Chapter 2

Assessment Methods

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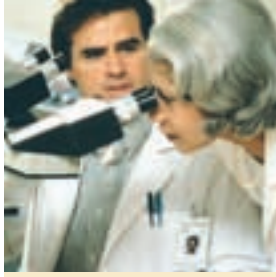

Chapter 2

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2.1 INTRODUCTION

Assessing the health risks associated with climate change and variability requires understanding both the vulnerability of a population and the capacity of the population to respond to the new conditions that arise. Several countries have completed some form of assessment of climate-related health risks (e.g. United States, India, Portugal, United Kingdom, Australia)[1] as part of their national communications to the United Nations Framework Convention on Climate Change. However, few of these assessments specifically identify existing vulnerabilities and adaptation options (Kovats et al., 2003a). Systematic approaches for identifying health risks, vulnerable populations and adaptation options are still being refined.

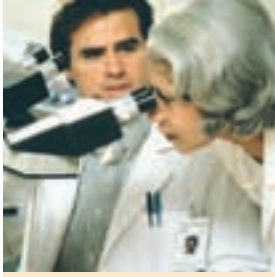
Vulnerability is a broad concept; the Intergovernmental Panel on Climate Change (IPCC) defines it as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2007, p. 21). Vulnerability to health impacts is a function of the sensitivity and exposure of populations to climate-related risks and the ability to manage these risks. Increasing adaptation measures and adaptive capacity helps to manage risks and reduce adverse health outcomes. Generally, the vulnerability of a population to climate-related health risks can be influenced by the following key factors of adaptive capacity: economic resources, technology, information and skills, infrastructure, institutions, equity and population health status (Grambsch and Menne, 2003).[2]

To assess the health risks of climate change, a number of important methodological issues must be considered and addressed. Challenges associated with the selection and application of methods for understanding human health vulnerabilities at the national scale arise because the impacts of climate change in Canada are expected to differ considerably according to the geographical location and the sensitivity of exposed populations. Because Canada has regions with dramatically different natural environments, and social and economic characteristics (e.g. north versus south), the methodologies for assessing vulnerabilities of populations need to address these variables.

In addition, there are also methodological challenges that arise from limited understanding of the complex pathways by which climate change can affect health, as well as from the timing of specific impacts. The pathways can be both direct and indirect and the severity of some impacts may not be felt for decades or longer. Direct and indirect health impacts may result from changes in day-to-day weather (e.g. deaths and illnesses from a heat wave) or from changes in ecosystems occurring over months to years (e.g. emerging infectious diseases from habitat alterations). Such impacts are often mediated through the effects of other

1 A more complete list of national impact assessments of climate change can be found in the Health Chapter of the *Fourth Assessment Report* of the IPCC (Confalonieri et al., 2007). The World Health Organization has also completed, or participated in, a number of assessments of climate change health risks (McMichael et al., 2003; Menne and Ebi, 2006).

2 See Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, for a more detailed discussion of vulnerability and adaptive capacity.



important determinants of population health (e.g. health care system, socio-economic factors). Both direct and indirect health impacts are discussed in *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity* (this Assessment).

For some health concerns (e.g. vector-borne and zoonotic diseases), assessments are supported by methods that are relatively well established. For others (e.g. food security, impacts on vulnerable populations), methods are underdeveloped or hampered by shortages of available data (Kovats et al., 2003b). An assessment of vulnerability to climate change impacts must take these factors into account by moving beyond conventional human health risk assessment approaches to investigate impacts that could occur in the future (Santos et al., 2002). Models, scenarios and other tools, designed to explore a range of possible futures, are used in vulnerability assessments to better understand future climate change impacts. Future projections of climatic conditions do, however, lack resolution over small geographical areas, and they may not represent the rate at which the changes may occur with a high enough degree of confidence to inform decision making. Those conducting vulnerability assessments need to account for the strengths and weaknesses of existing methods and tools.

2.1.1 Considerations Relevant to the Assessment Approach

In Canada, an investigation of climate change and health issues is included in the *Canada Country Study: Climate Impacts and Adaptation* (Maxwell et al.,1997), *Climate Change Impacts and Adaptation: A Canadian Perspective* (Lemmen and Warren, 2004) and in *From Impacts to Adaptation: Canada in a Changing Climate 2007* (Lemmen et al., 2008). Each of these reports is based on literature reviews and provided an overview of key health risks associated with climate variability under changing climatic conditions. However, owing to the limited scope of the human health component of the reports, little information is included on existing vulnerabilities of specific populations and regions, and on the capacity of governments and communities to take the needed actions to adapt.

The complexity of biophysical and social processes affecting human health requires that health assessments employ a broad range of health data, and analytical methods and tools, as well as draw upon interdisciplinary collaboration among researchers from many fields of expertise. Interdisciplinary collaboration unites the efforts of specialists from various domains: environmental science, medicine, public health, climate sciences, and social and behavioural studies (DesJarlais et al., 2004).

A range of both qualitative and quantitative methods and tools can be employed depending on the purpose of the assessment and the type of data available. Examples include literature reviews, expert judgement, ecological studies, geographic information systems, time-series analysis, risk assessment, community and stakeholder consultation, statistical models and scenario analysis.[3] The choice of whether to use qualitative or quantitative methods, or a combination of both, depends on the level and type of knowledge required by policy makers (Kovats et al., 2003b). Many assessments integrate both types of methods.

3 For example, Downing and Patwardhan (2005) provide a generic toolkit for climate change vulnerability and adaptation assessments.

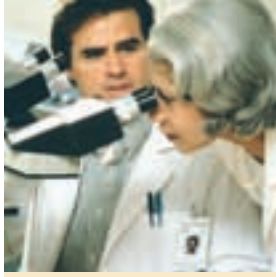
Whatever methods are chosen, they should support the goal of identifying the potential health risks of climate change, the most vulnerable populations and regions, and the measures required to protect health. A comprehensive assessment provides information on:

- current distribution and burden of climate-sensitive diseases;
- interactions among multiple climate and non-climate-related stressors (e.g. heat waves, air pollution, power failures, drought);
- estimates of the future potential health risks of climate change using scenarios of future climate change, population growth, community infrastructure, and other factors;
- likely threshold or dose-response effects that indicate whether, and how rapidly, the level of response increases or decreases with exposure to the hazard;
- health implications of the potential impacts of climate change on other sectors;
- effectiveness of current actions in place to reduce the burden of any particular health outcome;
- future coping capacity of individuals and their communities (e.g. economic resources, health and social services); and
- identification of short-term, medium-term and longer-term adaptation measures required to reduce current and future vulnerability.

2.2 OPTIONS FOR ASSESSING VULNERABILITY

Conventional environmental health risk assessment frameworks provide important methodological tools (e.g. hazard assessment, stakeholder engagement) for climate change and health vulnerability assessments. But these frameworks do not provide sufficient guidance for vulnerability assessments because they cannot account for the multiple interrelated causes of disease and the various feedback mechanisms that often limit the predictability of health outcomes (Bernard and Ebi, 2001). Several guidance documents and conceptual frameworks have been developed that provide general direction for the application of methods to assess vulnerability to the health impacts of climate change and to develop adaptation strategies and prioritize options (e.g. IPCC *Technical Guidelines for Assessing Climate Change Impacts and Adaptations*: Carter et al., 1994; *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*: Feenstra et al., 1998; *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*: Lim et al., 2005).

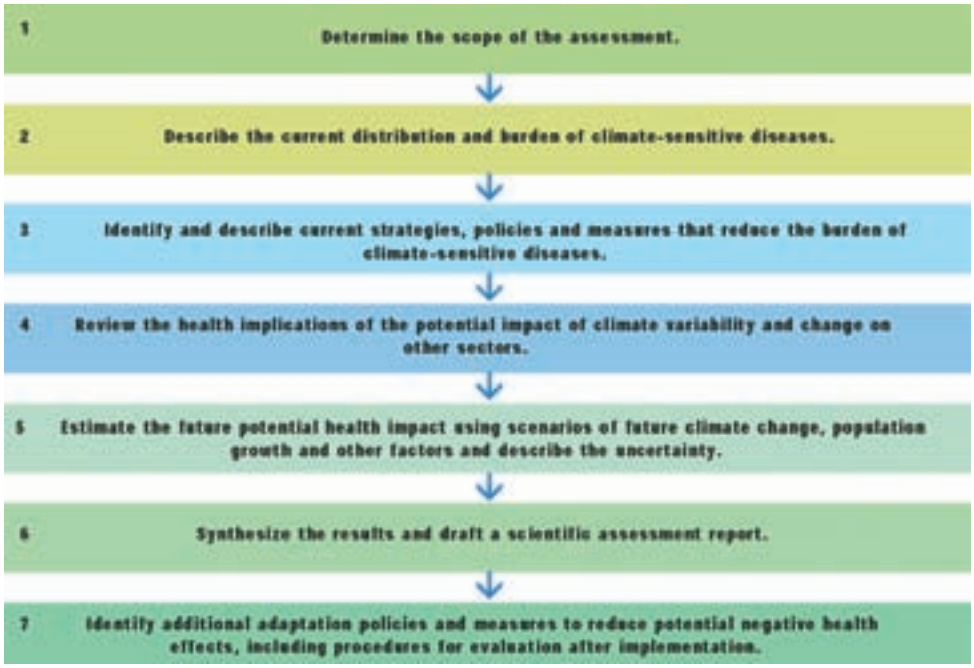
A literature review by Füssel and Klein (2004) surveyed existing guidance documents and conceptual frameworks related to adaptation to climate change, and evaluated their applicability to national and regional policy strategies aimed at reducing climate-related health effects. Many of the current approaches, such as the IPCC technical guidelines (Carter et al., 1994), were found to have significant limitations in their applicability to climate change and health vulnerability assessments. The authors reported that *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* (Kovats et al., 2003b) (described later in the text) is the "single most important guidance document for climate change adaptation assessment for human health" (Füssel and Klein, 2004, p. 82).



2.2.1 Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change

Kovats et al. (2003b) provided a basic approach for all countries to assess and better understand the risks of climate change to human health in regions throughout the world. They provided advice for dealing with the complexity of the subject matter and existing scientific uncertainties, outlined the strengths and weaknesses of existing tools and methods, and offered practical guidance for undertaking assessments to governments, health agencies, and environmental and meteorological institutions in both industrialized and developing countries. Figure 2.1 illustrates the steps in assessing vulnerability and adaptation as put forward by Kovats et al. (2003b).

Figure 2.1 Steps in assessing vulnerability and adaptation



Source: Kovats et al., 2003b

The approach advocated in the document by Kovats et al. (2003b) integrates activities aimed at understanding current vulnerability and adaptive capacity with efforts to increase knowledge of projected future impacts of climate change. Such information directs actions to revise, reorient and/or expand public health strategies, policies and measures to protect the health of populations. For a range of health outcomes, methods are presented to aid in the evaluation of evidence that climate change is affecting morbidity and mortality. Methods are also selected to aid in the projection of future impacts, and identify adaptation strategies, policies and measures to reduce current and future negative effects.

2.3 APPROACH AND METHODS USED FOR *HUMAN HEALTH IN A CHANGING CLIMATE: A CANADIAN ASSESSMENT OF VULNERABILITIES AND ADAPTIVE CAPACITY*

2.3.1 Assessment Approach

To the extent possible, the approach used in this Assessment followed the approach in *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* (Kovats et al., 2003b). It combined an investigation of vulnerabilities to current weather and climate variability with an exploration of specific health risks (e.g. air pollution health risks) that are anticipated under future climate scenarios. The assessment of vulnerability varied considerably for each chapter, given differences in data availability and in the focus and purpose of the respective chapters. Those chapters that examined specific health issues arising from climate change focussed the discussion of vulnerability on specific groups and populations within Canada that are most at risk.[4] Chapters dealing with specific regions (i.e. Quebec and the North) provided a broader assessment of vulnerability to the impacts through an examination of current adaptations and ability to cope with the multiple climate-related health risks within the respective regions. Some of these findings are expanded upon in Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, which provides a national perspective on vulnerability by highlighting trends in exposure to climate-related hazards and the sensitivity of individual Canadians, and by examining the status and effectiveness of key adaptations to reduce health risks. This Assessment went beyond a basic assessment; it not only reported on the available information about potential vulnerabilities in Canada through literature reviews, it also collected new data and research to quantify impacts and evaluate current responses (e.g. simulation exercises, informant interviews).

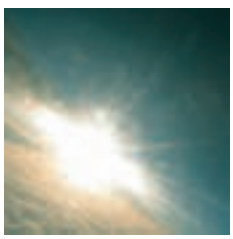
Determination of structure and scope

Existing literature identifies several potentially adverse health risks of climate change across Canada (Maxwell et al., 1997; Health Canada, 2003; McMichael et al., 2003; Lemmen and Warren, 2004):

- air quality-related health effects;
- water-, food-, vector-, and rodent-borne diseases;
- health effects of extreme weather events;
- health effects associated with stratospheric ozone depletion; and
- socio-economic impacts (e.g. economic and occupational losses).

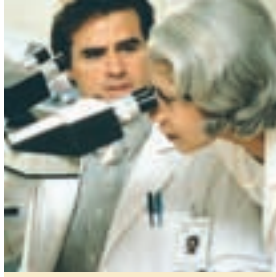







Through consultative mechanisms, including steering committee meetings and three expert workshops, the structure and scope of this Assessment were determined. Three areas that have important implications for human health—air pollution, water-, food-, vector-, and rodent-borne diseases and natural hazards related to climate variability—were chosen for investigation

4 Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, goes somewhat further by highlighting the characteristics that increase the vulnerability of communities, such as deteriorating infrastructure or factors related to urban design (e.g. large areas of concrete, limited green spaces).



in this Assessment based on the following criteria: (1) availability of data and analytical tools, (2) existing burden of disease, (3) existence of knowledge gaps, (4) availability of scientific expertise to address issues, and (5) the extent to which the health sector can adapt.

The investigation of air pollution related to climate variability provided findings that are relevant to many parts of Canada, given that many regions and several highly populated communities currently experience health risks from poor air quality. Expected impacts from climate change on air quality have been highlighted as a key issue for North America (McMichael et al., 2003; Confalonieri et al., 2007; IPCC, 2007). Literature reviews of health risks within Canada from water-, food-, vector-, and rodent-borne diseases, as well as natural hazards related to climate variability (e.g. heat waves, storms, wildfires) were also conducted in the course of this Assessment. In addition, two regional health assessments—one for the Canadian North and one for Quebec—were carried out to allow health decision makers to better understand how multiple health issues interact on one population, and to gauge the adaptive capacity of the region as it responds to several, and sometimes confounding, health issues. The North was chosen because it is currently experiencing severe impacts of climate change and because the *Arctic Climate Impact Assessment,* which was released in 2004, provided a body of knowledge from which to draw (Hassol, 2004). The province of Quebec was chosen because, at the time of writing, it had the institutional research capacity and expertise to carry out the research through key public health agencies in that province (e.g. Institut national de santé publique du Québec) and through the Ouranos Consortium, which includes Government of Quebec ministries, universities, federal agencies and industry partners, collaborating to increase understanding of climate change impacts and needed adaptations in Quebec.

Although this Assessment did not examine vulnerability to the health risks of climate change in all parts of Canada, it is possible to extrapolate specific findings to other regions that may share similar climate-related hazards. In addition, it provides lessons learned about how to conduct climate change and health vulnerability assessments for those regions and individual communities in Canada that may choose to undertake their own assessments in the future.

Key assessment components included:

- assessing health risks at the national scale related to decreased air quality, including an investigation of current risk management strategies;
- assessing a range of health risks and vulnerabilities at a local scale in Canada's northern communities and for people living in Quebec;
- assessing the capacity of communities and governments to adapt to health risks, including local-scale case studies;
- identifying populations most vulnerable to climate change;
- identifying knowledge gaps that need to be investigated further to fully understand the possible impacts of climate change on health; and
- literature reviews of water-, food-, vector-, and rodent-borne diseases and natural hazards related to climate variability.

Authors for each chapter drew upon input from experts and practitioners, working in a wide range of disciplines, who were engaged in collaborative research projects, as well as input gained from the peer review process. For example, Chapter 4, Air Quality, Climate Change and Health, involved governmental and non-governmental researchers with expertise in epidemiology, environmental health sciences, climate modelling and atmospheric sciences, in the

analysis of the potential impacts of climate change on future air quality and risks to human health. Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada, drew upon expert input from researchers in the fields of public health, health care system renewal, emergency management, natural hazards assessment, sociology and behavioural sciences to explore the ability of governments and communities to adapt to climate change health risks.

Assessment oversight

Oversight for this Assessment, including the peer review process, was provided by a multi-stakeholder National Steering Committee, comprising officials involved in these issues at local, regional and national levels, and representatives from governmental and non-governmental organizations. It is noted, however, that broad consultation with stakeholders, such as local medical officers of health, voluntary organizations and provincial health representatives did not take place, but would provide added value in future assessments.

2.3.2 Assessment Methods

This Assessment employed a broad range of health data, and analytical methods and tools. Key methods employed included climate models, climate scenarios, expert judgement, epidemiology, ecological studies, literature reviews and stakeholder consultations.

Data, methods and tools used for *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilitites and Adaptive Capacity*

Climate model: A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and which accounts for all or some of the known properties. Models may vary in complexity. As research tools, they are applied to study and simulate the climate, but are also used for operational purposes including monthly, seasonal and inter-annual climate predictions.

Climate scenario: A plausible and often simplified representation of the likely future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change and often serving as an input to impact models.

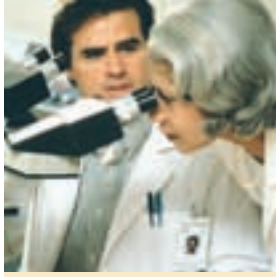
Expert judgement: Statements, which represent a process of evaluation that can be described as a set of conditions and criteria, by someone widely recognized as a reliable source of knowledge, technique or skill and whose judgement is accorded authority and status by the public or their peers.

Epidemiology: The science of public health and preventative medicine that studies the distribution and determinants of health-related states or events in specific populations, and that applies study findings to control and/or mitigate health problems.

Ecological study: An epidemiological study which seeks to find population- or community-level associations between exposure and the occurrence of disease.

Literature review: A comprehensive survey of publications that aims to critically analyze, summarize and compare prior research in a specific field of study.

Stakeholder consultation: Canvassing of views of stakeholders, which may include governments, non-governmental organizations, research institutes and private entities that focus on the issue being investigated, in the process of developing useful information, often through forums, roundtables and advisory bodies.



Strengths and limitations of the key methods and tools used for this Assessment are shown in Table 2.1. More detailed descriptions of specific methods used by the authors to examine climate change risks to health are presented in the respective chapters.

Table 2.1 Strengths and limitations of assessment methods and tools[5]

Study Method or Tool	Assessment Application	Strengths of Application	Limitations of Application
Climate Models and Scenarios	Chapter 4, Air Quality, Climate Change and Health: Modelled the impact of an increase in temperature of 4°C (2002 as the base year) on concentrations of ground-level ozone and particulate matter ($PM_{2.5}$) for all of Canada in 2080 using the Meteorological Service of Canada's Unified Regional Air-quality Modeling System (AURAMS), and then impacts on human health using Health Canada's Air Quality Benefits Assessment Tool (AQBAT).	Quantitative estimates of future health risks were derived; these were useful for developing adaptation measures to protect human health.	Chapter 4 used a single temperature increase of 4°C (not a range of possible increases) to assess selected changes arising from climate change. It also used a single 3 month time period for the analysis based on 2002 conditions, subject to the 4°C increase. Analysis in Chapter 4 was limited due to uncertainty about future exposure to air pollution (e.g. people spending more time outdoors) and other factors that may affect air quality as a result of climate change (e.g. wildfires, modification of biogenic and anthropogenic emissions).
	Chapter 6, Health Impacts of Climate Change in Quebec: Projected morbidity from heat waves for the certain cities and administrative areas in Quebec using the HadCM3 general circulation model and down-scaling techniques. Projections were made for the 2020, 2050 and 2080 timeframes.	Statistical downscaling techniques permitted the use of global general circulation model data at more local scales in Quebec (e.g. city level). Modelling of heat health effects allowed for the identification of impacts for different cities and regions.	Limitations in weather data for administrative areas made projections of impacts on mortality more difficult.
Expert Judgement	Key informant interviews were used in research projects for Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather; Chapter 4; Chapter 6; and Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada.	Qualitative findings complemented the analyses conducted through literature reviews. Surveys and consultations provided a stakeholder engagement and awareness-building function. Provided up-to-date and relevant information on adaptation initiatives of health sectors in Canada.	Small number of interviewees for Chapters 3, 4 and 8 limited the ability to generalize findings. Findings were subjective in nature.

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5 Note: Information on the general strengths and weaknesses of these, and other methods and tools for assessing climate change and health vulnerability can be found in Kovats et al. (2003b) and Lim et al. (2005).

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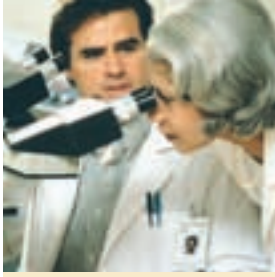
Study Method or Tool	Assessment Application	Strengths of Application	Limitations of Application
Epidemiology/ Ecology Studies	All chapters reported on results of epidemiology and/or ecology studies recently completed on climate change and health issues in Canada. The synergistic effects of heat wave and air pollution episodes (particulate matter [$PM_{2.5}$] and ground-level ozone) were investigated for Chapter 4.	Chapters 4 and 6 provided quantitative estimate of impacts. Chapters 4 and 6; and Chapter 7, Health Impacts of Climate Change in Canada's North, used these studies for understanding the risks associated with vulnerabilities in specific population groups. Quantitative estimates of future health risks were used to identify adaptation measures for protecting human health (e.g. Chapters 4 and 6).	Constraints on application of this method included the costs associated with, and the time-consuming nature of, these studies. Insufficient health data and/or relevant climate data in Canada meant that associations between current and future climate hazards and health outcomes could not be rigorously tested (e.g. Chapters 3 and 7; and Chapter 5, Impacts of Climate Change on Water-, Food-, Vector- and Rodent-borne Diseases). Insufficient understanding of system dynamics.
Literature Review	Used in all chapters of the Assessment. Focus was on new studies and findings released since *Canada Country Study: Climate Impacts and Adaptation* (Maxwell et al.,1997). Included the use of "grey" literature and policy reports in select chapters, particularly for Chapters 7 and 8. Reviews of existing documentation of traditional and indigenous knowledge, and observations of climate changes and health risks were conducted for Chapter 7.	Provided quantitative and qualitative analyses. Long-term records were accessed through electronic databases (e.g. Medline, Webscience, etc.). Analysis used descriptive information not found in traditional databases.	For some chapters, too few studies are available to characterize the level of risk to health faced by specific populations and regions in Canada from climate change (e.g. Chapters 3 and 5). Research on climate change and health adaptation measures and their effectiveness is particularly sparse.
Stakeholder Consultation	A multi-stakeholder steering committee provided oversight for the Assessment. Expert workshops were held to inform Chapters 3, 4 and 8. An advisory committee provided oversight for Chapter 6. Government authorities and individual citizens at local and sub-regional levels were consulted, and current perceptions and observations of climate changes and impacts over the province were assessed for Chapter 6.	Consultations built on engagement and awareness of issues. Supported making assessment results responsive to needs of user community. Accessed a wide range of scientists, experts and practitioners to increase credibility of results. Community consultations provided information based on direct observations of the environment by the general population and local managers for the Canadian North and Quebec.	Time consuming to ensure representation of all relevant stakeholders. Results were largely qualitative and influenced by factors affecting individual and collective perceptions, and understandings of environmental change (e.g. age, gender, lifestyle, health status, income, etc).

Note: Information on the general strengths and weaknesses of these, and other methods and tools for assessing climate change and health vulnerability can be found in Kovats et al. (2003b) and Lim et al. (2005).



2.4 UNCERTAINTY

Uncertainty is an inherent component of science. However, climate change introduces new challenges when identifying, assessing and managing health risks. Major sources of uncertainty in this Assessment resulted from knowledge gaps related to the biological and physical processes by which climate affects health as well as from difficulties inherent in estimating health impacts associated with projected climate trends. Uncertainty also resulted from incomplete knowledge about system dynamics, including a lack of information regarding processes operating on a range of scales—from local to national—that determine the capacity of individuals, communities and governments to adapt to climate variability and change.

Uncertainty must be addressed in assessments of vulnerability in order to better inform policy. When reporting uncertainties, some science assessments adopt a probability-based nomenclature for expressing likelihood and/or confidence, such as the *Fourth IPCC Assessment Report* (IPCC, 2007) or the *Arctic Climate Impact Assessment* (Hassol, 2004). Although the IPCC approach is recommended in *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change* (Kovats et al., 2003b), it was neither practical nor meaningful to adopt a standardized probability-based terminology for all chapters in this Assessment. This was due to the varying level of analysis used to assess and report health outcomes in each chapter, which was based upon available data and existing scientific studies. The qualitative statements of likelihood and confidence within this Assessment reflect the information that was available on any specific topic, as well as the use of expert judgement. In general, authors were able to express greater confidence and likelihood when the quantity and quality of the research available on the issues were high.

Improved understanding of existing vulnerabilities and the expected health impacts requires stronger health impact data and further progress in addressing existing knowledge gaps. Examples of key areas of uncertainty regarding the findings of this Assessment include:

- magnitude of expected increases in future air pollution and health risks;
- magnitude of expected stresses and pressures on the health care system and social services from a rise in climate-related health impacts; and
- degree of potential vulnerability of Canadians to climate change health impacts, given uncertainty in future demographic and health trends (e.g. age, chronic health, access to health services), and projected future exposures to climate-related hazards.

2.5 LESSONS FOR FUTURE ASSESSMENTS

This study constitutes one of the first assessments of impacts on health and well-being and vulnerabilities associated with climate change that draws extensively from the approach highlighted by Kovats et al. (2003b). It is the most comprehensive climate change and health assessment undertaken to date within Canada. As illustrated in Table 2.1, a wide range of methods were employed to examine the vulnerabilities of Canadians to climate variability and change. Application of these methods has produced new insights about the threats to the health and well-being of Canadians posed by climate change. However, time, research capacity and the availability of health data constrained the ability of authors to conduct comprehensive studies of all the potential climate change and health vulnerabilities in Canada.

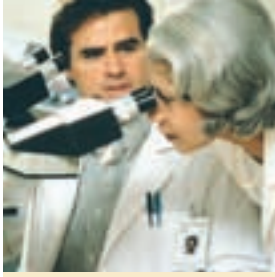
Extensive literature reviews, database searches and expert interviews were instrumental in pulling together, for the first time, baseline data and information on the magnitude of climate hazards, and the number of illnesses and deaths in Canada associated with key risks to health from climate change. For example, Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, presents information on the current health impacts of avalanches, rock-, mud- and landslides, debris flows, extreme temperatures including heat waves and cold waves, droughts, wildfires, thunderstorms, lightning, hail, tornadoes, tropical storms (e.g. hurricanes), floods, fog, freezing rain and ice storms in Canada. Decision makers in the public health and emergency management fields require such information to gauge future risks to health, prioritize risk management activities among other issues of concern, and develop needed adaptive options.

Engagement of stakeholders and partners was crucial in this Assessment. It contributed to (1) identifying and validating the assessment approach, (2) scoping out priority health issues and regions for examination, (3) obtaining key information needs of health sector decision makers, (4) providing advice on communicating results of this Assessment, and (5) enlisting needed expertise and research assistance when required. For example, as a result of consultative workshops, it was determined that decision makers need key information on the status of existing risk management activities and on the effectiveness of those activities for each health issue or region examined. Such analysis was included in a number of the chapters, particularly Chapter 8, Vulnerabilities, Adaptation and Adaptive Capacity in Canada.

Furthermore, analysis in this Assessment enlisted cooperation from a broad range of experts to best characterize and assess health impacts and vulnerabilities associated with climate change. Collaboration with climate modellers at Environment Canada was instrumental for projecting the potential impacts of possible future climate warming on air quality, and climate modelling input from officials with the Ouranos Consortium allowed authors of Chapter 6, Health Impacts of Climate Change in Quebec, to project the number of heat-related deaths from climate change for a number of communities in that province. In addition, integration of information from the Canadian Disaster Database in Chapter 3, Vulnerabilities to Natural Hazards and Extreme Weather, benefited from expert advice and review by officials in Public Safety and Emergency Preparedness Canada.

Experience with the application of key methods for assessing climate change-related health risks and vulnerabilities suggests that future assessments would benefit from:

- development of other models and tools to allow additional non-climate drivers of health impacts to be considered through cross-sectoral integrated assessment;
- development of climate scenarios, general circulation models and regional downscaling techniques that provide finer spatial and temporal resolutions to provide needed information on the changes in the frequency and intensity of extreme weather events (rather than just mean values) and inform regional or local adaptation initiatives. Data and model constraints, and limitations in temporal and spatial resolution of climate scenarios mean that examination of the future burden of disease could not be estimated for all health issues and for each region under investigation;



- development of quantitative indices of vulnerability and adaptive capacity to compare ability to cope with climate change and health risks at the country, regional and local levels; and
- more extensive data on (1) illnesses and deaths from key climate change health concerns (e.g. deaths related to extreme temperatures), (2) the role of health services in mitigating natural hazards or in aiding the victims of natural disasters, (3) the effectiveness of current adaptations, and (4) future socio-demographic trends with which to gauge vulnerability.

The experience of conducting climate change and health assessments in the North and in the province of Quebec provides insights and best practices for assessments at the regional scale that can be applied to future studies. For example, such initiatives benefit greatly from a comprehensive review of the current health and socio-demographic status of the relevant populations. They are also aided by investigations of perceptions and observations of local-level decision makers and stakeholders who have an important role to play in future adaptation development processes. Based upon investigations of the effectiveness and/or costs of adaptation measures, such information will be critical for the identification of priority actions that should be adopted to prepare for all, or the most likely, health impacts expected under climate change.

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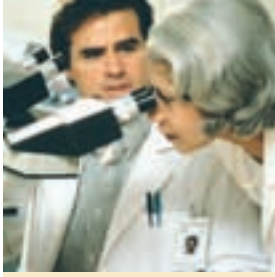

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