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Addressing the Health Effects of Climate Change: Family Physicians Are Key

Oscar Rejlander: Homeless (c. 1860).

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April 7, 2008

PREFACE

This is a landmark review of the science of climate change and its impacts on human health –now and in the near future. Climate change has led to a great deal of concern amongst Canadians and a world-wide debate on the strategies that are needed to address this all encompassing health issue. In spite of the concerns of governments and people around the world, physicians and the health care sector in general have been relatively silent on an issue that will have major impacts on the health of the people they serve and in the communities in which they practice.

This report was researched and written by family physicians for family physicians in response to the lack of a single, comprehensive document that provides family physicians with the information they need to understand an issue that has been described as the defining feature of this century – and it is a call for the medical community to take action.

The report emphasizes the important roles that family physicians will need to play in the primary prevention, diagnosis and management of a wide range of health conditions associated with climate change. It acknowledges that our medical students, family medicine residents and practicing family physicians need to acquire further education so they can practice effectively when these conditions arrive and escalate in their communities. While recognizing that family doctors already are stretched to the limit, dealing with an increasing volume of complex problems in their practices as their patients age and more care shifts to the community, this report forewarns them of the impending health problems they will need to address as individuals, communities, governments and industry are beginning to realize that decisive action must begin soon.

Family medicine is the foundation of our healthcare system and family doctors are afforded a great deal of respect for the work that they undertake on a daily basis. The key leadership roles that family physicians have traditional played amongst their patients and in their communities is well-recognized by Canadians. Family physicians are viewed by the public as the most trusted source of information about health and healthcare. Individual patients listen to their family doctors and, when family physicians speak collectively, the public listens. The actions that family physicians undertake now with their own patients, in their communities and through their provincial, national and international medical organizations, are seen as key to adapting, mitigating and managing the health effects of climate change.

To prepare family physicians for their roles in addressing the ramifications of climate change, this report:

- **Presents a summary of the science of climate change;**
- **Identifies relevant direct and indirect health effects of climate change;**
- **Describes the relevant impacts on the populations that are most vulnerable;**
- **Identifies the fact that today, economic and ethical imperatives are completely synchronized so the time for action is now;**
- **Provides an overview of preventive responses needed from society, individuals and families; and lastly,**
- **Identifies the role of the family physician in climate change.**

This is a "must read" report for every family physician in the country. Every family doctor has a number of "war stories" that they tell – the tightening in their stomach the day they were in the emergency department and were asked to standby as a tornado swept through Barrie, Ontario; the distress they felt when SARS overtook the City of Toronto; the anger and sadness that swept over them as lives were lost in Walkerton, Ontario due to contamination of the water supply; the impact of seeing the destruction of thousands of trees in Stanley Park in Vancouver and in the parks of Halifax due to catastrophic weather; the concern they felt when their public health unit decided to spray pesticides to prevent an outbreak of West Nile Fever; the anguish they experienced when a patient presented with symptoms of a disorder that they had only read about in a book concerning exotic diseases; the helplessness they felt while volunteering to deliver medical care in a third world country; the eight-hour wait-time in their emergency department on the February day when the smog count was as high as a hot summer day. That was just one of the days when children with asthma and the elderly with chronic disorders such as chronic obstructive pulmonary disease and congestive heart failure arrived in droves.

They call them "war-stories". They stand out in their memories because they are not today's norm. However, tomorrow, due to climate change, they will be a part of the patient problems that family physicians see on a daily basis and they are just some of the conditions that are the direct and indirect results of climate change.

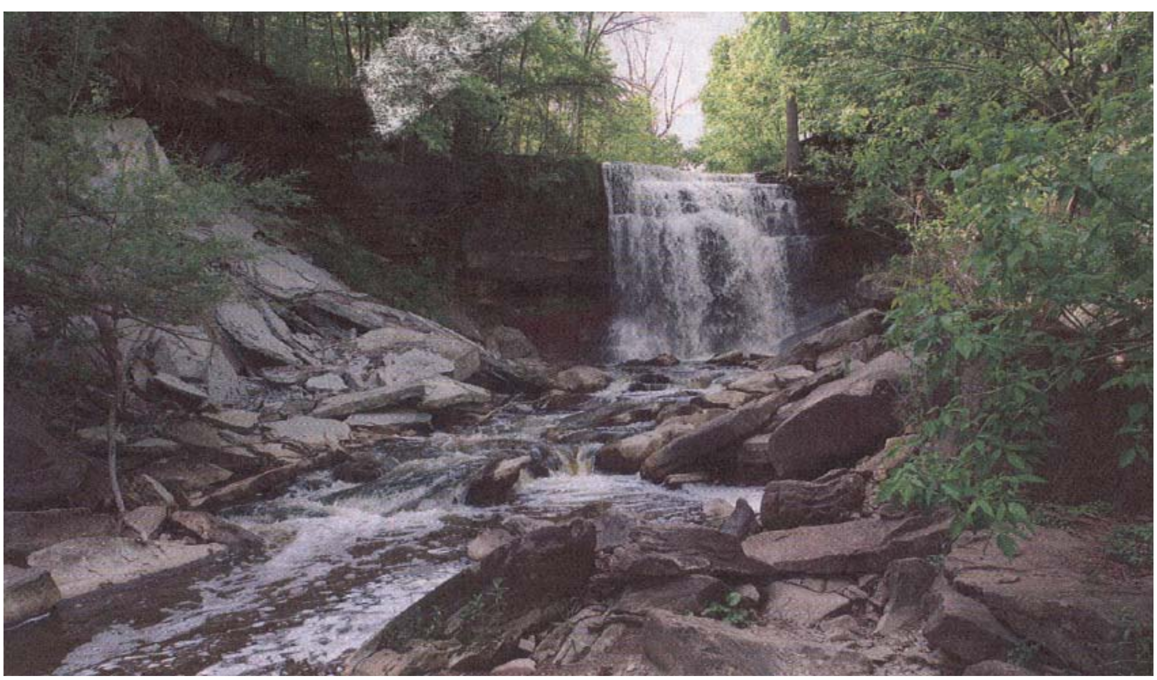
Family doctors can wait until a wide range of problems become part of the lexicon of their practices in Ontario and across Canada - or they can heed the call to action. This report calls upon them to look beyond the examination room and the needs of individual patients. It provides evidence of the effects of climate change on human health in Ontario, Canada and globally. It relies heavily on international research, in recognition of the fact that the greatest burden of disease will be felt in developing countries, in coastal communities and in the Arctic. Certain segments of the population will be affected the most including infants and children, the elderly, the poor, the disabled, immigrants and aboriginal peoples. However, Hurricane Katrina and other natural disasters have taught us that no-one will be immune from the projected short-term effects of climate change and the long-term and potentially irreparable changes that are occurring daily on Planet Earth.

As role models who are looked upon daily for guidance and advice, family doctors, individually and collectively, have within their grasp the means to really make a difference. Family medicine, together with other health care professions, is key to how we as a society deal with the health effects of climate change.

"YOU MUST BE THE CHANGE YOU WANT TO SEE IN THE WORLD."

Mahatma Gandhi

Our children and our children's children may inherit an earth in which the health effects of climate change are the order of the day. Primary and secondary prevention strategies (adaptation and mitigation) are needed to ensure that the catastrophic weather patterns depicted in the above two photographs do not become the norm. To ensure that the earth remains an oasis of peace and beauty, family physicians need to play vitally important roles now with their patients, their communities, governments and the private sector, to ensure that we leave a positive legacy for our future generations.



ACKNOWLEDGEMENTS:

The Ontario College of Family Physicians (OCFP) is grateful to the authors of this report who have devoted hours of their time to the review of the literature that underpins this report and to crafting this landmark report on the health effects of climate change. Our authors are as follows:

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The OCFP wishes to also thank Dr. Cathy Vakil for reviewing and editing the report and to the following well-respected experts in the field who undertook peer reviews of the report:

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INTRODUCTION

The earth's climate has changed, and will continue to change. The earth has warmed and global temperatures will continue to rise. This has led to complex changes in the climate, in Canada and across the world, that are expected to continue and escalate. The scientific evidence for this is sound and now widely accepted. The accumulation of human-made carbon dioxide and other greenhouse gas emissions in the atmosphere is responsible for these changes (anthropogenic climate change). These changes have led to great concern among Canadians, and have generated political debate about how to address these problems.

Physicians and the healthcare sector in general have not been prominent in this debate, although it is clear that climate change will have significant adverse health impacts both in Canada and globally. This report is a review of the health effects from climate change, and a call to action for the medical community. The health effects of climate change are multiple, and are mediated by complex pathways as seen in the following figure.

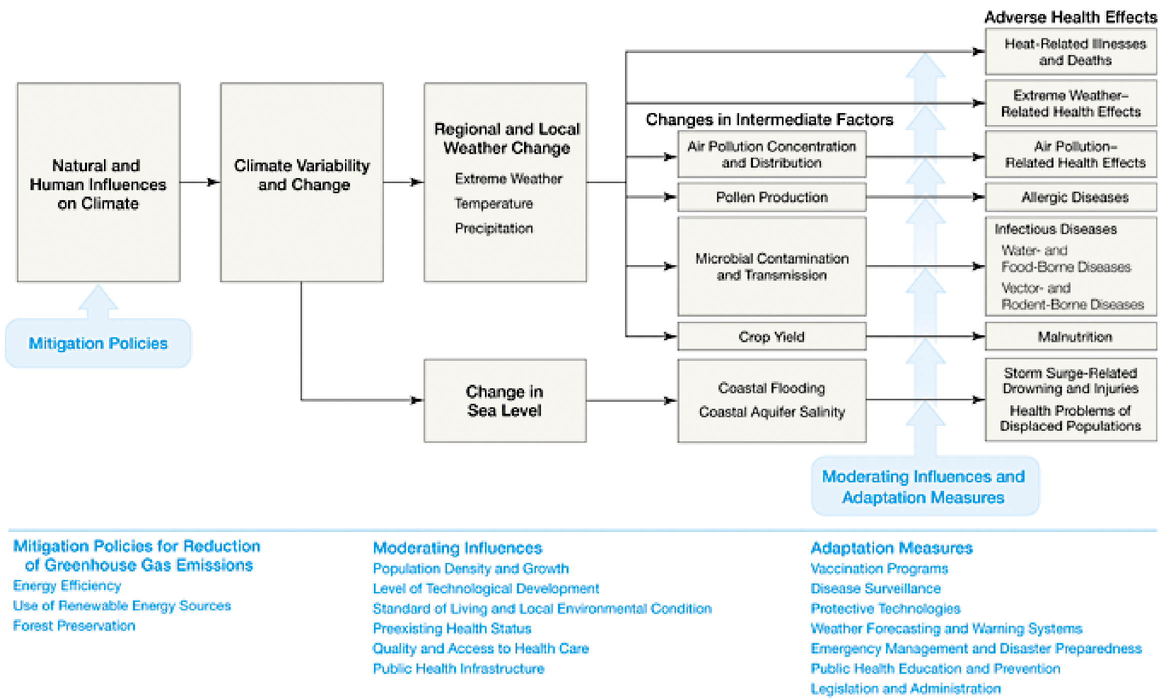


Figure 1: (Haines and Patz, JAMA 2004)

Health Concerns	Examples of Health Vulnerabilities
Temperature-related morbidity and mortality	Cold and heat related illnesses
	Respiratory and cardiovascular illnesses
	Increased occupational health risks
Health effects of extreme weather events (storms, hurricanes, flooding, ice-storm)	Damaged public health infrastructure, including contamination of food and water
	Injuries and illnesses
	Occupational health hazards
	Population displacement
	Anxiety/Depression/ Post traumatic stress disorder (PTSD)
Air pollution-related health effects	Changed exposure to outdoor and indoor air pollutants and allergens
	Asthma and other respiratory diseases
	Heart attacks, strokes and other cardiovascular diseases
Health effects of water- and food-borne contamination	Diarrhoeas and intoxication caused by chemical and biological contaminants
Vector-borne and zoonotic diseases	Changed patterns of diseases caused by bacteria, viruses and other pathogens carried by mosquitoes, ticks and other vectors
Socio-economic impacts on community health & well-being	Loss of income and productivity
	Social disruption
	Diminished quality of life
	Increased costs to health care

Table 1: Adapted from Canada's Health Concerns from Climate Change and Variability (Health Canada, Environmental & Workplace Health, 2007).

In this report, we will use a combination of the model depicted previously by Haines and Patz and the model developed by Health Canada seen in Table 1 to classify the health impacts of climate change.

Health Effects

The most easily recognized health impacts, or direct effects, are as follows:

- temperature related morbidity and mortality;
- health effects of extreme weather events (storms, flooding, etc).

The other health impacts have more complex pathways, and are considered the indirect effects of climate change and include:

- air pollution related effects;
- allergic diseases;
- infectious diseases

-water and food- borne contamination,
-vector-borne and zoonotic diseases;

- socio-economic impacts on community health and well-being.

Although the health effects from damage to the ozone layer and increased exposure to UV light are well documented and very significant, we will not cover this topic. The health effects, adaptation strategies, such as "cover up and use sun screen liberally", and mitigation efforts, including reducing ozone depleting chemicals such as the chlorofluorocarbon propellants in Metered Dose Inhalants, are very different and would warrant a separate report. Likewise, we will not cover the impacts of other global ecological changes such as species and biodiversity loss, and water resource depletion. These have potential to impact human health, and the effects interact with the health effects of climate change. However, we will focus only on the health effects of climate change itself.

Our report will review the health effects of current changes in climate, as well as predicted changes. We will discuss how some groups are more vulnerable, including seniors, children, chronically ill people, low income and homeless people, disabled people, northern residents, and people living off the land.

We have attempted to gather evidence for these effects from research specific to Ontario and Canada. However, much of the information is derived of necessity from published research and reports from the United States and from international organizations. We will review the international scope of the health impacts, because by far the greatest burden of disease will be felt in developing countries. People in these countries are more vulnerable because of the risk from vector borne and infectious diseases, sea level rise, floods and drought and do not have the resources to adapt. We will address the primary prevention of the health impacts of climate change in two ways:

- **Adaptation** means making changes to avoid the worst, or help us to prepare for the unavoidable health impacts of climate change. We will focus on the public health adaptation responses, although many of the adaptive strategies lie in other spheres such as policy development, infrastructure, resource management, etc.
- **Mitigation** refers to efforts directed further "upstream" that are aimed at reducing the level of greenhouse gases, by reduction of emissions of greenhouse gases or increased sequestration of carbon dioxide.

Finally, we will explore the role of the medical profession; what our medical organizations can and should be doing, the role of public health, but most importantly, what individual family physicians should be doing in their offices and as leaders in their communities.

Climate change has been called the defining issue for public health in the 21st century. (Chan, 2007) With this report, we hope that family physicians and other health professional colleagues will play an active role as part of the solution to this immense challenge.

The SOAP Format

In the discipline of family medicine, we use the ***S**ubjective, **O**bjective, **A**ssessment, **P**lan format* (**SOAP**). We have applied this format to the health impacts of climate change as if the Earth is the sick patient. The results are as follows:

Subjective

We all know that:

- summers have been warmer, longer; and,
- winters have been warmer

Objective

We have extensive data on changes in temperature and precipitation, including:

- past (historical) changes;
- present changes that we can measure today; and,
- projected changes.

Assessment

1. The health impacts are well described, and will be detailed in this report including:
   - presently detectable health impacts; and,
   - projected future health impacts.

2. As a society, we are in a state of denial about the reality of the health impacts of climate change, and the need for change. (Denial is defined as a "defense mechanism in which the existence of unpleasant realities is disavowed; refers to keeping out of conscious awareness any aspects of external reality that, if acknowledged, would produce anxiety.")(Kaplan et al., 2005)

Plan

1. Action is required, and we need to plan for changes in both individual behavior and societal changes. These changes are thought of in two categories:
   - **Mitigation**; are those actions that are aimed at reducing the amount of carbon dioxide emitted into the atmosphere; and,
   - **Adaptation**: are those actions aimed at adapting our households or communities to help reduce harm to human health from the inevitable changes in climate.

2. Physicians must assess the role they play in helping individuals and society to make appropriate changes. Most of us are in the pre-contemplative stage of change (Proch et al., 1994); however, we must take a lead role and inspire movement toward change, through the stage of contemplating change, and then to preparation for change and finally action.

3. Triage: As we use triaging protocols and ask ourselves, "How urgent is the condition of the patient?" It is clear from recent reports that the situation is critical and that urgent action is required.

CHAPTER 1

THE SCIENCE OF CLIMATE CHANGE

1.1. Global Context

1.1.1 Introduction/Definitions

- Weather is a term used to describe the hour-to-hour, day-to-day, and season-to-season changes in temperature, precipitation (rainfall/snowfall) and wind patterns.
- Climate is a broad term that describes average weather over the course of longer period of time
- Climate change describes long-term shifts in climate regionally, or in the planet as a whole. Like changes in the weather, this is usually reported as changes primarily of patterns of temperature, precipitation and wind patterns; however, it is described as changes in average measures over time, or changes in variability. This section will summarize the scientific understanding of climate change.

1.1.2 The Intergovernmental Panel on Climate Change (IPCC)

The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) in 1988. (IPCC) The IPCC does not itself conduct primary research; rather, it assembles groups of experts to conduct literature reviews on the peer reviewed scientific literature. It has published four assessments reports, in 1990, 1995, 2001, and recently, the Fourth Assessment Report (AR4) in 2007. Each report is based on the findings of three working groups.

- Each Working Group 1 covered the scientific data on climate change itself.
- Each Working Group 2 covered the environmental and socio-economic impacts, including health impacts of climate change and adaptive options.
- Each Working Group 3 assessed strategies to reduce Greenhouse gases (GHG) (i.e. Mitigation).

This section of the report gives a brief summary of the global picture of climate change science, borrowing extensively from Working Group 1 of the Fourth Assessment Report (AR4) of the IPCC (IPCC, Contribution of Working Group I). It contains information on the following:

- The currently observed changes in climate and their effects
- Historical trends in climate and future climate change
- Human emissions of greenhouse gases as the cause of climate change
- Projected climate change
- The urgency of the situation
- Mitigation

1.1.3 Observed changes in climate

It is now generally accepted that the earth has warmed, and the scientific debate that was so prominent in political discourse until recently, has subsided. Conclusive evidence for this is derived from direct measurements of:

- increases in global land-surface air temperatures;
- increases in global ocean temperatures;
- widespread melting of snow, ice, glaciers and permafrost; and,
- the rising global average sea levels.

Associated changes include:

- changes in precipitation patterns, with more frequent heavy rainfall storms in northern latitudes secondary to warming and increased atmospheric water vapour;
- increased drought in the tropics and subtropics;
- more heat waves; and,
- increased intensity of tropical cyclones (hurricanes) in the North Atlantic.

Figure 1.1, demonstrates the increase in the temperature of the global land-surface air temperature during the past 150 years.

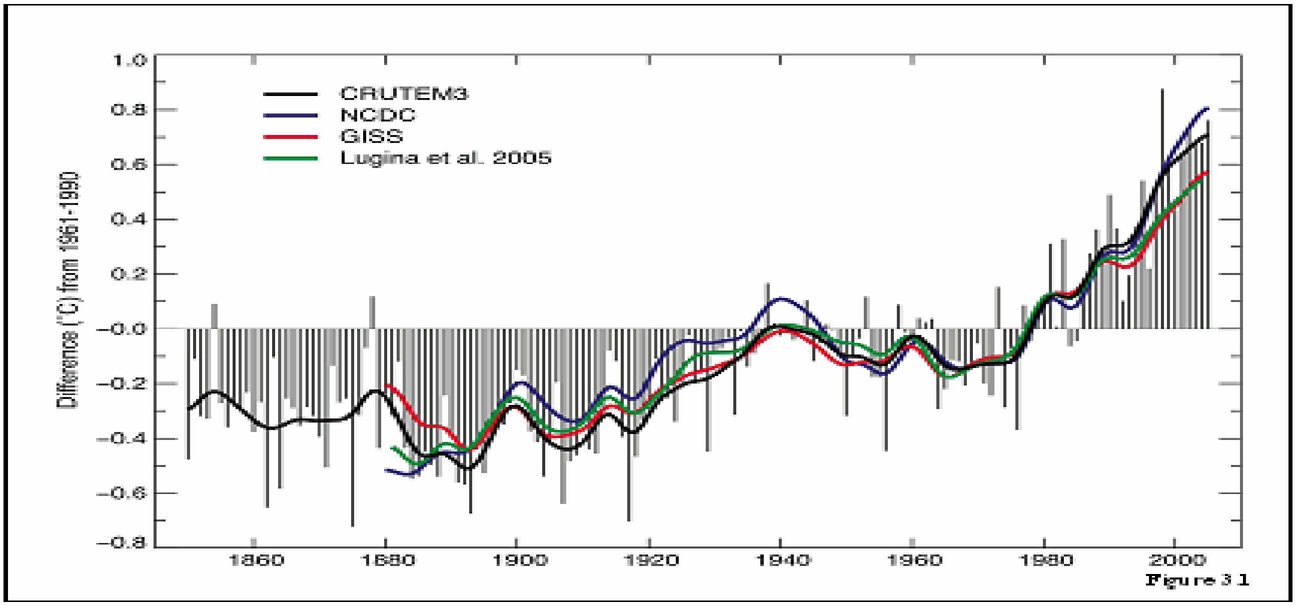


Figure 1.1: Annual anomalies of global land-surface air temperature (°C), 1850 to 2005, relative to the 1961 to 1990 mean for CRUTEM3 updated from Brohan et al. (2006). The smooth curves show decadal variations (see Appendix 3.A). The black curve from CRUTEM3 is compared with those from NCDC (Smith and Reynolds, 2005; blue), GISS (Hansen et al., 2001; red) and Lugina et al. (2005; green) (Trenberth et al., 2007).

1.1.4 The past and the future

Climate science is able to produce records of temperature and atmospheric gases with some accuracy for the last 150 years, well before historical records of temperature measurement. The technique used is referred to as palaeo-climatology - a scientific technique that uses tree ring records, air trapped in polar ice, sea and lake sediments with plankton fossils and pollen to model past climactic conditions. (Jansen et al., 2007). Thus, scientists are able to construct graphs showing temperature trends over several thousand years and Carbon Dioxide (CO2) trends for approximately the past 650,000 years.

Future trends in climate change are projected by creating models of climate, called *General Circulation Models* (GCMs). Scenarios or storylines are developed that project how many people there will be in the world, where they will live, the technologies they will use, and the degree to which they have developed. GHG emissions are determined from these scenarios, and are then fed into GCMs to project the degree to which temperature will increase. (Carter et al., 2007). The future scenarios vary from the highest GHG scenario (A1FI), which assumes a future world of very rapid economic growth and fossil fuel intensive energy sources (FI), while another scenario (B1) assumes a world with a high level of environmental and social consciousness, in which the emphasis is on local solutions to economic, social and environmental sustainability, intermediated levels of economic development and a lower population growth rate. With these scenarios, future GHG emissions and average temperatures can be projected, depending on how we shape our world. The average temperature rise (above 1990-2000 average) at 2100 is projected to be:

- 4.5^{o}C. with the A1F1 scenario; and
- 2.0^{o}C with the B1 scenario.

The current direct measurements of changes in temperature and precipitation correspond with the climate model projections, suggesting that we are "*getting the science right*".

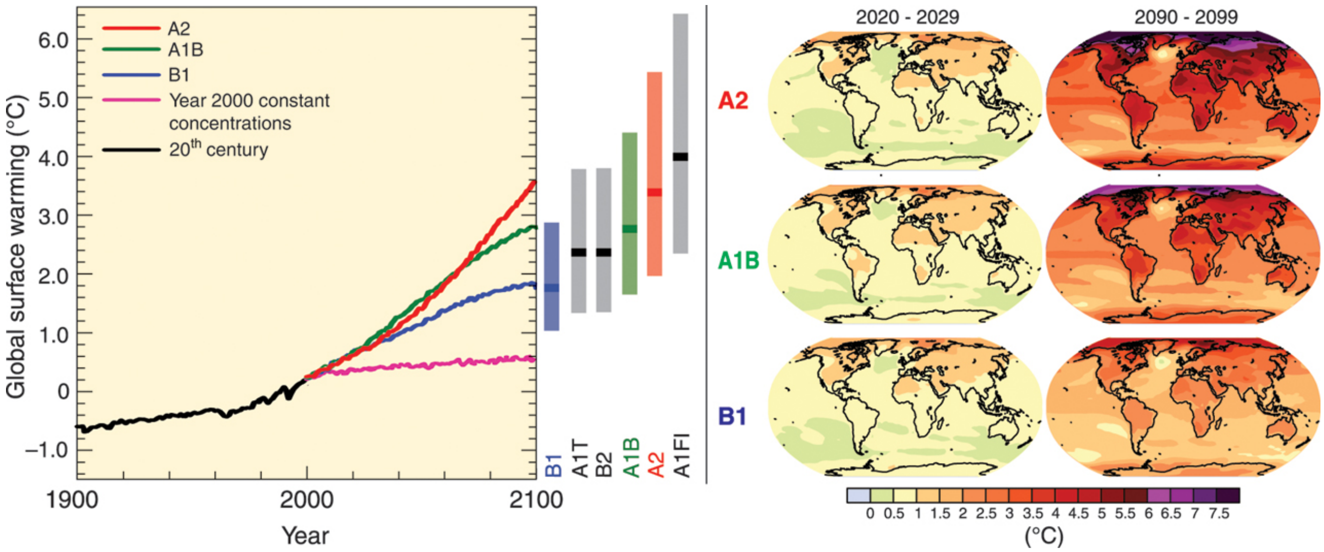


Figure 1.2 Left panel: Global averages of surface warming (relative to 1980-1999) for the SRES scenarios. The bars in the middle of the figure indicate the best estimate and the likely range assessed for the six SRES marker scenarios at 2100.
Right panels: Projected surface temperature changes for the early and late 21st century relative to the period 1980-1999.

1.1.5 Human emissions of greenhouse gases as the cause of climate change

The IPCC's AR4 stated clearly that human activity is responsible for climate change: "Most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely (>90% probability) due to the observed increase in anthropogenic GHG concentrations". (IPCC, 2007)

The natural greenhouse effect is the term used to describe the effect of greenhouse gases in insulating the planet from heat loss. Solar radiation from the sun penetrates the atmosphere, warming the surface of the earth. Some of the energy radiates from the earth's surface, is trapped by the greenhouse gases in the atmosphere and is reflected once again back to the earth's surface. The greenhouse effect helps to maintain the average global temperature at 15^0C, which is conducive to life on earth. Without the greenhouse effect, the earth would be 33^0C colder.

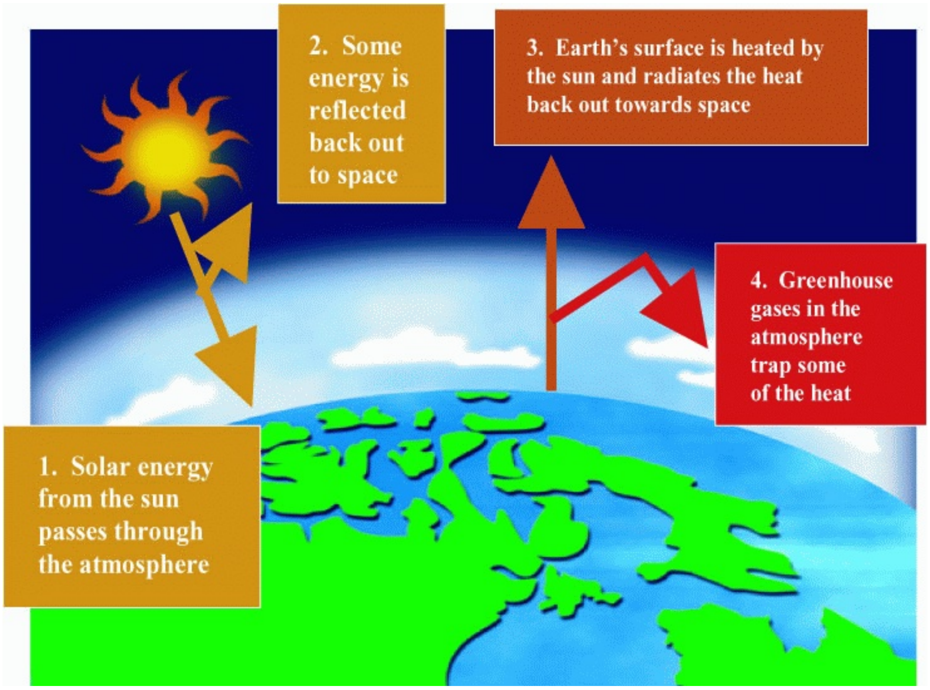


Figure 1.3: The Greenhouse Effect: Environment Canada. The science of climate change: http://www.msc.ec.gc.ca/education/scienceofclimatechange/understanding/greenhouse_gases/images/fig1_e.html (Environment Canada, 2003)

Greenhouse gases (GHGs)

Carbon Dioxide (CO_2) is the most important anthropogenic greenhouse gas, but it is not the only one. Atmospheric levels of CO_2 have increased from fossil fuel use in transportation, the heating and cooling of buildings and the manufacture of cement and other goods. Changes in how land is used, especially deforestation which releases CO_2 and reduces its uptake by forests is another method for increasing the levels on CO_2. Two other important GHGs are **methane** which is produced by decomposing organic matter in agriculture and landfills, natural gas distribution, and **nitrous oxide** which is emitted by human activities such as fertilizer use and fossil fuel combustion. It will take more than a hundred years for CO_2 to reach a state of equilibrium. Table 2 lists the main greenhouse gases, their concentrations in pre-industrial times compared to 1994, their atmospheric lifetimes, anthropogenic sources and relative Global Warming Potentials.

The main greenhouse gases

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP) *
Carbon-dioxide	CO^2	280 ppmv	358 ppmv	50-200	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1720 ppmv	12-17	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	312 ppmv	120-150	Fertilizer industrial processes combustion	310
CFCs	CFC12	0	503 pptv	102	Liquid coolants. Foams	125-152
HCFCs	HCFC-22	0	105 pptv	13	Liquid coolants	125
Perfluorocarbon	CF_4	0	110 pptv	50 000	Production of aluminium	6 500
Sulphur hexa-fluoride	SF_6	0	72 pptv	1 000	Production of magnesium	23 900

Note : **pptv**= 1 part per trillion by volume; **ppbv**= 1 part per billion by volume, **ppmv**= 1 part per million by volume

* GWP for 100 year time horizon. ** Includes indirect effects of tropospheric ozone production and stratospheric water vapour production. *** On page 15 of the IPCC SAR. No single lifetime for CO_2 can be defined because of the different rates of uptake by different sink processes.

GRID Arendal UNEP

Source: IPCC radiative forcing report ; Climate change 1995, The science of climate change, contribution of working groupe 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

Figure 1.4: Main greenhouse gases. (Main green ouse gases, UNEP/GRID-Arendal Maps and Graphics Library., 2000).

Human activities have led to the increase of GHGs since the pre-industrial times, with an increase of 70% between 1970 and 2004 as shown in Figure 4. (IPCC WG1, 2007)

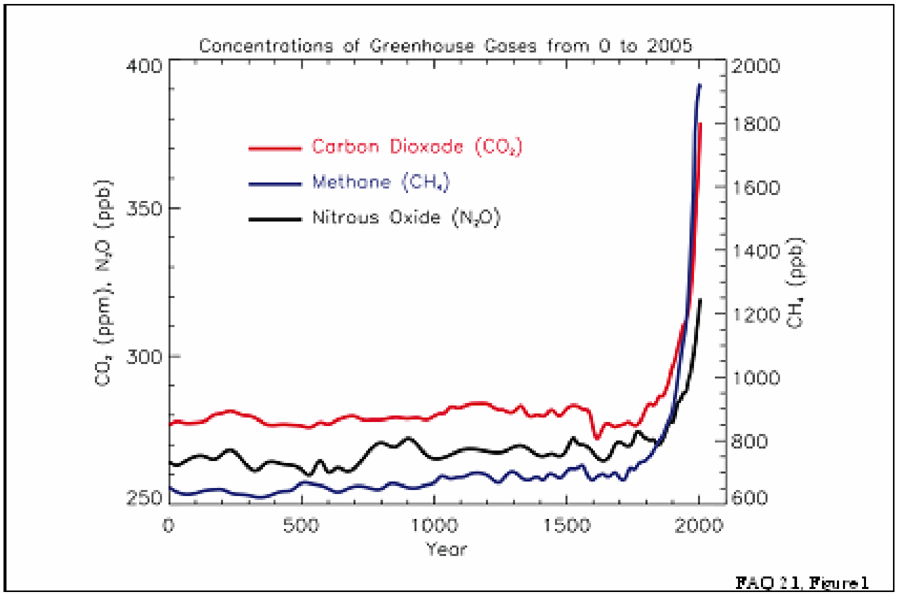


Figure 1.5: Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample. (Forster et al., 2007)

The current level of greenhouse gases in the atmosphere is equivalent to around 380 parts per million (ppm) CO2, compared with only 280 ppm before the Industrial Revolution. (Stern Report) Even with stable emissions, greenhouse gases in the atmosphere would reach double pre-industrial levels by 2050 and would continue growing thereafter. Of great concern is the fact that the growth rate of annual carbon dioxide concentration, rather than declining, is accelerating. This is due in great part to the three factors:

1. fast growing economies, especially in Asia, that consume carbon-based fuels, especially coal, for their rapidly increasing energy requirements;
2. increased demand for carbon-based energy; and,
3. increased motorized transportation in all parts of the world.

The doubling of atmospheric CO_2 could be reached as early as 2035. At this level, there is at least a 77% chance - and perhaps up to a 99% chance, depending on the climate model used - of a global average temperature rise exceeding 2°C increase above the 2000 level. (Stern Report)

1.1.6 Projected climate change and its impacts

Temperature

For the next two decades, warming of at least 0.2^0 C is projected, and continued GHG emissions at or above the current rate would lead to temperature increases larger than we have already seen, and greater over land and in northern latitudes. These projections vary depending on the scenarios used in the calculations. Stern, as reported above, warns that at present CO2 emission rates, average global temperatures will rise by 2 to 3^0C in fifty years or so. (Stern Report)

Changes resulting from warming

Figure 1.5 below, shows the range of impacts that might be expected at different levels of warming, showing impacts through effects on food, water, ecosystems, extreme weather events and the risk of rapid climate change and major irreversible impacts. This includes effects on glaciers, droughts, sea level rise, intense storms, flooding, heat waves and forest fires, but does not include effects on snow and ice cover and permafrost in the North, as described in Chapter 5: Vulnerable Populations.

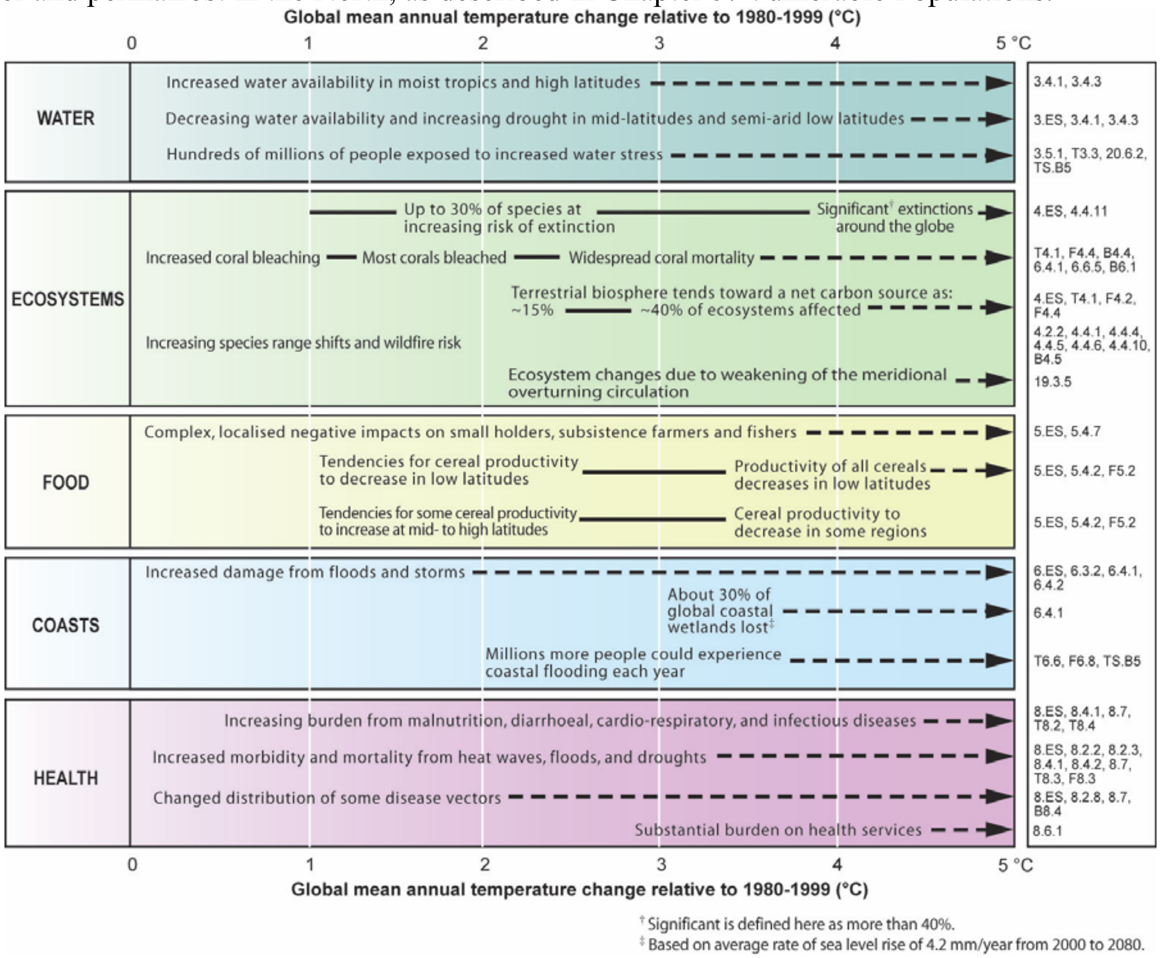


Figure 1.6: From IPCC AR4. WG2. Key impacts as a function of increasing global average temperature change (Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway). The black lines link impacts and the dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. (IPCC, Working Group II Report)

Over the long term, GHG induced changes of warming and sea level rise will continue for centuries, because of climate processes and feedbacks, even if GHG concentrations are stabilized.

1.1.7 How urgent is this?

The IPCC (IPCC WG1 2007) does not project extremely rapid climate change, (also referred to as dramatic or abrupt climate change), such as the collapse of the West Antarctic Ice Sheet, the rapid loss of the Greenland Ice Sheet or large-scale changes of ocean circulation systems this century. However, there are dissenting voices of concern in the peer-reviewed literature. (Hansen et al., 2007 and Schiermer 2006) It is accepted by the IPCC that the risk of such dramatic changes would become increasingly more likely as atmospheric CO2 levels increase and warming of the climate system progresses.

There are significant uncertainties in climate science, and there is a real risk of a large and potentially cataclysmic surprise that is not predicted by the models. (IPCC synthesis report)

> "Our actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes." (Stern Report)

A number of recent publications have raised concern about an acceleration of the rise of CO_2 and a consequent acceleration in the effects of climate change, beyond that expressed by the IPCC. CO_2 levels are rising faster than anticipated by models and this may be due to a decrease in the carbon sink previously provided by the oceans. (Canadell et al., 2007)

This clearly is a situation where the application of the ***precautionary principle*** is appropriate.

1.2. The Canadian Context

1.2.1 Introduction

In this section, we will focus on Canada, first by describing changes in temperature and other measures that have already been observed, and then by describing the changes that are projected to occur.

1.2.2 Observed changes in Canada

Data collected in southern Canada for over 100 years, and more recently satellite data, give a picture of changes that have occurred to this point. In the last 50 years, average temperatures in Canada have risen by 1.3^{0}C - twice the global average rate of warming. During this period, winters and springs in Canada have become warmer and Canada has on average become wetter, with a twelve (12%) percent increase in precipitation. Average changes are given, as these changes in both temperature and precipitation vary across regions. For example, southern Canada has seen a decrease in annual total snowfall, while there has been an increase in the north and northeast of the country, as well as in the western part of southern Ontario due to lake effect. There have also been changes in the frequency of extreme temperature and precipitation events, with less extreme cold, but more extreme warm days and nights. These changes in temperature and precipitation since 1950 have led to these observed changes:

Average temperature	1.3^{0}C rise in 50 years
Average precipitation	12% increase over 50 years
Sea ice	Late summer Arctic sea ice reduced 8% per decade since 1979
Snow cover	Snow cover duration in Arctic reduced 20 days
Permafrost	Increase in thaw depth
Water resources	Less glacial melt water in western Canada
	Drop in water levels in Great lakes
Sea level rise globally. Locally, extent is dependent on coastal rebound or subsidence	Atlantic coast: land subsidence with high rate of sea level rise; Charlottetown 0.32 metres sea level rise since 1911.
	West coast: small sea level rise; the Fraser River delta is the exception.
	In most of the Arctic coast; land is rising. with no sea level rise
	Yukon coast subsiding, sea level rise

Table 1.1: Observed Changes in Canada (Warren et al., 2007)

1.2.3 Temperature

Models show that Canada will continue to warm across the country. Canada is located in the northern latitudes; however, it is a large continental land mass with the oceans exerting a moderating effect on temperature. As a result, the warming effects are projected to be greater in Canada than global averages. Some estimates suggest that we will experience more than double the global average increase in temperature (NRCAN). (Lemmen et al) Models show average temperatures rising by 1 to 2°C above the current average by 2020 and increasing to 2 to 4°C by 2050 and 5 to 10°C by 2090. The winters will be milder and the summers hotter. But the greatest warming will occur over the High Arctic, where average annual temperatures increases may reach as high as 3 to 4°C by 2020, 5 to 10°C by 2050, and more than 15°C in some regions by 2090. Winter changes in the Arctic are even more dramatic, with average temperatures rising considerably more than 20°C above the current average by 2090.

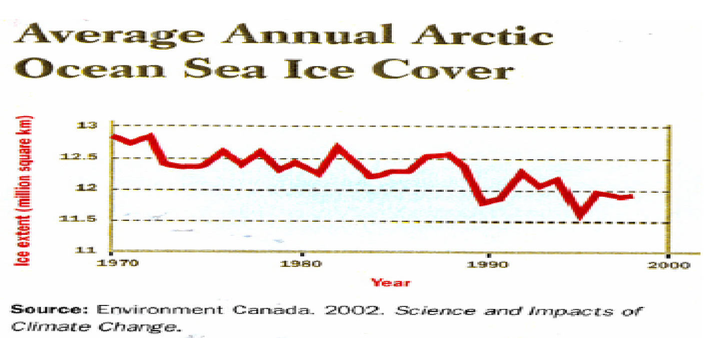


Figure 1.7: Average Annual Arctic Ocean Sea Ice Cover

The frequency of extreme summer heat (days over 30 degrees Centigrade) is expected to increase across the country, resulting in more frequent and more intense heat waves. For example, in 2080 Toronto, London and Winnipeg could have more than 60 days per year above 30^{0}C.(Fig 1.6) There will be fewer extreme cold days.

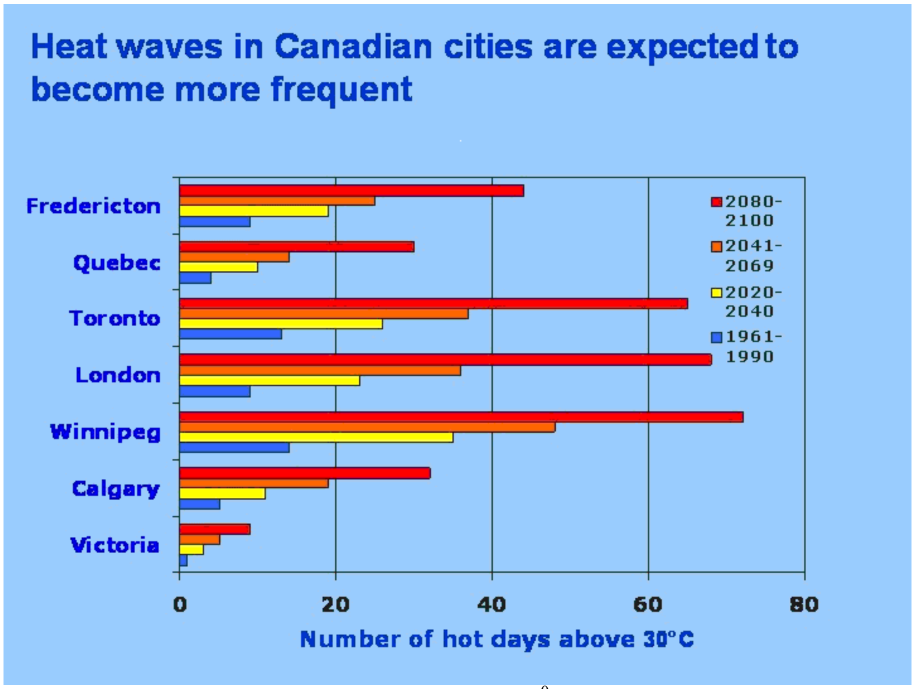


Figure 1.8: Number of days hotter than 30^{0}C. (Hengeveld et al., 2005)

1.2.4 Precipitation

Predictions of future precipitation have high uncertainty. Average precipitation is expected to increase across the country, although some regions (south-central Prairies and south-western BC) will likely have lower summer rainfall, especially important as this is the growing season. Evaporation rates will increase as the temperature warms, and this could lead to water shortages in other regions of the country.

Intense precipitation events are predicted to increase. Because these events are not frequent, it is difficult to accurately predict trends. However, it is thought that extreme events will increase in both frequency and intensity in Canada. (McBean et al., 2003) Intense rainstorms have caused enormous damage to society, and have increased from 2 to 4 per year in past decades to about 12 per year in the last decade. For example, the Saguenay flood of 1996 caused more than 15,000 people to evacuate their homes and cost the Canadian economy more than $1.5 billion.

1.2.5 Other projected changes

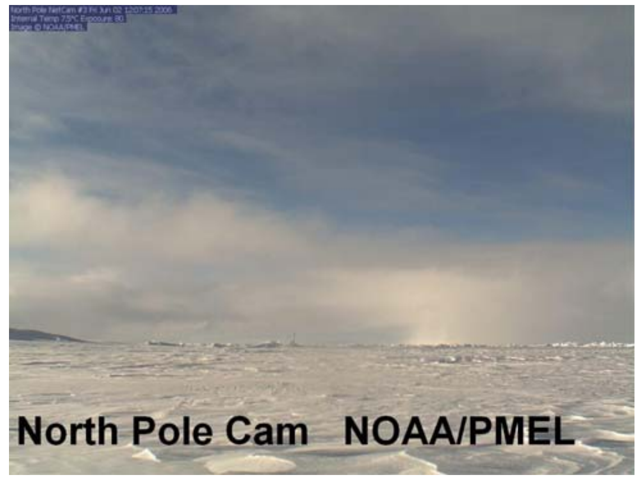
Sea levels will continue to rise. As discussed above, the effects will vary from coast to coast, with areas of subsidence such as much of the Atlantic coast, the Fraser River delta and the Beaufort Sea coast being most affected. The risk of storm surges in these most affected areas will increase as sea levels rise. Charlottetown has experienced already six episodes of storm-surge flooding and is especially vulnerable.

1.2.6 Effects of climate change

There will likely be benefits to agriculture in Canada in the short term, due to warmer temperatures and a longer growing season. But warmer temperatures will negatively affect forestry (damage due to fires from drought and damage from insects, parasites and diseases), agriculture (droughts and increased soil erosion) and fisheries (changes in species distribution). Other negative effects will arise due to reduced water levels in the Great lakes. The recently published report “From Impacts to Adaptation: Canada in a Changing Climate 2007” gives an extensive review of the effects of climate change in Canada, (Natural Resources Canada 2007)

1.2.7 The Arctic

Northern Canada will warm more than southern Canada, with resultant effects on snow and ice cover, and permafrost. Figure 1.7 demonstrates the dramatic decrease in the arctic ocean ice cover during the past thirty years. Further information on the impact of climate change on Northern Canada is discussed in chapter 4, section 4.3.1.



CHAPTER 2

THE DIRECT HEALTH EFFECTS OF CLIMATE CHANGE

2.1. Temperature related morbidity and mortality

2.1.1 Introduction

Excessive heat, referred to as thermal stress, can cause illness and death. Numerous epidemiological studies have shown the relationship between heat waves and public health. In 2003 in Europe, a two-week heat wave caused between 30,000 and 45,000 premature deaths, with the greatest impact being in France. Other notorious heat waves causing significant mortality occurred in Chicago and in London in 1995.

2.1.2 Heat waves

The effects of heat are worse in situations where extreme heat is sustained over a number of days, as in heat waves, and especially when the extremely hot days occurs early in a heat wave. People do not acclimatize rapidly to extreme heat. There is a similar effect when heat waves occur early in the season. The effects are even greater when there is associated high humidity, and when there is less night time cooling, which would have given relief from the heat. People living in temperate climates, where heat is less common, are also more vulnerable. Urban areas are hotter than suburban and rural areas, because the concrete, asphalt and roofs retain heat, creating the “heat island effect”. The urban heat island effect can add up to 2.3^0C to the ambient temperature.

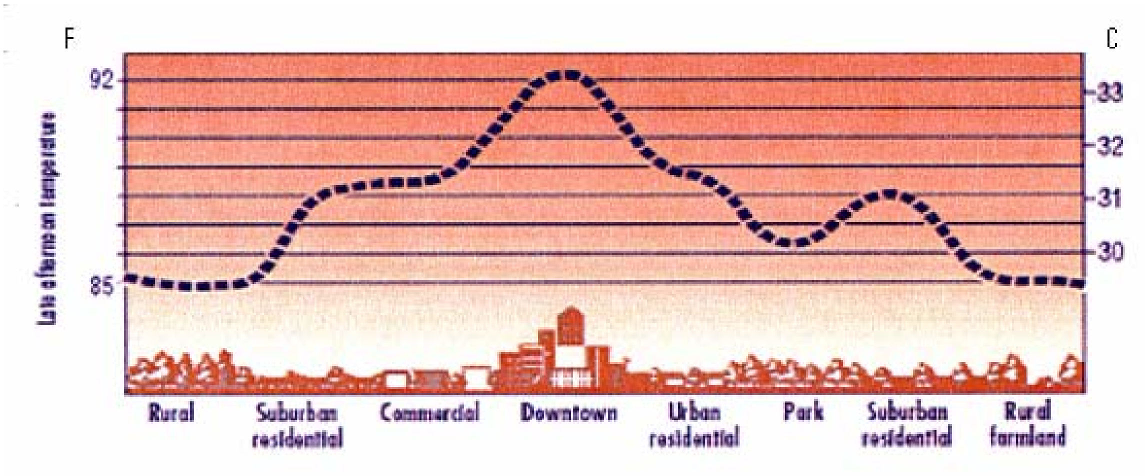


Figure 2.1: Heat Islands (Lemmen et al.)

2.1.3 Vulnerable populations

Although we are all affected by heat, there are population groups that are more vulnerable. These include infants, the elderly, people who are not physically fit or with existing chronic disease, especially cardiopulmonary disease and mental illness. Patients on some medications are at high risk, especially those medications that reduce the body's ability to regulate temperature, inhibit sweating or interfere with salt and water balance, including anti-psychotics, tricyclic antidepressants and anticholinergics. Other risk factors include excessive alcohol intake and cocaine, and poor housing conditions. People who are "housing poor", especially those living in top floor apartments with poor ventilation and without air conditioning are at special risk. In addition, those that are socially isolated or homeless are more vulnerable. Athletes and outdoor workers may also be at risk.

2.1.4 Clinical presentation of heat illness

Hyperthermia is a general term which describes the clinical situation when the core body temperature rises above the point of control of the body's homeostatic cooling mechanisms. Normally the body maintains a core temperature of 37 degrees centigrade, even in severe heat, by 1) peripheral vasodilatation which increases the blood flow to the skin and 2) sweating which cools the body as it evaporates. Clinical cases of hyperthermia may present as a continuum of severity, from heat stress, to heat exhaustion, to heat stroke and finally death. Besides the predisposing conditions mentioned above, there is significant variability in the response to severe heat situations. **Heat stroke** is a medical emergency and is often fatal. It is clinically recognized by a core temperature greater than 40.6 degrees centigrade and an altered mental status, including inappropriate behaviour, impaired judgment, delirium, convulsions and coma. The skin is often hot, dry and flushed. At this stage, individuals are dehydrated, although they may still be sweating. Death occurs from multi-organ failure. Management is directed at cooling the core temperature, re-hydration and the management of complications. **This is a medical emergency.**

2.1.5 Burden of illness

As discussed above, heat waves cause a significant impact on public health resulting in significant mortality and morbidity. (Riedel et al., 2004, Haines et al., 2004, Haines 2005, McMichael et al., 2001, Basu et al., 2002, Heat: Related Mortality 1993-2002, and 2005, and Kalkstein et al., 1997) How much of a burden of illness do we see in Canada? A comprehensive review from Toronto will be examined as an example. It is estimated that there are about 120 premature deaths annually in Toronto related to hot weather. (Cheng et al., 2005) On days of the year with extreme heat, the average daily mortality is almost twice as high as on comfortable days. (Cheng) Similarly, the numbers of premature deaths in Montreal, Ottawa, and Windsor were 121, 41, and 37 respectively. It is predicated that the number of days with temperatures greater than 30 degrees centigrade could double by 2050, and increase fourfold by 2080, and heat-related mortality is predicted to double by 2050, and triple by 2080. Similar studies in New York confirm these findings. (Knowlton, 2007) However, in a full analysis of the health effects of climate change, the increased morbidity and mortality related to heat must be balanced against the fact that with warmer winters, there will be fewer deaths, approximately 60% fewer by 2050, related to cold weather (Cheng).

	Air Pollution	# of Days with temp>30^0C	Heat alerts	Acute air pollution related elevated mortality	Heat related elevated mortality	Cold related mortality
Annual Mean #(1954-2000)		8	2.5	822	120	105
Predicted 2080 (based on a 3 fold increase in CO_2)	Substantial increase in high pollution days, especially related to Ozone	4 fold increase	4 fold increase in hot weather warnings	25-30% increase, to 1070	3 fold increase to 360	60% decrease

Table 2.1: Air pollution and weather related mortality in Toronto. (Derived from Toronto Public Health. Influence of Weather and Air Pollution on Mortality in Toronto: Summary Report (Pengelly et al., 2005)

2.1.6 Adaptation and mitigation

Heat related deaths are preventable. Many cities and municipalities across the country have developed heat-warning systems to predict hot weather, and heat health response systems to warn the public and intervene; thereby, reducing illness and death.

Heat alert systems across the country vary in the methodology used to call an alert. The Toronto system, perhaps the best developed system in place, will be described. The system is based on synoptic weather forecasts, which predict weather categories, based on historical data of the relationship between various aspects of weather, mortality and vulnerability, incorporating weather factors such as temperature, cloud cover, humidity and wind. (Hot Weather Response Plan Update, 2007) A heat alert is issued when the weather conditions forecast predict that the likelihood of additional deaths, above those that are typical for the same time of year, would be more than 65 % while an extreme heat alert is called when the figure is 90%. While on average 2.5 heat alerts were issued in the 1954 to 2000 period, in 2005, Toronto Public Health called 8 Heat Alerts and 18 Extreme Heat Alerts. The health effects are compounded by the associated air pollution. In 2005, there was a smog advisory in effect or terminated on 19 of these 26 days.

Heat alerts trigger coordinated public health interventions to alert those most at risk from the heat to take precautionary measures. In Toronto, the Hot Weather Response Program includes media advisories, opening of cooling centres and handing out bottled water. It also attempts to reach vulnerable people by notifying public health nurses and community agencies working with vulnerable populations such as isolated seniors, and the homeless. (Toronto Public Health: Heat Alerts and Extreme Heat Alerts, 2008) Because housing without adequate cooling is such an important determinant of vulnerability, a Hot Weather Protection Plan for Landlords has been developed for rooming houses, boarding houses and group homes, advising landlords to check tenants' ventilation, allowing tenants access to a cooler area such as the basement, and supplying fans for cooling hallways. (Toronto Public Health: How Weather Protection Plan for Landlords, 2008)

The greatest challenge in preventing illness and death is in reaching the most vulnerable and motivating them to make appropriate changes in their behavior. In Philadelphia, a buddy system has been set up, whereby a designated person in each street checks on elderly and vulnerable neighbours. (Kalkstein) In Montreal, Public Health is mapping the urban heat island "hot spots". In addition, medical clinics, pharmacies and home care programs are used to disseminate heat protective messages to vulnerable patients (King, 2008).

Adaptation and Mitigation: What can family doctors do?

- Help to identify and reach their patients in their practices who are vulnerable to the health effects of extreme heat.
- Establish as a standard clinical practice the need to inform vulnerable patients about the risk of heat exposure and the preventative measures that should be used, including being aware of heat and smog advisories, adequate hydration and moving to cooling stations if necessary.

2.2. Health effects of extreme weather events

Between 1992 and 2001, floods affected more than 1.2 billion people and caused almost 100,000 deaths. When Hurricane Katrina struck the southern US coast in 2005, it caused more than 1300 deaths, and many people went missing. About 45% of the victims were over 75 years old. With climate change, some regions in Canada may become more prone to the effects of flooding and severe storms. At the same time, in areas such as the Prairies, drought may become more common.

There has been much interest in the relationship between global warming, hurricanes and tropical cyclones. The 6th International Workshop on Tropical Cyclones of the World Meteorological Organization agreed that sea temperatures have risen significantly in the past 50 years. Water vapour levels have also increased and it is projected that peak wind-speed and rainfall will increase. All these factors play a role in increasing the intensity of hurricanes/tropical cyclones. It is possible that winter snowstorms may increase but warmer winters may preclude these or transform them into ice or rain storms. Figure 2.2 depicts the increase in weather-related disasters in Canada in the years between 1900 and 2000.

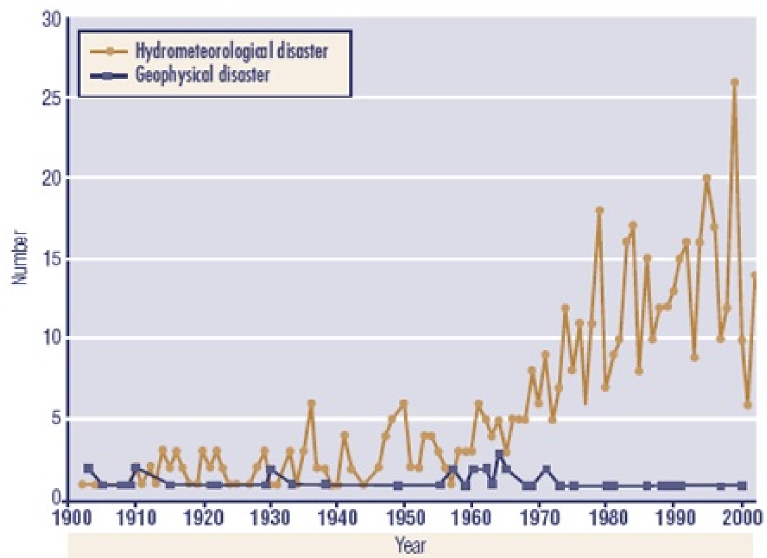


Figure 2.2: Natural Disasters in Canada (1900 – 2000)**.** (Etkin et al., 2004)

2.2.1 Health Effects of Floods

It is projected that there will be more extreme precipitation events in Canada due to climate change. The health consequences of floods can be summarized along a time scale from immediate effects (i.e. weeks) to delayed effects (i.e. months to years).

Immediate	
	-Injuries such as lacerations, blunt trauma, fractures -Deaths by Drowning -Cardio-respiratory emergencies -Loss of communication systems
Delayed:	
	-Destruction/incapacitation of water and sewage treatment facilities -Water contamination by infectious agents -Water contamination with toxic chemicals from damaged storage tanks and basins, industrial and waste sites -Salination of farmland, aquifers and wells reducing drinking water -Destruction of protective housing leading to vector-borne diseases

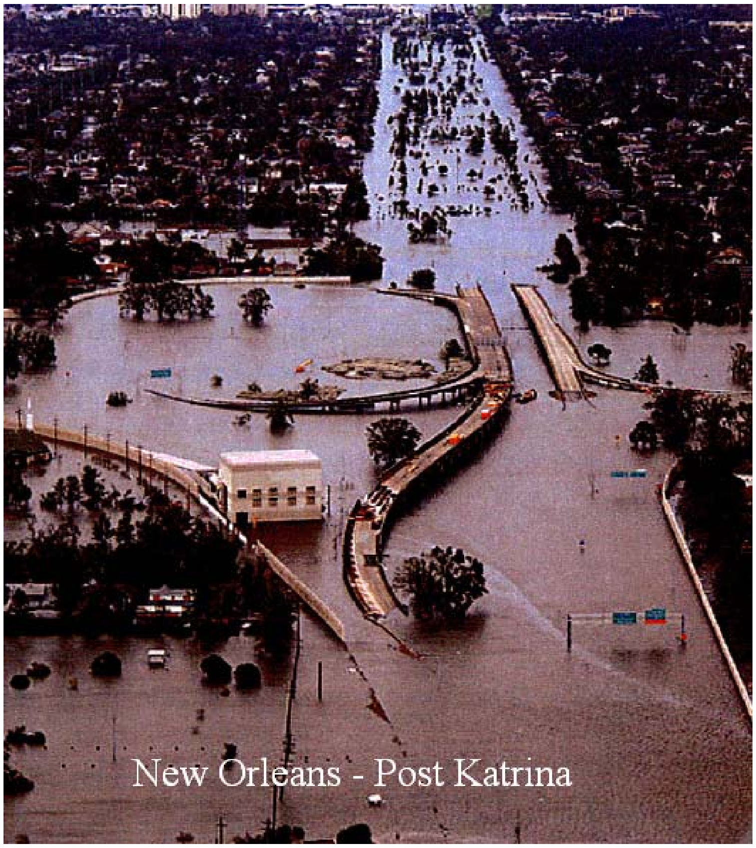
	-Destruction of crops resulting in food shortages and malnutrition -Irrigation of croplands with contaminated water -CO poisoning secondary to use of generators in confined areas -Respiratory diseases -Increased mould growth -Population displacement leading to potential conflicts -Mental health disorders – depression, anxiety, post-traumatic stress disorder -destruction or loss of patient medical records

Table 2.2: Immediate and delayed effects of flooding

Seven weeks after Hurricane Katrina made landfall, the U.S. Centre for Disease Control and Prevention reported that 20 % of housing units lacked water, 25% had no electricity, and 43% had no telephone service, while 56% of households contained at least one individual with a chronic health condition. A staggering 50% of adults were suffering from mental health problems. Gastroenteritis was common, with Norovirus the most common cause, although different vibrio species also played a causative role as a result of the ingestion of contaminated water and raw or partially cooked shellfish. Staphylococcus aureus non-toxicogenic vibrio wound infections along with blunt trauma, insect/animal bites and bruises were common.

Carbon monoxide poisoning occurred in the Montreal ice storm of 1998 resulting in six deaths and a significant number of other patients requiring treatment in a hyperbaric chamber. Elevated indoor CO levels resulted form the inappropriate indoor use of generators, and other fuel burning devices that should be vented or used outdoors. (Public Health Agency of Canada, 1999)

The psychological distress related to disaster exposure is significant with increased presentation of depression, anxiety and PTSD. The most important predictors are the severity of the exposure and losses, the perception of threat to oneself, and the prior existence of other stressors and mental health problems. Focusing on the negative consequences of the event and the use of alcohol or sedatives leads to a poorer prognosis. (Bourque et al.) The breakdown of social supports and communication systems, socioeconomic status, and the inherent resilience of the individual play a determining role, as well. Those affected do better when resources are devoted to returning the individual as fast as possible to pre-disaster living conditions.



One of the consequences of Katrina that impacted on health care systems was the loss or unavailability of medical records, including laboratory, radiology, and pathology reports. Displaced persons often did not have their medications, the exact nature of their diagnoses, or details of their treatment such as their chemotherapy regimen and other medications for chronic conditions. The Regional Veterans Affairs Department which keeps an electronic medical record (EMR) system reported that they did not lose any patient data. The opposite was true at the New Orleans Charity Hospital where more than 450,000 patient paper records were destroyed. Hospitals that have generators and EMRs can access patient records even in a disaster. This raises the need to explore the concept of a portable electronic record that includes an immunization record among other important aspects of the medical history.

Adaptation and Mitigation: What can family doctors do?

- Ensure that all immunizations for both children and adults are kept up-to-date
- Consideration of records being stored in the EMR system and the development of a EMR that healthcare providers and their patients can access easily

2.2.2 Droughts

Drought is the deficiency of precipitation over a significant period of time, usually a season or more. It is influenced by low humidity, high temperatures, and high winds. It causes loss of crops and grazing land, increases the risk of fires, destroys shrubs and plants that would other wise prevent erosion, and reduces the quantity and quality of water resources, as well as fish species. In poor countries malnutrition increases resulting in increased infant mortality. An increase in malnutrition, because of climate change related drought, is likely to have an especially large impact in developing countries, and together with increases in diarrhea and malaria, will place a huge burden of illness on the health care systems. (Haines 2006) In addition, with less water, hygiene is compromised leading to gastro-intestinal infections, eye disorders such as conjunctivitis and trachoma. (Patz and Kovats, 2002) In desperation, households will try to catch any water they can in receptacles. Subsequently, mosquito vectors may breed in these receptacles. Socio-political unrest can follow leading to war, terrorism, habitat destruction and displacement of large populations into refugee camp. The Australian continent is dry, and is drying further as a result of climate change. The livelihoods of many Australian farmers and their rural communities are severely threatened by drought. (Blashki et al, 2006)

2.2.3 Forest Fires

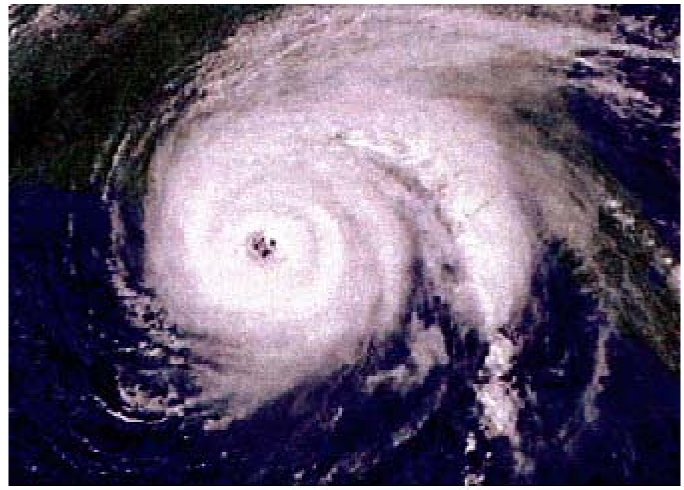
While all environmental disasters can affect human health, there are specific issues associated with forest fires. It is expected that with global warming there will be regional differences in precipitation with the result that large forest fires may become more common. In the last few years such catastrophic events have been witnessed in southern Europe and in North America. In western Canada, the pine beetle has destroyed thousands of hectacres of forests leaving them susceptible to fires.

One-third of particulate matter less than 2.5 microns in diameter (i.e. PM2.5) emissions in Canada are secondary to forest fires. These small particles are associated with lung problems. (Rittmaster et al., 2006) As a result of a fire in Chisholm Alberta, in which 116,000 hectares were destroyed, the PM2.5 levels rose significantly in Edmonton 160 km away. The health costs related to mortality, acute respiratory problems, lost wages and restricted activity were estimated to be between nine to twelve million dollars ($9,000,000 to $12,000,000), exceeded only by costs related to loss of timber. In the city of Kelowna, during the summer months of 2003 in which there were many more forest fires compared to the same period 10 years earlier resulting in a 46% increase in patient visits for respiratory conditions. (BC Centre for Disease Control)

Mercury exists naturally in soil and plant matter, particularly the needles of evergreen trees in our boreal forests. During intense forest fires, mercury is released into the atmosphere eventually settling in waterways where it is ingested by fish. Once again the effect is not localized to the area of the fire (Siegler et al., 2003). Furthermore, increasing ambient temperatures related to climate change increase the process of methylation of organic mercury to methlymercury, the major toxic form (Booth and Zellar, 2005). There are regions around the world where women of reproductive age have blood mercury levels that already exceed the guidelines. Any further rise in levels of mercury would pose an increased health risk.

2.2.4 Hurricanes, tornadoes and cyclones

Climate change is associated with an increased intensity of hurricanes, tornadoes and tropical cyclones. Sea temperatures have risen in the past fifty years and water vapour levels have also increased. It is projected that peak wind-speed and rainfall will increase. All these factors play a role in increasing the intensity of tropical hurricanes/cyclones. There seems to be a correlation between the destructive power of hurricanes/cyclones and the rise in ocean temperatures especially noted over the North Atlantic Ocean. Some controversy exists because monitoring methods in the past were not as sophisticated as they are today. Scientists point out that the increase in destructive impact on our societies is related to the massing of populations in coastal regions without the proper infrastructure to withstand the powerful ocean storms. With the projected rise in sea levels, storm surges will be more devastating. The destruction caused by tornadoes is expected to increase as well.



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CHAPTER 3

INDIRECT HEALTH EFFECTS OF CLIMATE CHANGE

3.1. Air pollution related health effect

3.1.1 Introduction

The health impacts of air pollution are well described. Exposure to air pollution is associated with increases in both morbidity and mortality. The health effects pyramid describes how we are better able to define the tip of the pyramid i.e. the numbers of people dying related to air pollution, than the much larger numbers of those who get sick from air pollution, causing them to present to emergency rooms, doctors offices or miss work or school, with asthma, bronchitis or cardiovascular disease. The numbers affected by minor symptoms or restricted activity is even greater, but harder to measure.

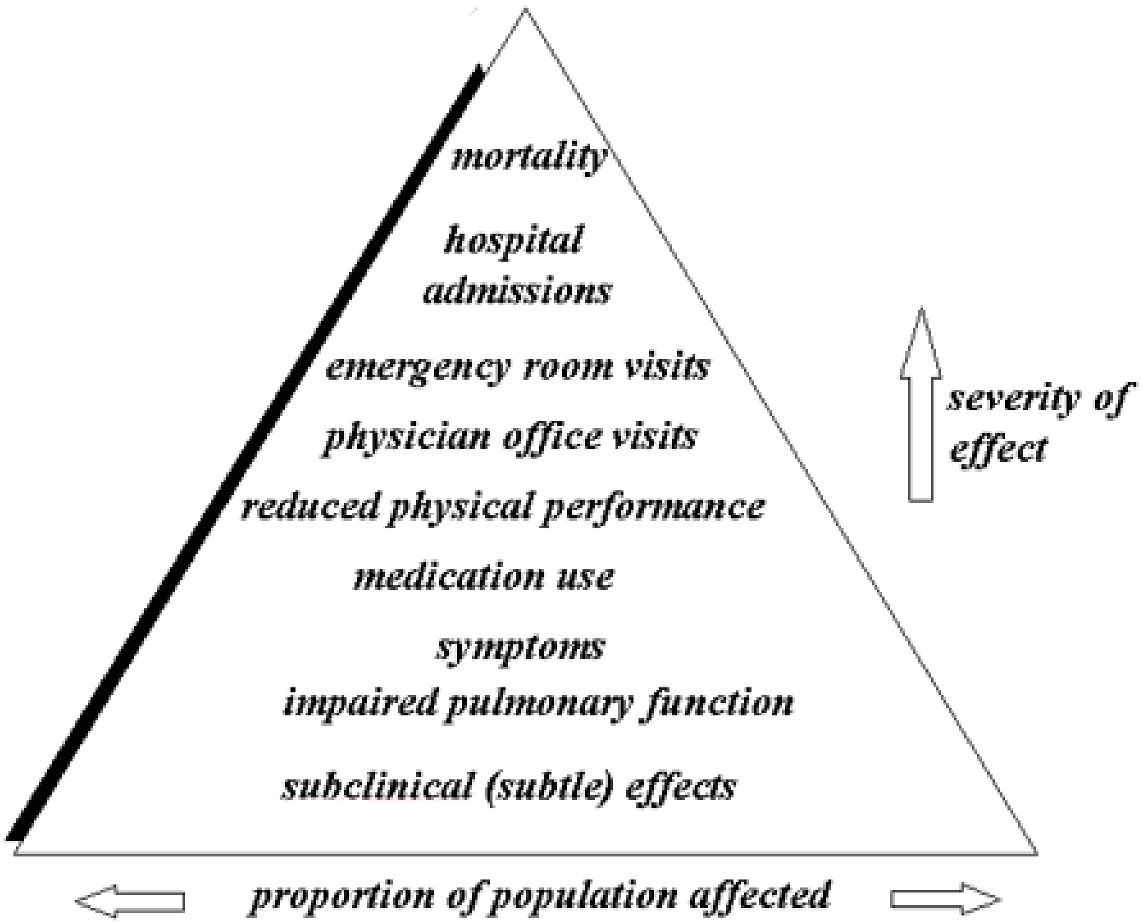


Figure 3.1: The Health Effects Pyramid. (Health Canada, 2006)

For example, the Ontario Medical Association, with its Illness Cost of Air Pollution model, has estimated the number of people affected by both acute and cumulative exposures to smog air pollution (ozone and particulate matter) in Ontario, and the economic costs associated.

	2000	2005	2015	2026
Premature death	1925	5829	7436	10,061
Hospital admissions	9807	16,807	20,067	24,587
Emergency room visits	45,250	59,696	71,548	87,963
Minor Illnesses	46,445,663	29,292,100	31,962,200	38,549,300
Total Economic Damages	Na	$7,809,201,700	$9,846,522,700	$12,914,238,300

Table 3.1: Ontario Provincial Health and Economic Damage Summary. Derived from OMA ICAP. (Ontario Medical Association, 2006)

The impact of climate change on air pollution and health will be mostly due to temperature related increases in the levels of ozone, one of the components of smog. This section of the report will describe first the formation of ozone, and how this could be affected by increasing temperature. The second section will describe the health effects of ozone. The third section will describe the expected increases in morbidity and mortality related to the increased ozone levels.

3.1.2 Temperature and ozone

Ground level or tropospheric ozone is one of the two main components of smog, the other being particulate matter. Ozone is a gas that is colourless and odourless. It is not a primary pollutant (i.e. it is not emitted directly from the tailpipes of cars or smoke stacks of industry). Rather, it is a secondary pollutant, formed by complex chemical reactions in the air, from two primary pollutants, oxides of nitrogen (NOx) and volatile organic compounds (VOCs). NOx result from the combustion of fossil fuels in transportation, heating and other industrial processes. VOCs are given off naturally by vegetation and forests, as well as, from transportation and solvent use.

The important point in relation to climate change is that this aero-chemical reaction is dependent on sunlight and temperature. Smog episodes, with elevated ozone levels, occur in summer time on warm, sunny days with the episodes usually extending over a number of days. Polluted air masses covering large areas of southern Ontario move slowly along the Great Lakes and St. Lawrence River valley from Windsor to Quebec. The lower Fraser valley in British Columbia and the South Atlantic region are other areas of particular concern for high ozone in Canada. The projections of ozone increase, because ozone formation requires sunlight, assume no change in cloud cover.

The relationship of temperature to ozone formation is non-linear, with greatly increased effects seen at higher temperatures. Thus, with climate change and the predicted increase in temperature, the average ozone levels are projected to increase dramatically. (Bell et al., 2007) Furthermore, with the warm season coming earlier in the spring and staying later in the fall, the average number of smog or high pollution days is predicted to increase as well. In a study of 50 US cities, the summertime daily one hour maximum ozone levels were predicted to increase by 4.8 ppb and a 68% increase in days exceeding regulatory air pollution limits was predicted by 2050, assuming cloud cover and emissions remain constant. In Ontario, the annual total number of high ozone days (one-hour maximum ozone ≥81 ppb) could increase by 4 to 11 days by the 2050s, and by 10 to 20 days by the 2080s. (Toronto Public Health: Influence of Weather and Air Pollution on Mortality in Toronto, 2005) During the hot summer of 2005, 48 smog advisory days were reported; the previous high was 20. (Ontario Ministry of the Environment: Climate Change)

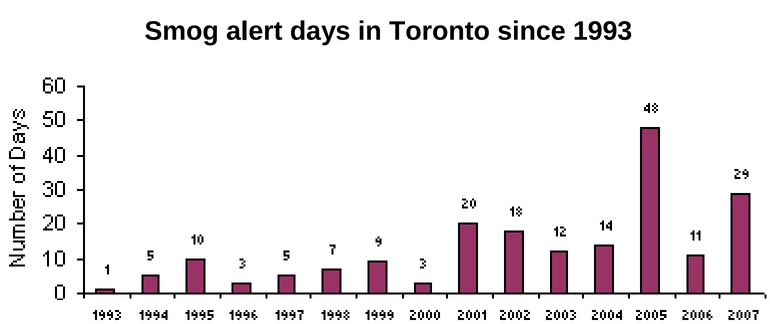


Figure 3.2

Another possible mechanism leading to increased ozone levels may be increases in the precursor VOCs. Some models show that increased temperatures will lead to increases in the natural production of VOCs by forests. (IPCC: Working Group 2, 2007) The effects of temperature on particulate matter (the other major component of smog) are less predictable, (Confalonieri et al., 2007) and most sources do not anticipate climate change related increases. However, an increase in the frequency of forest fires will lead to increases in particulate matter.

3.1.3 The health effects of ozone

The health impacts of air pollution are both acute and chronic. (Hen et al., 2007) Ozone is a highly reactive chemical that causes inflammation and oxidative damage to airways. Responsiveness varies from person to person. People with asthma showed an increased inflammatory response and are more sensitive to various allergens following exposure to ozone. (Uysal et al., 2003) This is important since allergen levels are also predicted to increase with climate change. In addition, ozone elevations have been associated with respiratory symptoms such as nasal and eye irritation, coughs, bronchitis and increased susceptibility to respiratory infections. (Schwartz 2004 & Gent et al., 2003 and Thurston et al., 2003) Increased hospitalizations, including those for infants and neonates, have also been documented. (Dales et al., 2006)

Recent studies have examined the effect of long-term exposure to ozone (i.e. from living in communities with higher levels of ozone). These studies suggest that ozone might lead to development of new cases of asthma, as opposed to exacerbating pre-existing asthma only. (McConnell et al., 2002) There is also concern about the long-term effects of air pollution on lung development. This has important implications for adult lung health if the respiratory systems of individuals are damaged in childhood and this raises the possibility of an increase in the prevalence of Chronic Obstructive Pulmonary Disease (COPD). The initial pollutant of concern in relation to delayed lung development was particulate matter, but recent research from Mexico City has also implicated ozone. (Rojas-Martinez et al., 2007)

Importantly, although there has been some debate about this in the literature, there is good evidence that ozone has been associated with increased morbidity and premature death from both respiratory and cardiac causes. (Levy et al., 2005)

Although responsiveness to ozone varies from person to person, likely in part due to genetic factors, some groups are more vulnerable:

- infants and children;
- the elderly; and,
- people with asthma; and other chronic lung diseases and cardiac diseases.

In addition, some groups are likely to be exposed more:

- people exercising outdoors; and,
- people working outdoors.

3.1.4 Climate change, air pollution and health effects

A number of studies have modeled the effect of climate change induced increases in ozone and the resultant health effects. A study was conducted by Toronto Public Health to assess the impact of climate change, through extreme heat and air pollution, on public health in Montreal, Ottawa, Toronto and Windsor. (Health Policy Research Program: Cheng et al.) The report on the climate effects on mortality in Toronto referred to previously, using historical data and data derived from modeling future scenarios, shows that mortality from air pollution and from heat extremes would increase significantly. (Toronto Public Health: Influence of Weather and Air Pollution on Mortality in Toronto, 2005)

Similar findings have been found in the United States (Knowlton et al., 2004) and the United Kingdom. (Anderson et al., 2001) A recent analysis in 50 US cities (Bell et al., 2007) predicted substantial increases in mortality from both cardiac and respiratory causes, and in hospital admissions for asthma and COPD related to predicted increases in ozone levels from climate change.

As discussed above, the health effects pyramid points to the fact that these figures for mortality and hospital admissions are the tip of the pyramid. Many more people are affected in terms of symptoms that are not severe enough to result in an admission to hospital, but may make them ill, or require a visit to the family doctor.

3.1.5 Other air pollution related health effects

The link between climate change and other air pollutants besides ozone is less clear. However, there is some evidence that increases in temperature and humidity will lead to higher levels of particulate matter. (Jacobson 2008) Particulate matter is the second component of smog commonly found in Canadian cities. Higher PM2.5 levels are associated with increased morbidity and mortality from both respiratory and cardiac causes. (Pope et al., 2006, Kappos et al., 2001, and Englert et al., 2004) Chronic exposure is also linked to delayed lung development in children (Gauderman et al., 2004) and to lung cancer. (Pope et al., 2002) Climate change also may increase particulate matter in an indirect manner, through an increased number of forest fires which are projected to occur. Forest fires produce both gaseous and particulate air pollution, which can travel large distances. As an example, in July 2002, a series of fires in Quebec led to significant increases in PM2.5 as far away as in Baltimore. (Sapkota et al., 2005)

Finally, the projected increase in heavy rainfall events will likely result in increased flooding and leaks into buildings and homes. The resulting increased growth of and exposure to indoor mould will lead to increases in allergies and asthma.

3.1.6 Allergens, allergic rhinitis and asthma

The Canadian Allergy, Asthma and Immunology Foundation has estimated that 20-25% of Canadians have allergic rhinitis, also referred to as “hay fever”. (Allergy Asthma Information Association: Statistics, 2007) CO_2 is necessary for plants to be able to carry out the process of photosynthesis. As

CO_2 levels increase, and the growing season becomes longer, levels of aero-allergens in the air may increase, possibly leading to an increase in both allergic rhinitis and asthma.

The following table summarizes the effects of climate change on the levels and timing of exposure to aero-allergens especially to ragweed (*Ambrosia artemisiifolia*) and mould spores. (Patz et al., 2002, Beggs 2004, Rogers et al., 2006, and Ziska et al., 2000)

Climate effect	**Effect on aero-allergens**
Increased CO2 plus increased temperature	Increased pollen and spore biomass Increased pollen allergenicity
Seasonal effect	Earlier flowering leading to longer pollen and spore season
Increased temperature	Increasing distribution to northern latitudes

Table 3.2: The effect of climate on allergens

A study in Montreal has shown an increase in the length of the pollen season, and an increase in the number of medical consultations for allergies from 1994 to 2002. (Breton et al., 2006) Associations between both increased ragweed pollen counts and allergic rhinitis (Breton), and fungal spores and asthma (Dales et al., 2004) have been shown. Conversely, it has been shown that exposure to ozone and particulates act synergistically with allergens to exacerbate allergic rhinitis and asthma. (Dales 2004)It has also been shown that rising CO2 levels will also encourage the growth of poison ivy. The poison ivy plants that have exposed to CO2 produce a more allergenic form of the poison ivy toxin, urushiol. (Mohan et al., 2006)

Adaptation and Mitigation: What can family doctors do?

- Encourage healthy behaviours – Many of the measures that reduce combustion of fossil fuels are preventative for other diseases. For example, walking and cycling improves cardio-respiratory health, mental health, reduces obesity and lowers blood sugars. They strengthen our limbs and, if done safely, may impact on osteoporosis and reduce fractures
- Provide education regarding the reduction of the carbon footprint of our workplaces and households
- Review with patients the Asthma Action Plan so they understand measures to be taken and the appropriate use of their medications when high pollution and pollen counts are forecasted
- Encourage eating habits that benefit the heart by recommending foods that are “lower on food chain” (i.e. eating more grains, fruits and vegetables since farm animal require more land for feed and produce methane, one of the greenhouse gases).

3.1.7. Adaptation

Many large urban areas in Canada have air quality warnings, informing the public when adverse air pollution episodes occur, and communicating and protective messages to high risk patients. These Air Quality Indices (AQIs) vary across jurisdictions in Canada. Environment Canada and Health Canada are developing and piloting a new system, the Air Quality Health Index (AQHI), (Environment Canada: About the Air Quality Index, 2007) that is health based and takes into account mixtures of air pollutants, with health messages to the public in general, and vulnerable groups, in particular (i.e. children, the elderly, asthmatics and people with cardiovascular or chronic lung disease). These health messages give guidance about actions to reduce short-term exposure to air pollution. Much of this health protective advice involves reduction of exposure, usually staying indoors or reducing outdoor exercise. This is of concern in that promotion of regular exercise is an important message in terms of dealing with the epidemic of obesity, diabetes, cardiovascular disease and cancer.

3.1.8 Mitigation and co-benefits of reducing GHGs

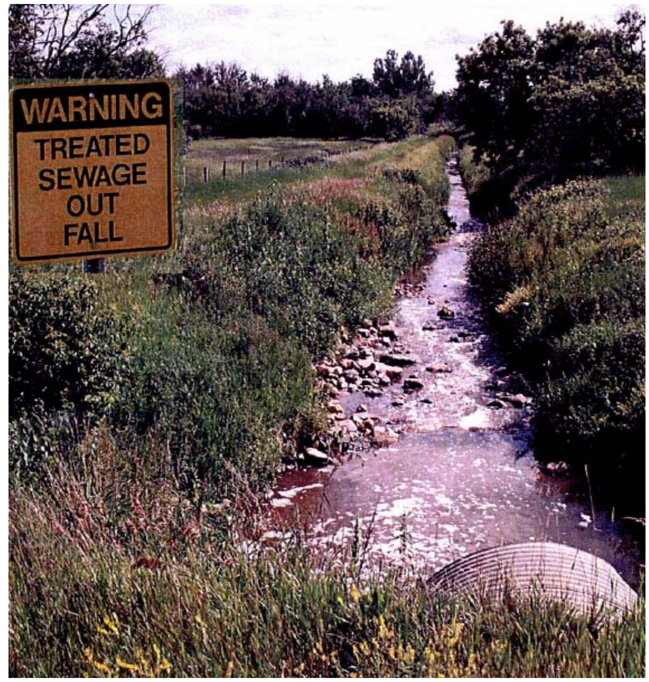
The combustion of fossil fuels for energy, heat and transportation, that is responsible for the production of the majority of CO2 and other GHGs, is also responsible for the release of many of the air pollutants that are harmful to our health, such as particulate matter, carbon monoxide and oxides of nitrogen that lead to ozone formation.

It follows therefore, that steps to reduce emissions of GHGs will lead to large health "co-benefits". While the health benefits of reducing GHG emissions will not be apparent for many years, because of the inertia of the climate system, these co-benefits will provide significant improvements in public health. Although Health Canada has discussed the difficulties inherent in these estimates (Health Canada: Climate Change and Health Economic Advisory Panel, 2000), a number of studies have looked at the value of these co-benefits. (Cifuentes et al., 2001, Cifuentes et al., 2001, & Jacobson et al., 2005) *The Working Group on Public Health and Fossil Fuel Combustion* estimated that mitigation efforts could save eight million premature deaths globally from reductions in mortality from particulate matter (PM) between 2000 and 2020. Similarly, an analysis in four large cities with a combined population of 45 million (Mexico City, New York City, Santiago and Sao Paulo) calculated that with GHG mitigation efforts, PM and ozone could be reduced by about 10%, with health savings of 64,000 premature deaths, 65,000 chronic bronchitis cases, and 37 million person-days of restricted activity or work loss in the same time period. (Cifuentes et al., 2001) There is, however also concern about mitigation initiatives negatively affecting air quality and health. Models that simulate increased use of ethanol in fuels show resulting increases in ozone levels, leading to increased ozone-related mortality, hospitalization, and asthma, as well as increased air toxics. (Jacobson 2007) Other concerns about biofuels include deforestation, increased use of fresh water resources for irrigation of the biofuel "crops", increased pesticide and fertilizers, and an increase in food prices due to increased non-food conversion of cereals and oil seeds.

3.2. Health effects of water and food-borne contamination

3.2.1 Introduction

A waterborne disease outbreak is defined as an outbreak in which epidemiological evidence points to a drinking water source from which two or more persons become ill at similar times (Thomas, Charron et



al., 2006) Sources of water for communities include lakes, rivers, wells and quarries. In Canada most communities have water treatment facilities to ensure safety from infectious agents and non-infectious contaminants. The process of decontamination involves several steps, most of which require a certain length of time in order to be effective. Chlorination may be only one of these modalities. The water is then transported via a system of pipes, some of which may be old and porous. Sewage waste is transported from houses and buildings through a series of pipes to a treatment centre. Here again, the treatment processes require a certain period of time to "cure" the waste before it is discharged. However, there are communities where the sewage flows without treatment directly into lakes, rivers, or oceans. The runoff from roads, lawns, and gardens should be diverted through a separate system of pipes and discharged into bodies of water after being treated. A significant number of cities and towns lack separate transport systems. During heavy rainfalls the treatment processes may be overwhelmed by the volume and increased rate of water entering the system. Under these conditions there is less exposure time for the decontamination process to work effectively. The high concentrations of contaminants from both sewage and storm runoffs are flushed into the bodies of water that also serve as the source of drinking water for the community. Chlorination itself is ineffective against cryptosporidium and often giardia which require very fine filtering processes. (Hrudey et al., 2002)

3.2.2 Health effects

The less secure the water source, the greater the risk of contamination with the addition of further risk factors. In addition, increases in ambient temperature in Alberta and Labrador-Newfoundland were found to be associated with increases in Salmonella, E. Coli, and Campylobacter (Fleury et al., 2006).

Canada has witnessed, between 1975 and 2004 more than 200 waterborne outbreaks. (Charron et al., 2004) In the USA between 1948 and 1994 there were 548 recorded water-borne disease outbreaks. The infectious agents were bacteria (commonly salmonella, shigella, campylobacter, E coli, and vibrio species), viral (Noro) or protozoan (giardia and cryptosporidium). Surface water contamination was associated with extreme precipitation during the month of the outbreak; groundwater contamination occurred about two months after the extreme event. In 2000, wells in Walkerton, Ontario located near a pig farm were contaminated with E coli from manure after heavy rainfalls leading to serious illness in 2300 people and the death of seven. In Milwaukee, more than 400,000 were infected with cryptosporidium following heavy rainfalls.

In Orangeville, Campylobacter jejuni was responsible for an outbreak and in Penticton, the organism was giardia. The U.S. Centre for Disease Control reported, in the two weeks following Hurricane Katrina, twenty-two cases of infections caused by different vibrio species. Most were a result of infected wounds; 72 % of those affected had an underlying chronic illness. There were five deaths. Physicians must be on the alert for contamination threats after heavy rainfalls and public health officials must communicate immediately any evidence of an outbreak.

If irrigation water is contaminated the crops in question may not be safe for consumption. Septic systems, if not properly maintained with periodic emptying, can be overwhelmed by heavy rainfalls dispelling infectious contaminants onto the surface of bodies of water resulting in ear, eye, and gastro-intestinal infections. In addition, the runoff water also is high in phosphates which along with high temperatures stimulate the growth of algae. (Lemmen and Warren) Some species of algae produce a toxin which renders the water unfit not only for drinking (even if boiled) but also for swimming. In Quebec and Ontario there are many examples of lakes that have been desecrated in this way. Research has also shown that following forest fires nearby lakes and rivers are contaminated by an increase in the concentration of mercury which subsequently enters the food chain and may render certain fish inedible (Kelly et al.).

Many diarrhoeal related pathogens in food and water are sensitive to climatic conditions. Salmonella and V cholerae, for example, proliferate more rapidly at higher temperatures, salmonella in the intestines of animals and in food, and cholera in water. So that, besides the risks from more flooding, there is an association between increasing temperatures and bacterial diarrhoeal disease. (McMichael 2006) Many studies worldwide have demonstrated this relationship, including a study in Alberta which found this association for salmonella, pathogenic E. Coli and Campylobacter, and for Campylobacter in Newfoundland and Labrador. (Fleury 2006) But the impact of this increased incidence of diarrhoeal disease developing countries will be enormous, (see section 4.3.2) with an estimated increase of between 2-5% by 2020. (Haines 2006)

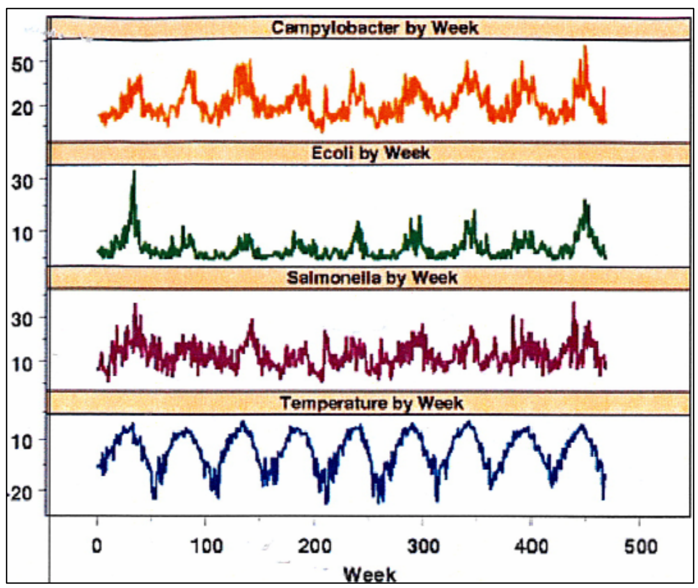


Figure 3.4: Weekly temperatures (^{o}C), and case counts of Campylobacter, Escherichia coli and Salmonella from 1992 to 2000, in Alberta

Adaptation and Mitigation: What can family doctors do?

- Be on the alert for contamination threats after heavy rainfalls and public health officials must communicate immediately any evidence of an outbreak or contamination by toxic chemicals or heavy metals…
- Be aware of the potential problems with household septic systems and educate their patients regarding the importance of system maintenance.

3.3. Vector-borne and zoonotic diseases

3.3.1 Introduction

When one examines the possible or real effects of climate change on the propagation of vector-borne diseases one must be aware of the entire life cycle of the infectious agent and the interactive effects of the entire ecosystem---the physical environment, the host animals and their predators, and the habits and state of health of the people who inhabit the specific region. (Greifenhagen and Noland, 2003)

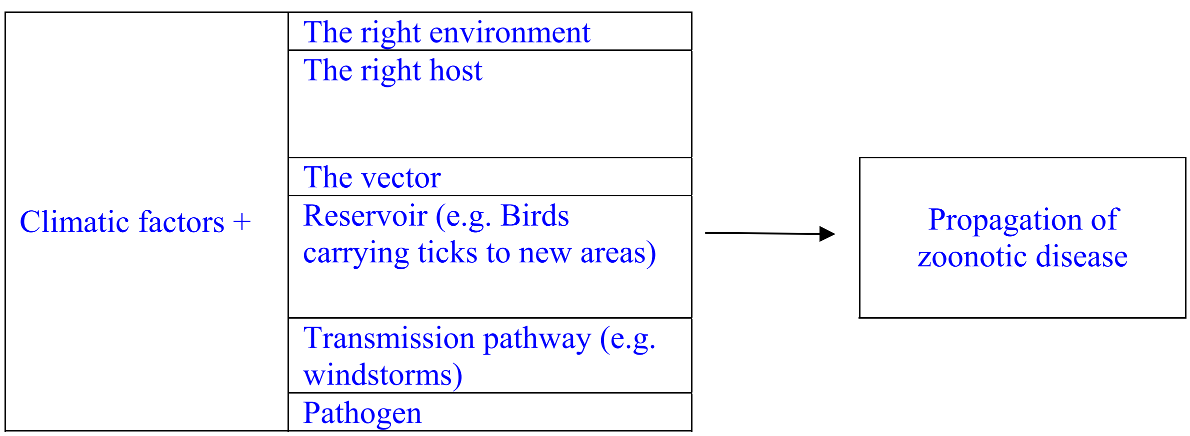


Figure 3.5: Propagation of zoonotic diseases

In a vector-borne disease, the infectious agent (a virus, bacteria, or parasite), is ingested by an insect vector which feeds on animals or birds and eventually human beings. Diseases that can be transferred from one animal to another, including humans, are called zoonoses. The West Nile Virus which first appeared in a corner of North America several years ago is carried by a mosquito that feeds on birds and animals including humans. Ticks can carry various bacteria and protozoa resulting in a number of different diseases. Many mosquito-borne infections are not indigenous to Canada but are increasing in frequency as more Canadians travel abroad or immigrants arrive from all over the world. Physicians must be aware of these potentially fatal infections. New vector-borne diseases might appear. An example of this is the outbreak of chikungunya fever, a mosquito borne disease in northeastern Italy in 2007. It is likely that infected mosquitoes arrived by boat or air from Africa, where it is endemic. (Greer, et al., 2008)

The propagation of zoonotic diseases is influenced by many factors which may affect not only the insect vector but also the reservoir hosts and the environment. How these work in concert will determine how the infection can affect the community. Ambient temperatures and precipitation patterns are only two of the important factors. Malaria, for example, was once prevalent in Canada, the USA and England where winters could be harsh. Marshlands, reservoirs created by dams, irrigation ditches and sewers provide optimal breeding grounds for mosquitoes. In Canada receptacles and puddles around the house may collect water where mosquitoes are able to breed. The state of immuno-competence may render a population more vulnerable. In many African countries where the incidence of HIV infected individuals is very high those people are more susceptible. Canadians who were born in countries like India and who are returning for a visit may have lost immunity to the common illnesses of their birthplace. Studies suggest that in Africa, malaria, dengue, yellow fever and West Nile Virus will extend to zones that fringe on endemic areas where the population will not have developed a degree of immunity from chronic community exposure to the infectious agent or perhaps have not developed appropriate public health programs. (Tanser et al., 2003) While the focus will be on tick-borne diseases, West Nile Virus, dengue fever and malaria, physicians should be alert to the fact that there are other diseases which may in some way be influenced by climate change. These include various viral encephalitides, hantavirus pulmonary syndrome, plague, and different mycoses. (Greer et al., 2008)

3.3.2 West Nile Virus

The West Nile Virus (WNV) causes a non-specific flu-like illness that can develop into an illness with serious neurological complications. These include encephalitis, myelitis, polyradiculitis, myositis, and optic neuritis. The patient may have difficulties of coordination and gait or even paralysis and seizures. Unfortunately the treatment is mainly supportive. Acute and convalescent antibody studies in the serum or CSF confirm the diagnosis.

Although there are several mosquito vectors for the WNV "*Culex pipiens*" is the most common one in North America. It breeds in urban settings where there is stagnant water and has a lifespan of two weeks. At a temperature of 30^{o}C the eggs of *Culex pipiens* hatch into larvae in 24 hours and at a temperature of 20^{o}C. in 3 days. (Bradford) The biting rate of mosquitoes increases up to a temperature of 40^{o}C. Cold winters destroy eggs but as ambient temperatures rise, the eggs may survive over the winters. In addition, mosquitoes can survive in the sewer systems of cities over the winter.

Climate change may influence the propagation of WNV in the several ways. The *Culex pipiens* mosquito is often found in the yards of the victims or their neighbours breeding in open containers, wheel barrows, pools, ditches, or footprints. The adult rests in the garden and shade during the day. Birds gathering around these accumulations of stagnating water become the natural hosts of the mosquitoes. An intense rainfall or flood can wash away these pools and consequently decrease the population of mosquitoes. Therefore, major outbreaks of WNV have often followed severe spring or summer droughts. Conversely, other mosquito vectors increase with heavy rainfalls which leave puddles, destroy protective housing in poorer countries, increase rotting organic matter, and in the aftermath result in people massing together.

Adaptation and Mitigation: What can family doctors do?

- Advise homeowners and communities of the need to reduce the breeding grounds of mosquitoes, including containers, old tires and depressions in the earth where puddles accumulate.
- Advise patients to reduce exposures especially at dawn and at dusk.
- Advise the appropriate use of DEET insect repellant on both the skin and clothing.
- Advise patients to wears protective clothing including hats and long sleeves and to tuck their pants into their sock.

3.3.3 Lyme Disease and other infectious disease caused by ticks

The *Ixodes scapularis* and *Ixodes pacificus* are the ticks responsible for Lyme disease in eastern Canada and Rocky Mountain spotted fever in British Columbia respectively. *I scapularis* readily reproduces on the north shore of Lake Erie where antibodies to the bacteria, *borrelia burgdorferi,* are found in resident animals. Migrating birds might spread the tick to other areas of Canada. Among the 172 Lyme Disease cases reported between 1999 and 2004 in Ontario, 18% were acquired in the province, 64% came from other areas and 18% were of unknown origin. The incubation period following a tick bite carrying the bacteria is three to twenty-four days. At that time, a rash of erythema migrans may appear. Rheumatoid manifestations may develop within four days, but may take as long as two years to appear. Cardiac sequelae may appear within three to five months and neurological symptoms within two weeks to several months.

In addition to Lyme Disease, *I scapularis* has also been responsible for transmission of the bacterium and protozoan that cause Human Granulocytic Anaplasmosis (HGA) and Babesiosis respectively. (Wormser et al, 2006.) Human granulocytic anaplasmosis (HGA) is caused by the bacteria *Anaplasma phagocytophilum*. It is manifested by flu-like symptoms including fever, headache, myalgia, fatigue and chills and usually occurs in spring and summer. The symptoms usually start a week after the tick bite and can progress to coagulopathies and renal failure. *Babesia microti,* the protozoan, is endemic along the northeast coast of the U.S.A. There was recently, in Ontario, a case of Babesiosis incurred through a blood transfusion. (Kain et al., 2001) Clinical symptoms vary from being asymptomatic to anaemia and low-grade temperature to a malaria-like infection with very high temperatures, rigours, haemolytic anaemia, respiratory distress syndrome, and multiple organ failure. The very young and old and those with immuno-deficient conditions are especially susceptible.

In May, the adult tick lays its eggs principally on the white-tailed deer. The eggs fall to the ground and later hatch into larvae which acquire the pathogen when they feed on mice and sometimes birds and reptiles during the summer before a period of winter dormancy. In the spring of the second year, the larvae turn into nymphs and, later during autumn, into adults. The nymph (1mm) will feed in the spring and early summer while the adult (5mm) will feed on humans usually during the late summer and fall. After a tick has attached, it takes about 48 hours for the borrelia bacteria to migrate from the gut into the salivary glands and subsequently be introduced into humans.

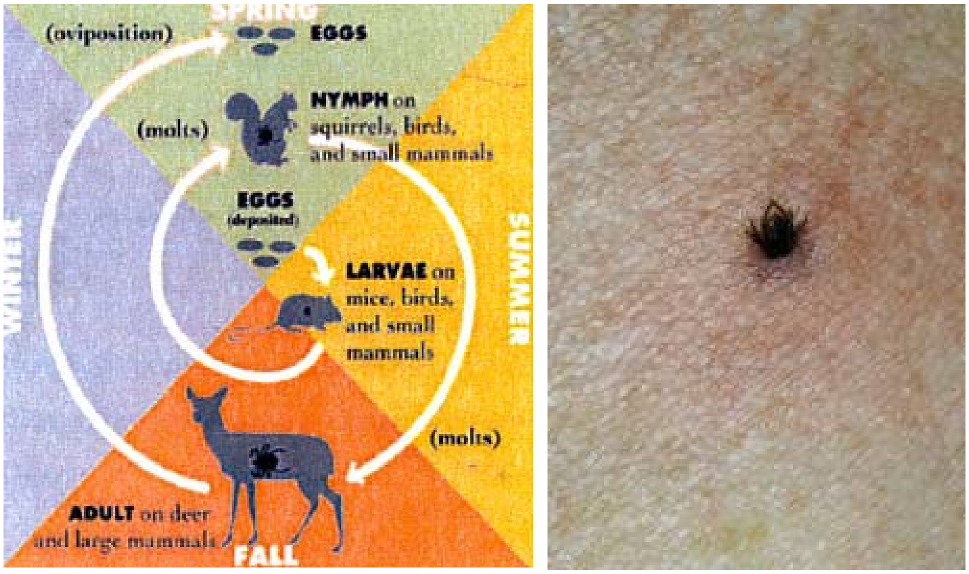


Figure 3.6: Ticks – in the field and attached to the skin of a human

Climate change models project that global warming will certainly lead to the northward spread of Lyme-disease related ticks in Canada (Figure 3.7), possibly into more densely populated areas, (Ogden et al., 2006) and into Alberta and Saskatchewan. (Greer,et al., 2008) However, other factors such as drought or heavy rainfalls may limit the extension of their habitat. Dry hot weather decreases the availability of food and water for the hosts and may desiccate the larvae and nymphs. Humidity and decaying organic matter encourage tick growth and the growth of vegetation leading to more seeds or acorns thereby increasing the number of mice. Although hotter wet weather may enhance the chances for transmission the bacteria, this may be countered by the reduction of outdoor human activity during inclement weather conditions. Nevertheless urban sprawl brings humans into closer contact with areas that provide a habitat for mice and white-tailed deer. (Charron and Socket)

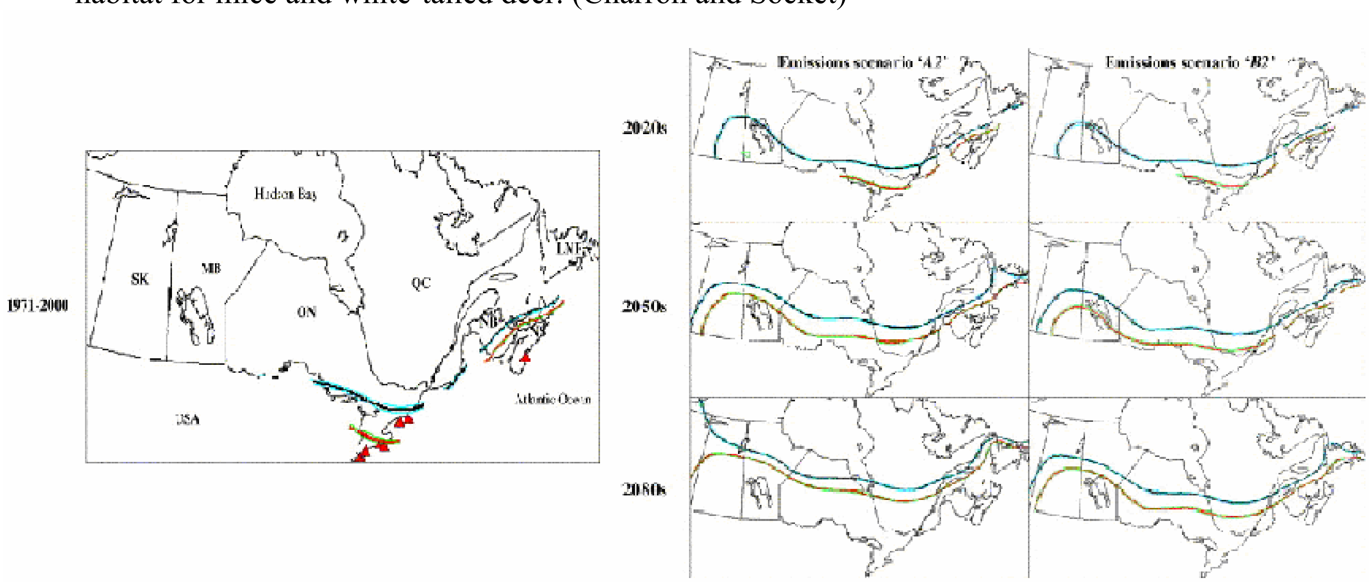


Figure 3.7: Model-derived temperature limits for Ixodes scapularis establishment in Canada under current (1971–2000) and projected climate. (From Ogden NH, Maarouf A, Barker IK, et al. Climate change and the potential for range expansion of the Lime Disease vector exudes scapularis in Canada. Int J Parasitol. 2006; 36(1):63-70.)

Adaptation and Mitigation: What can family doctors do?

Advise their patients regarding preventive strategies, such as

- Wearing protective light-coloured clothing with hats, long-sleeved shirts, tucked into pant legs. Light-coloured clothing allows clinging ticks to be more visible.
- Applying DEET both on the clothing and exposed skin.
- Removing the ticks within 24 hours of attachment reduces the risk of infection.
- Inspecting daily the entire body when in an endemic area or for anyone hiking in wooded areas and fields. Remove ticks immediately with fine forceps.
- If the tick has been attached for more than 36 hours, consider prophylaxis with a single dose of Doxcycline 200mg to prevent the onset of disease. (Nadelman et al., 2001)

3.3.4 Dengue Fever

Dengue Fever is an acute febrile illness lasting two to seven days after an incubation of three to fourteen days. It is characterized by fever plus two of the following symptoms: headache, retro-ocular pain, moderate to severe myalgia/arthralgia, fatigue, non-specific URI or GI disturbances, hemorrhagic manifestations (petechiae, epistaxis, bleeding gums) and a macula-papular rash that appears after the temperature falls. In the more severe form, which usually occurs in children or those with repeated infections, the bleeding may be more extensive and is associated with hypotension, renal failure, encephalopathy, coma, and death. It can be transmitted from a mother to a neonate up to 8 days before the birth. In a febrile individual returning from an endemic region IgM antibodies can be detected within 6 days.

Dengue is caused by four distinct types of "Flavivirus" which are usually carried by the *Aedes aegypti* mosquito. The eggs and larvae of this mosquito are killed by freezing temperatures so that dengue is not indigenous to Canada. *Ae. aegypti* breed in water-filled containers often in the immediate vicinity of houses and even indoors. The epidemic potential, however, is dependent on several factors. While slight rises in temperature may increase virus replication and mosquito reproduction rates, excessive temperature increases may shorten their lifespan and at the same time influence human migration away from the endemic area. Increased urbanization, increased population density, poverty, the lack of public health measures, basic protective housing and water systems play major roles in facilitating spread. As the level of immunity and the socioeconomic status of the human population rises, the incidence of dengue diminishes. But if the transmission of dengue increases then the number of individuals at risk of repeat flavivirus exposure will increase. This will raise the possibility for more potentially fatal cases of hemorrhagic fever. (Patz et al., 1998) Dengue fever occurs throughout south Asia, Southeast Asia, in Taiwan, the Republic of China, Puerto Rico and Hawaii. In Mexico and Texas, the vector may be *Aedes albopictus* whose eggs are resistant to desiccation. It feeds on all mammals and birds. The transmission of Dengue Fever has increased dramatically in tropical regions, and because high temperatures and high humidity contribute to its transmission, it is predicted that endemic areas will continue to expand, and that public health measures to contain the spread will have to be intensive. (Hales 2002)

Adaptation and Mitigation: What can family doctors do?

- Understand the prevalence of Dengue Fever. (Annually, there are 250,000 to 500,000 deaths worldwide) and consider Dengue Fever in febrile individuals returning from these areas with signs and symptoms listed above.
- Advise patients regarding protective measures against mosquitoes such as protective clothing, window screening, appropriate use of DEET, and use of mosquito nets if traveling to areas where Dengue Fever is endemic.
- Treatment of more benign from is supportive care with hydration. The hemorrhagic form requires much more intensive treatment since it carries a mortality rate as high as 40%.

3.3.5 Malaria

Malaria is the most ubiquitous vector-borne disease in the world. The *Anopheles* mosquito is the principal vector although there have been cases in North America transmitted by other mosquito species. In Canada, essentially all cases of this disease occur in individuals who have traveled to an area of the world where malaria is endemic. Travelers who are visiting friends and relatives (VFR's) are four times more likely to contract malaria than tourist travelers. (CDC Travelers Health Yellowbook: Chapter 9) It is essential to rule out its presence in any febrile patient who has been to one of these regions. The effects of climate change have to be considered in the context of other factors which affect propagation of the mosquito and development of the parasite. The *Anopheles* mosquito is inactive below 10°C, and development of sporozoites requires a temperature above 15° to 18°C. (Patz and Olson, 2006) The mosquito does not survive at temperatures above 39°C and in drought conditions.

Areas of higher elevation in Africa, incorporating many of the larger cities, have been free of malaria but this may change with global warming. This phenomenon has already been observed in highland regions of East Africa where the incidence of malaria has also increased. It is projected by modeling that although climate change will only cause a small (5 to 7%) increase in the population at risk from malaria, this translates into a large number of people affected, measured in Disability Adjusted Life Years (DALYs), because malaria is so prevalent in these regions. (Haines 2006) On the other hand, in more southern areas excessively high temperatures may decrease the incidence. (Pascual et al.) Deforestation and cultivation of land leads to higher soil and air temperatures than in forested habitats, thereby, supporting more rapid vector development and increased mosquito survival and biting rates.Other factors such as the immune status of the people in the community, drug resistance, and the public health measures adapted to control the propagation of mosquitoes and protect individuals (such as wide distribution of mosquito nets) may play a more significant role than the rise in temperatures or changes in precipitation patterns. It is also possible that the people who inhabit regions that border on areas where malaria is endemic may be more vulnerable because immunocompetency in the community has not been established. These regions may have felt no need to adopt protective public health measures.

A mosquito net

Adaptation and Mitigation: What can family doctors do?

- Be aware of the prevalence of malaria in different areas of the world.
- Refer to a travel clinic, if necessary.
- Educate people traveling to high risk countries and returning immigrants who are often unaware that their immunity may have waned. The children of immigrants, especially if born outside the country in question, are especially vulnerable.
- Advise regarding protective clothing, the appropriate use of DEET on both clothing and the skin and mosquito nets preferably impregnated with permethrin insecticide.

3.4. Socioeconomic impacts on community health and well-being

3.4.1 Introduction

The socio-economic costs of climate change on health differ between countries as well as between different regions within each country. Previously, we have discussed how climate change will impact upon health. These impacts often occur indirectly through the effects of climate change on forests and crops, water resources, transportation, energy and the built environments in which we live. Any discussion of strategies to deal with these issues should integrate the impact on health care into the equation. Climate change may result in social disruptions such as unemployment, and its sequelae, such as relocation for other employment opportunities, increased welfare costs, and an increase in “housing poor” families and homelessness. A brief review of the indirect effects is given below. (Hengeveld 2005 and Natural Resources Canada 2004)

Resource dependent communities, including many aboriginal communities are especially vulnerable to climate change.

3.4.2 Forestry

The forestry industry is important in Canada. Climate change related increase in temperature and changes in precipitation patterns will increase forest productivity in some areas, while having significant negative effects in other areas. Warm dry summers and mild winters lead to an increase in infestation, such as the mountain pine beetle in Western Canada. This, together with the drier conditions, predisposes forests to increased risk of fires. It is likely that, in most regions of Canada, these losses will increase as temperatures rise.

3.4.3 Agriculture

Warmer temperatures, a longer growing season, and the effect that carbon dioxide has of increasing plant growth will be potentially very good for Canadian agriculture, allowing expansion of valuable agriculture northward. For example, models show that by 2050 conditions in New Brunswick could resemble those of the productive Niagara peninsula. However, agricultural crop production is also very sensitive to changes and extremes in weather and climate, and agriculture in some areas could be negatively affected by increased extreme heat, decreased water availability, drier soils, and increased heavy rains that can damage crops and increase soil erosion.

3.4.4 Fisheries

Fish species are sensitive to changes in water temperature. The impacts of climate change on fisheries will be variable, with increased supply in some areas and species, and losses in other areas. Both coastal and fresh water fisheries will be affected. For example, it is thought that already climate change is part of the cause of the decline of salmon stocks in British Columbia and flounder in the Atlantic.

Climate change will have other effects on the economy of certain communities, especially coastal and northern communities.

3.4.5 Coastal communities

Many areas of Canada's long coastline will be impacted by rising sea levels, as described in section 3.3 and as illustrated in figure, with impacts on fisheries, wetlands, erosion, land use and tourism. More than 80% of the coast in the Atlantic Provinces is sensitive to sea level rise. The risks of local flooding and erosion are especially of concern in Prince Edward Island, where on the north shore about 10% of current assessed coastal property values could be lost within 20 years, and almost 50% within the next century. Adaptation to this will require extensive investment in infrastructure to prevent the devastation accompanying storm surges, A case study in two communities at risk from coastal flooding due to storm surges, in Newfoundland and New Brunswick demonstrated the importance of preparing emergency responses in the communities. This included drawing up emergency response plans, creating a management strategy and team, the importance of communication and coordination, and strengthening and coordinating the public health response. (Health Canada. Marielou Verge 2006)

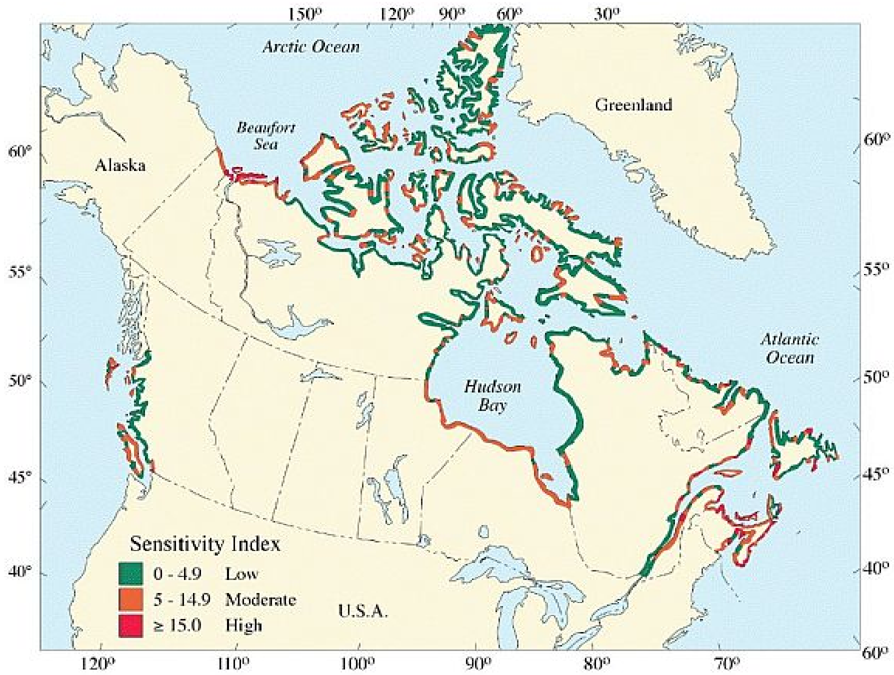


Figure 3.7: The sensitivity of Canadian coastlines to a rise in sea level.
Shaw, J., R.B. Taylor, D.L. Forbes, M.-H. Ruz and S. Solomon. 1998. Sensitivity of the Coasts of Canada to Sea-Level Rise. Geological Survey of Canada, Bulletin 505. 79 p

4.6 Northern communities

Northern communities will be affected in many ways and the effects will be discussed in Chapter 4.

CHAPTER 4

VULNERABLE POPULATIONS

4.1. Introduction

Some population groups will be more impacted by climate change than others. There are two main reasons: increased vulnerability and reduced adaptive capacity. (Health Canada. Climate Change: Preparing for Health Impacts) Vulnerability will be discussed in detail here. Adaptation will be discussed more in Chapter 6.

This section is divided into three sections
1. Vulnerability related to heat extremes and air pollution;
2. Communities more vulnerable due to geographic location and indirect effects of climate change; and,
3. Populations at special risk:

- Northern populations
- Developing countries

4.2. Vulnerability related to heat extremes and air pollution.

Some people are more vulnerable than others to the risks previously described, such as heat and air pollution. As mentioned earlier, those more vulnerable to air pollution are:

- Age related: children and the elderly;
- Pre-existing disease: asthma, other respiratory and cardiovascular diseases;
- Those more exposed: people exercising outdoors, and those working outdoors.

Those more vulnerable to heat extremes are:

- Age related: the elderly and those who are not physically fit;
- Pre-existing disease: chronic respiratory and cardiovascular diseases; mental health problems;
- People on specific medications which interfere with body temperature regulation
- The homeless;
- People living in housing that is hot, especially top floor apartments, with poor ventilation and no air conditioning;

- The poor, with inadequate housing and no access to A/C;
- Urban communities due to the heat island effect.

4.3. Communities more vulnerable due to geographic location and indirect effects of climate change

Some individuals and communities are more affected by indirect impacts on health, including through effects on local economies. These might include:

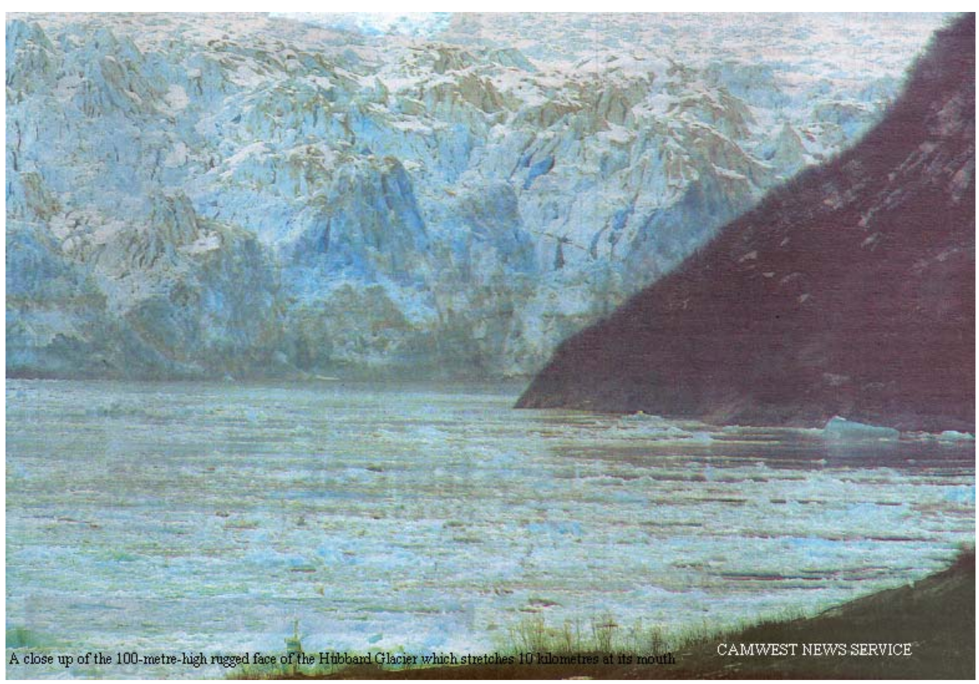
- Farming communities, affected by changes in temperature and precipitation, including drought;
- Communities economically dependent on natural resources such as forestry (forest fires, insects and diseases) and fishing (fish populations affected by warming water);
- Rural populations might have increased problems with water quality, and water quantity;
- People living off the land e.g. some aboriginal communities;
- Coastal communities, through effects of sea level rise (Reidel, 2004).

4.3.1. Northern Canadian populations

Northern communities are presently experiencing detrimental impacts due to climate change, and the predicted changes will have profound impacts on their lifestyles and communities.

Climate change science has shown that the North is more affected by climate change than in the rest of Canada. The western Arctic has warmed 2-3 degrees Centigrade over the last 30-50 years, with the warming more pronounced in winter. The eastern Arctic is slightly less affected. (Weller et al., 2005) The Arctic Climate Impact Assessment predicts continued warming of 2 -4°C, and more in winter (5°C on land, and 8-9°C over the Arctic Ocean) through this century.

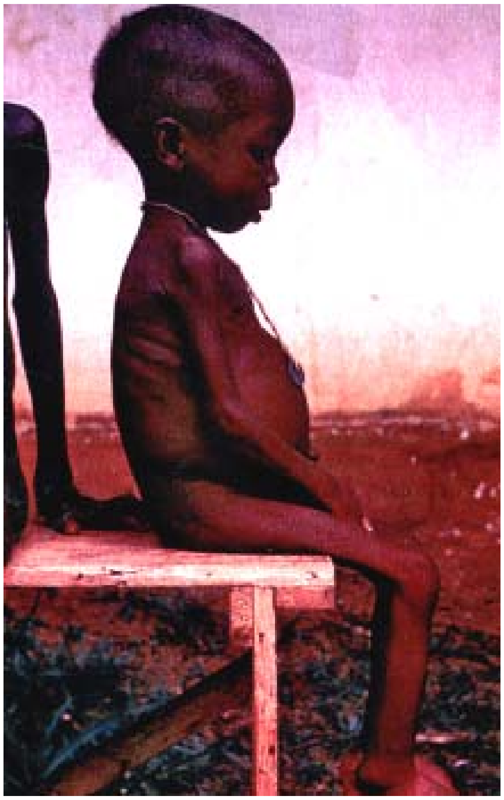
This has caused a number of ecosystem changes that are affecting, and will have greater effect over time, on the lifestyles, economies and wellbeing of northern populations. (Health Canada - Climate Change and Health and Well-Being: A Policy Primer for Canada's North, and Furgal et al., 2006) These impacts, which complement the impacts affecting the rest of Canada, are summarized in the following table. These factors interact with the complex and rapid cultural, social and economic changes with which


A close up of the 100-metre-high rugged face of the Hubbard Glacier which stretches 10 kilometres at its mouth CAMWEST NEWS SERVICE

northern populations are struggling. Chapter 15 of the Arctic Climate Impact Assessment gives a more detailed review. (Berner et al., 2005)

Identified climate-related change	**Potential indirect health impacts**
Increased (magnitude and frequency) temperature extremes	▪ Increase in infectious disease incidence and transmission, psychosocial disruption
Decrease in ice distribution, stability, and duration of coverage	▪ Increased frequency and severity of accidents while hunting and traveling, resulting in injuries, psychosocial stress and death ▪ Decreased access to country food items; decreased food security, erosion of social and cultural values associated with country foods preparation, sharing, and consumption
Change in snow composition (decrease in quality of snow for igloo construction with increased humidity)	▪ Challenges to building shelters (igloo) for safety while on the land
Increase in range and activity of existing and new infective agents (e.g., biting flies)	▪ Increased exposure to existing and new vector-borne diseases
Change in local ecology of waterborne and food-borne infective agents (introduction of new parasites and perceived decrease in quality of natural drinking water sources)	▪ Increase in incidence of diarrhoeal and other infectious diseases ▪ Emergence of new diseases
Increased permafrost melting, decreased structural stability	▪ Decreased stability of public health, housing, and transportation infrastructure ▪ Psychosocial disruption associated with community relocation (partial or complete)
Sea-level rise	▪ Psychosocial disruption associated with infrastructure damage and community relocation (partial or complete)
Changes in air pollution (contaminants, pollens, spores)	▪ Increased incidence of respiratory and cardiovascular diseases; increased exposure to environmental contaminants and subsequent impacts on health development

Table 4.1: Identified Climate Related Change (Furgal et al., 2006)



4.3.2 The developing world

There is and will be great inequity in the burden of illness from climate change, with significantly greater suffering in the developing world than in developed countries. Conversely, historically, the developed world is responsible for by far the greater amount of greenhouse gas emissions. And although total emissions in China, for instance, have now overtaken the US, (Netherlands Environmental Agency) presently, on a per capita basis, developing regions continue to emit far less CO2 than developed regions. In 2004, on average, an individual in developed regions emitted about 12 tons per year. In Western Asia, the highest per capita emitter among developing regions, an individual produced less than half that amount, while in sub-Saharan Africa that number is less than one tenth of the CO 2 produced by an average person in the developed world. (United Nations Millennium Development Goals Report) As shown in Figure 4.1, Canadians on average, emit 14.2 tonnes per capita. Our figure compares poorly with that of China (2.2 tonnes), with 1.1 tonnes in India, and, less than half a tonne in sub-Saharan Africa.

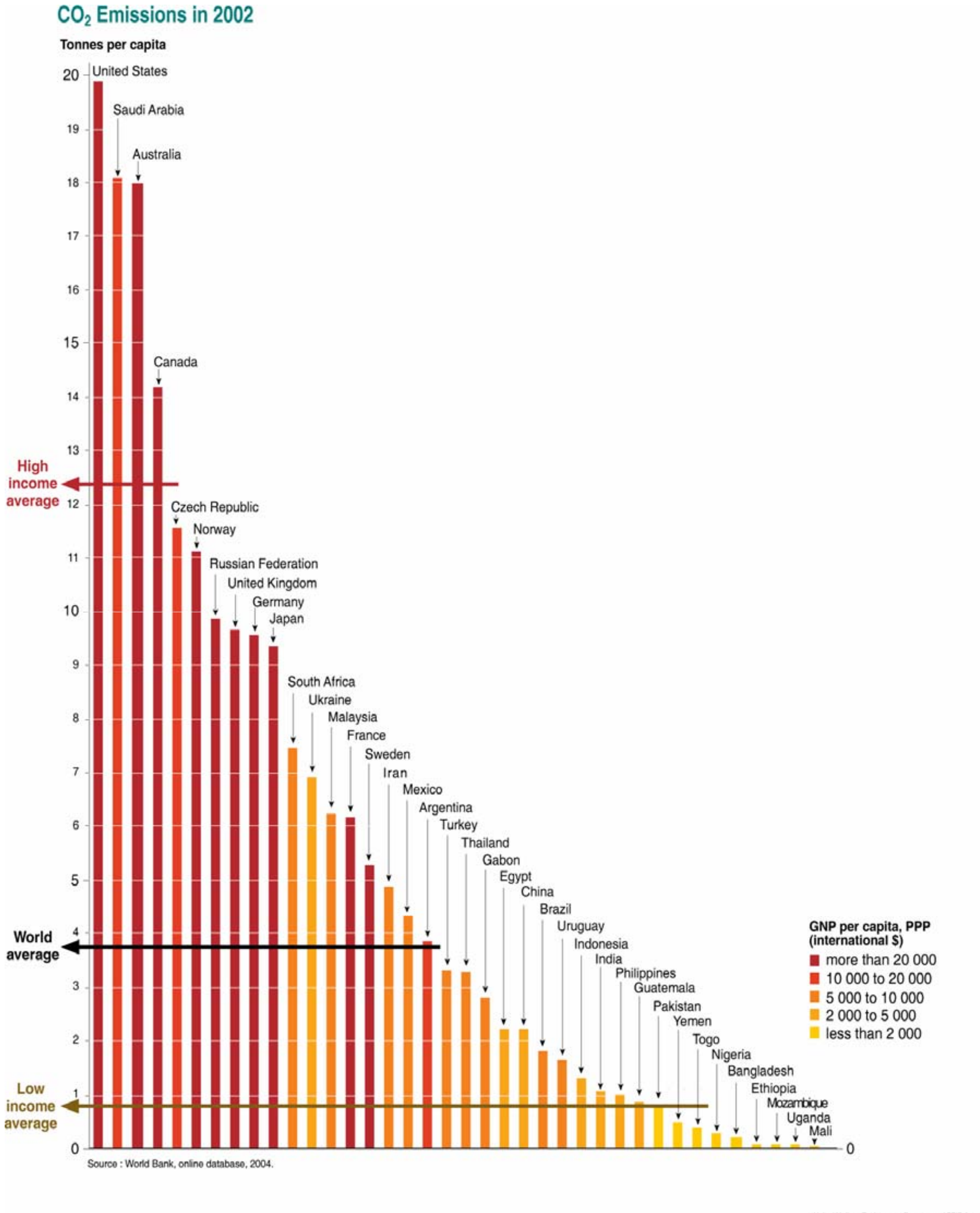


Figure 4.1: National carbon dioxide (CO2) emissions per capita. (2005). (UNEP/GRID-Arendal Maps and Graphics Library, 2005)

This shows various countries and their levels of CO2 emissions per capita, indicating the difference from high income to low income nations on CO2 output. Significant changes in rates of fossil fuel consumption in China and India will have a major effect on this graph in the future.

The World Health Organization (WHO) (WHO: The World Health Report, 2002, McMichael et al., 2004, & Patz et al., 2005) estimates that climate change may already be causing about 150,000 deaths (0.3% of global deaths) per year and 5.5 million Disability Adjusted Life Years (DALYs) per year (0.4% of global DALYs lost per year), mostly in developing nations. (WHO: Disability Adjusted Life Years) By working with models and scenarios of future climate change, and using epidemiological data to estimate the health impacts, the WHO predicts that by 2030 the health impacts of climate change could more than double. The large impact in the developing world is related to increases in the most devastating and prevalent diseases that are also climate sensitive, such as malaria, malnutrition and childhood diarrhoea. Although the relative increases in each disease might be small, the huge numbers affected by these diseases are large, and the majority of those affected are children and youth.

There are many uncertainties in these complex calculations of disease burden, but the WHO figures are considered conservative. Many potential health impacts were not included because of incomplete data. Climate change might bring some modest health benefits. For example in Canada, with warmer winters, we will see a reduction in cold-related deaths. (Haines et al., 2006)

Developing countries, already struggling with the huge burden of poverty and inadequate development, are at higher risk for a number of reasons besides this disease model described above. Geographically, they are in regions with higher temperatures, and more irregular rainfall already and, therefore, more vulnerable to further changes. Their economies and subsistence are agriculture dependent, and at great risk from climate induced drought or flooding. Thirdly, developing countries have a reduced ability to adapt, due to poverty and the relative lack of resources in public health, including surveillance, research and intervention, such as vaccines and water treatment, and lack of resources in other areas such as agriculture, technology, infrastructure and institutional capacity, creating an inability to adequately adapt to climate change. An accumulation of deficits in the determinants of health will aggravate the effects on health of climate change in these areas. (Fields, 2005)

Developing countries may be more vulnerable to the impacts of sea-level rise, floods, desertification, droughts, reduced availability of drinking water and reduced food security, coastal erosion and damage to coral reefs and fish stocks, deforestation, and worsening urban air pollution, potentially affecting millions of people, both urban and rural. (Campbell-Lendrum et al., 2007)

The Stern report warns that by the middle of the century, 200 million people may become permanently displaced as “climate change refugees”. The potential for increasing conflict, due to rising sea levels, heavier floods, and more intense droughts will be considerable. It also estimates that an additional 145-220 million people could be living on less than two dollars a day and there could be an additional 165,000 to 250,000 child deaths per year in South Asia and sub-Saharan Africa by 2100 (due to income losses alone). (Stern Report)

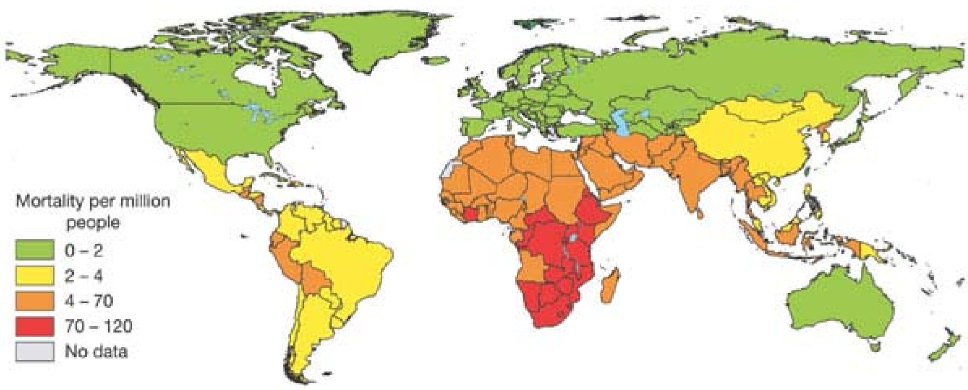


Figure 4.2: WHO estimated mortality per million people attributable to climate change by the year 2000. (Patz et al., 2005)

3.3 Other vulnerable populations

Other vulnerable populations, besides those mentioned above are:

- Small islands with low elevation in the Pacific and Caribbean, where the whole population is threatened by sea level rise.
- Large populations in African and Asia living in low lying coastal areas and large river delta areas, including large cities in these areas, where they are threatened by sea level rise, storm surges and river flooding. (IPCC working group 2, 2007)This could lead to large-scale migration, with resultant health impacts in countries such as Bangladesh or Vietnam.
- Large cities such as New York, Tokyo, London, and Cairo could also be affected by sea-level rise.

3.4 Future generations

The impacts of climate change on natural ecosystems and human health are projected to affect the world's population most significantly in the second half of this century and later – our children and our children's children. The Stern report makes this quite clear: "Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms. Using the results from formal economic models, the report estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next." (HM treasury: Stern Report)

CHAPTER 5

ECONOMIC AND ETHICAL BEHAVIOUR

"The difference between what we do and what we are capable of doing would suffice to solve most of the world's problems."

Mahatma Gandhi

5.1. Synchronization of economic and ethical imperatives

Perhaps there has never been a time before in human civilization when the concepts of smart economic planning and appropriate ethical behaviour have intersected to such an extent as there is today with the subject of our collective role in mitigation and adaptation of climate change. The Stern Review concludes that the evidence is undeniable that "the benefits of strong and early action far outweigh the economic costs of not acting".

Even if the economic imperatives were not so clear, the ethical requirements would surely stand alone in guiding our behaviour as we enter the second decade of the twenty-first century. The fact the economic and ethical imperatives are so completely in synchronization makes the actions that we must take all the more reasonable.

Climate change will affect the basic elements of life for everyone on the planet, including our access to water, food production, health, and the environment in which we live. Coastal flooding alone will permanently dislocate hundreds of millions of people around the globe. The previous chapter showed how, although the developed world has historically been responsible for the largest amounts of greenhouse gas emissions, ironically it will be the developing world that pays the greatest price for climate change, at least initially. The burden of illness in developing nations is compounded both by their relative inability to adapt, and by other factors such as poverty, dependence on agriculture and poor public health infrastructure. However, it is also clear that the developed nations will not be immune from the long term effects of climate change. Major cities such as New York, London, and Tokyo will be affected by rising sea levels, while mass disruption of civil society in other nations will have many complex international consequences around the globe.

5.2. Economic Factors

The Stern Review, using results from formal economic models, estimates the costs of not taking action are equivalent to a decrease of 5% of global gross domestic production (GDP) per year and that these effects will be permanent and irreversible. Worst case scenarios increase the estimate of damage to the world economy at 20% or more. In contrast, the cost of taking action to reduce greenhouse gas emissions could be limited to about 1% of global GDP per year.

The decisions that we take in the next two decades will determine the profound effects on the climate for the remainder of this century and for the next as well. If no action is taken, there is a high probability of a global temperature rise of two degrees Celsius by 2035 and it is even possible that the increase could be as much as five degrees in the long term. The consequences for where we live and how we live as a global community are almost beyond our collective comprehension.

It is no longer possible to prevent the climate changes that will take place over the next two to three decades, but rapid and coordinated worldwide adaptation is required. Such things as improved planning, better education, innovative infrastructure, and climate-resilient crops are required now. This will require billions of dollars, especially in the developing nations which are already without financial resources. Ethical behaviour from the developed countries will require enlightened leadership at all levels of governments.

From an economic standpoint, there are significant opportunities in these areas. Low carbon technologies, low carbon commodities, and low carbon services will create many new businesses and markets worth billions of dollars and will employ millions of people. It is not a question of economic growth or reduced greenhouse emissions. It is now a business principle of economic growth and reduced greenhouse emissions. Increased energy efficiency, changes in demand, adoption of sources of clean power, new heat and transportation technologies, carbon capture/storage, new agricultural and industrial processes, and reduced deforestation will ultimately stabilize the amount of the greenhouse gases in the atmosphere at levels that will allow our world civilizations to continue.

We must begin the process of understanding the future of our planet from the standpoint of our children and grandchildren. The last four decades have added an unprecedented level of greenhouse gases to our atmosphere and the changes to the climate of earth have already begun. We are a planet of tremendous diversity in terms of economic wealth of peoples and nations and yet, if we think about it, there is but one overriding ethical principle that must guide our decisions in the decades ahead. We must look after our collective home and ensure that it is a world that our children and the children of all nations can continue to enjoy for generations to come. That the actions that we must take also make complete economic sense only adds to the clarity with which these problems must be understood and solutions begun without delay. Sound economic decisions and global ethical behaviour have become as one.

Images obtained from guardian.co.uk "Pollution in China"

CHAPTER 6

PREVENTION

6.1 Introduction

Even if we dramatically reduced GHG emissions now, the climate changes and subsequent impacts on our ecosystems, our social and economic wellbeing, and human health would continue for many decades to come, because the climate system is slow to respond and to turn around. Since we are unable to completely prevent the impacts of climate change, and so we take a two-pronged approach to climate change, namely, adaptation and mitigation.

6.2. Adaptation

In public health terms, adaptation could be seen as the early detection of disease and secondary prevention activities to reduce the likelihood of irreversible damage. Adaptation measures should be targeted at the areas of greatest vulnerability, which vary from region to region, and certainly from developed to developing countries. As stated earlier in this report, the distribution of health impacts from climate change is inequitable, with some regions of Canada, especially northern communities, and developing countries being more impacted. In both of these situations, because of lack of resources and less developed infrastructure, there is less adaptive capacity. It is therefore important to consider adaptation in "southern' Canada, but also how we can aid in adaptation efforts and build adaptive capacity in the north and in developing countries.

Although this report focuses on the health impacts of climate change, it is clear that interventions to adapt to climate change must be planned across many intersecting disciplines and sectors, with public health being one of many. Thus adaptive measures in water resources, agriculture, forestry, fisheries, coastal zones, urban planning and transportation would be major strategies in preventing negative health impacts. (Natural Resources Canada) For example, reduced water levels in the Great Lakes-St Lawrence already affect transportation, fisheries, agriculture, tourism, hydroelectric power generation, and also increase gastro-intestinal illness from water contamination. (Natural Resources Canada) Adaptation in this respect would mean water conservation measures, enhanced monitoring of drinking water quality, improved water quality protection from industry and human wastes, and improved drinking water treatment facilities. Adapting to increased air pollution might include policy interventions to promote public transportation and sound urban planning to reduce sprawl. There are many ongoing adaptation projects and programs in Canada. The Ouranos Health Program in Quebec is engaged in a number of projects aimed at improving the developing adaptive responses to climate change risks, including heat waves, extreme weather events, and air pollution and water quality impacts. (Health Canada Your health 2006) Natural Resources Canada has produced the report: "Adapting to Climate Change: An

Introduction for Canadian Municipalities", which has a number of case studies, to assist municipal levels of government, where a lot of the adaptation work needs to be done. (Canadian climate impact and adaptation research network (C-CIARN)

As we engage in planning exercises, we need to be mindful of the fact that some adaptive interventions themselves could have negative impacts on health. For example, building a sea wall to prevent storm surges and flooding might, if not well planned, damage wetlands and endanger animal populations, as well as water quality. (Health Canada: Your Health and a Changing Climate, 2005) As another example, an increase in air-conditioning in adaptation to heat waves could result in more greenhouse gas emissions, depending on the source of electricity. Hence, adaptation interventions require careful planning and health impact assessment. The following table gives a number of examples of adaptation within the public health sector. Some of these have been discussed in the previous sections.

Health outcome	**Public health**	**Surveillance**
Mortality and morbidity due to heat waves	Health warning systems and public health education	Enhance health surveillance of routine data for early Effects (i.e. monitoring of funeral homes, calls to Telehealth and visits to family doctors.
	Emergency preparedness	
Floods	Public health education, boil water notices	Surveillance for flood effects, with long-term follow-up. Coordinated national surveillance for flood deaths, injuries and illnesses
	Emergency preparedness	
	Check list for post-flood activities	
Air quality	Warnings for high pollution days	Daily air pollution measurements
Vector-borne diseases	Public education, especially to avoid contact with ticks	Monitoring of vectors, and reservoir hosts, integrated surveillance for human and animal diseases
Food borne disease	Maintenance and strengthening of food hygiene measures	Integrated surveillance for human and animal diseases
Water-borne diseases	Risk assessment for extreme rainfall events	Increased microbiological and chemical monitoring of public water supplies and private wells, and enhanced surveillance during and following heavy rainfall events
	Risk assessment of health effects of algal blooms	

Table 6.1: Summary of public health adaptation measures in relation to the health impacts of climate change (applicable to European populations). (Haines et al., 2006)

Table 6.2 outlines the roles that family physicians could play in adaptation strategies. Clinical health professionals in Canada will likely be part of teams responding to emergencies related to extreme weather events. Depending on our success at adaptation, they might also see more asthma and other air pollution related illnesses, heat related illness, and some vector borne, and food and water borne diseases. But these increased demands will not need fundamental structural changes in health care delivery. Documenting these increases, through surveillance and monitoring along with our public health colleagues is important. We will need also to be involved in public education and awareness, research, health promotion, building public health infrastructure and emergency preparedness.

Family physicians could play the following roles in supporting adaptation strategies

- Public education and awareness
- Early alert systems (impending weather extremes and infectious disease outbreaks)
- Disaster preparedness including increasing the health system's "surge" capacity to respond to emergencies
- Enhanced infectious control programs (food safety, vaccine program, case detection and treatment)
- Improved surveillance: Risk indicators (e.g. mosquito numbers, aero-allergen concentration) and Health Outcomes (e.g. infectious disease outbreaks, rural suicides, seasonal asthma peakes)
- Appropriate health workforce training including mid-career development (e.g. updated understanding of climate influences on health or public health training. (Blashki et al., 2006)

Table 6.2. Primary health care adaptation strategies. (Blashki et al., 2006)

6.3. Mitigation

6.3.1 Introduction

Mitigation, in medical terms, could be seen as primary prevention – removing the precipitating cause of the health problem. In this cause, mitigation comprises the actions required to stabilize GHG concentrations in the atmosphere at levels that would prevent human made climate changes that pose risks to the sustainability and well-being of mankind. These interventions require a time frame for action, sufficient that natural ecosystems, as well as economic, social and human health are maintained. The United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto protocol is the international framework coordinating international mitigation efforts. (The IPCC coordinates the scientific reviews).

Actions to reduce CO2 atmospheric concentrations include both reduction of emissions, and increasing carbon sequestration. Mitigation, in health terms, is primary prevention; it deals with problems upstream from the health issues. In that respect, it is somewhat removed from health issues.

This section of the report will briefly outline societal mitigation efforts, and the urgency of the required changes. It will then discuss what we can do as individuals and families, and will discuss the ecological and carbon footprint.

The urgency of coordinated action in reducing GHG emissions and stabilizing carbon dioxide atmospheric levels has been stressed both by the Stern report and the IPCC.

A Planetary Emergency
"We, the human species, are confronting a planetary emergency – a threat to the survival of our civilization that is gathering ominous and destructive potential even as we gather here. But there is hopeful news as well: we have the ability to solve this crisis and avoid the worst – though not all – of its consequences, if we act boldly, decisively and quickly." Al Gore (on accepting the Noble Peace Prize - December 10 2007)

Important issues remain unresolved.

How high can we allow global average temperatures to go? 10C? 20C? At what level should we, or can we, stabilize atmospheric GHG concentrations? The Stern Report clearly states that GHG concentrations should be stabilized below 550 ppm CO2 equivalents (430 at present), and that any delay in reducing emissions would lead to significantly more future costs, and give rise to greater risks from dramatic climate change. Although there will be significant costs in reducing GHG, about 1% of the global GDP by 2050, the Stern Report suggests that this is manageable and consistent with continued growth and development, whereas unabated GHG emissions would pose significant risks to growth and development. (Stern Report and the IPCC, 2007)

6.3.2 Mitigation strategies: societal responses

Meaningful mitigation will require political will at all levels of government. It will also require major changes in the way we as a society do business, in increasing efficiency, reduced consumption, switching to low carbon technologies for power, heat and transport, and maintaining CO_2 sequestration such as reducing deforestation. We have a long way to go in this regard.

Then and Now

New technologies or mitigation interventions can have negative health consequences. For example, the building of dams for "green" hydroelectric power has, in some situations, led to an increased incidence of malaria in the population and caused displacement of populations. (Haines et al, 2006). In Canada there is an increase in the mercury content of fish in hydro-electric reservoirs. But there are significant gains to health, co-benefits, to be made through mitigation interventions. One example, of reducing air pollution, has been described previously. Other benefits of sustainable transportation include reduced motor vehicle accidents and weight loss from more walking and cycling. Mitigation efforts are compatible with sustainable development, and have the potential also to support appropriate development in the third world.

6.3.3 Mitigation strategies: individual and family responses

We are all citizens of the world. We need to be informed about the dangers of climate change. But equally important, we need to be empowered to do something about it! Al Gore, in his climate project, has suggested ten simple things that we all can do: (The Climate Project)

Al Gore has suggested ten simple things that we all can do:

TEN THINGS TO DO
Want to do something to help stop global warming? Here are 10 simple things you can do and how much carbon dioxide you'll save doing them.
Change a light Replacing one regular light bulb with a compact fluorescent light bulb will save 150 pounds of carbon dioxide a year.
Drive less Walk, bike, carpool or take mass transit more often. You'll save one pound of carbon dioxide for every mile you don't drive!
Recycle more You can save 2.400 pounds of carbon dioxide per year by recycling just half of your household waste.
Check your tires Keeping your tires inflated properly can improve gas mileage by more than 3%. Every gallon of gasoline saved keeps 20 pounds of carbon dioxide out of the atmosphere!
Use less hot water It takes a lot of energy to heat water. Use less hot water by installing a low flow showerhead (350 pounds of $CO2$ saved per year) and washing your clothes in cold or warm water (500 pounds saved per year).
Avoid products with a lot of packaging You can save 1,200 pounds of carbon dioxide if you cut down your garbage by 10%.
Adjust your thermostat Moving your thermostat just 2 degrees in winter and up 2 degrees in summer you could save about 2,000 pounds of carbon dioxide a year with this simple adjustment.
Plant a tree A single tree will absorb one ton of carbon dioxide over its lifetime.
Turn off electronic devices Simply turning off your television, DVD player, stereo, and computer when you are not using them will save you thousands of pounds of carbon dioxide a year.
Spread the word!

6.4 The carbon calculator

Another very useful and simple exercise is to calculate your Carbon Footprint. A Carbon Footprint is a measure of the impact human activities have on the environment in terms of the amount of green house gases produced, measured in units of carbon dioxide. Calculating one's Carbon footprint is a simple exercise, taking 5 to 10 minutes, and can be made specific for your household in Canada or anywhere in the world. It heightens awareness of one's own role in GHG emissions, thus increasing "carbon literacy", and in so doing, illustrating options for carbon use reduction. The **ecological footprint** is a similar exercise, with a broader focus beyond carbon. Physicians have been urged to get more involved, by becoming carbon literate, and even making medical conferences and research trials carbon neutral. (Roberts, 2006, Godlee, 2006, & Sustainable Trials Study Group, 2007)

A recent article in the British medical journal contains a simple carbon calculator. (Hillman, 2006) This

http://www.caronfootprint.com/calculator.aspx
http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview
http://www.safeclimate.net/calculator/index.php

and other resources are shown in the box below.

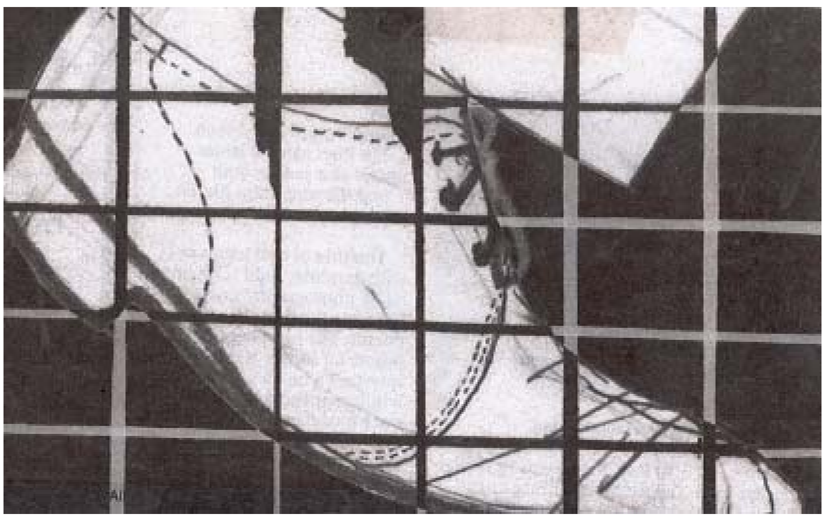


Figure 6.1

Physicians can set an example in reducing their carbon footprints, and their ecological footprints. The OCFP's Green Office Brochure lists 13 possible steps to take to "green" the office, including using energy efficient equipment, green transportation and water saving strategies. The health care system is a large part of the economy, and a large producer of fossil fuels in Canada. Healthcare institutions should be encouraged to reduce, reuse and recycle as much as possible.

Adaptation and Mitigation: What can family doctors do?

- Calculate your own ***carbon footprint***, and display this, and actions you plan to take to reduce it in your office
- Use active transportation as much as you can
- Encourage your patients to calculate their own carbon footprints. Ask them to become carbon watchers (like weight watchers)
- Encourage your colleagues, clinics and hospitals to promote the carbon footprint.

CHAPTER 7

THE ROLE OF FAMILY PHYSICIANS IN CLIMATE CHANGE

7.1. Introduction

On December 21 1968, Apollo 8 lifted off its launch site and became the first manned voyage to the moon. Three days later, on Christmas Eve, the first images of earth ever taken by man from outer space were broadcast worldwide. These were images that would forever transform the way we think about our planet and our relationship with it. A small, beautiful round island of reds, blues, greens and white in an endless sea of black made all of us suddenly realize that just as our collective home had, for millions of years, sustained us and a multitude of other life forms, so too it would now be our responsibility to look after that home for millennia to come.

This publication gives us a comprehensive review of the science of climate change, global warming, and the present and impending health effects that will be faced by each of us. The latest report of the Intergovernmental Panel on Climate Change (IPCC) was released on November 17, 2007 and formed the basis for intensive discussion at the United Nations Climate Change Conference held in Bali a few weeks later. That conference brought together over 10,000 participants from over 180 nations.

The 2007 report of the IPCC, bringing together a synthesis of three earlier reports examined the science behind climate change, the combined impacts, adaptations and vulnerabilities of various parts of the world, the potential mitigation of further changes, and the role of all national governments in the future decades ahead. These 600 leading world scientists who authored the report on climate change spoke with a single voice when they concluded: “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” As well, they concluded:

- “Global greenhouse gases (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.
- Carbon dioxide is the most important anthropogenic GHG. Its annual emissions grew by about 80% between 1970 and 2004.
- Most of the observed increase in globally-averaged temperatures since the mid 20th century is very likely due to the observed increase in anthropogenic GHG concentrations.”

Climate change and global warming will become major health issues in the decades ahead. On this point there can be no debate. Indeed, it may overwhelm all other health issues both locally and globally within the timeframe of our own careers. The central question we must ask ourselves is what our role should be as family physicians. At a time when human and financial health resources are already at a premium and when our time to manage an increasingly aged and complex population are constantly under stress, it is much to ask of ourselves, to take on an additional role within this emerging health care crisis. Perhaps at a time such as this, it is reasonable to look back at the Four Principles of Family Medicine, those guideposts that have chartered the course of our careers since their inception over five decades ago.

7.2. Skilled Clinicians

The first principle states that we should be Skilled Clinicians. We are instructed to make use of our "understanding of social systems" and have an "expert knowledge of the wide range of common problems in the community". Those social systems and common problems are about to undergo an unprecedented transformation, and a careful reading of this document will help prepare all of us for what lies ahead. Over the next few decades, we will each of us need to become increasingly proficient in diagnosis and management of a range of diseases that may have been less common and less part of the lexicon of our practices up until now. There will come a time, when we will have to know how to deal with increasingly common cardio-pulmonary disorders associated with extremely hot days and nights and the wide ranging health effects of cataclysmic climate events such as tornadoes, floods, droughts, and hurricanes including damage to public health infrastructures, water and food contamination, population displacement, and physical as well as psychological injuries. New diseases similar to West Nile Fever, which have never before been witnessed in temperate climates, may be introduced through various mechanisms. We will have to become increasingly more vigilant about our patients who may return from trips abroad carrying infections such as malaria, yellow fever, and dengue. A proliferation of rodents may require of us expert knowledge about conditions such as tularaemia and viral hemorrhagic fevers. The movement northward of tick-borne diseases will mandate that we become experts in conditions, such as Lyme Disease and tick-born Encephalitis. Flooding and its devastating effects on water quality will mean that we will need to know how to manage typhoid, cholera, and many other diarrhoeal illnesses that we have rarely seen in our daily practices up until now. Finally, the direct effects of air pollution itself will see an increase within our patient population of asthma, heart disease, various cancers, and strokes.

We must begin now the process of further enhanced education concerning these conditions so that we are ready to act effectively when they arrive in our communities. This education will be in the form of continued medical education for the present cadre of family physicians and as a new integral part of the curriculum for medical students and residents at our university health science centres.

7.3. Community Based Discipline

The second principle states that we are a Community Based Discipline. We are "to respond to changing needs, to adapt quickly to changing circumstances, and to mobilize appropriate resources to address patients' needs". No other group within the entire spectrum of health care personnel will be as involved at the grass roots level, as family physicians. We will be the first to see and begin to understand how the health effects of climate change are unfolding around us. It will be our responsibility to monitor these changes, giving crucial feedback to other medical and governmental organizations, and working in much more effective and innovative ways with other care providers, especially Public Health. More importantly, we must begin to understand how specific groupings of patients within our local and national communities are at far greater risk as vulnerable populations. The very young and the elderly, those with pre-existing medical conditions such as asthma and heart disease, individuals taking specific kinds of medications, the homeless and those living without access to air conditioning and/or clean water, aboriginal societies, those living in the northern parts of our country, and coastal communities must be identified now so that we will be able to monitor and intervene quickly when the need arises.

7.4. Resource to a Defined Population

The third principle describes us as a Resource to a Defined Population. Most significantly, this principle states that "family physicians have the responsibility to advocate public policy that promotes their patients' health". This is certainly going to be new territory for most of us. However, as both individual family physicians, and as a part of larger organizations such as the CMA, the CCFP, and WONCA, it is something we are going to have to understand as part of our increasingly important role in the future healthcare for our local and global societies. As family physicians, we are respected and credible leaders in health care in our offices, our communities, and beyond. Our patients listen to us when we speak individually, and our local, national, and international communities listen to us when we speak collectively. No individual or group has more potential influence in this area than we do. Each of us will have to decide what role we will take individually. For some, it may take the form of talking to patients when the opportunity arises, helping them to understand how they can help, and managing the increasingly common health issues evolving in our local and global communities. For others it may mean taking on leadership roles at the hospital or society levels. And for others, it may translate into being a go-to resource for colleagues, our medical schools, continuing medical education, the media, or the political spheres of influence. One thing is clear however. Our patients and the greater public will be looking to us for leadership in the decades ahead and we must start the process of imagining how each one of us will rise to the occasion.

7.5. Patient-Physician Relationship

Finally, the fourth principle states that the Patient-Physician Relationship is Central to our Role. Perhaps, the patient in this case, is Mother Earth herself. Taken in that context, the words of the Fourth Principle have a new meaning that we should all embrace. “The patient-physician relationship in family medicine has the qualities of a covenant, a promise, to be faithful to our commitment to the patient’s well being.” Those images from four decades ago of our little planet, surrounded by light years of emptiness, should remind us how amazing and yet how fragile our existence is, and how we all inhabit that single life boat. We need to take care of her, as she has taken care of us for millennia in the past and hopefully into the future as well. We each need to look at ways that can individually begin to make a positive difference in our contribution to making things better. We can be a positive example and role model for our families, our patients, and our communities. Each small step that we each take will contribute to the bigger picture and help ensure that this planet, the home we all share, will continue to provide sustenance and a future of endless wonderment for generations to come.

“For in the final analysis, our most basic common link is that we all inhabit this small planet. We all breathe the same air. And we all cherish our children’s future”

John F. Kennedy

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