

## SCIENCE NARRATIVE

# CLIMATE CHANGE IMPACTS ON THE HEALTH OF CANADIANS



PROTECTING AND EMPOWERING CANADIANS TO IMPROVE THEIR HEALTH

**TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP,  
INNOVATION AND ACTION IN PUBLIC HEALTH.**

—Public Health Agency of Canada

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Les incidences des changements climatiques sur la santé de la population canadienne*

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CLIMATE CHANGE IMPACTS  
ON THE HEALTH OF CANADIANS

Office of the Chief Science Officer



# TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY . . . . .</b>	<b>1</b>
<b>1.0 HEALTH IMPACTS OF CLIMATE CHANGE . . . . .</b>	<b>3</b>
1.1 INFECTIOUS DISEASE . . . . .	4
1.2 FOOD SAFETY AND SECURITY . . . . .	5
1.3 WATERBORNE DISEASE . . . . .	6
1.4 EXTREME WEATHER . . . . .	6
1.5 EMERGENCY MANAGEMENT, HEALTH SECURITY AND GLOBAL STABILITY . . . . .	7
1.6 CHRONIC DISEASE . . . . .	8
1.7 MENTAL HEALTH . . . . .	9
1.8 PHYSICAL ACTIVITY . . . . .	10
<b>2.0 ADDRESSING CLIMATE CHANGE RISKS TO HEALTH . . . . .</b>	<b>11</b>
2.1 ADAPTATION MEASURES AND STRATEGIES TO PROTECT HEALTH . . . . .	11
2.2 HEALTH ADAPTATION IN CANADA . . . . .	15
2.2.1 ASSESSING IMPACTS AND VULNERABILITIES . . . . .	15
2.2.2 PREPARING FOR THE IMPACTS . . . . .	16
2.2.3 COMMUNICATING HEALTH RISKS TO THE PUBLIC . . . . .	16
2.2.4 HEALTH RELATED RESEARCH NEEDS . . . . .	17
<b>3.0 SOCIETY, CULTURE AND BEHAVIOUR . . . . .</b>	<b>19</b>
<b>4.0 CLIMATE CHANGE, HEALTH AND AN INTEGRATED APPROACH . . . . .</b>	<b>21</b>
<b>5.0 FUTURE CONSIDERATIONS . . . . .</b>	<b>23</b>
<b>6.0 REFERENCES . . . . .</b>	<b>25</b>
CITED REFERENCES . . . . .	25



# EXECUTIVE SUMMARY

There is considerable science-based evidence that the global climate is changing, with increasing overall temperatures, increasing carbon dioxide and other greenhouse gases, and altered patterns of precipitation. The *Lancet Commission* (2015) speaks to the many and serious impacts of climate change on health, and how addressing these could be “the greatest global health opportunity of the 21<sup>st</sup> century”. Extreme weather events and increased climate variability associated with climate change exacerbate current public health challenges globally, and present new risks to populations. For Canada, various effects of climate change play a significant compounding factor that negatively affects the health and resilience of vulnerable communities. Notable direct and indirect impacts include:

- Droughts and flooding and the links with incidence of water-borne diseases and to psychosocial effects
- Food security and the nutritional status of individuals, which further undermine resistance to diseases
- Heat-related morbidity and mortality as well as compounding health issues related to poor air quality such as asthma, allergies, respiratory diseases, cancer, cardiovascular diseases and stroke
- The spread of disease vectors favouring the emergence and re-emergence of infectious diseases
- Natural disasters and the loss of land, cultural heritage, natural resources and property with significant impact on mental health and well-being
- Special challenges and impacts on northern Canadians such as dangerous travel, damaged infrastructure, threats to traditional food sources, disappearance of drinking water sources and related psychosocial and cultural impacts
- Sustainable healthcare in a changing climate presents future risks to Canadians as its capacity is strained in various ways (aging population, resource intensive infrastructure, budget constraints)



As the impact of climate change further highlights weaknesses in many systems, a social determinants of health approach to considering the changing climate would add great value in national efforts toward reducing vulnerability and risk (e.g. addressing food security, availability of potable water, safe housing, working conditions, stable income, and sustainable development). This would support a more integrated or horizontal approach whereby adaptation frameworks are informed by different perspectives. Many authors argue that most mitigation and adaptation responses to climate change are “no-regret” options, which lead to direct reductions in the burden of ill-health, enhance community resilience, alleviate poverty, and address global inequity. It is important for all sectors to bring their unique positions and perspectives together to define future considerations in governance and actions towards successful adaptations for mitigating health impacts of climate change in Canada and globally.

## 1.0 HEALTH IMPACTS OF CLIMATE CHANGE

Risks to the health of Canadians from climate change include direct and indirect illnesses<sup>1</sup> and deaths related to poor air quality, water- and food-borne contamination, changing patterns of diseases spread by animals, ticks and insects, and extreme weather events including extreme heat events and urban heat islands. Human-generated greenhouse gas emissions<sup>2</sup> (GHGs) contribute to climate change and these gas emissions derive in part from aspects of the built environment<sup>3</sup> such as transportation systems and infrastructure, building construction and operation, and land-use planning (1,2).

Special challenges and impacts on northern Canadians are already being observed such as more dangerous travel (unusual changes in ice, snow and land conditions), damaged infrastructure due to permafrost melt, threats to traditional food sources, disappearance of drinking water sources and related-psychosocial and cultural impacts. Those most vulnerable are facing several compounding risks such as chronic health conditions, multiple environmental hazard exposures, the extremes of age, socio-economic deprivation, physical and/or social isolation. Sustainable healthcare in a changing climate presents further risks to Canadians as its capacity is strained in many ways such as from the aging population, resource intensive infrastructure, professional needs and budget constraints (1).

Key areas of health risks linked to climate change are now examined.



<sup>1</sup> Such as: asthma, respiratory allergies, and airway diseases, cancer, heat-related morbidity and mortality, human developmental effects, cardiovascular disease and stroke, mental health and stress-related disorders, foodborne diseases and nutrition, neurological diseases and disorders, vector-borne and zoonotic diseases, waterborne diseases, weather-related morbidity and mortality.

<sup>2</sup> These are gases that trap heat in the atmosphere.

<sup>3</sup> The built environment means the buildings, transportation systems, energy systems, open space, and agricultural lands that make up and support our communities (*Toronto Public Health; [www1.toronto.ca/wps/portal/contentonly?vgnextoid=d06e23bf6d481410VgnVCM10000071d60f89RCRD](http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=d06e23bf6d481410VgnVCM10000071d60f89RCRD)*)

## 1.1 INFECTIOUS DISEASE

There is consensus that climate change is affecting human health. The linkages between public health and climate change are complex and interact with other factors. Arthropod-borne diseases are infections spread by insect (e.g. mosquitoes and sandflies) or arachnid (e.g. ticks) vectors. Major shifts in the epidemiology of several vector-borne diseases and appearances on new continents have been predicted as a result of climate change (3,4). Climate change is likely to have both direct and indirect impacts on the burden of West Nile fever, dengue, Chickungunya fever, malaria, leishmaniasis, tick-borne encephalitis, Lyme borreliosis, Crimean-Congo haemorrhagic fever, spotted fever rickettsioses, Yellow fever, Zika and Rift Valley fever (5,6). Population mobility is a main factor in globalization of public health threats and risks due to infectious diseases. Traditional health policy approaches have focused on diseases of global public health significance such as tuberculosis, Yellow fever, and cholera; however, new diseases and resistant organisms challenge existing approaches. Clinical implications and health policy challenges associated with movement of persons across barriers permeable to products, pathogens, and toxins (e.g. geopolitical borders, patient care environments) are complex. Outcomes are complicated by high numbers of persons who move across disparate and diverse settings of disease threat and risk. Existing policies and processes merit an approach to global public health risk management that integrates population factors with effective and timely application of policies and processes (7,8).

The incidence, outbreak frequency, and distribution of many infectious diseases are generally expected to change as a consequence of different factors related to climate change. Temperature and precipitation patterns influence food- and water-borne diseases. Changes in seasonal precipitation and temperature influence vector-borne diseases through *i.* effects on vector survival, reproduction rates, habitat suitability, distribution, and abundance; *ii.* the intensity and temporal pattern of vector activity (biting rates); and *iii.* rates of pathogen development, survival, and reproduction within vectors. The projected climate changes may shift the distributional ranges of vector-borne diseases (5,6). As an example, the number of tick-borne diseases of humans has increased in incidence and geographic range over the past few decades, and there is concern that they will pose an even greater threat to public health in the future. Global warming is often cited as the underlying mechanism favouring the spread of tick-borne diseases, as climate will influence which tick species are found in a given geographic region, their population density, the likelihood that they will be infected with microbes pathogenic for humans, and the frequency of tick-human contact. Changes in climate will influence spread and survival of other insect vectors including mosquitoes, fleas, sandflies, tsetse flies, and houseflies, known to carry highly pathogenic microorganisms infecting man. Given the pace of international travel the global consequences to these changes are currently unknown. Another concern with increasing temperatures is that ancient bacteria and viruses could re-emerge and revive as global warming melts ice at the poles exposing long dormant organisms. An example is the August 2016 Anthrax outbreak in the Russian Federation which was triggered by ice melt in temperatures of 35°C in the Arctic Circle<sup>4</sup>. This brought anthrax spores to the surface. Animal contact with those spores and then subsequent human infection resulted in the hospitalisation of 97 people and a child's death. These situations highlight similar potential risks to vulnerable populations living in areas with diminishing ice cover and thawing permafrost.

<sup>4</sup> Anthrax outbreak triggered by climate change kills boy in Arctic Circle. 1Aug2016 The Guardian  
[www.theguardian.com/world/2016/aug/01/anthrax-outbreak-climate-change-arctic-circle-russia](http://www.theguardian.com/world/2016/aug/01/anthrax-outbreak-climate-change-arctic-circle-russia). Accessed 5Oct2016

## 1.2 FOOD SAFETY AND SECURITY

There are other diseases that are likely to be exacerbated in a warmer world including food-borne and respiratory diseases. It has been shown that reported cases of salmonellosis and campylobacteriosis peak in the hot summer months and that this association was observed at temperatures greater than 37.5°C (9). In Canada, some experts may consider the effect of climate change on food-borne diseases to be minimal providing appropriate food handling and storage procedures and improved food hygiene (10).

Indigenous Peoples are among the most vulnerable to climate change and experience distinctive challenges (11), particularly those living in remote locations. A range of factors that apply to each vulnerability assessment are layered with issues that are unique to Indigenous communities and culture to varying degrees. These may include reliance on the rapidly changing natural environment for cultural, social, mental and physical health and well-being, and livelihoods. Historical legacies have influenced development of Indigenous communities in Canada. Many have a number of socio-economic challenges, including disproportionate fiscal and population pressures; sub-standard infrastructure; and limited access to health services (12). Many of these factors are exacerbated by the more dramatic impacts of climate change in extreme environments. Food security and access to potable water are fundamental to health. Store-bought food and water are extremely expensive in remote areas. This combined with decreased access to traditional food sources and increasingly expensive and undependable conditions for safe and affordable transportation in remote regions are deepening existing food and water security concerns (13). Household food insecurity has been associated with a range of poor physical and mental health outcomes, including multiple chronic conditions and depression (14,15).



## 1.3 WATERBORNE DISEASE

Waterborne diseases are also likely to be influenced by climate change. The importance of climate as a driver of disease risk is derived from observations that waterborne disease outbreaks are often preceded by heavy rainfall. This link is likely to be most obvious for inadequately treated water or small rural supplies. Several authors have pointed out links between cholera and climate variables especially with higher temperature and rainfall, flooding and major climatic cycles such as El Niño. Cyanobacteria are present in drinking and recreational waters and most reported human cases were associated with observable cyanobacterial blooms with known neurotoxicity. The impact of droughts on health through reduced agricultural productivity and access to water in affluent countries is not clear, but effects in resource poor countries are likely to be dramatic (16).



## 1.4 EXTREME WEATHER

Extreme weather events pose particular challenges to populations. The frequency and intensity of extreme weather events is predicted to rise as a result of climate variability. Beyond physical damage, effects of disasters such as floods, extreme droughts, storms and hurricanes on human health seem to be mostly indirect (mediated through vector and waterborne diseases). Acute injuries, fatalities and mental health illnesses are also significant public health outcomes and their management and prevention require disaster preparedness and response planning (17,18).

Disasters significantly impede progress towards sustainable development (19). This is of particular relevance internationally through the sustainable development goals and nationally through the revised Federal Sustainable Development Strategy<sup>5</sup>. Evidence indicates that exposure of persons and assets in all countries has increased faster than vulnerability

<sup>5</sup> Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada.  
[www.fsds-sfdd.ca/index.html#/en/detail/all/](http://www.fsds-sfdd.ca/index.html#/en/detail/all/)

has decreased, thus generating new risks and a steady rise in disaster related losses, with a significant economic, social, health, cultural and environmental impact in the short, medium and long term, especially at the local and community levels. Recurring small-scale disasters and slow-onset disasters particularly affect communities, households and small and medium-sized enterprises, constituting a high percentage of all losses. All countries are faced with increasing levels of possible hidden or unanticipated costs and challenges in order to meet financial and other obligations (19).

## 1.5 EMERGENCY MANAGEMENT, HEALTH SECURITY AND GLOBAL STABILITY

Between 2008 and 2012 there were 144 million people displaced by disasters (20) with people in vulnerable situations affected disproportionately. This represents a population larger than the combined populations of Britain and France. For some disasters the effect of the displacement can be indirect such as with environmental refugees, or that new conflicts arise due to scarcity of basic resources (20). The problems of heat stress and heat stress-related mortality are considered an area of major direct impact because of the severity of the outcome (death) and increased pressure on governments to respond. An example is the intense 2003 European heat wave, which caused the death of more than 35,000 mainly elderly persons (21).

Event coincidence analysis was used to investigate data from armed-conflict outbreaks and climate-related natural disasters for the period 1980–2010 (22). A coincidence rate of 9% regarding armed-conflict outbreak and disaster occurrence such as heat waves or droughts was observed. During this period, about 23% of conflict outbreaks in ethnically highly fractionalized countries robustly coincided with climatic calamities. Although climate-related disasters do not act as direct triggers of armed conflicts, the disruptive nature of these events seems to play out in ethnically fractionalized societies in a particularly tragic way. This observation has important implications for future security policies as several of the world's most conflict-prone regions, including North and Central Africa as well as Central Asia. Both of these areas are exceptionally vulnerable to anthropogenic climate change and characterized by deep ethnic divides (22).

Medical countermeasures (MCMs), such as anthrax vaccine, are therapeutic products (i.e., drugs, vaccines, and medical devices, as defined by the *Food and Drugs Act*) which aim to prevent, mitigate or treat the adverse health effects of a public health event or emergency. Globally, MCMs play a critical role in addressing all manner of health security threats. This is highly relevant with regards to climate change impacts on the evolving public health threat and risk landscape. Increased movement of people and goods leads to increased risk of disease transmission; emerging and re-emerging infectious disease outbreaks, including antimicrobial-resistant pathogens; and increased risk of terrorism threat agents due to evolving geo-political landscapes. Ongoing awareness and foresight in ensuring that effective and relevant MCMs are developed and acquired for use to protect Canadians is a key area of responsibility for the federal government.

The uncertainty and potentially extreme impacts of these types of events on health security in Canada and globally are important considerations in emergency preparedness and response systems' evolution, innovation and responsiveness.

## 1.6 CHRONIC DISEASE

There is an emerging literature about the pathways by which climate change can have an impact on health and non-communicable diseases (18). For example air pollution, increased heat exposure and changes to agricultural systems (land use) have been linked to the built environment (23) with aspects such as walkability, travel, and vehicle emissions. Furthermore, scientific evidence has linked air pollution to cardiovascular diseases (24), asthma and lung cancer (25), neurological diseases (26), diabetes (26) and symptoms of depression (27). Air pollution is also associated with decreased physical activity among adults of normal weight (28).

Extreme heat events have been linked to increases in hospital admissions for respiratory, kidney and heart-related conditions (28); the effects can be made worse due to the urban heat island effect and the types of built structures and the materials used (23). Urbanization, with its high levels of vehicle emissions, extreme temperatures and westernized lifestyle, is linked to the rising frequency of respiratory allergic diseases and cardiovascular disease observed over recent decades in most industrialized countries. Concentrations of air pollutants (mainly ozone and particulate matter) increase with greenhouse gas emissions and higher temperatures (24). The main driver of respiratory disease is air pollution itself rather than climate change and the main intervention for respiratory diseases is emission reduction.

There is a risk of increased exposure to toxic chemicals, known or suspected to cause cancer, that are released into the environment following thawing permafrost, heavy rainfall or flooding and by increased volatilization of chemicals under conditions of increased temperature (25). Cancer, diabetes, cardiovascular disease and respiratory disease are the leading causes of preventable death and disability in Canada (26). Reducing risk of these chronic diseases through innovations to the built environment, active living and personal behavioural change present a unique opportunity for strategic public health innovation (28). This presents a classic example of possible health adaptations to climate change that both reduce vulnerability and enhance community resilience.

## 1.7 MENTAL HEALTH

Climate change affects mental health due to changes in the prevalence and severity of natural disasters on human settlements. These events can cause anxiety-related responses and later potentially lead to chronic and severe mental health disorders, with implications for mental health systems and supports (27). These effects will fall disproportionately on individuals who are already vulnerable, especially for Indigenous people and those living in low-resource settings (30). Additionally, individuals might feel a distressing sense of loss that people experience when their land is damaged and they lose amenities and opportunity (31). The mental health effects of these losses are becoming evident in many Indigenous communities where connectivity to the land is integral to psychological, physical and cultural wellbeing. Changing climatic conditions are causing a variety of changes to the land, sea and snow environments, which are impacting the security of spirituality, food, travel and culture (14). Elevated levels of anxiety, depression, and post-traumatic stress disorders have been reported in populations who have experienced flooding and during slow-developing events such as prolonged droughts; impacts include chronic distress and increased incidence of suicide (32,33). Even in high-income regions where the humanitarian crisis might be less, the impact on the local economy, damaged homes, and economic losses can persist for years after natural disasters (34). Government and agencies now emphasise psychological and psychosocial interventions within disaster response and emergency management. Social adaptation processes can mediate public risk perceptions and understanding, psychological and social impacts, coping responses, and behavioural adaptation (35).



## 1.8 PHYSICAL ACTIVITY

As the climate changes, various impacts on the ability to be physically active, as well as impacts on those who are being physically active, are in evidence. Conditions that are known to be associated with physical activity, such as obesity, pulmonary and cardiac health, and mental health are thus being influenced both directly and indirectly by climate change.

Outdoor activities can be limited by increased heat and air pollution (36). Longer-term shifts in environmental conditions, such as shorter seasons with snow and ice, can both provide opportunities for some outdoor activities (hiking, walking, cycling) or decrease others and their hazards (skiing, snowmobiling; sunburns, avalanche risk). A significant source of climate change comes from private motor vehicles emissions and home energy expenditure (e.g. home heating and cooling). Urban planning, which supports more compact living and sustainable transportation such as transit and active transportation, would reduce greenhouse gas emissions and encourage greater physical activity and its associated health benefits (37). As a result, benefits from policies and programs aimed at mitigating climate change at the individual level, and particularly in the transportation sector, also have the benefit of increasing active transportation and as a result physical activity levels (38).



## 2.0 ADDRESSING CLIMATE CHANGE RISKS TO HEALTH<sup>6</sup>

*"Much of the potential health impact of climate change can however be avoided through a combination of strengthening key health system functions and improved management of the risks presented by a changing climate."<sup>7</sup>* As the climate continues to change and impacts on health are increasingly evident, adaptation is needed to reduce growing risks to vulnerable populations and communities.

Successful adaptation requires intersectoral collaboration (e.g. health, environment, planning, transport, infrastructure) on monitoring and surveillance of climate change health outcomes, addressing root causes that limit preparedness (e.g. poverty), identification of vulnerable populations, reducing uncertainty through increased research on impacts, educating the public and decision makers about potential disasters and the benefits of preparedness, and the financing of needed measures. Adaptations are most effective when they maximize co-benefits (e.g. increase social capital, improve urban design) that address related health concerns, and when they are mainstreamed into existing programs and planning. For instance, federal departments are mandated by the *Cabinet Directive on the Environmental Assessment of Policy, Plan, and Program Proposals* (*Cabinet Directive*) to complete Strategic Environmental Assessments (SEAs) for all policy, plan, and program proposals (39). Completing a SEA (40) ensures that decision makers at all levels have taken economic, social, and environmental considerations into account to make informed decisions in support of sustainable development.

### 2.1 ADAPTATION MEASURES AND STRATEGIES TO PROTECT HEALTH

There is now a large body of scientific work to frame the concept of adaption in a changing climate. Decision makers across health issue files and different levels of government have exchanged knowledge and promising practices in health promotion, public health intervention, and emergency management. Despite this, Canada does not have a comprehensive and systematic framework to address the interface between climate change and health. In moving towards this, it is important to have a shared understanding of key concepts that underpin this process.

**Adaptation** to climate change is commonly defined as 'the process of adjustment to actual or expected climate and its effects, in human systems in order to moderate harm or exploit beneficial opportunities, and in natural systems human intervention may facilitate adjustment to expected climate' (41).

<sup>6</sup> Section 2.0 is adapted from 'Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation' (2014).

<sup>7</sup> Protecting Health from Climate Change. Vulnerability and Adaptation Assessment. 2013. WHO Report

**Vulnerability** is commonly defined as the degree to which a system or person is susceptible to, or unable to cope with, the adverse effects of climate change (42). This definition considers demographics, geographical circumstances, effectiveness, and coverage of the health-care system, pre-existing conditions, and socioeconomic factors such as inequity (43).

**Resilience** is commonly defined as the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to still retain essentially the same function, structure, identity and feedbacks. Resilience has also been referred to as the ability of human communities to withstand external shocks to their social infrastructure (44). Resilience includes the capacity of a system to not only absorb a disturbance, but to innovate and transform (45).

Adaptive actions to address climate change in the health sector require action across the whole spectrum of public health core functions (promotion, protection, prevention, public health surveillance and emergency preparedness) (46). The scale up of adaptive actions to Federal/Provincial/Territorial (F/P/T) jurisdictions has been currently limited by the breadth and depth of the knowledge uptake as well as cross disciplinary application, commonly referred to as "mainstreaming". Understanding of adaptation options that can be taken by public health and emergency management officials to build resilience has increased, although information about adaptation success is limited. Measures identified in recent literature address climate change risks to health, and build upon the list of public health adaptations presented by Séguin (2008) (1). Overall, new adaptation areas of focus by public health officials and researchers include:

- Horizontal cross-cutting needs to understand vulnerability and strengthen resilience such as: Vulnerability assessments of high risk populations; Actions to address secondary health effects of climate hazards such as psychosocial impacts; Use of new technologies to facilitate adoption of individual adaptive behaviours (e.g. use of automated devices in cars to warn of water depth or landslide early detection systems); Advice to health care providers about actions they can take to reduce climate-related health risks; Emergency management planning measures tailored to increase the resiliency of health care facilities from climate change; and Identification of preventative measures to reduce harmful exposures before negative health outcomes occur (e.g. infrastructure development such as green roofs to reduce the urban heat island)
- Extreme heat and air pollution such as: Health impacts from higher temperatures, increased frequency and severity of heat waves, increased air pollution; Air conditioning, during extreme events, with the caveat that seasonal use contributes to climate change and air pollution through greater use of fossil fuel; additionally seasonal use interrupts the human body's ability to acclimate to regional weather which increases the individual's vulnerability; Better quality housing stock, appropriate infrastructure with the ability to capture energy and recycle water; Infrastructure development such as green roofs, reflective road and building surfaces, urban green spaces, interior air sealing, use of elastomeric roof coating; Public awareness and education campaigns to promote personal protection from air pollution (e.g. Air Quality Health Index or AQHI<sup>8</sup>); Vulnerability assessments of high risk regions/populations; Physician attention

<sup>8</sup> Definitions as per Environment and Climate Change Canada. [www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=CB0ADB16-1](http://www.ec.gc.ca/cas-aqhi/default.asp?lang=En&n=CB0ADB16-1). Accessed 3Oct2016

to vulnerable patients, pre-summer vulnerability assessments, advice on routine care, education of health risks and appropriate behaviours; Development and use of vulnerability maps to allow targeting of vulnerable populations; and, Promotion of social capital development

- Wildfires, such as: Increased contact with fire/fire front and evacuations; Avoid building in vulnerable locations; Access to appropriate clothing, fire shelters (e.g. bunkers), and equipment (e.g. particle filtering masks) for high risk areas; and, Infection control, disease surveillance and appropriate emergency accommodation
- Increases in air pollution, such as: Relocation to clean air locations such as office, libraries, etc.; Use of air conditioners, especially reverse cycle air conditioners set to recycle mode to filter air particles; Avoidance of exercise in affected environments; Spending less time outdoors; and, Use of air masks
- Drought, such as: Distribution of public awareness materials/public service announcements, public education programs; Decreased availability and quality of water; Physical relocation of individuals/families to non-drought affected areas; School-based mental health programs in rural areas, participation of trusted adults who understand drought, early identification of mental health problems and referral; and, Training in coping mechanisms
- Decreased availability and higher costs for fresh fruits and vegetables (for consumers), such as: Technological advances to increase production in new climate conditions; and, Improved food delivery systems
- Increase in water-borne pathogens and water contamination, such as: Boil water advisories; and, Monitoring of gastroenteritis
- Increase in drought and temperature enabled vector-borne disease such as: Public education; Vector control (e.g. mosquito spraying); Medical prophylaxis and treatment; and, Vaccination
- Floods, such as: Flood-appropriate building and infrastructure construction standards for vulnerable areas (e.g. higher level bridges and causeways, water resistant emergency power); Physical and mental health impacts from increased flood incidence rates and



severity; Early warning systems based upon weather predictions of flooding, landslides, river flooding and coastal flooding; Flood evacuation plans, especially for nursing homes, hospitals, schools; Proper design and siting of health infrastructure; Assessment of the resiliency of health care facilities to climate change; Education of health risks and appropriate behaviours by physicians; Mapping of high risk populations with 100- and 500-year flood zones; Post-flood disease surveillance; Use of automated devices in cars to warn of water depth, landslide early detection systems; Disaster mental health services that is sensitive to socioeconomic status, livelihood patterns, local traditions, cultures and languages; and, Immediate family reunion and support (for families that have been separated)

- Increased mold and respiratory contaminants from mold, bacteria, fungal growth on damp structures, such as: Inspection of heating, ventilating and air conditioning system (HVAC) by a professional after a flood; and, Drying out homes using fans or dehumidifiers when safe to do so
- Zoonoses and vector-borne diseases, such as: Spread of vector-borne and zoonotic diseases, including exotic diseases; Development of new surveillance methods; Dissemination of information for public health officials and the public; and, Tools for risk-based decision making on management (i.e. surveillance, prevention and control) of emerging/re-emerging zoonoses/VBDs (e.g. Multi-Criteria Decision Analysis), prioritization of zoonoses/VBDs for public health action, and weather-based forecasting of West Nile Virus
- Food and water quality, such as: Increased water contamination and water-borne diseases, contamination of food; Protocols for chemical and contaminant risk management; Monitoring of harmful algae bloom outbreaks; Boil water advisories; Expanding water reuse systems to offset reduced supply, increased demand, or both; Improving or expanding water treatment regimes; Adopting alternative energy sources at treatment plants (e.g. diversifying power sources, adding energy-efficient water pumps); Establishing collaborative management regimes with power suppliers; and, Abandoning or enhancing water infrastructure at risk



## 2.2 HEALTH ADAPTATION IN CANADA

An international comparison of health adaptation activities among developed countries listed in the United Nations Framework Convention on Climate Change (UNFCCC) reported that Canada is further ahead of many countries in efforts to protect health from climate change (47). Specifically, it is one of the leading countries with respect to the depth of research being led on vulnerability, to the impacts of climate change and adaptation options within the health sector. It is also one of the few countries to recognize and develop specific adaptation options around vulnerabilities of Indigenous Peoples. Health adaptation efforts ongoing at federal, provincial, territorial and local levels related to assessing vulnerabilities, preparing for the impacts and communicating health risks to Canadians were examined. Neither a comprehensive inventory of all local and regional adaptations (e.g. infectious disease surveillance, emergency management programs), nor a comprehensive assessment of the state of health adaptation in Canada are available at this time. However, communities can draw from information from various sources in order to set priorities, select appropriate strategies and implement them in a sustainable manner as a complement to existing programs, to protect and enhance health in their respective jurisdictions.

### 2.2.1 ASSESSING IMPACTS AND VULNERABILITIES

Climate change and health vulnerability assessments help identify populations in a community or region who are vulnerable to the impacts, gauge the effectiveness of existing interventions and programs, identify additional measures necessary to respond to climate change, strengthen capacity to take action, and provide a baseline of information to monitor adaptation progress. The World Health Organization (WHO) recently released new guidelines for assessing health vulnerabilities to climate change and adaptation options and Health Canada released guidelines for assessing the vulnerability of communities and individuals to extreme heat. Such assessments rely on monitoring and surveillance data illustrating health impact trends associated with climate variability and change. Gaps in data exist for many climate change impacts of concern to Canadians. Cheng and Berry (2013) have identified a key basket of climate change and health indicators that can be used by health authorities to track impacts on health over time (25). At present, few health authorities at regional and local levels have conducted full climate change and health vulnerability assessments. Analysis of possible health impacts from climate change have been undertaken in British Columbia (48). Ontario's Adaptation Strategy and Action Plan 2011–2014 (49) recognized extreme heat events as a key health concern and committed to the creation of a heat vulnerability assessment tool. At the local level, Peel Public Health (Ontario) used the new WHO guidelines to conduct a health vulnerability assessment that will contribute to implementation of the Region of Peel Climate Change Strategy (50). In addition, some public health authorities and their partners are currently undertaking or have undertaken research projects that contribute to knowledge of local vulnerability to specific health impacts. Expertise on climate change and health issues is growing and many universities and organizations across Canada are undertaking research in this area.

## 2.2.2 PREPARING FOR THE IMPACTS

Protecting health from climate change impacts requires “mainstreaming” climate change considerations into existing risk assessment and management activities. Mainstreaming is based on “flexible” adaptation and institutional learning, which is responsive to changing risks to health, climate surprises, and individual- and community-level vulnerabilities. Mainstreaming aims to reduce duplication and contradictions between existing public health interventions and new adaptations developed in response to climate change. Evidence of mainstreaming in provincial and territorial policies, regulatory instruments and planning tools includes Strategic Direction 1 in the *“Quebec In Action – Greener by 2020: Government Strategy for Climate Change Adaptation”* (51) that integrates climate change adaptation into government administration by modifying, where needed, the content of laws, regulations, strategies, policies, and planning tools. In Nunavut, the climate change adaptation plan requires all departments and agencies to “[...] integrate climate change projections, impacts, and best practices in all levels of their decision-making in order to implement a comprehensive response to climate change” (52).

One study in Ontario found evidence of adaptation through the mainstreaming of climate change into existing public health programs (50). Outside of government, the Insurance Bureau of Canada is developing a municipal risk assessment tool (53) that can help community decision makers use climate change information to address infrastructure vulnerabilities to projected flood events. Other initiatives also contribute to reducing health risks from climate change. Many health authorities utilize HARS (heat alert response systems), air pollution monitoring activities, and programs to raise awareness of vector-borne diseases, which helps to manage a range of climate-related impacts.

For example, the provinces of Manitoba, Quebec, and Nova Scotia have provincial HARS (50) in place while Alberta is initiating one, and health authorities in Ontario are collaborating to maximize the effectiveness and integration of local systems. In addition, some activities that were not developed with the primary purpose of protecting health can indirectly help to improve health and wellbeing and thereby reduce the impacts of climate change (e.g. Drought Response Plan by the British Columbia Inter-Agency Drought Working Group) (54). New approaches and tools have been developed that could facilitate efforts to assist vulnerable groups in Canada and improve understanding of adaptation options at the individual and community levels.

## 2.2.3 COMMUNICATING HEALTH RISKS TO THE PUBLIC

There are few formal evaluations of public education efforts to reduce health risks associated with climate change. Those that have been completed show mixed results. A study of the education campaign in Montreal, Quebec indicated that people who have been exposed to education materials were more likely to take protective measures against heat through, for example, the use of lightweight clothing, avoiding strenuous exercise, taking a shower or bath to cool down, and hydration. However, other studies suggest that while knowledge of heat warnings is very broad (>90%), protective actions taken by individuals are inadequate or that perceptions of health risks are generally low and the adoption of preventative actions is not widespread.

Research on levels of public awareness and the effectiveness of health promotion campaigns related to air quality advisories, food safety and reducing risks from vector-borne diseases show similarly mixed results. Public awareness messaging on climate-related risks can be contradictory (e.g. exercising later in the day to avoid extreme heat versus not going outdoors at night to avoid contracting West Nile Virus). To maximize effectiveness, health promotion programs should develop consistent messaging across health issue areas.

## 2.2.4 HEALTH RELATED RESEARCH NEEDS

Over the last 15 years, calls for expanded research efforts on climate-related health risks have resulted in a growing body of research to help guide actions to protect the health of Canadians. Many gaps in health related research areas would still benefit from integration and collaboration with non-health sectors, as well as across government, academia and the private sector. Strides have been made in the areas of air quality, extreme heat, and the understanding of some climate-related infectious diseases. Although it is important to understand and recognize how far Canada has come, knowledge development has not been uniform among issue areas nor across regions of Canada. The following examples are recognised gaps where integrated research could maximise efficient delivery of diversely useful outcomes.

- **Air Quality:** Estimates of the contribution of black carbon emissions in Canada originating from sources such as: Open biomass burning and wood stove burning; Identification of the extent of proliferation, impact and allergenicity of aeroallergen-producing plants as warming continues; Identification and monitoring of potentially invasive fungal diseases that could establish with climate change; Understanding of the effects of various GHG mitigation and adaptation activities (e.g. energy efficiency trade-offs, green roofs) on ambient and indoor air quality and associated health impacts; Understanding of how heat and poor air quality interact to impact health and adaptive strategies to reduce health risks; and, Identification of how dampness and temperature affect degradation of materials in buildings and how indoor material product design may affect human exposure to chemicals.
- **Food and Water Quality:** Understanding of the impact of water contaminants on human health and monitoring of illnesses; Monitoring of food-borne illness cases to reduce underreporting, including attention to emergence or re-emergence of specific diseases; Knowledge of the impacts of climate change on food and water security in northern and southern Canada; Understanding of the capacity and preparedness of water utilities to adapt to climate change; and, Defining the characteristics of resilient water and food management systems.
- **Zoonoses and Vector-borne Diseases:** Surveillance for zoonoses, vectors and vector-borne diseases, including attention to emergence of novel diseases; Basic and applied research studies to inform the development of surveillance, prevention and control methods, vaccines and licensed products for vector control; and, Enhanced capacity to train highly qualified personnel for both research and public health activities.
- **Natural Hazards:** Improved projections of extreme weather events due to climate change and modelling of possible health impacts; Surveillance of direct and indirect health impacts from extreme weather-related events; Interdisciplinary (psychology, social work, community

development, health promotion, emergency management) research on the effects of natural hazards on psychosocial health; and, Understanding of climate-resilient infrastructure that is protective of human health.

- **Vulnerable Populations:** Definition of robust environmental health indicators of climate change to monitor impacts on individuals and communities and develop adaptive measures; Understanding of how the nature of vulnerabilities to the health impacts of climate change for specific groups are changing in order to inform new protective measures for such populations; Understanding how current perceptions and attitudes about climate change and health risks influence the adoption of adaptations; and, Longitudinal studies across different demographic groups (children, elderly, urban, rural and outdoor workers) to identify health impacts from slow developing hazards (e.g. drought) and cumulative effects of climate change (e.g. extreme heat, drought and wild fires).



## 3.0 SOCIETY, CULTURE AND BEHAVIOUR

Global climate change impacts on human and natural systems are predicted to be severe and far reaching. The most physically and economically vulnerable will be affected disproportionately. Adaptation and mitigation are two strategies that society can employ to respond to these threats. Importantly, these approaches must take diversity in society, and cultural norms, practices and preferences into account to ensure uptake and success. Industry, commerce, and government play indispensable roles in these actions but outcomes are ultimately dependent on individuals and receptivity to behavioural changes. Thus, the climate change discourse could be framed from a health perspective to motivate behaviour change (55). There is however, little evidence on how to change behaviours that contribute to climate change (56). In considering the broader scientific discourse on the determinants of behaviour and behavioural change, four themes stand out<sup>9</sup>.

First, knowledge deficits are not the primary barrier to action; knowing about the causes and consequences of climate change does not, on its own, motivate people to change their lifestyles (57). Instead, it is *emotions*—the feelings that accompany thinking—that are central (58). Negative emotions, including fear, pessimism, and guilt, can produce passive and defensive responses, and do little to encourage individuals to change their behaviour and to press for wider social action. So-called ‘fear appeals’ only work if accompanied by equally strong messages about how to address the problem (59).

Second, climate change is best represented in ways that anchor it in positive emotions (60), by framing action in ways that connect with *people’s core values and identities*. Examples include framing climate change as: an ethical and intergenerational issue; about safeguarding ancestral lands and the sanctity of the natural world; or an appreciation of the global injustice of anthropogenic climate change driven by rich countries but paid for by poorer ones (61). Aligning climate change to a range of ethical positions and a core set of identities can offer a way of appealing to diverse social groups, and thus securing a broad and inclusive platform of public support for action. Avoiding the rhetoric of climate catastrophe could facilitate this, and emphasise, instead, human capacity to steer a course to a sustainable future, including lifting the burdens that unmitigated climate change would otherwise impose on future generations (62).

Third, integral to such an ethical framing of climate change is the *implied duty* on national and international organisations to take action. A recurrent finding is that the public sees the main responsibility for action lying with governments and other powerful institutions, not least because the options open to individuals to take radical action to cut their own GHG emissions are often sorely limited by cost or availability (e.g. poor public transport provision). Public willingness to take action is also contingent on those considered responsible for climate change, taking action themselves (63). The majority of the public in cross-national surveys believe that their country has a responsibility to take action on climate change, and that their government is not doing enough.

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<sup>9</sup> Excerpt from Lancet Commission on Health and Climate Change: Policy responses to protect public health (2015).

Fourth, many climate-affecting behaviours are *habitual and resistant to change*. Everyday domestic energy use (e.g. cooking, heating the home), travel behaviour, and eating patterns are undertaken as part of a daily routine and without conscious thought. Such behaviours are resistant to change, even if alternative options are available, and interventions relying on increasing knowledge have limited effect (64).

While adaptation is largely dependent on the availability of information relevant to climate change, it appears that motivation for voluntary mitigation is mostly dependent on perceived susceptibility to threats and severity of climate change or climate variability impacts.

The technological, financial, and behavioural changes needed to meet ambitious long-term goals are in principle feasible. But they need to be accomplished in the face of highly diverse social, cultural, economic, and political contexts. Opposing national (and vested) interests, clashing views of what constitutes fair distribution of effort, and a model of economic growth that is currently tied to fossil fuel use, can make progress fraught. Hulme (2011) outlines several key climate change issues that when framed as a health issue, rather than purely as an environmental, economic, or technological challenge, makes the need for action that much clearer (65). Health puts a more personal and human face on what can sometimes seem to be a distant threat. By making the case for climate change as a health issue, it is hoped that the civilizational crisis we face will achieve greater public resonance. Public concerns about the health effects of climate change, such as under-nutrition and food insecurity, have the potential to accelerate political action in ways that attention to carbon dioxide emissions alone do not.

The scientific literature relates a few avenues for public health engagement in the context of mitigation: the continued work towards establishing a framework for a strong, predictable, and international carbon pricing mechanisms; rapidly expanding access to renewable energy in low-income and middle-income countries; ensuring adequate local capacity and political support to develop low-carbon healthy energy choices; adopting mechanisms to facilitate collaboration between Ministries of Health and other government departments and empowering health professionals; agreeing and implementing an international agreement which supports countries in transitioning to a low-carbon economy; and investing in climate change and public health research.

## 4.0 CLIMATE CHANGE, HEALTH AND AN INTEGRATED APPROACH

An integrated approach to addressing climate change and health related issues will require innovative horizontal program development. Understanding and meeting the different needs and objectives of participating government departments, provincial partners and various stakeholders will be critical to effective and ongoing engagement. Grounding this approach in a climate change framework will require strategic engagement across files that are normally structured in a ‘silo’ or thematic way in order to enhance common understanding of the horizontal nature of the health impacts of climate change. Programs can be designed by aligning work across key activities, with strong integration of the science and policy. This will ensure best use of limited resources to address the complex and layered issues presented by the health effects of climate change.

Weaknesses in systems and infrastructures in various sectors are necessarily interconnected, with a variety of anticipated and unanticipated knock on effects. Climate change is exacerbating already vulnerable situations, which puts demands not only on the impacted region itself, but also on external efforts to establish sustainable ways to reduce human health impacts. Stark evidence of this can be seen in resource poor regions. The recent Ebola health crisis in West Africa was an extreme example of a tipping point of multiple systems that already had little to no resilience. In Sierra Leone (the epicenter of the Ebola outbreak) climate change had already weakened that country’s vulnerable infrastructures and capacity (health, physical, agriculture, etc) with unusually intense “seasonal droughts, strong winds, thunderstorms, landslides, heat waves, floods, and changed rainfall patterns” (66). This made all aspects of emergency response to the emerging disease situation that much more difficult. Ultimately, the cost, both in human lives and financially, was very high. Globalization in all markets rapidly moves goods, people and infectious diseases to new areas of the world. This is further complicated by the fact that novel pathogens are emerging more rapidly, often from areas with high populations, poor sanitation and nutrition, and greater mobility than ever before. Overarching understanding and awareness of existing and future risk and trends in various sectors, and how they interact and support each other, will be critical to adaptive capacity globally. Proposed key areas for effective horizontal alignment in addressing climate change and health include:

- **Education and Awareness:** Public communication and education initiatives to establish healthy behaviours and choices related to the impact of climate change on human health.
- **Surveillance and Monitoring:** Using research data and analysis gathered from public health surveillance systems to address health impacts related to climate change including identifying disease trends and identifying vulnerable individuals and communities.
- **Building and Sustaining Healthy Environments:** Playing a role in making infrastructure more resilient by informing and educating the public about health risks, advocating for changes that promote and improve health, and encouraging the adoption of health-promoting change in urban planning and community infrastructure.
- **Capacity Building:** Building community resilience by increasing the capacity of individuals and communities to cope and adapt to current and anticipated changes in climate.

- **Research and Innovation:** Research to increase knowledge and address gaps on potential climate-related health risks and health resilience including how and which populations and communities are most vulnerable.
- **Emergency Planning:** Advancing overall public health preparedness for climate impacts to enhance public health security related to health, critical public health services and infrastructure (e.g. enhanced monitoring and surveillance and risk management measures).
- **Leadership:** Strengthening partnerships across Canada by engaging Provincial and Territorial governments and key stakeholders to strengthen the national capacity to deal with current and future impacts of climate change on public health
- **Integrating Adaptation and Sustainable Development into Federal Policy and Planning:** Ensuring that climate change considerations are integrated into and across federal activities, such as research, policy, and planning processes. These actions also serve to strengthen accountability and transparency, providing greater public confidence that decisions in the federal government are being made in full awareness of potential social, health, economic and environmental impacts.



## 5.0 FUTURE CONSIDERATIONS

Identified as “the greatest health threat of the 21<sup>st</sup> century” (8), the global impact of climate change is a key cross cutting issue of our time that has the potential to cause instability on an unprecedented scale. Adaptation measures are *already required* as the effects of climate change are being experienced today. From a health-based perspective, a number of key elements should be considered to enhance our knowledge of the impacts of climate change and develop effective interventions.

**There is a need for greater understanding of the leadership role that health has to play in changing the behaviour of Canadians** leading to both effective adaptation and mitigation efforts while recognizing the importance of implementing health adaptations within the health systems and increasing the advocacy role of health professionals with their patients. It is critical to recognize the powerful influence that health considerations have to play in mitigation. A recent report by researchers at the International Monetary Fund identifies the omission of health impacts from polluting fuels as the largest of the subsidies provided to global energy production and use, which will total US\$5.3 trillion in 2015 (67). This is larger than total health spending by all the worlds’ governments. Therefore, the health implications could and should be more effectively harnessed in efforts to build support for a stronger response to climate change.

**There is a need for horizontal understanding and participation for effective interventions with multiple co-benefits.** The built environment plays a vitally important role in promoting and maintaining health, so health considerations should be a key component of infrastructure discussions. A strong health-based vision would be city planning that encourages reduced air pollution and thus supports and promotes lifestyles that are healthy for the individual and for the planet. This is relevant to many interventions. For example air pollution, where encouraging a transition to cities that support and promote lifestyles that are healthy for the individual and for the planet would have far-reaching impacts on chronic disease conditions (68).

**There is a need to integrate health security considerations into upstream risk mitigation plans** linked to health innovation, national security and climate change to as well as reinforce the mechanisms and systems to manage health emergency preparedness and response. Given recognised increases in the frequency and/or intensity of extreme weather events and emerging infectious disease outbreaks, this preparedness and foresight is critical.

**There is a need to define cross-cutting adaptations that provide resiliency to both outbreaks of infectious disease, and the mounting burden of non-communicable disease.** This can be achieved through the continued development of strong, flexible, and resilient health systems (69). Moving strategically “upstream” in our common understanding of the social determinants of health can enable and enhance the health of Canadian populations with considerations to health equity and patient-centered care. This provides a strategic approach to scaling up systematic strengthening of the health system through targeted public health and population health approaches.

**There is a need to develop a long-term vision of health with considerations to the fundamental need for clean air and clean water to support the health of Canadian communities.** These include the strategic management of biodiversity to both protect the ecosystem services delivered in or natural environments, and in enhancing our One Health management of infectious diseases. Adoption of mechanisms to facilitate collaboration between Ministries of Health and other government departments will empower health professionals and better integrate health and climate considerations in government-wide strategies. This must acknowledge and seek to address the extent to which additional global environmental changes, such as deforestation, biodiversity loss, and ocean acidification, will impact on human health and decrease resilience to climate change. Ecosystem-based adaptation utilises ecosystem services, biodiversity, and sustainable resource management as an adaptation strategy to enhance natural resilience and reduce vulnerability (70). These interventions can be effective in reducing certain climate change vulnerability as they provide disaster risk reduction functions and enable improvements in livelihoods and food security, especially in poor and vulnerable settings.

**There is a need to enhance mechanisms to evaluate the effectiveness and ability of interventions in reducing the burden of high priority climate sensitive diseases and health conditions.** Linkages between public health and climate change are complex and interact with other factors. It is important to be able to evaluate effectiveness through various outcome metrics including single interventions with multiple direct and indirect outcomes. While implementation of effective control interventions is the only way to reduce the disease burden of climate change, evaluation of the effectiveness of public health interventions is lacking.

The health and well-being of populations is necessarily dependant on the resilience, adaptability and strength of interacting systems across all sectors. This complex web of dependencies has become more acutely emphasised as the effects of a changing climate become more and more prominent in various dimensions. Actions to mitigate the potential enormity of these impacts have been relatively slow. Perhaps this is, in part, due to being stymied by the inherent complexity of how to proceed. However, many authors argue that most mitigation and adaptation responses to climate change are “no-regret” options, which lead to direct reductions in the burden of ill-health, enhance community resilience, alleviate poverty, and address global inequity.

Encouraging and supporting the integration of unique strengths and capacities from different sectors will address the challenges of complexity and move the agenda forward. Innovation and foresight in creating and leading these opportunities should define future considerations in governance and actions towards successful adaptations for mitigating health impacts of climate change in Canada and globally.

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There is a large body of evidence summarizing the multiple impacts of climate change on health. This technical synthesis collates scientific information on this subject, and presents considerations pertaining to health and public health. Though health is the focus of this paper, it is important to encourage a collective and integrated thinking and response from multiple sectors in addressing, mitigating or adapting to the challenges that are posed. Among the many references consulted, a few key scientific reports of particular relevance complement this work. These include: *The Chief Public Health Officer's 2014 report on the state of Public health in Canada, public health in a changing climate* (71); *Human health in Canada in a changing climate: sector perspectives on impacts and adaptation* (47); and *Health and climate change: policy responses to protect public health* (69), by the Lancet Commission.

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