causes of climate change may have influenced the perception of some managers. Various factors related to the organization with which they were affiliated may also have contributed; municipal managers seem somewhat less convinced of the reality of climate change than health managers.

The sources of information preferred by municipal and health managers may have had an influence on their different perceptions of the reality of climate change (Tebourbi, 2000). Municipal managers primarily consult publications from government departments and agencies, and economic development organizations[21] (Ippersiel and Morissette, 2004) (i.e. a more general literature focusing on the impacts on infrastructure or territory (MAMR, 2005b)), while health managers usually refer to the scientific literature on the relationships between certain risk factors (e.g. climatic variables) and morbidity and/or mortality (e.g. Patz et al., 2005; McMichael et al., 2006).

The perception that climate change is in progress also has different implications for managerial practices. In the municipal sector, the formal development of numerous procedures and regulations specify what is to be done and how it will be done, and directives specify how to proceed (Tebourbi, 2000). Legislation, policies and best practice guides often direct the actions of municipal managers. Consequently, the information related to climate change must be perceived (and then integrated) as being sufficiently strong, foreseeable and reliable to justify the implementation of the procedures and regulations. The same is not true for public health managers; the system allows for greater ambiguity or uncertainty, particularly because it is mandated to protect public health from risks that may be incurred, even in the absence of irrefutable evidence (the precautionary principle) (Chevalier et al., 2003).

6.6.4.5 Concerns about climate change

Most managers were concerned about climate change over a period of 10 years and others, with some exceptions, over a period of 20 years. The main concern, regionally and provincially, related to the health impacts of climate change. Some managers indicated the need to improve public awareness. Few managers commented on actions that had been taken; the small budgets allocated to this area are probably instrumental in this regard.

According to Bélanger et al. (2006a), no data are available on the portion of public sector (federal, provincial and municipal) budgets in Canada or Quebec that are allocated specifically to preventative environmental activities or preventative public protection purposes. No category other than the allocation of public funds for pollution prevention exists (Statistics Canada, 2000). This category included expenditures for such activities as drinking water supply and purification; waste removal and destruction (and recycling); and other expenses, such as soil decontamination, atmospheric pollution, environmental assessments and administration of environment departments. This publication is currently being revised, but the numbers have probably remained similar (i.e. approximately 4.5% of the total public sector budget allocated to all of these activities, which are only partially or not at all of a preventative nature). Of these expenditures, totalling approximately $10 billion, 66% was assumed by municipal administrations, approximately 21% by the provinces and approximately 13% by the federal government. Allocation by province was not presented, but it can be assumed that this proportion also applies to Quebec.

21 This observation is likely. According to Ippersiel and Morissette (2004), the five main sources of information that municipalities in Quebec consult or would consult are: (1) government departments and agencies and their publications; (2) economic development organizations and their publications; (3) seminars, conferences and fairs; (4) associations or non-profit organizations and their publications; and (5) specialized publications and print media.

The situation is clearer for the health sector. In 2005, approximately $8 billion or 5.6% of public sector budgets was allocated to preventative public health activities (Canadian Institute for Health Information, 2005). The vast range of such activities covers all areas of health, including food and drug safety; health and environmental inspections; health promotion activities; community mental health programs; public health nursing services; measures to prevent the spread of infectious diseases; and measures to promote and improve workplace health and safety in public agencies. A breakdown of expenditures by province was not possible. Specific data for Quebec for these types of expenditures are not available either from ISQ or MSSS. It is assumed here, given the lack of information, that proportions (5.6%) are similar in Quebec and the rest of Canada

6.6.4.6 Regional impacts of climate change

All municipal and health managers reported that climate change could have regional impacts on the general public; more vulnerable subgroups; natural and/or built environments; recreational, sports and tourism activities; and/or the economy. Generally, the climatic impacts perceived by respondents referred to regional vulnerabilities that they saw as already existing, whether environmental, socio-economic or health-related. Overall, however, the impacts and vulnerabilities most indicated by municipal managers differed from those of health managers. This is partially attributable to their respective duties and the legislative framework within which they work.

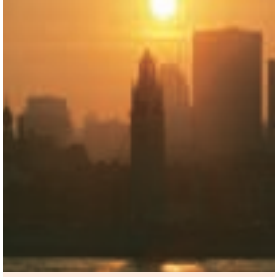
Municipal managers must ensure that municipal services meet the diverse needs of the community or region, particularly from the perspective of socio-economic development (especially among elected officials) while taking into account an aging population, major environmental issues and the globalization of markets (Soucy, 2002). A considerable number of laws and regulations govern the activities of these managers, including the *Municipal Powers Act* (e.g. water management, transportation) (MAMR, 2006c), the *Land Use Planning and Development Act* (e.g. planting and cutting trees, shared agricultural use, erosion and flooding) (MAMR, 2006b), the *Environment Quality Act* (e.g. waste management) (Éditeur Officiel du Québec, 2006a), the *Act to amend various legislative provisions concerning municipal affairs* (e.g. hog farming) (MAMR, 2006a), the *Civil Protection Act* (e.g. civil protection) (MSP, 2005), and the *Municipal Code of Quebec* (e.g. housing) (Éditeur officiel du Québec, 2006b).

Public health managers are mainly accountable under the *Public Health Act* (Éditeur officiel du Québec, 2006c) to protect, maintain or enhance public health and well-being. Their focus is on a range of illnesses—their causes, prevention and treatment—and the related risk factors, including pollution and environmental phenomena.

6.6.4.7 Need to implement regional programs specific to climate change

Some respondents felt there was a need to implement regional programs specific to the effects of climate change over a period of 10 years. To date, very few measures have been developed and those that have deal mainly with heat waves.

Decision makers in southern Quebec were greatly influenced by the heat wave in France in 2003 (Giguère, 2005). This highly publicized heat wave demonstrated that some members of the general public—particularly seniors and the socially or economically disadvantaged—can die from heat. It also underscored the need to take quick political and administrative action; to do so, however, first the actions to be taken must be completely planned. Thus, plans were developed throughout the province to mitigate the negative effects of heat waves, particularly for major urban centres (Giguère and Gosselin, 2006d).



On the other hand, although heavy rains and their impacts on waterways, wastewater and drinking water were often mentioned by municipal and health managers, few indicated they had taken relevant action to include considerations of the effects of climate change. However, flooding affects 80% of shoreline communities in Quebec (including Montreal and Quebec City) and, on average, costs an estimated $10 to $15 billion per year (NRCan, 2006a). They are, in fact, the most commonly occuring natural disaster and the consequences of which can be major, as illustrated by the Saguenay flood in 1996 (Warren et al., 2004). Despite the observed increase in ECEs over the last 15 to 20 years, the evidence does not seem to be enough to motivate immediate implementation of adaptation programs integrating climate change considerations. A similar situation applies to the road networks that are perceived as highly vulnerable, due to increasingly common sudden temperature changes in the winter possibly resulting in rains, flooding and damaged infrastructure (NRCan, 2006a).

The question that arises relates to the mandate of managers to implement regional programs to better manage the effects of climate variability and long-term climatic change. According to some managers, responsibility in this area falls to federal and provincial levels of government, and to municipal organizations and public health branches. Some managers also felt involved, given their respective duties. However, for authorities to become involved, their mandates in this area must be clear and precise; this does not seem to be the case. For example, the guide to develop an action plan for the renewal of drinking water and sewer lines, developed in October 2005 (MAMR, 2005a), referred only to the numerous downstream factors in this process (e.g. ability to pay, opportunity costs, discounted costs based on the funding rate). A federal and provincial mandate to adapt to climate change would have provided the necessary incentive and direction to also consider possible upstream factors, including climatic factors such as heavy rains and flooding.

To date, political consideration of climate change seems centred on GHG emissions and associated rising temperatures, including heat waves. However, increases in flooding and snowstorms are serious climate change concerns (Warren et al., 2004). In Quebec, they are also much more common and widespread than heat waves and have a major impact on public health and well-being, and the economy.

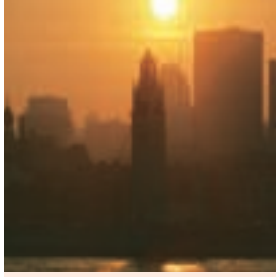
Public service organizations in Quebec place more importance on organizational innovation than on technological innovation (Ippersiel and Morissette, 2004). The lack of capital and qualified personnel for developing and using new technologies might delay some decisions, but it would be likely that managers and the public would be not be interested in investing in such innovations, even if the necessary funds were available. There could be greater publicity and better use of various existing "no regrets"[22] measures that are perceived by managers as being already effective and not necessarily innovative: for example, the construction of dykes, retention ponds and highway diversions; development of mass transit and cycling paths; construction away from flood zones; public health surveillance systems; public health emergency measures training and simulation; and programs on daily life and domestic life aids offered by MSSS.

22 No regrets measures are those for which benefits, such as energy savings and reduced pollution, at least equal their costs to society, regardless of the benefits stemming from the mitigation of the effects of climate change.

Budget constraints were also mentioned by managers. Even "no regrets" measures incur direct costs (e.g. specialized equipment for clearing icy roads in the winter) and indirect costs (e.g. personnel). The amalgamation of municipalities could facilitate the implementation of certain strategies for adapting to the effects of climate change (e.g. pooling of specialized material and human resources) that exceed the financial capacity of many smaller municipalities. For instance, the additional cost of building all-season roads (other than on permafrost) and bridges was estimated, respectively, at $85,000 per kilometre and between $65,000 and $150,000 per bridge (in 2001 dollars), for average increases of 5% in temperature and 10% in precipitation in this century (Dore and Burton, 2004). However, it is unlikely that amalgamations will remedy all regional program issues, such as the problems inherent in interaction between numerous stakeholders during a disaster (e.g. values, training, varying procedures). With respect to technological innovation, public services in Quebec rarely have access to funds for such development or to encourage innovators (Ippersiel and Morissette, 2004). As early as 1999, the Municipalities Issue Table (MIT) noted limited access to capital and limited experience with external capital sources in relation to the funding of energy savings or GHG emissions reduction programs (MIT, 1998). In the area of public health, it is primarily research funds that permit the exploration of new technology and innovation (Bédard et al., 2003).

Unlike federal and provincial government managers often working at macro policy levels, regional and municipal managers are responsible for implementing in the field and managing programs specifically related to climate change in their areas. Managers identified municipal branches and their land use and urban planning services, public health branches and environmental health teams, as possible key players in dealing with the effects of climate change. They also remarked that the support of colleagues, leaders (elected officials) and the public was insufficient. This adds to the difficulties faced particularly by municipal managers who must ensure that actions taken are approved by the public (Ippersiel and Morissette, 2004) and contribute to improving the services already offered, while reconciling economic constraints (Soucy, 2002). Even with popular support for a large number of adaptations, managers have many other considerations. For example, public health managers must work in close cooperation with other institutional partners in the region (e.g. hospitals), which have priorities other than climate change and are not necessarily convinced of its impact on health care services because its impacts on health are not yet readily observable (McMichael et al., 2006).

Bélanger et al. (2006a) suggested it would be highly desirable to add a component on reducing existing vulnerabilities to those actions targeted at mitigating GHGs and adapting to climate change. This would facilitate viewing vulnerability not as the net result of climate change once the adaptations are in place, but as a characteristic (such as available income) or a condition (such as being disabled) generated by various social and environmental processes and exacerbated by climate change (O'Brien et al., 2004). In their opinion, this approach would solidify the integration of this "human" dimension as the cornerstone of the entire process to address climate change.



6.6.4.8 Comments on the validity and reliability of results

In this research, the rate of participation was 84.4% (n=130). Managers from various activity sectors of public and regional interest were interviewed in the 15 socio-health regions in southern Quebec to reflect the variability of climate impact in coastal, agricultural, forestry, tourist and urban areas. Respondents included public health directors, emergency measures officials, occupational health officials, environmental health officials and infectious disease officials from health and social services agencies in each of the 15 regions. They also included municipal managers from 40 of the 86 municipalités régionales de comtés (MRC) and 14 cities that would be concerned with land-use planning (including agricultural), civil protection, services and infrastructure, culture, recreation and tourism, communications and public relations, and administration. This sample includes managers who play key roles in the area of climate change in the various sectors of southern Quebec's 15 regions.

Consideration was given to whether some managers answered the questions so that their statements would be in keeping with media coverage on climate change, particularly in the context of debates over the Kyoto Protocol (Paulhus, 1991). However, Bélanger et al. (2006c) believe that the influence of media coverage in favour of ratifying the Kyoto Protocol in Quebec has had little influence on the data for the following reasons. First, distribution of responses covered a wide range of possibilities (e.g. from completely "for" to completely "against" the idea that climate change is a reality). Second, some managers did not hesitate to indicate their scepticism about the actual reality of climate change. Before the interviews were concluded, views on the reality of climate change were confirmed and, if needed, responses were clarified.

It is possible that one-on-one interviews, or longer telephone interviews, would have allowed for a more detailed response to certain questionnaire topics, such as existing vulnerabilities or obstacles to the implementation of specific climate change programs. However, this is highly unlikely for the following reasons. During data collection, the information provided a diminishing return and the data saturated (which means that little or no new information showed up from interviewees after the initial period, a methodological criterion used to assess a qualitative survey's validity) (Deslauriers, 1991). In addition, although increased ECEs were noted as significant, as was the rise in winter temperature (based on certain climatic indicators, such as rain, snow cover), few managers considered this information as significant and sufficiently predictable to include climate change issues in their agendas. Apart from heat wave plans, very few new measures are currently in place to systematically mitigate or counter the impacts of climate change.

This situation is not surprising (Berkhout et al., 2004). Evidence of climate change is not readily apparent because the signal of such change is "muddied" by natural climate variability (increased frequency and severity of existing situations). In addition, the interpretation of that signal depends on specialists outside the organizations with which managers are associated, and these specialists use complex mathematical modelling that is not familiar to managers. At this stage of evolving knowledge, the specialists (scientists) cannot provide, with absolute certainty, exact responses to crucial questions managers would ask about the scope and timing of climate changes. Therefore, it is difficult for municipal and health managers to translate the signals of climate change into concrete action.

6.6.5 Synthesis

Based on the preceding findings, Bélanger et al. (2006a) inquired if immediate action on climate change was possible—considering that currently the scope of its effects is more expected than experienced, and its effects will be most evident in populations that for various other reasons are already vulnerable. In an affirmative response, they put forward a "no regrets" intervention strategy, adapted for use by municipalities and public health agencies. It integrates various proven methods for preventing the negative effects of climate change and includes the following five components.

1. Clarify the mandate for consideration of climate change

Federal and provincial levels of government must present a clear, consistent message about climate change, including a clear definition of the mandates and roles of the parties involved in addressing this issue. According to interviewees, this is necessary for municipal and public health managers to feel that they can proceed with implementing concrete measures and, as required, start internal processes to develop innovative responses. To support managers, this message should likely be in the form of a legal obligation to consider the risks of climate change in the decision-making processes of health and social services agencies, municipalities and provincial departments.

2. Benefit from the present cycle of investment in public infrastructure

Under the present cycle of investment in public infrastructure, standards and practices that reflect the possible impact of climate change should be adopted. Several adaptations to climate change would involve improvements to infrastructures, often those with a life span of 30 to 50 years (e.g. water treatment plants, buildings, roads). A cycle of major investment in Canada is beginning as a result of aging infrastructures, many having been constructed more than 40 years ago. Great opportunities are available at this time for action in the area of climate change, at minimal additional cost. Taking this opportunity will have beneficial effects for the next 50 years.

3. Support strengthened standards, procedures and organizational routines

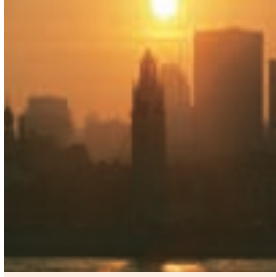
Standards, procedures and organizational routines should be strengthened, particularly by implementing training to develop skills (e.g. risk assessment, including maps of risk areas), developing intervention protocols or structured guides that are easy to use, and creating ad hoc provincial committees with various experts and managers with field experience who can provide technical assistance to disadvantaged areas facing uncommon situations.

4. Transfer and share knowledge more effectively

Knowledge about R&D activities, particularly those undertaken to date within Ouranos, should become more widely available. This transfer of knowledge would facilitate decision making and the definition of standards and procedures that could be used locally by organizations and municipalities throughout Quebec. This approach would help to remove the "high-tech cloud" that seems to surround the climate sciences in the minds of managers. Some adaptations to climate change have already been implemented by local authorities as local and regional interventions to address issues other than climate change. The knowledge gained by sharing "know-how" in this area could be a significant asset for those who do not have the expertise or resources to implement climate change adaptations.

5. Raise public awareness of climate change

The public and elected officials must be aware of current and future climate change issues so that initiatives taken by managers receive timely support. A structured, long-term program to raise public awareness would be a valuable contribution to taking action on climate change.



6.7 CONCLUSION

The first *Canada Country Study: Climate Impacts and Adaptation* (Bergeron et al., 1997) included a chapter on Quebec, which incorporated a health component. The report concluded that information on impacts and adaptations about health and the effects of climate change were poor or sketchy. Several recommendations were made, the first being:

> "Initiate multidisciplinary studies to quantitatively assess the direct impacts of oppressive heat waves, intense cold waves and winter storms on morbidity and human mortality and on the social behaviour of people living in urban and semi-urban environments in Quebec." (p. 196)

It has taken almost 10 years since the study to implement this recommendation; the summary results are presented in this chapter in brief. Since the study, the base of scientific knowledge in Quebec has grown significantly, and the understanding of climate change issues in Canada and globally has evolved. Therefore, the expected scope of certain effects can be estimated, and preparations for the required adaptations can be made immediately.

With regard to southern Quebec, these effects are likely to have a negative effect on health; the effects appear be major in scope, if judged by the simulated future deaths presented here. In absolute number of deaths per year, there would be an increase of 150 deaths per year by 2020, 550 annual deaths by 2050 and 1,400 by 2080 in southern Quebec. This is likely a lower value, considering the range of expected impacts. The simulations do not take into account the fact that the Quebec population will age considerably during that period; the percentage of people aged 65 and over (who are much more sensitive to climate variations) will more than double during that period. These estimates also do not include increases in mortality from extreme weathers events such as heat waves or storms, or a possible future outbreak of water-, vector- or food-borne infectious diseases. Other illnesses related to climate change have not yet been accounted for. It is predicted that the general health of the population could further deteriorate; for example, the current epidemic of obesity and diabetes—conditions that increase vulnerability to the effects of climate change—could also complicate this picture over 20 or 30 years. These simulations also assume that GHGs will be stabilized at twice the current level, which may be considered optimistic. Important impacts are also expected in Quebec's northern regions; these are presented in Chapter 7, Health Impacts of Climate Change in Canada's North.

In comparison with the preceding estimates of mortality, traffic accidents kill some 700 people a year in Quebec, while approximately 6,000 are seriously injured (Société de l'assurance automobile du Québec, 2006). Major programs are directed toward prevention of traffic accidents and the mitigation of their consequences, and the costs of these accidents to society are hundreds of millions of dollars each year (Société de l'assurance automobile du Québec, 2006). The negative health effects of climate change are not yet of the same scope, but could be in 30 or 40 years according to the simulations, or possibly earlier.

The good news is that much of the expected effects can be minimized and even prevented. Just as traffic injuries have fallen by 60% over 25 years because of effective awareness and prevention programs directed to the public and involving institutions across all sectors, it is possible to act as effectively with regard to the effects of climate change. This chapter has outlined a number of opportunities and examples that can be supported and reinforced that confirm that Quebec has many of the tools and means to undertake such a challenge.

The other good news is that Quebec has begun to take action in the last few years in certain areas that will be useful in adapting to climate change. The provincial 2006–2012 action plan on climate change (Government of Quebec, 2006e) and most of its planned measures are generally supported by the population. These province-wide measures include the northern regions where the majority of Aboriginal and Inuit populations reside.

The research results and recommendations emanating from the research projects commissioned for this Assessment and reported in this chapter have already helped to raise awareness among health officials in Quebec about the need to implement concrete measures. The importance of the health research program (and the dissemination of this research) for the period 2006 to 2009 supported by Ouranos with INSPQ, MSSS, Health Canada, Environment Canada and university researchers must be noted. Some significant measures to reinforce health surveillance during ECEs and heat waves are also planned for this same period. A program for promoting cool islands in urban areas has also been announced, as have efforts to upgrade ventilation and air conditioning in health care establishments. Finally, a program to train health care providers is planned. Under the safety of people and property component of the action plan, the government also recently put in place a program to prevent and minimize the impact of major natural hazards. The approximately $75 million program (Government of Quebec, 2006b), administered in collaboration with municipalities and regional stakeholders, will address problem situations related to coastal erosion, flooding and landslides. This initiative will guide all future planning in regards to infrastructure and buildings.

A number of sectors of society have already begun work on adaptation. At the municipal and provincial level, the priority issue is the reduction of GHG emissions, because no new or existing adaptation measures will be effective if action is not taken now to stabilize the future climate. Cities and towns, for example, are capturing the gas emitted by sanitary landfills, taking preventative measures to reduce emissions through changes in zoning and incorporating weather emergencies into emergency plans. Businesses are buying hybrid vehicles, working to lower trucks' maximum speed to save gasoline and reduce GHGs, replacing trucks by maritime transport, and moving towards geothermal heating systems. There is a long list of such initiatives, including the future carbon exchange in Montreal and the sustainable development and climate change response plan to be released in the near future by Quebec's health network.

Still, programs remain to be defined, systematized, solidly budgeted and implemented. These programs must also be directed in particular to the people and communities who need or will need them and to those who do not or will not have the means of funding required infrastructures, services or other adaptations. Great differences, based on income and state of health, must be taken into account as well, as shown in this chapter with regard to access to air conditioning and pools during heat waves and adequate

heat during cold snaps. Differences in behaviours that vary according to age, gender, habits, ethnic origin and/or social environments must also be taken into account, particularly for effective awareness campaigns and warnings. With these considerations, an integrated public health program on adaptations to climate change can be realized. Many other factors that are brought forward in this chapter also warrant consideration. Most adaptations to climate change are interventions that have already been implemented (or could be implemented) by existing departments, agencies and local or regional municipalities. Nevertheless, these interventions exist for reasons other than the effects of climate change, and must be adjusted, better targeted and strengthened to address these effects.

Climate change presents a challenge of societal equity, between generations and regions, between the disabled and the able-bodied, and between the rich and the poor. It also presents the challenge of global equity. The World Health Organization recently reported that climate change already results in the death of more than 150,000 people each year, primarily in developing countries that cannot afford the infrastructure needed to address its effects or reduce GHGs, which are predominantly generated by the developed and wealthier countries, including Canada (Basu, 2005).

While investments in adaptation are on the rise, a single ingredient still seems to be lacking in order to maximize the opportunities present in all sectors of society: a clear and unequivocal message from senior levels of government regarding the need to think "adaptation" to the effects of climate change and a legal obligation for institutions to consider this in their daily decisions for the next two or three generations. The public in Quebec continues to deem this issue a very important one (Léger Marketing, 2006), as it has for several years.

6.8 REFERENCES

Academy for Educational Development. (2003). *Behavioral determinants inter-working group meeting.* Retrieved February 23, 2006, from http://www.coregroup.org/working_groups/Determinants_meeting_rpt0903.pdf

Agence de développement de réseaux locaux de services de santé et de services sociaux. (2003). *Algues bleues: Cyanobactéries* [Blue-green algae: Cyanobacteria]. Retrieved March 14, 2005, from http://www.regie-monteregie.gouv.qc.ca/Menu_Gauche/4-Publications/6-Dépliants_Guides_Outils_Information/Sante_Environnementale/DSP_pub_Depliant_cyanobacteries_fr.pdf

Agence de la santé et des services sociaux de la Montérégie (ASSSM). (2002). *Protéger la santé* [Health protection]. Retrieved April 11, 2006, from http://www.rrsss16.gouv.qc.ca/santepublique/protection/environnement/Qualiteairexterieur/tqhp/infopro/fiches/Prot%E9ger%20la%20sant%E9.pdf

Agriculture and Agri-Food Canada. (2003). *Algae, cyanobacteria and water quality.* Retrieved June 15, 2006, from http://www.agr.gc.ca/pfra/water/algcyano_f.htm

Akaike, H. (1973). Theory and an extension of the maximum likelihood principal. In B.N. Petrov, and F. Csaki (Eds.), *International symposium on information theory.* Budapest, Hungary: Akademiai Kaiado.

Alavi, A., and Beaumont, J-F. (2003). *Evaluation and adjustment for non-response in the Canadian Labour Force Survey.* Retrieved February 10, 2006, from http://www.statcan.ca/bsolc/english/bsolc?catno=11-522-X20030017598

Albert, C., Proulx, R., and Richard, P. (2006). Chaleur accablante et usage de médicaments: Étude exploratoire en Estrie [Extreme heat and medication use: Exploratory study in the Eastern Townships]. *Bulletin d'information en santé environnementale (BISE), 17*(3), 5–8. Retrieved December 4, 2006, from http://www.inspq.qc.ca/pdf/bulletins/bise/BISE-17-3.pdf

American Water Works Association. (1999). *Manual of water supply practices—M48: Waterborne pathogens (1st ed.).* Denver: Author.

Aubin, B. (2002, December 15). *Inquiets, mais pas encore assez* [Worried, but not worried enough yet]. L'actualité.

Auger, N., and Kosatsky, T. (2002). *Chaleur accablante. Mise à jour de la littérature concernant les impacts de santé publique et proposition de mesures d'adaptation* [Extreme heat. Update on literature regarding effects on public health and proposed adaptation measures]. Montréal: Régie régionale de la santé et des services sociaux de Montréal-Centre.

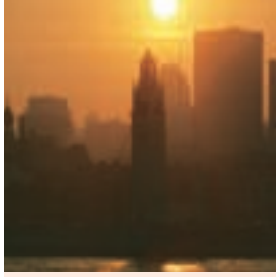
Auger, P., Verger, P., Dab, W., Guerrier, P., Lachance, A., et al. (2003). Sinistres naturels et accidents technologiques [Natural disasters and technological accidents]. In M. Gérin, P. Gosselin, S. Cordier, C. Viau, P. Quénel, et al. (Eds.), *Environnement et santé publique: Fondements et pratiques [Environment and public health: Foundations and practices]* (pp. 517–535). Montréal and Paris: Édisem and Éditions Tec et Doc.

Azzah, J., Lemmen, D., et al. (2002). *Final Report on Federation of Canadian Municipalities municipal infrastructure risk project: Adapting to climate change.* Retrieved February 16, 2006, from http://adaptation.nrcan.gc.ca/app/filerepository/BF7416415FCF45F4A6146DE5B6D1EF97.pdf

Basu, P. (2005). *Third world bears brunt of global warming impacts.* Retrieved August 31, 2006, from http://www.news.wisc.edu/11878.html

Beaudreau, P., Besancenot, J.P., Caserio-Schönemann, C., Cohen, J.C., Dejour-Salamanca, D., et al. (2004). *Froid et santé: Éléments de synthèse bibliographique et perspectives* [Cold and health: Summary bibliography and perspectives]. France: Institut national de veille scientifique. Retrieved May 15, 2006, from http://www.invs.sante.fr/publications/2004/froid_et_sante/rapport_froid_et_sante.pdf

Bédard, Y., Gosselin, P., Rivest, S., Proulx, M-J., Nadeau, M., et al. (2003). Integrating GIS components with knowledge discovery technology for environmental health decision support. *International Journal of Medical Informatics, 70*(1), 79–94.



Bélanger, D., and Gosselin, P. (2007). *Changements climatiques au Québec méridional: Perceptions de la population générale et suggestions d'adaptations futures* [Climate change in southern Quebec: Perceptions of the general public and suggestions for future adaptations]. Québec: Institut national de santé publique du Québec. Retrieved March 15, 2007, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

Bélanger, D., Gosselin, D., and Lebel, G. (2002). Tendances, initiatives et besoins dans le domaine de la surveillance en protection de la santé [Trends, initiatives and needs in health protection surveillance]. In *Bilan et perspectives en matière de surveillance en protection de la santé*. Comité d'orientations stratégiques en matière de surveillance (COSMAS). Québec: Ministère de la Santé et des services sociaux.

Bélanger, D., Gosselin, P., and Poitras, P. (2006a). *Changements climatiques au Québec méridional: Perceptions des gestionnaires municipaux et de la santé publique* [Climate change in southern Quebec: Perceptions of municipal and public health managers]. Québec: Institut national de santé publique du Québec. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

Bélanger, D., Gosselin, P., Valois, P., and Abdous, B. (2006b). *Vagues de chaleur au Québec méridional: Adaptations actuelles et suggestions d'adaptations futures* [Heat waves in southern Quebec: Current and proposed future adaptations]. Québec: Institut national de santé publique du Québec. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

——. (2006c). *Vagues de froid au Québec méridional: Adaptations actuelles et suggestions d'adaptations futures* [Cold snaps in southern Quebec: Current and proposed future adaptations]. Québec: Institut national de santé publique du Québec. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

Bergeron, L., Lacroix, J., and Vigeant, G. (Eds.)(1997). *Canada Country Study, Volume V. Responding to global climate change in Quebec.* Environment Canada. Retrieved January 15, 2008, from http://dsp-psd.pwgsc.gc.ca/Collection/En56-119-3-1997-1E.pdf

Berkhout, F., Hertin, J., and Gann, D.M. (2004). *Learning to adapt: Organisational adaptation to climate change impacts.* Tyndall Centre working paper, no. 47. Brighton, U.K.: Tyndall Centre for Climate Change Research.

Bord, R.J., and O'Connor, R.E. (1997). The gender gap in environmental attitudes: The case of perceived vulnerability to risk. *Social Science Quarterly, 78*(4), 586–593.

Bouchard, L., Roy, J.F., Krewski, D., Lemyre, L., Brand, K., et al. (2005). Projet 1.2.2: Analyse de contenu. Abridged version of the masters thesis of Roy, J.F. (2004). *L'amplification sociale du risque: Les changements climatiques dans la presse écrite au Canada 1990–2004* [Social amplification of risk: Climate change in the print media in Canada 1990–2004]. Faculté des études supérieures et postdoctorales, département de sociologie, Université d'Ottawa. In D. Krewski, L. Lemyre, L. Bouchard, K. Brand, C. Dallaire, et al. (2005), *Public perception and acceptable levels of health risk among Canadians. Ottawa.*

Bouden, M., Moulin, B., Gosselin, P., Back, C., Doyon, B., et al. (2005). *The geosimulation of West Nile virus infection on the basis of climate: A tool for risk management in public health.* Paper prepared for C-CIARN conference, Adapting to climate change in Canada 2005: Understanding risks and building capacity, Montréal, QC. Retrieved June 13, 2006, from http://www.adaptation2005.ca/posters/bouden_e.html

Canadian Automobile Association. (2006). *En route vers un environnement et un avenir sains* [Driving towards a cleaner environment – a healthier future]. Retrieved January 17, 2007, from http://www.caa.ca/eco-mobility/francais/pdf/CAA_En_Route.pdf

Canadian Cancer Society. (2005). *Canadian cancer statistics 2005.* Toronto: Canadian Cancer Society/National Cancer Institute of Canada.

Canadian Council of Ministers of the Environment (CCME). (2004). *From source to tap: Guidance on the multi-barrier approach to safe drinking water.* Retrieved March 14, 2005, from http://www.ccme.ca/

——. (2005). *Infosheets on contaminants.* Retrieved April 15, 2005, from http://www.ccme.ca/sourcetotap/infosheets.html

Canadian Heritage. (2006). *The non-official languages.* Retrieved April 5, 2006, from http://www.pch.gc.ca/progs/lo-ol/pubs/census2001/5_e.cfm

Canadian Institute for Health Information (CIHI). (2005). *Total health expenditure by use of funds, Canada, 2005.* Retrieved April 15, 2006, from http://www.cihi.ca/cihiweb/dispPage.jsp?cw_page=statistics_results_topic_macrospend_e&cw_topic=D%E2%80%9Apenses%20de%20sant%E2%80%9A&cw_subtopic=Macro-d,%20penses

Canadian Public Health Association (CPHA). (2001). *Roundtable on health and climate change.* Retrieved February 16, 2006, from http://www.cpha.ca/english/natprog/rndtable/proceede.pdf

Canadian Red Cross. (2003). *Drownings and other water-related injuries in Canada 1991–2000.* Retrieved January 29, 2006, from http://www.redcross.ca/cmslib/general/10drwn_English.pdf

Canadian Strategy for Cancer Control. (2001). *Priorities area: Primary prevention action group.* Retrieved April 13, 2006, from http://209.217.127.72/cscc/priorities_pppage.html

Cassel, C.K. (1990). Medical responsibility and global environmental change. *Annals of Internal Medicine, 113*(6), 467–473.

Centers for Disease Control and Prevention. (2004). *Extreme heat bibliography.* Retrieved February 6, 2006, from http://www.bt.cdc.gov/disasters/extremeheat/bibliography.asp

——. (2006). *Heat stress.* Retrieved February 6, 2006, from http://www.cdc.gov/niosh/topics/heatstress/

Centre de recherche sur l'opinion publique (CROP). (2002). *Sondage d'opinion sur le protocole de Kyoto* [Opinion survey about the Kyoto Protocol]. Retrieved April 19, 2006, from http://www.cpeq.qc.ca/apropos/SondageKyoto.ppt

Centre for Research and Information on Canada (CRIC). (n.d.). *Quick guide, freshwater.* Retrieved April 3, 2006, from http://www.cric.ca/en_html/guide/water/eau.html

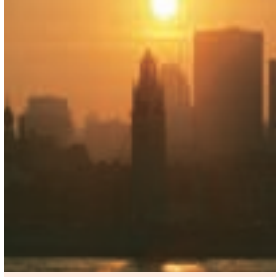
Centre on Global Change and Health. (2006). *2006 publications.* Retrieved February 12, 2006, from http://www.lshtm.ac.uk/cgch/publications.html

Chaumont, D. (2005). *Développement de scénarios climatiques à des fins de prévision de la demande énergétique au Québec pour les besoins de chauffage et de climatisation* [Development of climate scenarios to forecast energy demand in Quebec for heating and air conditioning]. Ouranos Consortium. Retrieved August 22, 2006, from http://www.ouranos.ca/doc/Rapports%20finaux/Chaumont_energie.pdf#search=%22chaumont%20sc%C3%A9narios%20climatiques%20ouranos%22

Cheng, C. S., Campbell, M., Li, Q., Li, G., Auld, H., et al. (2005). *Differential and combined impacts of winter and summer weather and air pollution due to global warming on human mortality in south-central Canada.* Technical Report to Health Canada. Retrieved January 15, 2008, from http://www.toronto.ca/health/hphe/pdf/weather_air_pollution_impacts.pdf

Chevalier, P., Cordier, S., Dab, W., Gérin, M., Gosselin, P., et al. (2003). Santé environnementale [Environmental health]. In *Environnement et santé publique: Fondements et pratiques.* Montréal and Paris: Édisem and Tec and Doc.

Citizenship and Immigration Canada. (2005). *Recent immigrants in metropolitan areas: Montreal—A comparative profile based on the 2001 census.* Retrieved January 17, 2007, from http://www.cic.gc.ca/francais/ressources/recherche/recensement2001/montreal/partiea.asp



Commission de la santé et de la sécurité du travail (CSST). (2004). *Attention au coup de chaleur* [Watch out for heat stroke]. Retrieved March 27, 2006, from http://www.csst.qc.ca/NR/rdonlyres/52A95AD2-8BAB-4D1C-B110-2845888A24A9/1454/dc_100_1113_5.pdf

Committee on Climate, Ecosystems, Infectious Diseases, and Human Health. (2001). *Under the Weather: Climate, Ecosystems, and Infectious Disease.* Board on Atmospheric Sciences and Climate, National Research Council. Retrieved January 14, 2008, from http://www.nap.edu/catalog.php?record_id=10025

Core Group. (2003). *Behavioral determinants inter-working group meeting at the academy for educational development.* Retrieved February 23, 2006, from http://www.coregroup.org/working_groups/Determinants_meeting_rpt0903.pdf

Crawford, E., and Williams, T. (2006). *Smog and population health.* The parliamentary information and research service of the Library of Parliament (PRB 05-101E). Retrieved January 19, 2007, from http://www.parl.gc.ca/information/library/PRBpubs/prb05101-e.pdf

Croley, T.E. (2003). *Great Lakes climate change hydrologic assessment, I.J.C. Lake Ontario-St-Lawrence River regulation study.* National Oceanic and Atmospheric Administration technical memorandum GLERL-126.

Curriero, F.C., Patz, J.A., Rose, J.B., and Lele, S. (2001). The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948–1994. *American Journal of Public Health, 91,* 1194–1199.

Del Matto, T., Foster, D., Wolnik, C., Kassirer, J., Southam, T., et al. (2004). *Feasibility assessment of a change-out/education program for residential wood combustion.* Report prepared for the Canadian Council of Ministers of the Environment. Retrieved June 8, 2006, from http://www.ccme.ca/assets/pdf/rwc_final_report.pdf

Deslauriers, J-P. (1991). *Recherche qualitative: Guide pratique* [Qualitative research. Practical guide]. Collection THEMA. Montréal: McGraw-Hill.

Direction de santé publique (DSP) de Montréal. (2004). Extreme heat. In *Prévention en pratique médicale* [Prevention in medical practice], June, Retrieved January 15, 2008, from http://www.santepub-mtl.qc.ca/Publication/pdfppm/ppmjune04.pdf

——. (2006). *Plan montréalais de prévention et protection en cas de chaleur accablante* [Montréal plan for prevention and protection during extreme heat]. Retrieved June 16, 2006, from http://www.santepub-mtl.qc.ca/Environnement/chaleur/pdf/planchaleur2006.pdf

Direction de santé publique (DSP) de la Montérégie. (2004). *Plan d'urgence spécifique "mesures accablantes" (2004 ed.)* [Specific emergency plan for dealing with oppressive conditions]. *Preliminary version.*

Dixsaut, G. (2005). Vague de chaleur et climatisation: Revue bibliographique [Heat waves and air conditioning: Bibliographic review]. *Bulletin d'information en santé environnementale BISE, 16*(3), 1–6. Retrieved June 16, 2006, from http://www.inspq.qc.ca/pdf/bulletins/bise/BISE-16-3.pdf#search=%22dixsaut%20bise%22

Donaldson, G.C., Kovats, R.S., Keating, W.R., and McMichael, A. (2001). Overview of climate change impacts on human health in the U.K. In Expert Group on Climate Change and Health in the U.K. (Ed.), *Health effects of climate change in the U.K.* Retrieved April 14, 2006, from http://www.dh.gov.uk/assetRoot/04/10/80/61/04108061.pdf

Dore, M., and Burton, I. (2004). The costs of adaptation to climate change: A critical literature review. In F. Warren, E. Barrow, R. Schwartz, J. Audrey, B. Mills, et al., *Climate change impacts and adaptations: A Canadian perspective* (p. 31). Ottawa: Natural Resources Canada.

Dotto, L. (2000). *Public confusion over climate change: The role of the media.* Communication conference. Session F1. Influence on public understanding of climate change 2. Retrieved January 17, 2007, from http://www.fes.uwaterloo.ca/research/climateconference/F1.pdf

Doyon, B., D. Bélanger and P. Gosselin. (2006) *Effets du climat sur la mortalité au Québec méridional de 1981 à 1999 et simulations pour des scénarios climatiques futures* [Climate effects on mortality in southern Quebec from 1981 to 1999 and simulations for future climate scenarios]. Québec: Institut national de santé publique du Québec. Retrieved 29 November 2007, from http://www.inspq.qc.ca/publications/notice.asp?E=p&NumPublication=536

Ducas, S. (2004). Presentation given at the 8th annual public health day. *Montréal au premier plan* [Montreal first]. Retrieved April 13, 2006, from http://www.inspq.qc.ca/jasp/archives/pdf/2004/20041130/02Chaleur/JASP2004-Ducas-Urbanisme.pdf

Earth Institute. (2007). *Companies lay out global framework to fight climate change.* Retrieved February 27, 2007, from http://www.earth.columbia.edu/news/2007/story02-20-07.php

Eco-Santé. (2005a). *Eco-Santé Québec* [Eco-Health Quebec]. Retrieved March 5, 2006, from http://www.inspq.qc.ca

——. (2005b). *Revenu personnel disponible par habitant* [Personal disposable income, by inhabitant]. Retrieved September 11, 2006, from http://www.ecosante.fr/QUEBFRA/120600.html

Éditeur officiel du Québec. (2005a). *An act respecting local health and social services network development agencies.* R.S.Q., c. A–8.1. Retrieved February 15, 2006, from http://www.publicationsduquebec.gouv.qc.ca/accueil.fr.html

——. (2005b). *Politique de protection des rives, du littoral et des plaines inondables.* [Québec Water Policy : Water. Our Life. Our Future.] L.R.Q., c. Q-2, a. 2.1. Retrieved January 14, 2008, from http://www.mddep.gouv.qc.ca/eau/rives/

——. (2006a). *Environment Quality Act.* Retrieved April 11, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/Q_2/Q2A.htm

——. (2006b). *Municipal Code of Quebec.* Retrieved April 11, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/C_27_1/C27_1-A.htm

——. (2006c). *Public Health Act.* Retrieved April 11, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/S_2_2/S2_2-A.htm

Energy Information Administration. (2002). *Norway: Environmental issues.* Retrieved April 5, 2006, from http://www.eia.doe.gov/emeu/cabs/norenv.html

Environment Canada. (2001). *The new formula for cold.* Retrieved June 26, 2006, from http://www.ec.gc.ca/science/sandenov01/article2_e.html

——. (2002). *Impacts et adaptation lies aux changements climatiques: Perspective canadienne—Les resources en eau* [Climate change impacts and adaptation : A Canadian perspective – Water resources]. Rapport de la Direction des Impacts et de l'adaptation liés aux changements climatiques. Natural Resources Canada.

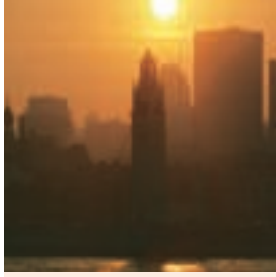
——. (2005a). *National climate archive.* Retrieved March 4, 2006, from http://climate.weatheroffice.ec.gc.ca/

——. (2005b). *The science of climate change.* Retrieved April 3, 2006, from http://www.ec.gc.ca/science/sandejan01/article 4-e.html

——. (2006a). *Fact sheet: Winter info-smog program.* Retrieved June 8, 2006, from http://lavoieverte.qc.ec.gc.ca/atmos/dispersion/main_e.html

——. (2006b). *Info-smog now serving 7.2 million Quebeckers all year round.* Retrieved July 11, 2006, from http://www.ec.gc.ca/press/2006/060517_n_e.htm

Erlandson, D.A., Harris, E.L., Skipper, B.L., and Allen, S.D. (1993). *Doing naturalistic inquiry. A guide to methods.* Newbury Park, CA: Sage Publications.



Fagherazzi, L., Guay, R., and Sassi, T. (2005). *Climate change analysis of the Ottawa River system.* Report to the International Joint Commission—Lake Ontario – St. Lawrence River study on discharge regulation.

Federation of Canadian Municipalities (FCM). (2002). *Final report on FCM (Federation of Canadian Municipalities) municipal infrastructure risk project: Adapting to climate change.* Retrieved February 16, 2006, from http://adaptation.nrcan.gc.ca/projdb/pdf/16-e.pdf

——. (2006). *Green Municipal Fund.* Retrieved January 15, 2006, from http://www.fcm.ca/english/gmf/gmf.html

Filion, P., and Lauzier, J.J. (2002). *L'énergie au Québec, edition 2002* [Energy in Quebec, 2002 edition]. Retrieved 14 April, 2006, from http://www.mrn.gouv.qc.ca/publications/energie/energie/energie-au-quebec-2002.pdf

Fishbein, M., Triandis, H.C., Kanfer, F.H., Becker, M., Middlestadt, S.E., et al. (2001). Factors influencing behavior and behavior change. In M. Fishbein, H.C. Triandis, F.H. Kanfer, M. Becker, S.E. Middlestadt, et al. (Eds.), *Handbook of health psychology.* New Jersey: Laurence Earlbaum Associates.

Gachon, P., and Dibike, Y. (2006). *La méthode de mise à l'échelle statistique utilisée pour la construction de scénarios de changements climatiques* [Statistical scaling method used to build climate change scenarios]. Internal report, not published. Montreal: Ouranos Consortium.

Gachon, P., St-Hilaire, A., Ouarda, T., Nguyen, V-T-V., Lin, C., et al. (2005). *A first evaluation of the strengths and weaknesses of statistical downscaling methods for simulating extremes over various regions of Eastern Canada.* Sub-component, Climate Change Action Fund (CCAF). Final report. Montréal: Environment Canada.

Garneau, M., Milton, J., Vigeant, G., Drouin, L., Bonvalot, Y., et al. (2005). *Hausse des concentrations polliniques causée par le changement climatique et ses conséquences potentielles sur les maladies respiratoires des populations vulnérables en milieu urbain* [Increased pollen concentrations due to climate change and the potential consequences on respiratory disease among vulnerable populations in urban areas]. Université du Québec à Montréal and Ouranos Consortium. CCAF Project. Retrieved August 21, 2005, from http://www.ouranos.ca/doc/ia/MGarneau.pdf

Gelbspan, R. (2000). *The mismatch between the cultures of journalism and science.* Communication conference. Session F1. Influence on public understanding of climate change 2. Retrieved January 17, 2007, from http://www.fes.uwaterloo.ca/research/climateconference/F1.pdf

Giani, A., Bird, D.F., Prairie, Y.T., and Lawrence, J. (2005). Empirical study of cyanobacterial toxicity along a trophic gradient of lakes. *Canadian Journal of Fisheries and Aquatic Sciences, 62*(9), 2100–2109.

Gibbs, G. (2002). *Qualitative data analysis: Exploration with NVivo.* Buckingham, Philadelphia: Open University.

Giguère, M. (2005). *Les impacts des vagues de chaleur et de l'effet d'îlot thermique urbain sur la santé: Examen des initiatives d'adaptation actuelles au Québec* [The effects of heat waves and the urban thermal island effect on health: Review of current adaptation initiatives in Quebec]. Essay presented to the Centre universitaire de formation en environnement. Sherbrooke: Université de Sherbrooke.

Giguère, M., and Gosselin, P. (2006a). *Eau et santé: Examen des initiatives actuelles d'adaptation aux changements climatiques au Québec* [Water and health: A review of current initiatives for adaptation to climate change in Quebec]. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

——. (2006b). *Événements climatiques extrêmes et santé: Examen des initiatives actuelles d'adaptation aux changements climatiques au Québec* [Extreme climatic events and health: A review of current initiatives for adaptation to climate change in Quebec]. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

——. (2006c). *Maladies zoonotiques et à transmission vectorielle: Examen des initiatives actuelles d'adaptation aux changements climatiques au Québec* [Zoonotic and vector-borne diseases: A review of current initiatives for adaptation to climate change in Quebec]. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

——. (2006d). *Vagues de chaleur, effet d'îlot thermique urbain et santé: Examen des initiatives actuelles d'adaptation aux changements climatiques au Québec* [Heat waves, urban thermal island effect and health: A review of current initiatives for adaptation to climate change in Quebec]. Retrieved October 15, 2006, from http://www.inspq.qc.ca/publications/default.asp?E=p&Theme=8

Gordon, C., Cooper, C., Senior, C.A., Banks, H., Gregory, J.M., et al. (2000). The simulation of SST, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments. *Climate Dynamics, 16,* 147–168.

Gosselin, P. (2005). *A first interactive web tool to better understand health vulnerabilities and climate.* GEOIDE and INSPQ project, Health Canada and Ouranos Consortium. Retrieved September 19, 2006, from http://www.ouranos.ca/programmation/atlas_e.html

Gosselin, P., and Grondin, J. (2002). *Changing behaviours in a time of climate change: Social science perspectives on the health impact assessment of climate change and adaptative behaviours.* Sainte Foy, QC. Report on a workshop held in Québec, QC, August 27-28, 2002.

Gosselin, P., Lebel, G., Rivest, S., and Douville-Fradet, M. (2005). The integrated system for public health monitoring of West Nile Virus (ISPHM-WNV): A real-time GIS for surveillance and decision-making. *International Journal of Health Geographics, 4*(21). Retrieved September 13, 2005, from http://www.ij-healthgeographics.com/content/4/1/21

Government of Canada. (2005). *Climate Change Action Fund.* Retrieved February 18, 2006, from http://climatechange.gc.ca/francais/ccaf

Government of Quebec. (2000). *Quebec action plan on climate change 2000–2002.* Retrieved February 16, 2006, from http://www.mrnf.gouv.qc.ca/publications/climatiques/climat.pdf

——. (2002). *Water. Our life. Our future. Quebec water policy.* Retrieved January 28, 2006, from http://www.mddep.gouv.qc.ca/eau/politique/policy.pdf

——. (2005a). *An Act respecting land use planning and development,* R.S.Q. c. A-19.1. Retrieved April 13, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/A_19_1/A19_1-A.html

——. (2005b). *Quebec in action to fight climate change.* Retrieved February 16, 2006, from http://www.mddep.gouv.qc.ca/chang-clim/clim-change.pdf

——. (2006a). *Better choices for citizens: Québec public transit policy.* Retrieved September 19, 2006, from http://www.mtq.gouv.qc.ca/en/modes/personnes/polit_collectif2006.asp

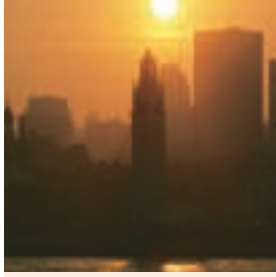
——. (2006b). *Cadre de prévention des risques naturels* [Natural hazards prevention framework]. Retrieved November 30, 2006, from http://www.mddep.gouv.qc.ca/Infuseur/communique.asp?no=1029

——. (2006c). *Démographie. Le phénomène du vieillissement* [Demographics. Aging of the Population]. Retrieved February 27, 2007, from http://www.gouv.qc.ca/portail/quebec/pgs/commun/portrait/demographie?lang=fr#Vieillissement

——. (2006d). *Portrait du Québec* [Portrait of Quebec]. Retrieved February 27, 2007, from http://www.gouv.qc.ca/portail/quebec/pgs/common/

——. (2006e). *Québec and climate change: A challenge for the future. 2006–2012 action plan.* Retrieved June 19, 2006, from http://www.mddep.gouv.qc.ca/changements/plan_action/2006-2012_en.pdf

Green, H., Gilbert, J., James, R., and Byard, R.W. (2001). An analysis of factors contributing to a series of deaths caused by exposure to high environmental temperatures. *American Journal of Forensic Medicine and Pathology, 2220,* 196–199.



Haines, A., Kovats, R.S., Campbell-Lendrum, D., and Corvalan, C. (2006). Climate change and human health: Impacts, vulnerability and public health. *The Lancet, 367*(9528), 2101–2109.

Harju, E-L. (2002). Cold and warmth perception mapped for aged, gender, and body area. *Somatosensory & Motor Research, 19*(1), 61–75.

Health Canada. (2005). *Exercice de chaleur accablante* [Extreme heat exercise]. Report prepared by DDH Environnement Ltée, report # DDH-05-044.

——. (2006). *A health-based national Air Quality Index (AQI).* Retrieved February 27, 2007, from http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/air_quality_f.html

Hill, D., White, V., Marks, R., Theobald, T., Borland, R., et al. (1992). Melanoma prevention: Behavioral and nonbehavioral factors in sunburn among an Australian urban population. *Preventive Medicine, 21*(5), 654–669.

House, J., and Brovkin, V. (2005). Climate and air quality. In R. Hassan, H. Scholes, and N. Ash (Eds.), *Ecosystems and human well-being. Volume 1: Current state and trends.* Washington: Island Press. Retrieved March 8, 2006, from http://www.millenniumassessment.org//en/Products.Global.Condition.aspx

Huberman, A.M., and Miles, M.B. (1991). *Qualitative data analysis: A sourcebook of new methods.* Beverly Hills, CA: Sage.

Hydro-Québec.(2006a). *Annual report 2005: People with energy.* Retrieved February 28, 2007, from http://www.hydroquebec.com/publications/en/annual_report/2005/index.html

——. (2006b). *EnerGuide grant for existing houses.* Retrieved June 8, 2006, from http://www.hydroquebec.com/residential/energuide/index.html

——. (2006c). *Serving consumers effectively: Meeting special needs.* Retrieved May 25, 2006, from http://www.hydroquebec.com/sustainable-development/societe/servir_clients_rep.html

Institut de la statistique du Québec (ISQ). (2000). *Perspectives démographiques du Québec 1996–2041, régions administratives, régions métropolitaines et municipalités régionales de comté, édition 2000, Quebec.* [Demographic perspectives in Quebec, 1996–2041, administrative regions, metropolitan regions and regional county municipalities, 2000 edition, Quebec]. Retrieved August 29, 2006, from http://www.stat.gouv.qc.ca/donstat/societe/demographie/persp_poplt/index.htm

——. (2001). *Enquête québécoise sur les limitations d'activités, 1998.* [Quebec survey of activity limitations, 1998]. Retrieved January 17, 2006, from http://www.stat.gouv.qc.ca/publications/sante/enq-qla98-an.htm

——. (2003a). *Perspectives de la population. Édition 2003 basée sur 2001: Six nouveaux scénarios* [Population projections. 2003 edition based on 2001: Six new scenarios]. Retrieved August 29, 2006, from http://www.stat.gouv.qc.ca/donstat/societe/demographie/persp_poplt/index.htm

——. (2003b). *Population projections, Québec and regions, 2001–2051, 2003 edition.* Retrieved August 21, 2006, from http://www.stat.gouv.qc.ca/donstat/societe/demographie/persp_poplt/pers2001-2051/index_an.htm

——. (2005a). *Population and land occupation, Montréal and Laval administrative regions, 2001.* Retrieved March 10, 2006, from http://www.stat.gouv.qc.ca/regions/recens2001_06/population06/occupter06_an.htm

——. (2005b). *Québec 2001 population census: Québec.* Retrieved January 27, 2005, from http://www.stat.gouv.qc.ca/regions/lequebec/quebec_index_an.htm

——. (2006a). *Interprovincial comparisons. Income, table 5.2.* Retrieved April 5, 2006, from http://www.stat.gouv.qc.ca/donstat/econm_finnc/conjn_econm/TSC/pdf/chap5.pdf

——. (2006b). *Interprovincial comparisons. Production, table 4.1.* Retrieved April 5, 2006, from http://www.stat.gouv.qc.ca/donstat/econm_finnc/conjn_econm/TSC/pdf/chap4.pdf

——. (2006c). *Proportion des ménages qui disposent de certaines composantes de l'équipement ménager et d'une maison de campagne, Québec, Ontario et Canada, 1972–2003* [Proportion of households with certain household equipment and a country home, Quebec, Ontario and Canada, 1972–2003]. Retrieved January 11, 2006, from http://www.stat.gouv.qc.ca/donstat/societe/famls_mengs_niv_vie/patrm_equip/4equip_pourcent.htm

——. (2006d). *Proportion des ménages qui disposent de certaines composantes de l'équipement ménager, selon la tranche de revenue, Quebec, 2004* [Proportion of households with certain household equipment, by range of income, Quebec, 2004]. Retrieved January 11, 2006, from http://www.stat.gouv.qc.ca/donstat/societe/famls_mengs_niv_vie/patrm_equip/5equip_repar.htm

——. (2006e). *Quebec handy numbers.* Retrieved April 5, 2006, from http://stat.gouv.qc.ca/publications/referenc/pdf2006/QCM2006_an.pdf

——. (2006f). *View of regions.* Retrieved June 18, 2006, from http://www.stat.gouv.qc.ca/regions/profils/region_00/region_00_an.htm

Institut de veille sanitaire (InVS). (2003a). *Impact sanitaire de la vague de chaleur en France survenue en août 2003. Rapport d'étape* [Health impact of the heat wave in France in August 2003. Progress report]. Retrieved April 12, 2004, from http://www.invs.sante.fr/publications/2003/chaleur-aout_2003/index.html

——. (2003b). *Vague de chaleur et santé: Revue bibliographique* [Heat waves and health: Bibliographic review]. Retrieved April 12, 2004, from http://www.invs.sante.fr/beh/2003/45_46/index.htm

——. (2004a). *Étude des facteurs de risque de décès des personnes âgées résidant à domicile durant la vague de chaleur d'août 2003* [Study of risk factors in the death of seniors living at home during the heat wave of August 2003]. Retrieved January 12, 2006, from http://www.invs.sante.fr/publications/2004/chaleur2003_170904/

——. (2004b). *Système d'alerte canicule et santé 2004 (SACS 2004). Rapport opérationnel* [2004 extreme heat and health warning system (SACS 2004). Operational report]. Retrieved January 12, 2006, from http://www.invs.sante.fr/publications/2004/syst-alerte_canicule/index.html

——. (2006). *Chaleur et santé* [Heat and health]. Retrieved February 6, 2006, from http://www.invs.sante.fr/surveillance/canicule/default.htm

Institut national de santé publique du Québec (INSPQ). (2006a). *Changements climatiques et développement durable* [Climate change and sustainable development]. Retrieved March 29, 2006, from http://www.inspq.qc.ca/domaines/index.asp?Dom=50&Axe=55

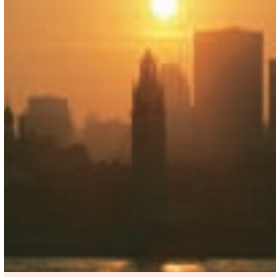
——. (2006b). *Infocentre de santé publique* [Public health infocentre]. Retrieved April 11, 2006, from http://www.inspq.qc.ca/domaines/ind.ex.asp?Dom=surv&Axe=103

——. (2006c). *Portrait de santé du Québec et de ses régions 2006. Les analyses (section 1.4)* [2006 health portrait of Quebec and its regions. Analyses (section 1.4)]. Les publications du Québec. Retrieved December 4, 2006, from http://www.inspq.qc.ca/pdf/publications/portrait_de_sante.asp?E=p

——. (2006d). *Portrait de santé du Québec et de ses régions 2006. Les statistiques* [2006 health portrait of Quebec and its regions. Statistics.] Retrieved January 21, 2007, from http://www.inspq.qc.ca/pdf/publications/545-PortraitSante2006_statistiques.pdf

Intergovernmental Panel on Climate Change (IPCC). (2007). Summary for policymakers. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, et al. (Eds.). *Climate change 2007: The physical science basis. Working Group I contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report* (pp. 1–18). Cambridge, U.K.: Cambridge University Press.

Ippersiel, M.F., and Morissette, J.F. (2004). *L'innovation dans les municipalités: Perceptions des acteurs et defies* [Innovation in municipalities: Perceptions of actors and challenges]. Retrieved April 22, 2006, from http://sbisrvntweb.uqac.ca/archivage/18046447.pdf



Isuma Canadian Journal of Policy Research. (2001). *Climate change.* Retrieved February 16, 2006, from http://www.isuma.net/v02n04/index_e.shtml

Jacques, L., and Kosatsky, T. (2005). Commentaires faisant suite à la parution de l'article Vague de chaleur et climatisation de Gilles Dixsaut [Comments following publication of the article Heat waves and air conditioning, by Gilles Dixsaut]. *Bulletin d'information en sante environnementale (BISE), 16*(4), 5–7.

Judek, S., Jessiman, B., Stieb, D., and Vet, R. (2005). *Estimated number of excess deaths in Canada due to air pollution.* Retrieved January 19, 2007, from http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/2005/2005_32bk2_e.html

Kalkstein, L.S., and Greene, J.S. (1997). An evaluation of climate/mortality relationships in large U.S. cities and the possible impacts of climate change. *Environmental Health Perspectives, 105*(1), 84–93.

Kalkstein, L.S., and Smoyer, K.E. (1993). *The impact of climate on Canadian mortality: Present relationships and future scenarios.* Report no. 93-7. Unpublished manuscript. Ottawa: Environment Canada/Canadian Climate Centre.

Keatinge, W.R., and Donaldson, G.C. (2006). Heat acclimatization and sunshine cause false indications of mortality due to ozone. *Environmental Research, 100,* 387–393.

Kempton, W. (1993). Will public environmental concern lead to action on global warming? *Annual Review of Energy and the Environment, 18,* 217–245.

Klaassen, J., Cheng, S., Auld, H., Li, Q., Ros, E., et al. (2003). *Estimation of Severe Ice Storm Risks for South-Central Canada.* Retrieved January 15, 2008, from http://ww3.ps-sp.gc.ca/research/resactivites/natHaz/EC-MSC_2002D002_ENG_CD.pdf

Klinenberg, E. (2002). *A social autopsy of disaster in Chicago: Heat wave.* Chicago: The University of Chicago Press.

Kunst, A.E., Caspar, W.N., Looman, W.N., and Mackenbach, J.P. (1993). Outdoor air temperature and mortality in the Netherlands: A time-series analysis. *American Journal of Epidemiology, 137,* 331–341.

Lafrance, G., and Desjarlais, C. (2006). *Impact socio-économique du changement climatique: La demande d'énergie* [Socio-economic impact of climate change: Demand for energy]. Retrieved February 5, 2007, from http://www.ouranos.ca/doc/Rapports%20finaux/Lafrance.pdf

Lajoie, P., Dagenais, G., Ernst, P., and Neukirch, F. (2003). Systèmes respiratoire et cardio-vasculaire [Respiratory and cardio-vascular systems]. In *Environnement et santé publique: Fondements et pratiques.* Paris and Montréal: TEC & DOC and Edisem.

Last, J.M., and Chiotti, Q.P. (2001). Climate change and health. *Isuma Canadian Journal of Policy Research, 2,* 66–74.

Laverdière, J. (2001). *Portrait de la pauvreté sur le territoire du CLSC-CHSLD Basse-Ville-Limoilou-Vanier: Étude de la vulnérabilité socioéconomique des quartiers et des secteurs de dénombrement* [Portrait of poverty in the Basse-Ville-Limoilou-Vanier CLSC-CHSLD: Study of the socio-economic vulnerability of neighbourhoods and enumeration areas]. Québec: CLSC-CHSLD Basse-Ville-Limoilou-Vanier.

Léger Marketing. (2006). *Greenpeace/equiterre poll.* Retrieved April 5, 2006, from http://www.greenpeace.ca/f/archives.php

Leiss, W., Dowlatabadi, H., and Paoli, G. (2001). *Who's afraid of climate change? A guide for the perplexed.* Retrieved January 30, 3006, from http://www.isuma.net/v02n04/leiss/leiss_f.pdf

Leloup, X. (2005). *Conditions de logement des ménages immigrants au Québec: Une réalité contrastée* [Housing conditions of immigrant households in Quebec: A contrasted reality]. Retrieved January 17, 2007, from http://www.habitation.gouv.qc.ca/publications/M18366.pdf

MacCracken, M., Barron, E., Easterling, D., Felzer, B., and Karl, T. (2001). *Scenarios for climate variability and change.* Cambridge, U.K.: Cambridge University Press.

Magnuson, J.J., Webster, K.E., Assel, R.A., Bowser, C.J., Dillon, P.J., et al. (1997). Potential effects of climate change on aquatic ecosystems: Laurentian Great Lakes and Precambrian Shield Region. In C.E. Cushing (Ed.), *Freshwater ecosystems and climate change in North America: A regional asssessment.* New York: John Wiley & Sons.

Mailhot, A., Rivard, G., Duchesne, S., and Villeneuve, JP. (2007). *Impacts et adaptations liés aux changements climatiques (CC) en matière de drainage urbain au Québec* [Impacts and adaptations linked to climate change (CC) in relation to urban drainage in Quebec]. Report no. R-874. Retrieved February 5, 2007, from http://www.ouranos.ca/doc/Rapports%20finaux/Mailhot.pdf

Mäkinen, TM., Pääkkönen, T., Palinkas, LA., Rintamäki, H., Leppaäluoto, J., Hassi, J. (2004). Seasonal changes in thermal responses of urban residents to cold exposure. *Comparative Biochemistry and Physiology, Part A, 139*(2), 229–238.

Maltais, D., Robichaud, S., and Simard, A. (2001a). *Sinistres et individus* [Disasters and individuals]. Chicoutimi, Quebec: Éditions JCL.

——. (2001b). *Sinistres et intervenants* [Disasters and interventions]. Chicoutimi, Quebec: Éditions JCL.

Manitoba Energy, Science and Technology. (2003). *Energy development initiative.* Retrieved April 5, 2006, from http://www.gov.mb.ca/est/energy/initiatives/hydro.html

McCullagh, P., and Nelder, J.A. (1989). *Generalized linear models.* Boca Raton: Chapman & Hall/CRC.

McGeehin, M.A., and Mirabelli, M. (2001). The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environmental Health Perspectives, 109*(Suppl. 2), 185–189.

McMichael, A.J., Woodruff, R.E., and Hales, S. (2006). Climate change and human health: Present and future risks. *The Lancet, 367*(9513), 859–869.

Menne, B., and Ebi, K.L. (Eds.). (2006). *Climate change and adaptation strategies for human health.* Published on behalf of the World Health Organization Regional Office for Europe. Germany: Steinkopff Verlag Darmstadt.

Michelozzi, P., DeDonato, F., Bisanti, L., Russo, A., Cadum, E., et al. (2005). The impact of the summer 2003 heat waves on mortality in four Italian cities. *Eurosurveillance, 10*(7), 161–165. Retrieved April 3, 2006, from http://www.eurosurveillance.org/em/v10n07/1007-226.asp

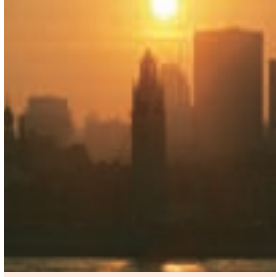
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ). (2006). *Surveillance de la santé animale* [Animal health surveillance]. Retrieved June 28, 2006, from http://www.mapaq.gouv.qc.ca/Fr/Productions/santeanimale/surveillance/

Ministère de la Santé et des Services sociaux (MSSS). (1992). *Policy on health and well-being.* Retrieved March 30, 2006, from http://publications.msss.gouv.qc.ca/acrobat/f/documentation/1992/92_713.pdf

——. (2003a). *Programme sur les aides à la vie quotidienne et à la vie domestique* [Daily and domestic living assistance program]. Retrieved February 12, 2006, from http://msssa4.msss.gouv.qc.ca/fr/sujets/handicape.nsf/0/5e878d8ba912ed3e85256d8000560fb6/$FILE/AVQ-AVD_guide_de_gestion_oct03_rev-mai04.pdf

——. (2003b). *Quebec public health program 2003–2012.* Retrieved March 27, 2006, from http://msssa4.msss.gouv.qc.ca/fr/document/publication.nsf/ed7acbc94b12630f852566de004c8587/f83fd818c4afad8085256e3800553476?OpenDocument

——. (2004). *Heat waves are deadly serious.* Retrieved August 28, 2006, from http://www.canlii.org/qc/laws/sta/c-47.1/20061117/whole.html



——. (2005). *Quebec's health and social services system.* Retrieved March 28, 2006, from http://msssa4.msss.gouv.qc.ca/fr/reseau/santebref.nsf/49dd266bd183416e852566e2005c98b6/feaef2d6fb32728c852568eb000bdbd8?OpenDocument

——. (2006a). *Plan chaleur accablante, volet santé publique* [Extreme heat plan, public health component]. Retrieved August 28, 2006, from http://www.msss.gouv.qc.ca/sujets/santepub/pdf/plan-chaleur.pdf

——. (2006b). *Smog.* Retrieved January 27, 2007, from http://www.msss.gouv.qc.ca/sujets/santepub/environnement/index.php?smog.

Ministère de la Sécurité publique (MSP). (2004). *Typologie des risques.* [Typology of risks]. Internal document.

——. (2005). *Civil Protection Act.* Retrieved April 3, 2006, from http://www.msp.gouv.qc.ca/secivile/secivile-en.asp?txtSection=loi

Ministère des Affaires municipales et des Régions (MAMR). (2005a). *Guide d'élaboration d'un plan d'intervention pour le renouvellement des conduites d'eau potable et d'égout: Pour une gestion efficace de l'eau* [Guide for the development of an action plan for the renewal of drinking water and wastewater pipes: For effective water management]. Retrieved April 17, 2006, from http://www.mamr.gouv.qc.ca/publications/infrastructures/guid_plan_interv.pdf

——. (2005b). *Guide des bonnes pratiques: La réduction des émissions de gaz à effet de serre et l'aménagement du territoire* [Best practices guide: Reducing greenhouse gas emissions and land use planning]. Retrieved April 14, 2006, from http://www.mamr.gouv.qc.ca/publications/amenagement/Guide_bonnes_pratiques.pdf

——. (2005c). *L'organisation municipale du Québec* [Municipal organization in Quebec]. Retrieved February 16, 2006, from http://www.mamr.gouv.qc.ca/publications/organisation/org_mun_qc_fra.pdf

——. (2006a). *An Act to amend various legislative provisions concerning municipal affairs.* Retrieved January 15, 2008, from www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=5&file=2003C3A.PDF

——. (2006b). *An Act respecting land use planning and development,* R.S.Q. c. A-19.1. Retrieved April 11, 2006, from http://www.canlii.org/qc/laws/sta/a-19.1/20050211/whole.html

——. (2006c). *Municipal Powers Act,* R.S.Q. c. C-47.1. Retrieved April 11, 2006, from http://www.canlii.org/qc/laws/sta/c-47.1/20061117/whole.html

Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP). (1998). *La politique québécoise de gestion de matières résiduelles 1998–2008* [Quebec's waste management policy 1998–2008]. Retrieved January 23, 2007, from http://www.mddep.gouv.qc.ca/matieres/mat_res/

——. (2002a). *Bilan de la qualité de l'eau potable au Québec, janvier 1995–juin 2002* [Report on the quality of drinking water in Quebec January 1995–June 2002]. Retrieved April 13, 2006, from http://www.mddep.gouv.qc.ca/eau/potable/bilan03/bilan.pdf

——. (2002b). *General orientation paper for a future policy on water management.* Retrieved March 31, 2006, from http://www.mddep.gouv.qc.ca/eau/orientation/index.htm

——. (2002c). *Quebec water policy. Water. Our life. Our future.* Retrieved March 30, 2006, from http://www.mddep.gouv.qc.ca/eau/politique/index-en.htm

——. (2005a). *Fleurs d'eau de cyanobactéries* [Cyanobacterial blooms]. Retrieved February 15, 2006, from http://www.menv.gouv.qc.ca/eau/eco_aqua/cyanobacteries/

——. (2005b). *Regulation respecting the quality of drinking water.* Retrieved March 30, 2006, from http://www.mddep.gouv.qc.ca/eau/potable/brochure-en/index.htm

——. (2005c). *Signing of the Great Lakes–St. Lawrence River Basin Sustainable Water Resources Agreement.* Retrieved March 30, 2006, from http://www.mnr.gov.on.ca/mnr/water/greatlakes/index.html

——. (2006a). *Sustainable Development Act.* Retrieved August 14, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=5&file=2006C3A.PDF

——. (2006b). *Wood heating.* Retrieved May 15, 2006, from http://www.mddep.gouv.qc.ca/air/chauf-bois/index.htm

Ministère du Développement économique, de l'Innovation et de l'Exportation (MDEIE). (2007). Le commerce extérieur du Québec [Quebec foreign trade]. *Le calepin,* édition décembre 2007. Retrieved 14 janvier, 2008 from http://www.mdeie.gouv.qc.ca/page/web/portail/exportation/nav/publications.html?&page=details_publication.jsp&iddoc=62167

Municipalities Issue Table (MIT). (1998). *Canada's national climate change process.* Retrieved February 16, 2006, from http://www.nccp.ca/NCCP/pdf_f/mun_found.pdf

——. (1999). *Municipalities table options paper.* Retrieved February 16, 2006, from http://www.nccp.ca/html_f/tables/pdf/options/MT_OR_fr-12-1999.pdf

Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., et al. (2000). *Emissions scenarios.* A special report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge, U.K.: Cambridge University Press.

Natural Resources Canada (NRCan). (1997). *1997 survey of household energy use. Major household appliances.* Retrieved February 2, 2006, from http://www.oee.nrcan.gc.ca/publications/infosource/pub/energy_use/sheu_e/sheu_5.cfm

——. (2002). *Climate change impacts and adaptation: A Canadian perspective.* Retrieved April 14, 2006, from http://adaptation.nrcan.gc.ca/perspective/index_ephp

——. (2006a). *A change in the wind: Climate change in Québec.* Retrieved April 22, 2006, from http://adaptation.nrcan.gc.ca/posters/gc/index_e.php

——. (2006b). *Idle-free zone.* Retrieved June 8, 2006, from http://oee.nrcan.gc.ca/communities-government/idling.cfm?attr=16

——. (2006c). *Office of Energy Efficiency-Residential.* Retrieved January 29, 2006, from http://oee.nrcan.gc.ca/Equipment/english/page125.cfm?Text=N&PrintView=N

Nguyen, T., Nguyen, V., and Gachon, P. (2005). *Using statistical downscaling model to project local climate change in future under scenarios simulated by Hadcm3: A case study at 20 stations in Quebec province, Canada.* Ouranos Report, in review.

O'Brien, K., Eriksen, S., Schjolden, A., and Nygaard, L. (2004). *What's in a word? Conflicting interpretations of vulnerability in climate change research.* Retrieved April 15, 2006, from http://www.fishclimate.ca/pdf/OBrien_CICERO_March_2004_Vulnerability.pdf

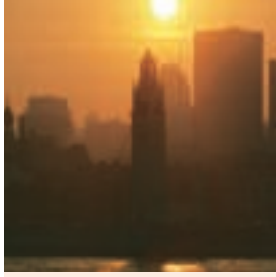
Office of the Auditor General of Canada. (2006). The commissioner's perspective. *2006 Report of the Commissioner of the Environment and Sustainable Development.* Retrieved January 15, 2008, from http://www.oag-bvg.gc.ca/domino/reports.nsf/html/c2006menu_e.html

Ogden, N.H., Maarouf, A., Barker, I.K., Bigras-Poulin, M., Lindsay, L.R., et al. (2006). Climate change and the potential for range expansion of the Lyme disease vector *Ixodes scapularis* in Canada. *International Journal of Parasitology, 36*(1), 63–70.

Oke, T.R. (1982). The energetic basis of urban heat island. *Journal of the Royal Meteorological Society, 108*(455), 1–24.

Ontario Forest Research Institute. (2003). *A synopsis of known and potential diseases and parasites associated with climate change.* Forest research information paper no. 154. Sault Ste. Marie, Ont.: Author.

Ontario Medical Association. (2005). *Illness costs of air pollution (ICAP) 2005.* Retrieved January 19, 2007, from http://www.oma.org/Health/Smog/report/icap05a.asp



Ory, M.G., Jordan, P.J., and Bazzarre, T. (2002). The behavior change consortium: Setting the stage for a new century of health behavior change research. *Health Education Research, 175,* 500–511.

Ouranos Consortium. (2004). *Adapting to climate change.* Retrieved March 27, 2006, from http://www.ouranos.ca/cc/table_e.html

Pageau, M., Choinière, R., Ferland, M., and Sauvageau, Y. (2001). *Le portrait de santé—Le Québec et ses regions* [A portrait of health: Quebec and its regions]. Quebéc: Institut national de santé publique du Québec. Retrieved January 17, 2006, from http://www.publicationsduquebec.gouv.qc.ca/accueil.fr.html

Paillé, P., and Mucchielli, A. (2003). *L'analyse qualitative en sciences humaines et socials* [Qualitative analysis in human and social sciences]. Paris: Armand Colin.

Pattenden, S., Nikiforov, B., and Armstrong, B.G. (2003). Mortality and temperature in Sofia and London. *Journal of Epidemiology and Community Health, 57,* 628–633.

Patton, M.Q. (1990). *Qualitative evaluation and research methods.* Thousand Oaks, CA: Sage Publications.

Patz, J.A., Campbell-Lendrum, D., Holloway, T., and Foley, J.A. (2005). Impact of regional climate change on human health. *Nature, 438*(7066), 310–317.

Patz, J.A., McGeehin, M.A., Bernard, S.M., Ebi, K.L., Epstein, P.R., et al. (2000). The potential health impacts of climate variability and change for the United States: Executive summary of the report of the health sector of the U.S. national assessment. *Environmental Health Perspectives, 108*(4), 367–376.

Paulhus, D.L. (1991). Measurement and control of response bias. In J.P. Robinson, P.R. Shaver, and L.S. Wrightsman (Eds.), *Measures of personality and social psychological attitudes* (pp. 17–59). New York: Academic Press.

Phipps, S. (2003). *The impact of poverty on health: A scan of research literature.* Canadian Institute for Health Information (CIHI). Retrieved June 15, 2006, from http://www.cihi.ca/cihiweb/dispPage.jsp?cw_page=GR_323_E

Presser, S., Couper, M.P., Lessler, J.T., Martin, E., Martin, J., et al. (2004). *Methods for testing and evaluating survey questionnaires.* New Jersey: John Wiley & Sons Inc.

Prochaska, J.O., Norcross, J.C., and Diclemente, C.C. (1995). *Changing for good. A revolutionary six-stage program for overcoming bad habits and moving your life positively forward.* New York: Avon Books.

Quality Systems Registrars. (2005). *Qualitative analysis and software services.* Retrieved December 5, 2005, from http://www.qsr.com/

Quénel, P., Dab, W., Festy, B., Viau, C., and Zmirou, D. (2003). Qualité de l'air ambient [Ambient air quality]. In M.P. Gérin, P. Gosselin, S. Cordier, C. Viau, P. Quénel, et al. (Eds.), *Environnement et santé publique: Fondements et pratique*. Canada: Editions TEC & DOC.

Rachlinski, J.J. (2000). *The psychology of global climate change.* Ithaca, NY: Cornell Law School. Retrieved February 22, 2007, from http://env.chass.utoronto.ca/env200y/ESSAY2001/globwarm.pdf

Rainham, D.G.C., and Smoyer-Tomic, K.E. (2003). The role of air pollution in the relationship between a heat stress index and human mortality in Toronto. *Environmental Research, 93,* 9–19.

Recyc-Québec. (2004). *La performance relative à la gestion des matières résiduelles selon les objectifs de 2008* [Waste management performance in relation to the 2008 objectives]. Retrieved January 31, 2007, from http://www.recyc-quebec.gouv.qc.ca/upload/publications/MICI/BILAN2004/Fiche1B.pdf

Régie du bâtiment du Québec. (2006). *An Act respecting the conservation of energy in buildings.* Retrieved January 29, 2006, from http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=/E_1_1/E1_1_A.HTM

Rittmaster, R., Adamowicz, W.L., Amiro, B., and Pelletier, R.T. (2006). Economic analysis of health effects from forest fires. *Canadian Journal of Forest Research, 36*(4), 868–877.

Rolland, A., Bird, D.F., and Giani, A. (2005). Effects of environmental factors and composition of cyanobacterial communities on the occurrence of hepatotoxic blooms in four eutrophic Quebec lakes. *Journal of Plankton Research, 27*(7), 683–694.

Royal Society of Canada. (1995). *Implications of global change for human health.* Final report of the Health Issues Panel of the Canadian Global Change Program.

Sandalow, D.B., and Bowles, I.A. (2001). Climate change: Fundamentals of treaty-making on climate change. *Science, 292*(5523), 1839–1840.

Sautory, O. (2005). *Atelier sur les procédures SAS d'échantillonnage et d'analyse de données d'enquête* [Workshop on SAS sampling procedures and analysis of survey data]. Québec: Francophone symposium on surveys.

Schwartz, J., Spix, C., Touloumi, G., Bacharova, L., Barumamdzadeh, T., et al. (1996). Methodological issues in studies of air pollution and daily counts of deaths or hospital admission. *Journal of Epidemiology and Community Health, 50,* S3–S11.

Scottish Executive. (2001). *Potential adaptation strategies for climate change in Scotland.* Retrieved August 28, 2006, from http://www.scotland.gov.uk/cru/kd01/lightgreen/pascc-00.asp

Semenza, J.C., McCullough, J.E., Flanders, W.D., McGeehin, M.A., and Limpkin, J.R. (1999). Excess hospital admissions during the July 1995 heat wave in Chicago. *American Journal of Preventive Medicine, 164,* 269–277.

Société de l'assurance automobile du Québec. (2006). *Bilan routier 2005* [2005 highway report]. Retrieved August 31, 2006, from http://www.saaq.gouv.qc.ca/salle_presse/communiques_2006/20060530a.html

Société d'habitation du Québec (SHQ). (2006). *Programmes et services* [Programs and services]. Retrieved March 29, 2006, from http://www.habitation.gouv.qc.ca/programmes/liste_alphabetique.html

Solomon, S., and Kington, R. (2002). National efforts to promote behavior-change research: Views from the Office of Behavioral and Social Sciences Research. *Health Education Research, 175,* 495–499.

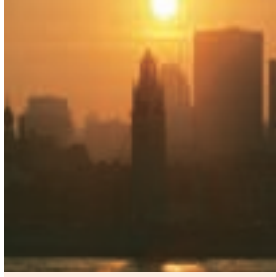
Soucy, C. (2002). *La réforme de l'organisation municipale au Québec: Bilan et contexte* [Reform of municipal organization in Quebec: Report and context]. Retrieved April 11, 2006, from http://www.mamr.gouv.qc.ca/publications/obse_muni/ReformeMunicipaleAuQuebec.pdf

Statistics Canada. (2000). *Human activity and the environment 2000.* Retrieved May 23, 2006, from http://www.statcan.ca/bsolc/english/bsolc?catno=11-509-X

——. (2006). *Canadian environmental sustainability indicators: National status and trends.* Retrieved March 5, 2006, from http://www.statcan.ca/francais/freepub/16-251-XIF/2005000/findings/air/status f.htm

Strecher, V., Wang, C., Derry, H., Wildenhaus, K., and Johnson, C. (2002). Tailored interventions for multiple risk behaviors. *Health Education Research, 175,* 619–626.

Tardif, I., Bellerose, C., and Masson, E. (2006). Environnements et santé: Le point de vue des Montérégiens [Environment and health: Point of view of the people of Montérégie]. *Bulletin d'information en santé environnementale (BISE),17*(6). Institut national de santé publique du Québec. Retrieved February 14, 2007, from http://www.inspq.qc.ca/pdf/bulletins/bise/BISE-17-6.pdf



Tebourbi, N. (2000). *L'apprentissage organisationnel: Penser l'organisation comme processus de gestion des connaissances et de développement des théories d'usage* [Organizational learning: Thinking of organization as a knowledge management process and developing theories of use]. A research paper by the Bell chair in technologies and work organization, under the direction of D. G. Tremblay, Télé-Université. Université du Québec.

Télasco, A. (2004). *La problématique et les interventions relatives au chauffage résidentiel au bois.* [The problem and interventions regarding residential wood heat]. Retrieved June 15, 2006, from http://www.apcas.qc.ca/2004052710h30Telasco.ppt

Thomas, M.K., Charron, D.F., Waltner-Toews, D., Schuster, C., Maarouf, A.R., et al. (2006). A role of high impact weather events in waterborne disease outbreaks in Canada, 1975–2001. *International Journal of Environmental Health Research, 16,* 167–180.

Thompson, S.K. (1987). Sample size for estimating multinomial proportions. *The American Statistician, 411,* 42–46.

Tremblay, M. (2003). *Wind chill and humidex (The ridiculous got a temperature).* Retrieved June 12, 2006, from http://ptaff.ca/humidex/?lang=en_CA

Triandis, H.C. (1979). Values, attitudes, and interpersonal behavior. In *Nebraska Symposium on Motivation.* London: University of Nebraska Press.

U.K. Department for Environment, Food and Rural Affairs (DEFRA). (2005). *Consultation on draft AQEG report. Air quality and climate change: A U.K. perspective.* Retrieved March 31, 2006, from http://www.defra.gov.uk/corporate/consult/airqual-climatechange/chapter4.pdf

Union des municipalités du Québec (UMQ). (2006). *La municipalité, maître d'œuvre de son développement et de son avenir* [The municipality: architect of its own development and its own future]. Annual report 2005. Montréal: Author. Retrieved December 4, 2006, from http://www.umq.qc.ca/publications/rapport_annuel/_pdf/Version%20finale.pdf

United Nations. (2007a). *Report of the Conference of the Parties on its twelfth session, held at Nairobi from November 6–17, 2006.* Part one: Proceedings. Retrieved February 27, 2007, from http://unfccc.int/resource/docs/2006/cop12/eng/05.pdf

——. (2007b). *UNFCCC Executive Secretary calls for speedy and decisive international action on climate change.* Retrieved February 27, 2007, from http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/070202press_rel_paris_en.pdf

U.S. Environmental Protection Agency (USEPA). (1988). *Wood stoves certification.* Retrieved June 25, 2006, from http://www.epa.gov/Compliance/monitoring/programs/caa/whcert.html

Vadnais, C. (2005). *Au frais, en silence. Protégez-vous* [Stay cool in silence. Protect yourself]. Retrieved January 12, 2006, from http://www.protegez-vous.qc.ca/cahiers/statique/cahiers16.html

Van der Pols, J.C., Williams, G.M., Neale, R.E., Clavarino, A., and Green, A.C. (2005). *Long-term increase in sunscreen use in an Australian community after a skin cancer prevention trial.* Retrieved January 26, 2006, from http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=16325898&query_hl=4&itool=pubmed_docsum.

Vescovi, L. (2003). The state of Canada's water. In A.K. Biswas (Ed.), *Water resources of North America.* Centre for Water Management. Mexico City: Springer Verlag.

Ville de Montréal. (2005). *Le plan stratégique de développement durable de Montréal* [City of Montreal sustainable development plan]. Retrieved April 13, 2006, from http://www2.ville.montreal.qc.ca/cmsprod/fr/developpement_durable/plan_strategique

Ville de Québec. (2004). *Plan de réduction des gaz à effet de serre* [Greenhouse gas reduction plan]. Retrieved December 4, 2006, from http://www.ville.quebec.qc.ca/fr/document/gesplanaction.pdf

——. (2006). *Québec prend le virage* [Quebec City moves in a new direction]. Retrieved December 4, 2006, from http://www.ville.quebec.qc.ca/fr/ma_ville/ville_action/ecologie.shtml

Villemaire, M. (1998). Les compteurs d'eau domestique, la goutte qui fait déborder le vase: Entrevue avec François Patenaude, chercheur à la Chaire d'études socio-économiques de l'UQAM [Arguments against domestic water meters : Interview with François Patenaude, UQAM research chair in socio-economic studies]. *Changements, 7*(2). Retrieved January 24, 2007, from http://www.consommateur.qc.ca/union/133.htm

Villeneuve, C., and Richard, F. (2001). *Vivre les changements climatiques: L'effet de serre expliqué* [Living with climate change: The greenhouse effect explained]. Sainte-Foy: Éditions MultiMondes.

Warren, F., Barrow, E., Schwartz, R., Audrey, J., Mills, B., et al. (2004). *Climate change impacts and adaptations: A Canadian perspective.* Ottawa: Natural Resources Canada.

Wilkinson, P., Landon, M., Armstrong, B., Stevenson, S., Pattenden, S., et al. (2001). *Cold comfort: The social and environmental determinants of excess winter death in England, 1986–96.* Bristol, UK: The Policy Press.

Wittrock, V., Wheaton, E.E., and Beaulieu, C.R. (2001). *Adaptability of prairie cities: The role of climate. Current and future impacts and adaptation strategies.* Retrieved February 21, 2006, from http://www.parc.ca/pdf/research_publications/communities6.pdf

World Health Organization (WHO). (2000). *Climate change and human health: Impact and adaptation.* WHO/SDE/OEH00.4. Retrieved April 14, 2006, from http://whqlibdoc.who.int/hq/2000/WHO_SDE_OEH_00.4.pdf

——. (2001). *Monitoring Health Impacts of Climate Change in Europe: Meeting report.* London: World Health Organization.

——. (2002). *Planning meeting for ministries of health to address climate change and health.* WHO/SDE/OEH02.4. Meeting report. Geneva. Retrieved April 14, 2006, from http://whqlibdoc.who.int/hq/2002/WHO_SDE_PHE_02.04.pdf

——. (2003). *Climate change and human health—Risks and responses.* Retrieved March 30, 2006, from http://www.who.int/globalchange/publications/cchhsummary/en/

——. (2005). *Health topics: Disasters.* Retrieved February 12, 2006, from http://www.euro.who.int/healthtopics/HT2ndLvlPage?HTCode=disasters

World Health Organization and European Environment Agency. (2002). *Children's health and environment: A review of evidence.* Geneva: World Health Organization.

Yagouti, A., Boulet, G., and Vescovi, L. (2006). *L'évolution des températures au Québec méridional entre 1960 et 2003* [Changing temperatures in southern Quebec from 1960 to 2003]. Retrieved January 12, 2006, from http://www.mddep.gouv.qc.ca/chang-clim/meridional/resume.htm