Climate Change and Health in Northern Ontario

An overview of the health impacts of climate change in northern Ontario - August 2022

North Bay Parry Sound District Health Unit

Northwestern Health Unit
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Porcupine Health Unit • Bureau de santé

Services de santé du Timiskaming Health Unit

Thunder Bay District Health Unit

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This report provides health professionals working in northern Ontario with a background on the health impacts of climate change relevant to the region. By identifying and describing notable impacts of concern, this report serves as a first step to understanding the complex, interconnected and far-reaching challenges climate change poses to human health and will assist public health units in northern Ontario to undertake vulnerability and adaptation assessments to prioritize evidence informed action.

The project partners would like to acknowledge the generous funding and support from Health Canada's HealthADAPT program that made this work possible.

Health Canada Santé Canada

The views expressed herein do not necessarily represent the views of Health Canada.

Land Acknowledgment

The Northern Ontario Climate Change and Health (NOCCH) collaborative acknowledges that this project and the lead partnering health units operate on the Ancestral Traditional Territory lived on in respect and reciprocity by Indigenous peoples of, what is now known as northern Ontario from time immemorial. As a settler-run organization, the NOCCH collaborative operates within Treaty 11 (1798), Treaty 45 (1836), Treaty 60 (1850, Robinson-Superior), Treaty 61 (1850, Robinson-Huron), Treaty 3 (1873), Treaty 5 (1875), Treaty 9 (1905-1906 & 1929) and Williams Treaties (1923). As people working and living in these treaties we are called to treat this sacred land, its plants, animals, stories and its peoples with honour and respect, while acknowledging that many treaties within this region have not been fully honoured. As a collaborative, we have a responsibility to understand the colonial history of Canada and are committed to the shared goal of reconciliation. We have greatly valued the involvement and partnership of our Indigenous elders, youth, leaders and communities in this project and continue to work towards enhancing our relationships to achieve equitable collaboration.

Overview

Climate change is impacting the health of people that live in northern Ontario. As temperatures in northern Ontario continue to rise at three times the rate of the global average, the impacts experienced by populations living in northern Ontario are predicted to increase in intensity, duration and frequency.[1] Understanding the local impacts of climate change is important for public health units across northern Ontario in order to appropriately prepare for and adapt to the current and projected impacts of climate change on community health. This report provides a background on climate change and describes the current and projected health impacts of climate change specific to northern Ontario that health professionals and decision makers should recognize and prioritize within their ongoing efforts to protect and improve health.

The Ontario Public Health Standards (2021) acknowledge the importance of addressing climate change and, through the Healthy Environments and Climate Change Guideline (2018), require health units across the province to take appropriate, evidence-informed action to understand and minimize the negative health impacts of climate change.[2,3] In response, seven northern health units formed a collaborative network to develop a deeper, context-specific understanding of how a changing climate will impact health in northern Ontario. This collaborative network was established as an approach to enhance capacity to address the complex and previously unexplored challenges posed by climate change on health in northern Ontario. The collaborative submitted a successful funding application to Health Canada's HealthADAPT program and in April 2019 began a project to build and sustain the capacity of the northern Ontario health units to protect health by identifying, prioritizing and adapting to the risks posed by climate change.

This report is the first step as part of the larger project investigating vulnerabilities and adaptation action to address climate change and health impacts throughout northern Ontario. The report was created for public health professionals as a resource to better understand and inform future health and climate action. This report identifies climate hazards and health risks that are particularly relevant to northern Ontario public health units, which share a unique geography and climate that differs from southern Ontario.

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Definitions

Adaptation - Adjusting (adapting) to the actual and expected future climate. The process of acting to lower the risks posed by the consequences of climatic changes.[4]

Adaptive capacity - The ability of a person, community or health system to adjust to a hazard, take advantage of new opportunities, or cope with change.[5]

Climate stressor - A condition, event or trend related to climate variability and change that can exacerbate hazards.[5]

Exposure - The presence of people, assets and ecosystems in places where they could be adversely affected by hazards.[5]

Hazard - An event or condition that may cause injury, illness or death to people or damage to assets.[5]

Mitigation – The process of reducing the flow of heat-trapping greenhouse gases into the atmosphere, to reduce the rate for climate change .[6]

Resilience - The ability to anticipate, plan for, absorb, respond to and successfully recover from adverse events with minimal damage to social well-being, physical and spiritual health, the economy and environment.[6]

Risk - Describes the possible consequences of future changes in climate and factors that will impact health. Risk is generally described as the probability of occurrence of an adverse event multiplied by the consequences of that event if it occurs.[11]

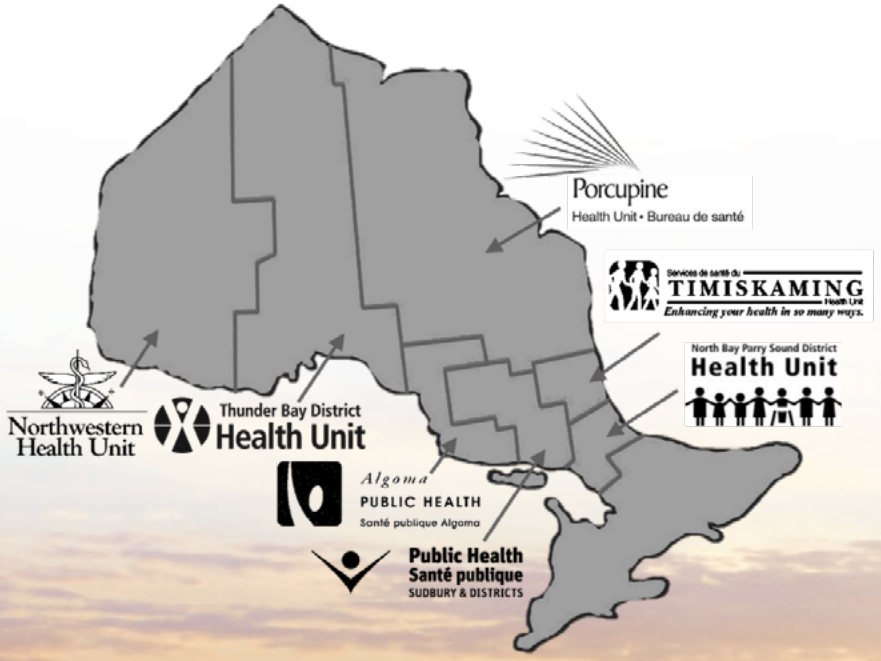
Sensitivity – The degree to which a community or system is affected (positively or negatively) by climate variability or change.[11]

Chapter 1
Introduction

The impacts of a changing climate are broad and overwhelmingly negative, affecting not only our environment but also our economy, infrastructure and the health of Canadians.[7–9] While all Canadians may not recognize or feel they are experiencing these impacts personally, research shows that the health of all Canadians is being impacted to some degree.[8] The increasing intensity, duration and frequency of these impacts has led health authorities to label the rapid change in climate as one of the greatest threats to human health which requires immediate, effective action to avoid reversing the significant health advancements made over the last 50 years.[7,10,11]

Climate change is the long-term shift in average weather patterns that define Earth's global, regional and local climates.[12] As such the impacts of climate change are felt not only on a global scale but also regionally and locally. Changes in temperature extremes, shifting precipitation patterns and extreme weather are all projected, based on climate modelling, to occur more frequently and to a greater intensity in northern Ontario prompting the need to better understand and adapt to localized impacts to protect population health.[9,13–15] The preventative, population health-centered role of public health presents significant potential to educate, initiate and support action addressing the health impacts posed by climate change. Through assessing vulnerabilities and informing adaptation policies to predicted impacts, public health units are positioned to become key players in supporting climate change and health action.

Framing this impending challenge as an opportunity to improve the health of populations living in northern Ontario, seven northern health units formed a collaborative network in response to address the health risks of a changing climate. To increase the understanding of health impacts posed by climate change among public health professionals, this collaborative network merged resources and will produce local Vulnerability and Adaptation Assessments to better review and project the impacts of climate change on health. These assessments will provide prioritized, appropriate and applicable recommendations that health units can take to adapt to the diverse range of impacts and protect health. This climate science and health report was designed as part of this larger, collaborative project, to provide a fundamental background on the science of climate change and the impacts posed to human health.



Chapter 2
Background

Geography & Demographics

The region of northern Ontario spans approximately 806,000 km^2 with a dispersed population of over 780,000 residents, giving the region a population density of 0.9/km^2.[16] The primary economic sector of predominantly mining and forestry, continues to shape the changing landscape of northern Ontario.[17,18] These resource extractive industries are precarious in nature and significantly jeopardized by climate change, contributing to the existing challenges of labour uncertainty and service limitations experienced by many small and single-industry dependent communities across northern Ontario.[19,20] Large emission-generating fossil fuel intensive industries are depended upon by many northern Ontarians and provide their primary means of economic stability, highlighting the complex and polarizing challenge of addressing climate change.[21,22]

Over half (55.9%) of northern Ontarians reside in large urban and medium population centres, which serve as regional hubs for health and social services.[16] The remaining 44.1% of the population resides in small population centres and rural areas, including 106 First Nations, often with limited health and social services.[16,23,24] Within this report we have divided our population centers into four distinct categories, broadly encompassing the diverse and abundant population centers in northern Ontario. As visualized in Figure 1, these population centers include:

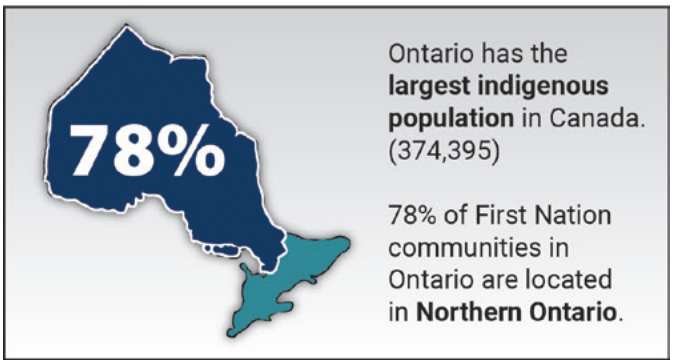
1. Larger Urban areas such as Sudbury, Sault Ste. Marie and Temiskaming Shores;
2. Rural areas such as Red Lake, Marathon and Chapleau;
3. Isolated Road Access communities such as Armstrong, Pickle Lake and Aroland; and finally
4. Remote, isolated communities, largely represented by First Nations within the far Provincial North.

These representative population center categories will provide a basis for comparison within the report, allowing for a broad discussion on projected health impacts and adaptive capacity.

Figure 1: Report population center classifications.

Health

Health disparities and inequities persist across northern Ontario as demonstrated through elevated rates of chronic illness, food insecurity, premature mortality and suicide, often far above provincial averages and experienced disproportionately among Indigenous populations.[25] Indigenous (First Nations, Métis and Inuit) peoples across northern Ontario "have faced various discriminatory policies … that created inequities that continue to affect the health of populations, including forced relocations, residential schools and forced sterilizations" (Truth and Reconciliation Commission of Canada, 2015).



Climate change vulnerability is constructed by numerous factors, which vary depending on region, health status, age, socioeconomic status and many other social determinants of health and as such, communities will experience the impacts of climate change in different ways.[26] Many communities across northern Ontario are geographically isolated,

dependent on the land for their livelihood and cultural traditions, and face economic and political challenges, all leading to an increased vulnerability to climate change impacts.[27–29] Although a range of factors may increase the climate change vulnerability of individuals and communities across northern Ontario, many strengths and assets also exist within this region that can support resilience in the face of climate change.[30,31] Traditional knowledge, close ties with the land, a strong sense of community and baseline understanding and concern about climate change are examples of these strengths.[30]

Northern Ontario presents a context where health impacts and inequities are predicted to increase in the context of climate change, calling for the creation of stronger, more resilient health systems which take opportunistic approaches to better health. [4,31,32]

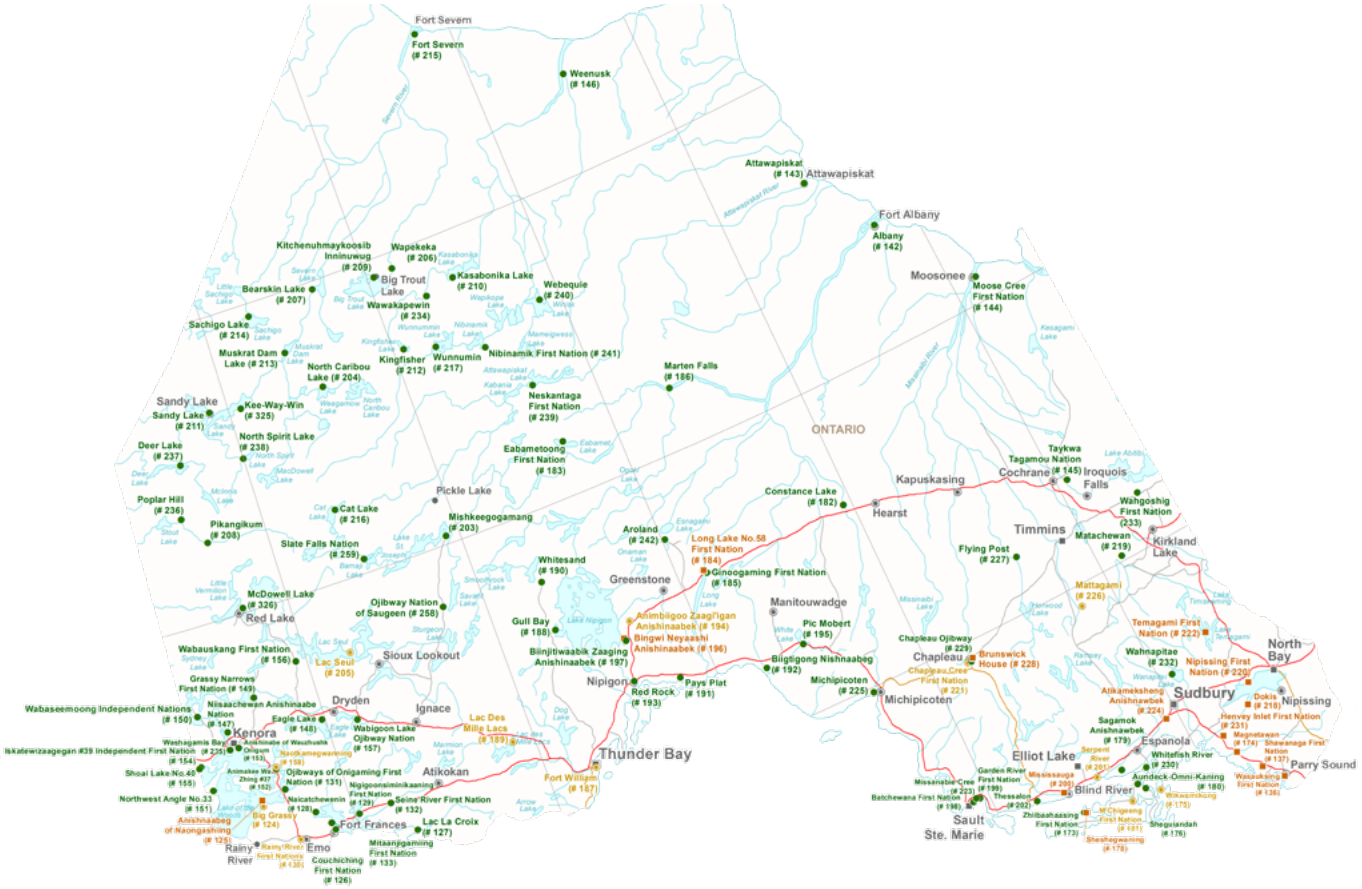


Figure 2: Visualization of dispersion and remoteness of some First Nation communities within northern Ontario, adapted from CIRNAC interactive map.[33]

Chapter 3
The Science

Science has made significant advancements towards understanding the impacts climate change will have – and is having – on human and environmental health. While climate science remains a complex field with more to understand, the current body of evidence strongly and definitively supports the fact that climate change is occurring and is largely caused by human activity.

This chapter provides a summary of climatic processes and the underlying science; a more context-specific overview of climate projections and associated climate-amplified impacts in northern Ontario follows in Chapter 5. Additionally, ***Appendix I*** provides an in-depth overview of supplementary climate processes, which may help readers further understand climate science.

Climate and Weather

Figure 3: Visualization example, difference between weather and Climate, adapted from NOAA.[35]

Although closely related, climate and weather are not the same. Climate and weather both describe atmospheric conditions; however the difference is the timescale they occur on. Weather describes the short-term, variable conditions in the atmosphere, often occurring on a timescale of hours to days. In contrast, climate describes the long-term, stable patterns in weather occurring on a timescale of months to years. While there may be short term benefits to climate change in northern Ontario such as a longer crop growing season with warming temperatures, the impacts predicted from even an additional 2°C of warming are cause for concern.[6,34] People are accustomed to dealing with the current day-to-day impacts of weather, however it is important to differentiate these daily changes against long-term changes in climate, as the severity of the consequences are unknown, complex and interact in ways that can be difficult to predict.

The Greenhouse Effect

Earth's atmosphere is composed of a variety of gases that act to regulate the earth's temperature, support life and protect us from harmful ultraviolet (UV) radiation and cosmic debris.[35,36] Among these atmospheric gases a specific subset of greenhouse gases exists which trap heat and cause the earth to warm, much like a greenhouse.[37] Greenhouse gases including carbon dioxide, methane, nitrous oxide and water vapour naturally exist within our atmosphere and play a critically important role in regulating the temperature on Earth. Without greenhouse gases Earth's surface temperature would be approximately -18°C on average as all of the heat radiated from the earth would escape.[35,38] However, what we are seeing on Earth is quite the opposite, with greenhouse gases increasing. The natural balance of greenhouse gases is changing as a result of human activity, primarily through the production and burning of fossil fuels which release an excess of greenhouse gases such as carbon dioxide into the atmosphere.[6]

Approximately 1/3 of all incoming solar energy that reaches the earth is reflected back to space by bright surfaces such as clouds, snow and ice. The remaining 2/3 of solar energy is absorbed by the earth's surface such as by land, lakes and oceans. As the surface of the earth absorbs solar energy it warms and radiates heat back to the atmosphere. This radiant heat either escapes or is re-absorbed by greenhouse gases and is further radiated in all directions. The energy radiated back towards the surface of the earth, in addition to the incoming energy directly from the sun, adds to the heating of the earth's surface.[5,21]

Blanket Analogy

The greenhouse effect is often simplified by comparing the process to a 'quilt' or 'natural blanket' that encompasses the earth. This quilt is made up of a variety of patches (heat-trapping or greenhouse gases such as carbon dioxide, methane, or water vapour) which allow the sun's energy to go through the blanket and heat up the earth. The earth gives off heat energy, but that heat is trapped by this natural blanket keeping the earth warmer than it otherwise would be. However, problems arise when additional blankets or greenhouse gases are added, resulting in increasing global temperatures that will drastically increase.

3 most common greenhouse gases

CARBON DIOXIDE

The main contributor to climate change through the burning of fossil fuels

METHANE

Predominantly produced through cattle farming, waste and the production of oil and gas

NITROUS OXIDE

Released by chemical fertilizers and burning of fossil fuels. 310 x global heating impact potential in comparison to CO_2

Climate Modelling

Climate modelling arose from the desire to understand the potential trajectory climate change could take, as well as better anticipate associated risks, to inform adaptation planning. While several frameworks were developed for climate modeling, Representative Concentration Pathways (RCPs) became the most widely used and supported. RCPs are used within climate modeling to illustrate scenarios projecting greenhouse gas concentrations over time.[5] These RCP scenarios are directly dependent on human action to reduce emissions, with a low emission scenario (RCP 4.5) depicting gradual reductions in greenhouse gas generation over time and a high emission scenario (RCP 8.5) indicating increases in greenhouse gas emissions over time.[39]

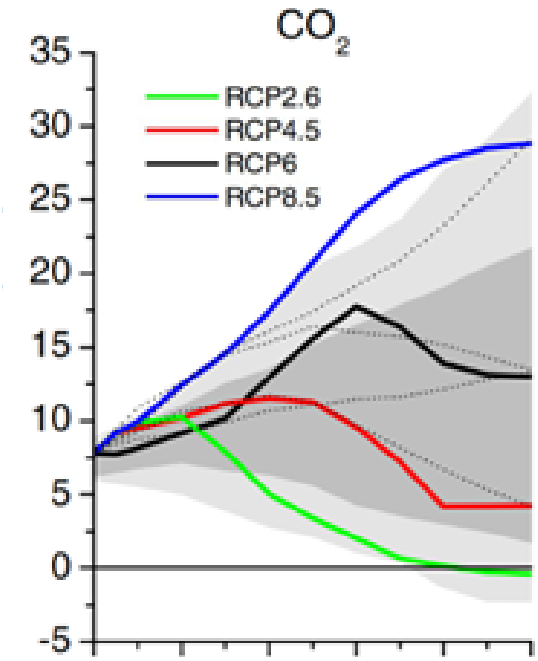


Figure 5: Global carbon dioxide emission scenarios in gigatonnes of carbon per year

In recent years, climate scientists, economists and energy systems modellers have developed new pathways that consider the ways in which global socioeconomic factors will shape society and the impacts of climate change, known as Shared Socioeconomic Pathways (SSPs). Population, economic growth, education, urbanization and technological development rates are all factored within the SSP models, which are used to provide hypothetical contextualization to climate models. While upcoming climate modelling reports will be integrating SSPs into their projections, SSPs are still relatively new within climate modelling and as such, are not widely considered within current literature.[40]

Within this report the low and high emission scenarios (RCP 4.5 and 8.5) are used throughout to highlight the differences in potential impacts experienced across northern Ontario. RCP 4.5 is the 'stabilization' scenario for stabilizing climate change, where shifts in climate policy and action result in emission limitations. RCP 8.5 is the "business as usual" scenario, where emissions continue to rise, stabilizing in 2100 at levels approximately four times greater than levels from 2000.

Northern Heating

Climate modeling and projections, traditional knowledge and a fundamental understanding of processes within our climate system all provide conclusive evidence that the earth is heating as a result of human activity.[32] Global temperatures have increased and are projected to increase further; however the rate of heating is not evenly distributed around the world. In Canada, atmospheric heating is occurring at more than double the global rate on average, with many northern regions of the country experiencing intense warming at close to triple the global rate.[7] This rapid heating is projected to continue on a global scale leading to a cascade of environmental, economic and health impacts.[8,9,27,29]

To understand the disproportionate increase in the rate of warming in Canada's north, it is important to recognize that the consequences from rapid warming can lead to further warming. This continual process is referred to as a positive feedback loop, where climate impacts amplify the factors that drive climate change. This process is largely responsible for the disproportional rate of warming seen in

northern Canada, as visualized in Figure 6. As more heat-trapping greenhouse gases are emitted into the atmosphere the earth continues to warm which results in the increased melting of snow and ice. With the increased melting, incoming solar energy has fewer light surfaces to reflect from and more dark surfaces, including newly exposed open water and uncovered land, to absorb solar energy. These dark surfaces absorb solar energy and radiate heat back to the atmosphere, which is trapped by greenhouse gases and further warms the atmosphere.

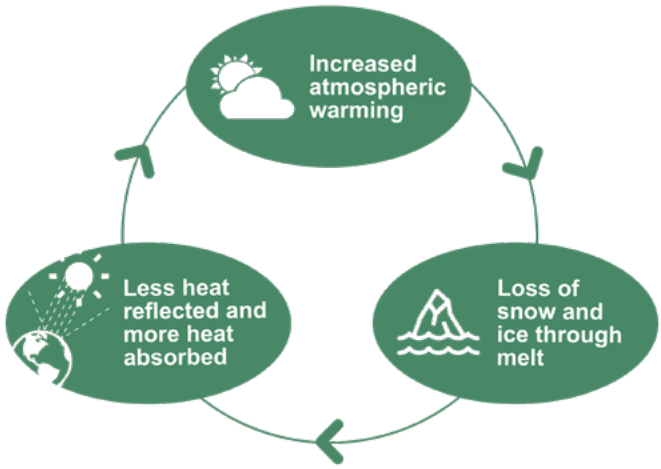


Figure 6: Atmospheric heating positive feedback loop leading to amplified warming.

This warming feedback loop has contributed to the dramatic loss of sea ice in the Arctic and resulted in significant changes to the structure of the atmosphere, which has important implications for northern Ontario. One implication of rapid warming is the impact on the stability of the polar vortex – the cold, dense, continually circulating air mass above the Arctic.[41] The boundary of the polar vortex exists between the cold, dense Arctic air in the north and the warm, lighter sub-tropical air to the south and is defined as the polar jet stream. The polar jet stream naturally shifts depending on the season, moving north in the summer months and south in the winter; however the stability and predictability of this boundary is being impacted as a warming climate has diminished the difference in density between the air masses.[42]

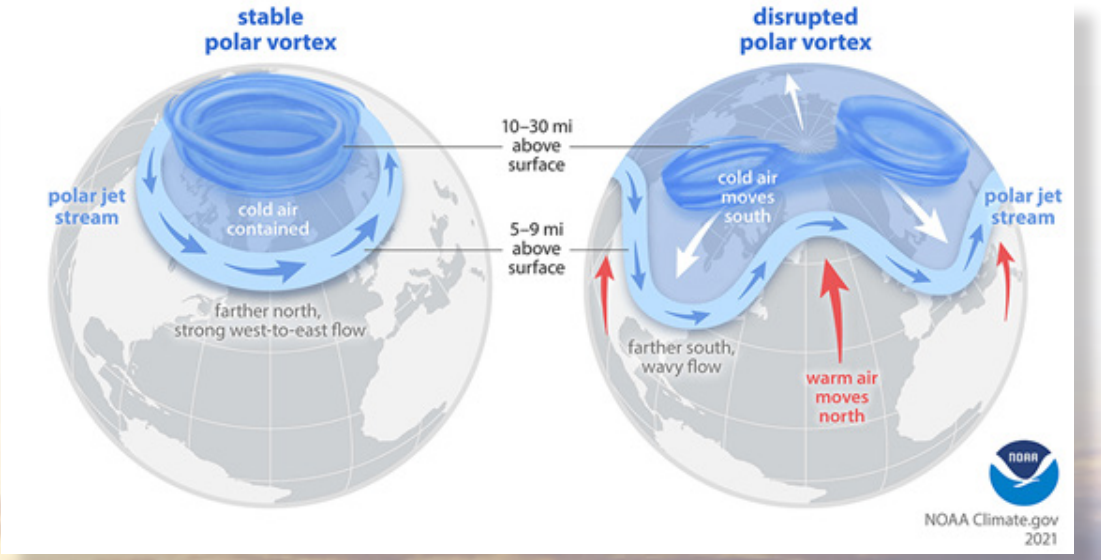


Figure 7: Comparison of polar vortex stability.

The boundary between the cold and warm air has become more convoluted, resulting in frequent occurrences of cold air pushing further south and warm air pushing north. These dramatic temperature fluctuations are becoming more evident in northern Ontario communities, particularly in the winter months and will be explored further in the Temperature Extremes impacts section below.

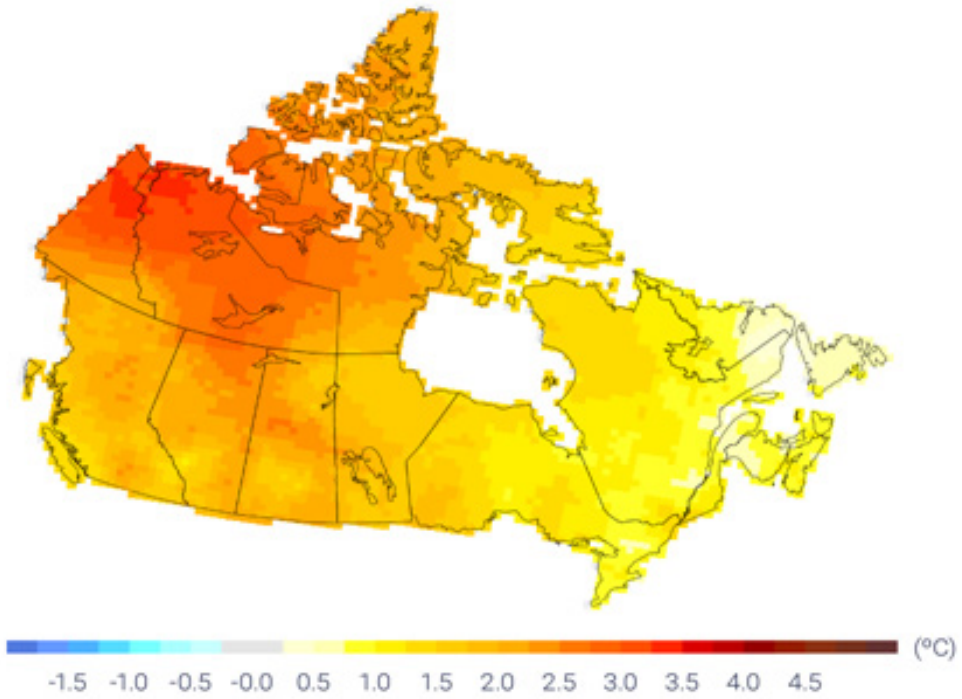


Figure 8: Observed changes in annual temperature across Canada between 1948 and 2016, based on linear trends. Chapter 4 Canada's Changing Climate Report 2019.

Chapter 4
The Relationship between Climate Change and Health

The health impacts of climate change are difficult to predict with precision as a result of the interconnected nature of climate systems, ecosystems and society as a whole.[9,43] However, there is wide consensus among health professionals that climate change is resulting in substantial negative health impacts that will worsen in the absence of significant action.[7,8,10,28] The public health sector has an important role to play as public health professionals who are well-positioned to understand the complexity and scale on which climate change impacts physical, emotional, spiritual and mental health. In turn, these impacts can then be communicated to the communities they serve. Public health professionals are being called upon as trusted community leaders and health advocates to increase awareness and influence healthy public policy to protect human health from the impacts of climate change.[28,44,45]

Impact Pathways - Overview of Climate Change Impact Pathways on Health

Although it is difficult to establish causation between climate change and health outcomes, research advancements that reduce bias and account for confounding variables have allowed for clear conclusions on the connection between climate and health impacts.[6,46] Previous studies have identified numerous areas of health that are negatively impacted by climate change through a variety of complex, interacting pathways.[6,11,47] These pathways can be separated into three distinct groups based on method of exposure:

1. Direct impacts
2. Indirect impacts mediated through natural ecological systems
3. Indirect impacts mediated by human, social systems

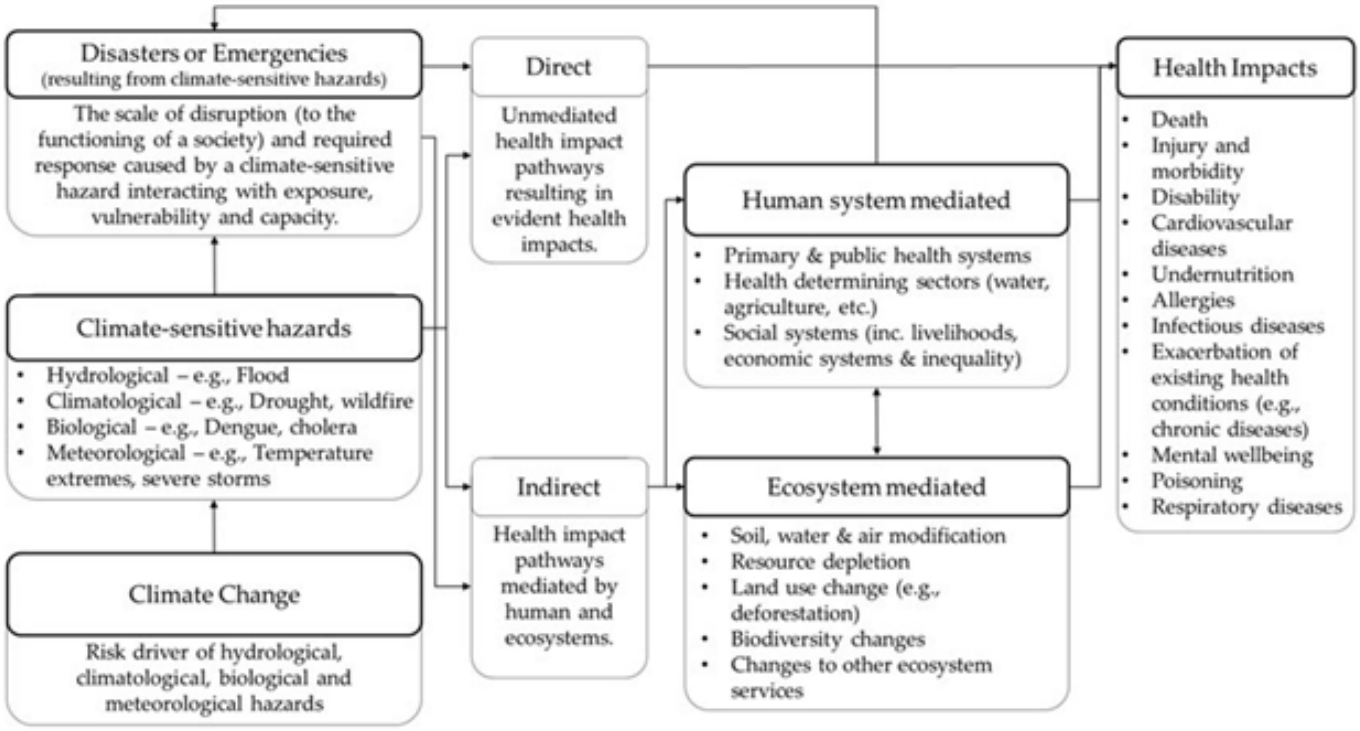


Figure 9: Exposure pathways for health and well being impacts of climate change.[48]

Direct impacts

Direct impacts refer primarily to changes in the frequency and intensity of extreme weather. Instances of flooding, forest fires, heat waves and other extreme weather events due to climate change have a direct impact on the health of populations through increased rates of illness, injury and death.[11] One of the most notable examples of a direct impact is an instance of extreme heat, when local elevated temperatures contribute to increased heat illnesses such as heat stroke and hyperthermia. This thermal stress presents a significant threat to public health as populations are unable to quickly acclimatize to extreme heat.[7,49]

Indirect impacts mediated through natural ecological systems.

Changes to the environment indirectly impact health through increased allergens, incidences of vector-borne diseases and pollution to air, water and food.[50,51] Vector-borne diseases, including infections carried by mosquitoes and ticks, have been widely studied in relation to climate change.[52–54] Warmer, wetter climates are favourable for disease spread, such as Lyme disease carried by ticks, and lead to increased incidences of disease outbreaks across Canada.[55,56]

Indirect impacts mediated by human social systems

The third and final pathway is characterized by climate change impacting social and economic systems by altering how communities function in ways that can be detrimental to health. These health impacts include alterations to nutrition, occupational health and mental health. For example, climate change affects agricultural production, which in turn affects food cost, quality and availability, leading to issues with food accessibility and increasing risk of suboptimal nutrition, which places vulnerable populations at increased risk of chronic disease.[57,58]

Impact on Vulnerable Populations

Vulnerability to climate change is defined as the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and extremes.[27,59] Understanding climate change vulnerability within public health and beyond is heavily dependent on conducting regional vulnerability assessments which can facilitate the implementation of appropriate and timely adaptation measures to protect individuals, populations and communities.[28] A community

or region's vulnerability to the health impacts of climate change is a multidimensional process that encompasses three elements with strong linkages to social determinants of health. Vulnerability is a function of

1. the degree of climate related exposure
2. a person or population's physiological sensitivity to these exposures and
3. a person or population's adaptive capacity or ability to adjust to the changing circumstances.

Exposure refers to the likelihood of a climate-related health impact occurring to an individual, population or community. Exposure is constructed from factors incorporating the frequency and severity of climate change impacts while also considering the specific area impacted by climate hazards. The degree of exposure is individually and collectively shaped by a range of determinants including occupation, socioeconomic status and geography.[27,59,60] For example, within Ontario those working in jobs that involve primarily outdoor labour (n=450,000) face increased exposure to UV and heat-related impacts as well as vector-borne diseases.[16,56,61]

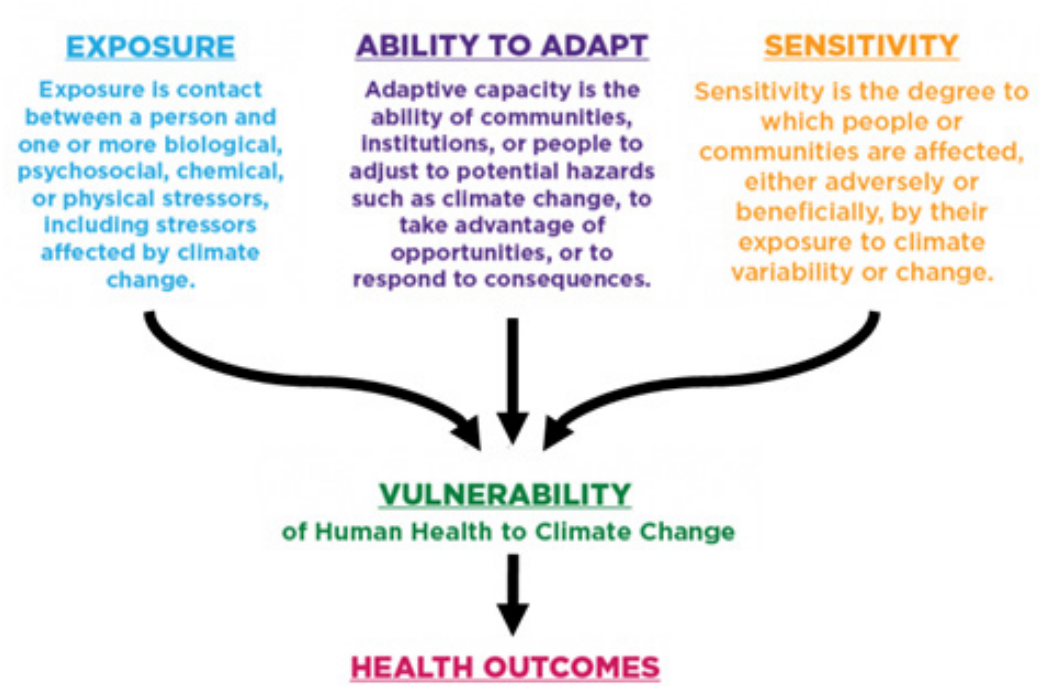


Figure 10: Determinants of vulnerability (Adapted from the USGCRP Climate and Health assessment).[62]

Sensitivity is the degree to which individual, population or community health is impacted by climate variability and change.[27] Sensitivity incorporates biological and physiological traits such as age, health status and gender, in addition to social and economic factors that compound health disparities such as the prevalence of chronic health conditions.[63] Sensitivity to climate hazards fluctuates throughout life stages, with infants, children and older adults commonly experiencing a heightened sensitivity to climate induced changes.

Adaptive capacity is the ability of an individual, population, or community to manage the impacts of climate change by minimizing the threats and negative consequences of predicted and experienced impacts.[27,62,64] Adaptive capacity is constructed by a variety of interconnected individual, community and systems level factors. Individual adaptive capacity is influenced by factors such as income, health status and education, whereas community adaptive capacity encompasses program availability, existing resources and supports. Adaptive capacity is further shaped by overarching, systems-level factors such as societal norms, governance and social, health and economic policy. Within this report we examine adaptive capacity from a community or population level perspective, as public health largely operates within this

realm and is most ideally situated to create positive change from this level.

Adaptive capacity affects exposure and sensitivity in addition to the resilience of individuals and populations experiencing health impacts.[59,62,64] Resilience, the ability to effectively prepare, cope, respond and recover from climate impacts, is intricately shaped by adaptive capacity, influencing access to healthcare and preventive services.[5,27,65] As a result individuals and communities with strong adaptive capacity possess greater resilience and are more able to respond and recover in an appropriate and timely fashion when faced with adversity.

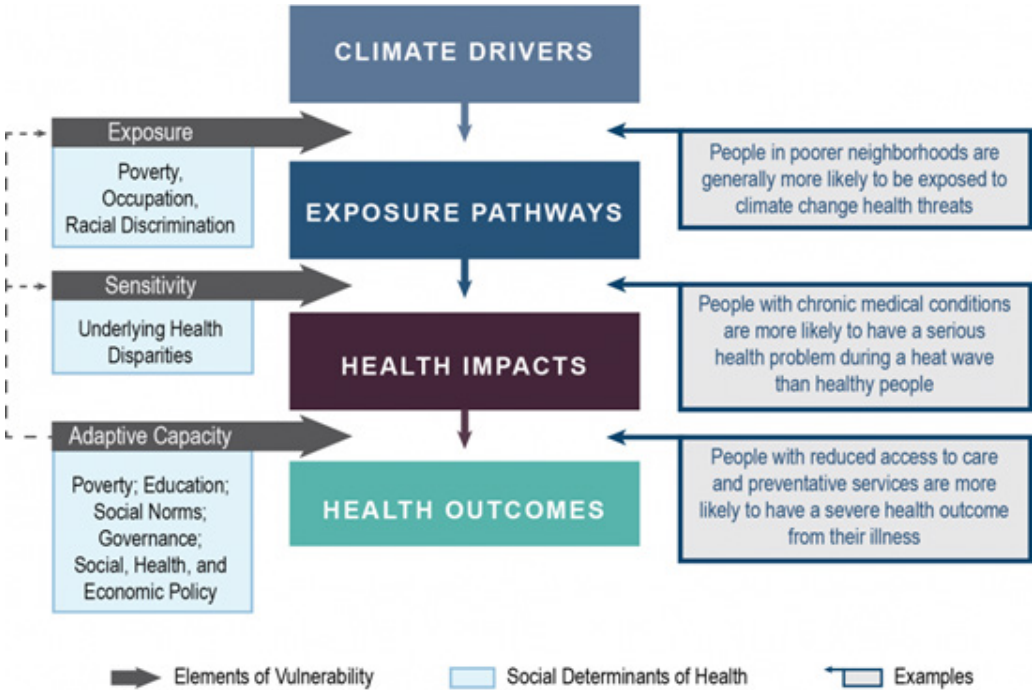


Figure 11: Illustrative overview of causal chain of climate amplified impacts on human health with considerations of elements of vulnerability.[64]

The three elements of vulnerability are consistently altered by social, political and economic forces on local and global scales and interact with many factors that increase and decrease risk to the impacts of climate change.[27] Recognizing that many factors contribute to assessing risk, Figure 12 provides a framework for understanding and assessing vulnerability beyond climate change, to incorporate all factors needed to comprehensively assess risk and develop adaptive capacity.

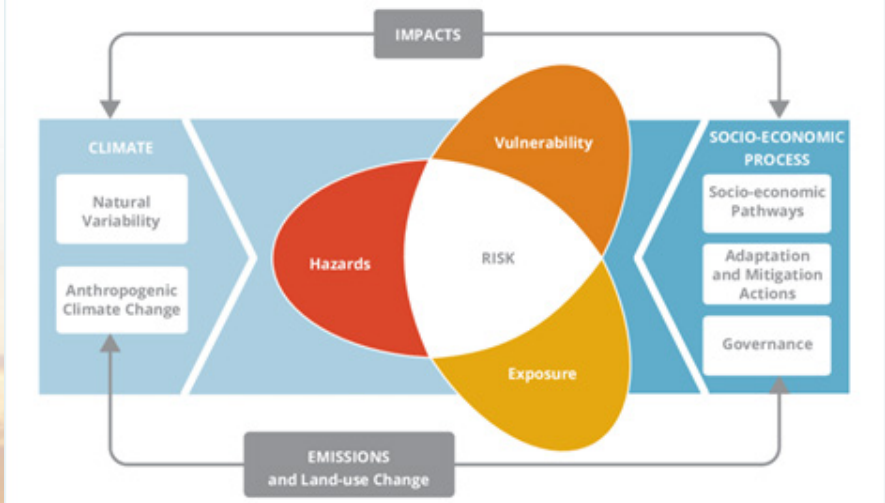


Figure 12: Vulnerability assessment framework.[26]

Vulnerability in northern Ontario

Vulnerability is constructed by many factors which vary depending on region, health status, age, socioeconomic status and many other social determinants of health.[27] Populations in northern Ontario are more likely to experience the impacts of climate change when compared to the rest of the province as environmental and social conditions have left communities and specific populations more vulnerable to the health impacts of climate change.[8,13,25,27,40,47,66–68]

Geographic location contributes to many direct impacts such as susceptibility to flooding and extreme heat events and indirect impacts such as access to services and food. Northern Indigenous communities, who are already experiencing significant climate change impacts, now face additional health challenges that are related to climate change.[23,69–72] These communities are made vulnerable by geographic isolation, which contributes to social and health disparities and makes access to health care challenging. Fluctuating temperature extremes disproportionately impact isolated northern communities through; (a) decreasing ice coverage and stability; (b) impeding access to communities accessible primarily by ice road; (c) decreasing food security and access to traditional food sources; and (d) decreasing access to external health and social services.[73] While many more centrally located communities are able to adapt to climate change impacts, isolated northern communities may not have this ability, which only increases their vulnerability.

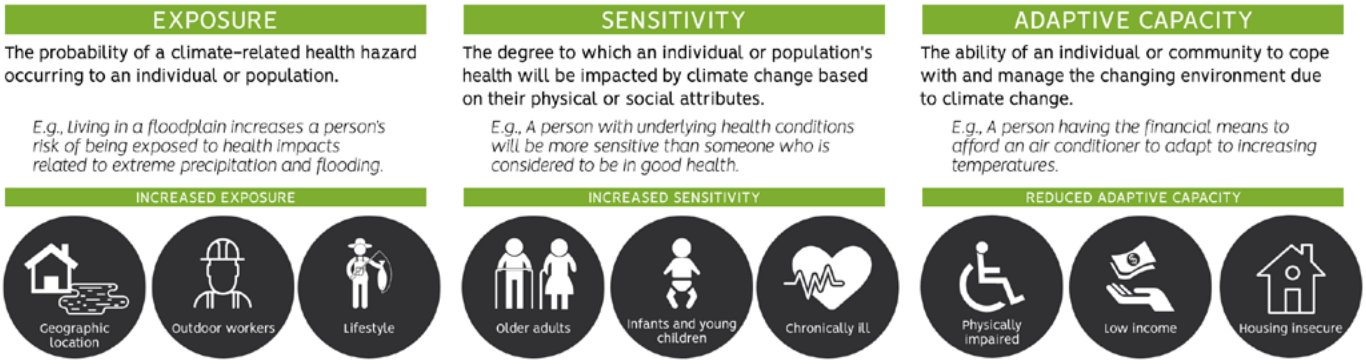


Figure 13: Populations more likely to be negatively affected by specific vulnerability categorizations.

Some populations are more vulnerable to the health impacts of climate change. These populations include infants and older adults, those with socioeconomic challenges or considered low income, individuals living in remote or isolated areas, individuals with chronic illnesses (including mental health and addictions, as well as those with physical impairments), individuals who are physically active, those working outdoors or indoors without air conditioning and newcomers to Canada.[27]

Figure 14: Populations at elevated risk for adverse health outcomes as a result of climate-amplified heat events.

Chapter 5
The Impacts of Climate Change on Health in northern Ontario

Climate change is negatively affecting the health of Canadians. These impacts are observed through extreme examples of raging wildfires along the west coast or historic floods in the east, leading to clear health implications ranging from smoke inhalation to physical injury in addition to death. As discussed earlier, we understand that the pathways in which climate change affects human health are diverse and often interconnected and the ways these impacts are experienced differs depending on a variety of factors including wealth, age, health status and geography. Therefore, to properly understand how climate change is impacting the health of a region, a localized, context-specific approach must be applied. The expansive geography, diverse and dispersed population, inequitable health services delivery and limited research currently available in northern Ontario all contribute to the challenge of understanding how climate change will impact northern Ontario. This chapter provides an overview of the prioritized climate change impacts on health being experienced and projected to impact northern Ontario to deliver a high-level overview of how these changes will impact human health. The following framework is not exclusive or exhaustive and as a result, not all health impacts or vulnerable populations are represented. However, the chapter provides a framework based upon verified, scientific research to explore and understand the regional challenges and potential 'northern Ontario-specific' responses to understand and respond to climate change impacts on health.

The following chapter investigates five climate-amplified impacts that are relevant to northern Ontario. These climate amplified impacts include:

1. Temperature extremes
2. Extreme weather events
3. Food and water security
4. Vector-borne disease
5. Mental health impacts

Each of the five sections are organized by subheading to explore the associated climate-amplified hazards, sensitivities and potential adaptive actions to protect human health where such information is available. The hazards subheading explores the projected changes in the climate and the associated impact on exposure. The sensitivity subheading incorporates the understanding of changing exposure to highlight the degree to which selected populations and representative communities are impacted by climate variability. Finally, the adaptation subheading provides a description of regional adaptive capacity, while highlighting viable adaptation actions for northern Ontario.

Information is focused on the northern Ontario context. Where localized information was not available, data and approaches from similar regions was used.

Figure 15: Projected temperature changes in northern Ontario from present to 2050, based on a continued high emissions scenario (8.5 RCP).

Temperature Extremes

Hazards

Extreme Heat

The climate in northern Ontario is rapidly warming. Average temperatures are projected to increase at a rate over twice the global average[30,71], in addition to historical climate records that indicate areas of northern Ontario have already warmed by 2°C since the 1970s.[32,74,75] However, it is important to note that the large geography of northern Ontario results in a varied gradation of warming across the region.

Average temperatures are predicted to increase further with southern, urbanized parts of the region projected to experience changes of over 2°C under a high emission, 'business as usual' scenario (RCP 8.5) by 2050 (Figure 15). More concerning, northern, rural parts of the province are predicted to experience an increase in average temperatures of over 2.5°C (RCP 8.5) by 2050. The Ministry of Environment and Climate Change Canada's criteria for a heat warning in northern Ontario is a daily temperature high of 29°C or greater and nightly temperature high of 18°C or greater, or a daytime maximum humidex of 36°C. As the climate continues to warm, it is predicted that by the 2080s, the average summer temperatures across northern Ontario could increase by 2°C to 6°C, meaning a projected increase of 15 additional heat warnings per year.

Extreme heat and the associated health impacts are a growing public health concern. Heat-related mortality in central Canada, without consideration of population acclimatization, is expected to be more than double by the 2050s and triple by the 2080s.[70] Within Ontario, clear trends between heat and health exist indicating greater morbidity and a 2.5% increase in mortality associated with moderate increases of 5°C.[76] It is important to recognize that in these studies death exclusively from heat exposure is rare. More commonly, exposure to heat makes existing diseases and health challenges worse. As heat waves in the region continue to increase in frequency, morbidity and mortality associated with heat may also increase. This trend can be seen when examining the number of heat related visits to emergency departments in northern Ontario, compared to the occurrence of days with temperatures exceeding 30°C. These visits arise for a variety of heat-related conditions such as heat exhaustion, heat stroke, heat cramps, dehydration and electrolyte disorders, cardiovascular and cerebrovascular diseases, respiratory disorders, acute renal failure, neurological conditions and mental illnesses. These impacts are observed more frequently in populations with existing chronic disease, low income and working outdoors for reasons discussed below.

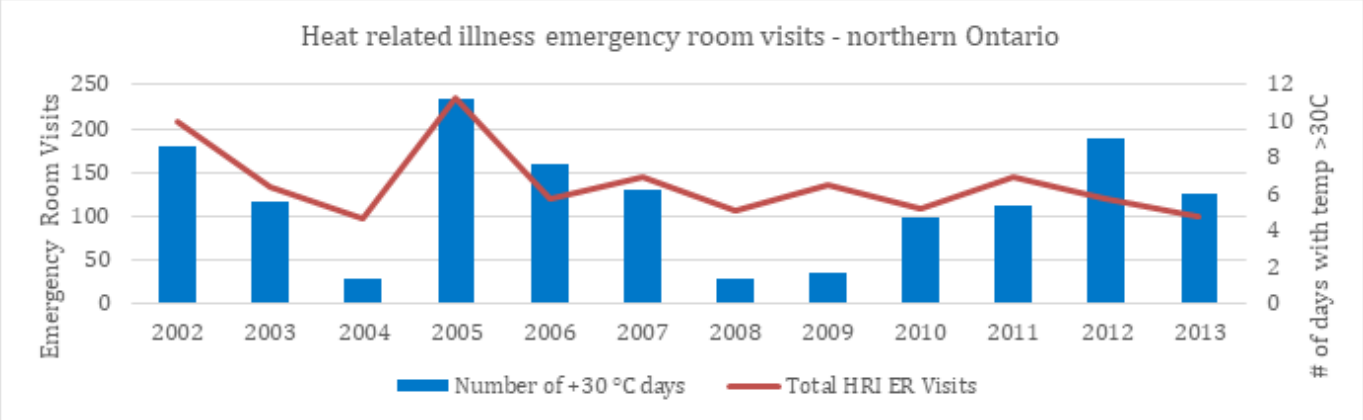


Figure 16: Association of temperature and heat-related emergency room visits in northern Ontario.

Extreme Cold

In northern Ontario, the greatest changes in temperature are projected to occur in the winter.[38] Temperature averages across northern Ontario could increase by 4°C by 2080, resulting in dramatic impacts.[15] As winter average temperatures increase, impacts will be felt in the far northern regions of Ontario with notable impacts on resource development, infrastructure, traditional lifestyles and health. Warming winters result in destabilized ice roads, which many remote First Nations communities depend on for access to food, resources and health services. Increased ground temperatures result in shifting permafrost, reducing the stability of infrastructure and established communities.

Extreme cold events are projected to occur less often and with reduced intensity.[15] Few studies have investigated the impact of extreme cold on human health within Ontario, particularly within the rural and remote settings of northern Ontario.[49] However, recent studies have illustrated the association of decreasing temperatures with increased incidence of cardiovascular-related mortality within the regions of Thunder Bay, Sudbury, Algoma and Parry Sound.[76] These findings are projected to be amplified with a changing climate, as extreme cold events present the additional risk of health impacts such as hypothermia, frostbite and windburn. Though the climate in northern Ontario is warming and the frequency of extreme cold warnings are projected to decrease this is not projected to result in fewer cold-weather days. Therefore, as individuals become acclimatized to a warmer climate and lose their acclimation to the cold, studies have predicted increased incidences of mortality due to the impacts of extreme-cold weather days.

Table 1: Projected temperature changes for the year 2050 within northern Ontario cities and towns. Recent past represented as historical baseline average of 1976-2005. Low carbon future (RCP 4.5) displays greenhouse gas emissions continuing to rise until 2050 and then rapid declining, resulting in less rapid change. High carbon future (RCP 8.5) depicts greenhouse gas emissions increasing at our current rate, with no change or reduction, resulting in more dramatic change.[15]

Community	Average hottest temperature of the year			Average coldest temperature of the year			Average number of days per year above 25°C			Average number of below zero days per year			Average length of the frost-free season		
	Recent past	Low-Carbon Future	High-Carbon Future	Recent past	Low-Carbon Future	High-Carbon Future	Recent past	Low-Carbon Future	High-Carbon Future	Recent past	Low-Carbon Future	High-Carbon Future	Recent past	Low-Carbon Future	High-Carbon Future
Parry Sound	31.1°C	33.2°C	33.5°C	-32.2°C	-28.8°C	-28.2°C	42	67	72	158	135	134	152	171	175
Little Current	30.7°C	32.8°C	33.1°C	-31.0°C	-27.6°C	-27.1°C	31	54	59	163	140	138	150	171	176
North Bay	31.5°C	33.5°C	33.8°C	-33.2°C	-29.8°C	-29.2°C	37	59	63	173	154	151	136	155	162
Sudbury	32.3°C	34.3°C	34.6°C	-34.7°C	-31.2°C	-30.7	41	64	68	177	156	154	134	154	160
Sault Ste. Marie	31.4°C	33.5°C	33.8°C	-30.0°C	-26.6°C	-26.1°C	34	55	58	166	143	141	144	166	172
New Liskeard	32.9°C	34.9°C	35.3°C	-38.2°C	-34.8°C	-34.3°C	43	63	66	186	166	164	123	143	148
Chapeau	31.4°C	33.3°C	33.6°C	-39.2°C	-36.1°C	-35.4°C	30	47	51	204	182	180	106	127	130
Timmins	33.7°C	35.6°C	36.0°C	-38.6°C	-35.3°C	-34.6°C	42	60	63	199	178	176	110	131	135
Thunder Bay	31.2°C	33.2°C	33.5°C	-35.0°C	-31.8°C	-31.4°C	26	45	48	195	173	170	120	142	144
Kenora	32.4°C	34.5°C	34.8°C	-36.7°C	-33.7°C	-33.1°C	42	62	66	185	167	166	137	154	158
Sioux Lookout	32.5°C	34.6°C	34.9°C	-38.3°C	-35.5°C	-34.9°C	37	55	59	194	175	173	128	145	149
Pikangikum	31.1°C	33.2°C	33.4°C	-38.9°C	-36.2°C	-35.5°C	28	44	48	202	186	183	124	142	145
Attawapiskat	31.2°C	33.0°C	33.3°C	-39.9°C	-36.0°C	-35.3°C	16	26	29	219	201	198	100	122	127
Fort Severn	28.0°C	29.7°C	30.1°C	-40.4°C	-36.5°C	-35.8°C	6	12	13	232	216	213	102	120	123

Sensitivity

Population Center Sensitivity

Community characteristics related to the built environment contribute to heat and cold related morbidity and mortality. Urban centers are often warmer than their rural, road-access and remote surroundings. This difference is due to what is known as the urban heat island effect, where surfaces like asphalt and concrete absorb heat during the day and release it at night and the cooling effect of tree cover is limited.[77] In addition, the availability of, and accessibility to, services to cope with heat such as public transportation, health services, community outreach services and easy-to-access cooling options also have an effect on heat related morbidity and mortality.[77]

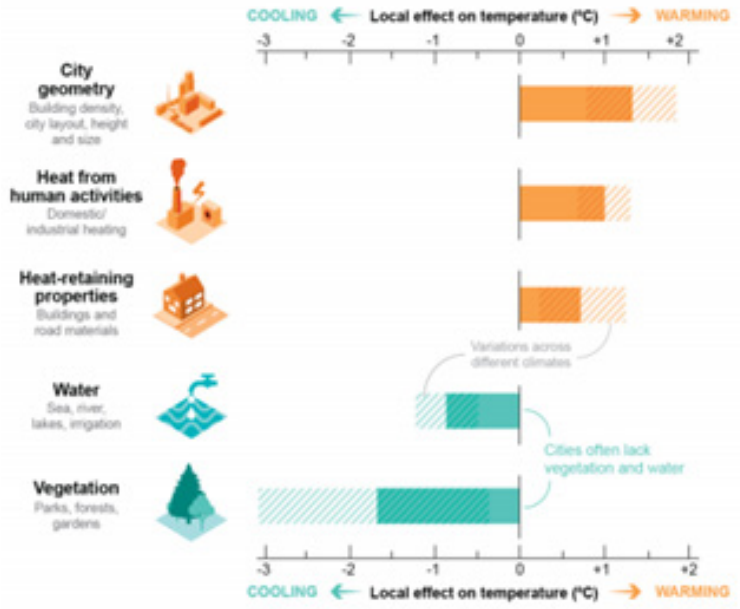


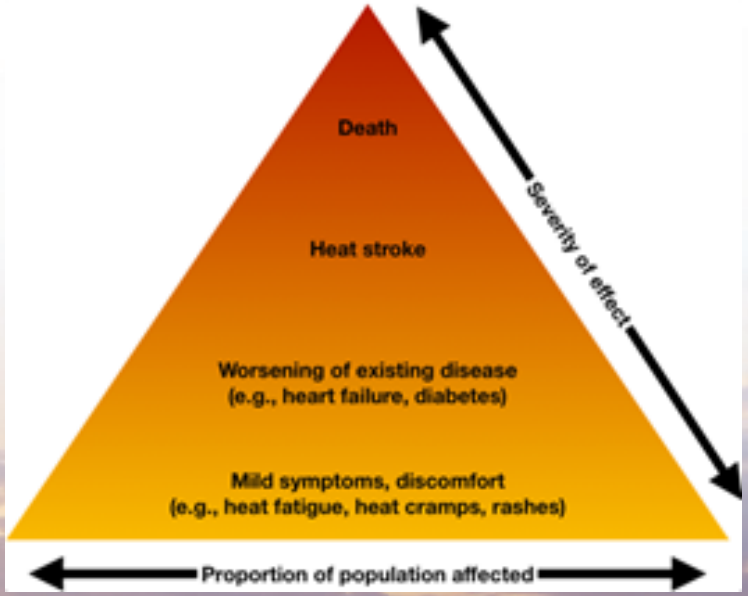
Figure 17: Influence of infrastructure on local temperature.[78]

Physiological and Social Sensitivity

The way in which health impacts from temperature extremes are experienced can vary depending on pre-existing health and sociodemographic circumstances. Pre-existing health challenges, chronic conditions, financial limitations and employment all influence the degree to which individuals or communities are affected by temperature extremes.

Older Adults

Demographic projections of northern Ontario indicate an aging population with the proportion of older adults in northwestern Ontario doubling by 2050.[16] As people age they may become more sensitive to extreme temperatures for various physiological reasons. Decreased plasma volume and decreased blood flow to skin and extremities, in addition to reduced cardiovascular output, are all factors that can limit an older adult's ability to sweat and therefore cool themselves as an adaptation strategy for extreme heat days. In addition some older adults have a lowered fitness level, with increased body fat and reduced lean body mass, which can inhibit their ability to effectively regulate their internal temperature. A reduced thirst sensation may also lead to an increased susceptibility to chronic dehydration, and limited mobility may reduce ability to access community cooling spaces. Finally, some older adults can be socially dependent on caregivers for awareness and recognition of the impact of temperature extremes.



Infants and Children

Children under the age of five years have a reduced sweating ability, and a decreased ability to regulate cardiac output, limiting their capacity to regulate their internal temperature. Infants and children gain heat from the environment faster if the air temperature is greater than skin temperature due to a greater surface area to body weight ratio. Children also

often exercise at a lower intensity but for a longer amount of time and have a social dependence on caregivers for awareness and recognition of the impact of temperature extremes.[79]

Existing Health Challenges and Chronic Conditions
Individuals with existing health challenges and chronic conditions often possess physiological characteristics that may amplify health risks, such as cardiovascular and respiratory illness, hypertension, mental illness, renal illness, diabetes or obesity.[80] These physiological characteristics may also be the result of comorbidities. Individuals with existing health challenges may also be engaged in treatment that affects heat sensitivity, interferes with the body's cooling functions, or prompts water and salt retention. Certain health challenges may limit mobility and confine an individual to bed rest, while some may make the individual dependent on caregivers for activities of daily living. In these circumstances, recognition and response to temperature extreme depends on the caregiver. There may also be social isolation because of a social or mobility impairment which may limit access to services and supports.

Low Income and Socioeconomic Conditions
Populations with limited financial resources may face barriers to adequately adapting or taking action against temperature extremes such as purchasing an air conditioner to address extreme heat. These populations may also experience limited access to health care and social services to respond to the impacts of extreme temperatures as well as challenges accessing drinking water and cool places during extreme heat. Individuals who experience low income have a higher likelihood of also experiencing inadequate housing or housing insecurity which can result in increased environmental exposure to outdoor elements or social isolation from support systems.

Outdoor and Industrial Workers
Outdoor and industrial workers have increased rates of exposure to extreme temperatures and experience increased metabolic heat production which increases their risk of heat-related illness. This population can experience insufficient blood replenishment as well as blood volume loss due to insufficient fluid replenishment and profuse sweating, as well as pooling of blood in the cutaneous circulation.

Newcomers to Canada
Newcomers to Canada may be unfamiliar with local alert systems and with health and social service programs available to them. There may also be cultural differences such as food consumption habits, clothing choices, or pre-existing cultural or social beliefs that complicate a newcomer's ability to engage in recommended adaptation action. French or non-English newcomers also experience the social sensitivity due to language and literacy barriers, further compounding previous sensitivity factors.

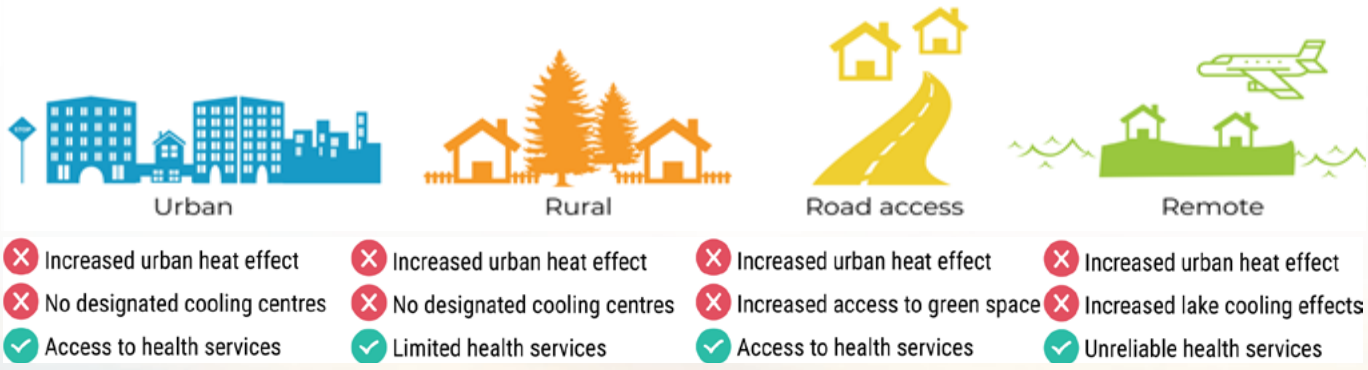


Figure 18: Sensitivity generalization based on representative communities in northern Ontario.

Adaptation

Adaptive capacity is influenced positively or negatively by many factors including resources (e.g., money, infrastructure), abilities (e.g., community health, age, mobility, disease) and knowledge (e.g., understanding of climate impacts and actions that can be taken). In northern Ontario some of the populations most sensitive to heat-related illness are also some of the least mobile. Because of this lack of mobility adaptation strategies for extreme heat events must also include outreach. Any comprehensive response to extreme heat should include targeted interventions specific to the vulnerable populations. While accessibility is important, in many cases it is not enough to ensure that the most susceptible receive help. For these reasons it is important to consider outreach, access to, and equity of interventions in moving forward with creating and prioritizing adaptation strategies to ensure that those most at risk have the tools and supports needed to combat the potential negative health effects of extreme temperatures. The adaptation action examples below would increase adaptive capacity and reduce vulnerability to the impacts of climate change. It is important to note that these actions have co-benefits to health, meaning actions that protect individuals and communities from the impacts of climate change also work towards protecting and improving human health.

The combined effect of increased vulnerable populations and escalating temperatures will make extreme heat a growing public health concern. The following figures illustrate the differing degree to which specific communities and populations will be impacted by changing temperature.

Outside of the PHU

- Community connection – Community programs to help establish community connection and increase resiliency
- Educational awareness – increase community knowledge and skills in recognizing and responding
- Infrastructure – environmental design to maximize energy usage
- Partnership – emergency preparedness collaboration, warming/cooling centers

Within the PHU

- Health equity impact assessments to identify populations/communities at risk
- Collect and consolidate data on extreme temperature events
- Heat and cold alerts
- Coordinated emergency response planning
- Educational campaigns surrounding protective individual action communities can take

Extreme Weather Events

The severity and frequency of extreme weather events across Canada has increased dramatically over the past decade.[27] Impacts such as extreme precipitation and flooding, wildfire and intensified storms are affecting northern Ontarians with direct and cascading impacts to health.

Hazards

Extreme Precipitation and Flooding

Annual precipitation is projected to increase throughout northern Ontario.[15,27,32] This is concerning as flooding is recognized as the leading cause of public emergencies in the province. While northern Ontario historically receives between 80 cm and 320 cm of precipitation per year in the form of snow, current climate projections anticipate a shift to occur in the spring and fall seasons, with warming temperatures resulting in wetter, inconsistent forms of precipitation.[15] Due to the warming climate the atmosphere has an increased capacity to hold moisture and is creating conditions favorable to mixed precipitation such as rain, freezing rain and snow. Winter storms are projected to increase in frequency and intensity in northern Ontario.

RCP 8.5: High Carbon climate future

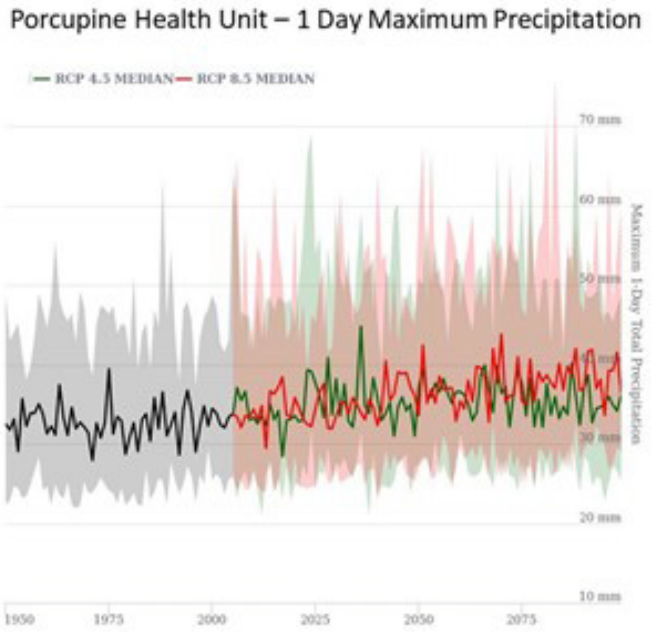
GHG emissions continue to increase at current rates

Variable	Period	1976-2005	2021-2050			2051-2080		
		Mean	Low	Mean	High	Low	Mean	High
Precipitation (mm)	annual	816	724	869	1026	757	912	1074
Precipitation (mm)	spring	169	119	182	257	127	202	285
Precipitation (mm)	summer	248	170	253	342	164	249	345
Precipitation (mm)	fall	236	178	253	331	183	261	350
Precipitation (mm)	winter	164	126	181	239	139	199	259

Figure 19: Precipitation projections for northern Ontario under continued high emissions.

Historical trends and future projections indicate a trend towards more frequent, intense incidences of heavy precipitation days which involve precipitation amounts greater than 10mm in one day. This excess precipitation will lead to increased incidences of flooding. Among natural weather events reported throughout the province flooding already leads in frequency of occurrence and economic damage.[72] Rainfall, snow melt and ice jams are all common causes of flooding in northern Ontario which are currently experienced and projected to increase. Larger rain and snow falls, along with precarious weather warming patterns, may also result in unpredictable snow melt, causing flooding.

Increased precipitation and the resulting floods can impact many facets of human health including physical, psychosocial, and socioeconomic wellbeing. Increased mortality due to more frequent incidents of drowning and increased morbidity due to injuries related to flood events are examples of some of the physical impacts. The loss of land can also carry a cultural significance to many Indigenous populations. Indigenous identity places heavy importance on the connection to the land and the loss of this connection can have devastating and lasting impacts to identity and mental health. This is discussed further below in the mental health section. Community housing and infrastructure is often damaged during extreme flooding causing distressing displacement and a delay in accessing crucial services for post-event recovery as well as socioeconomic impacts stemming from the cost of repairing damaged infrastructure and providing emergency services. This is particularly important in northern Ontario where access to services is already limited in many rural, road access and remote communities.



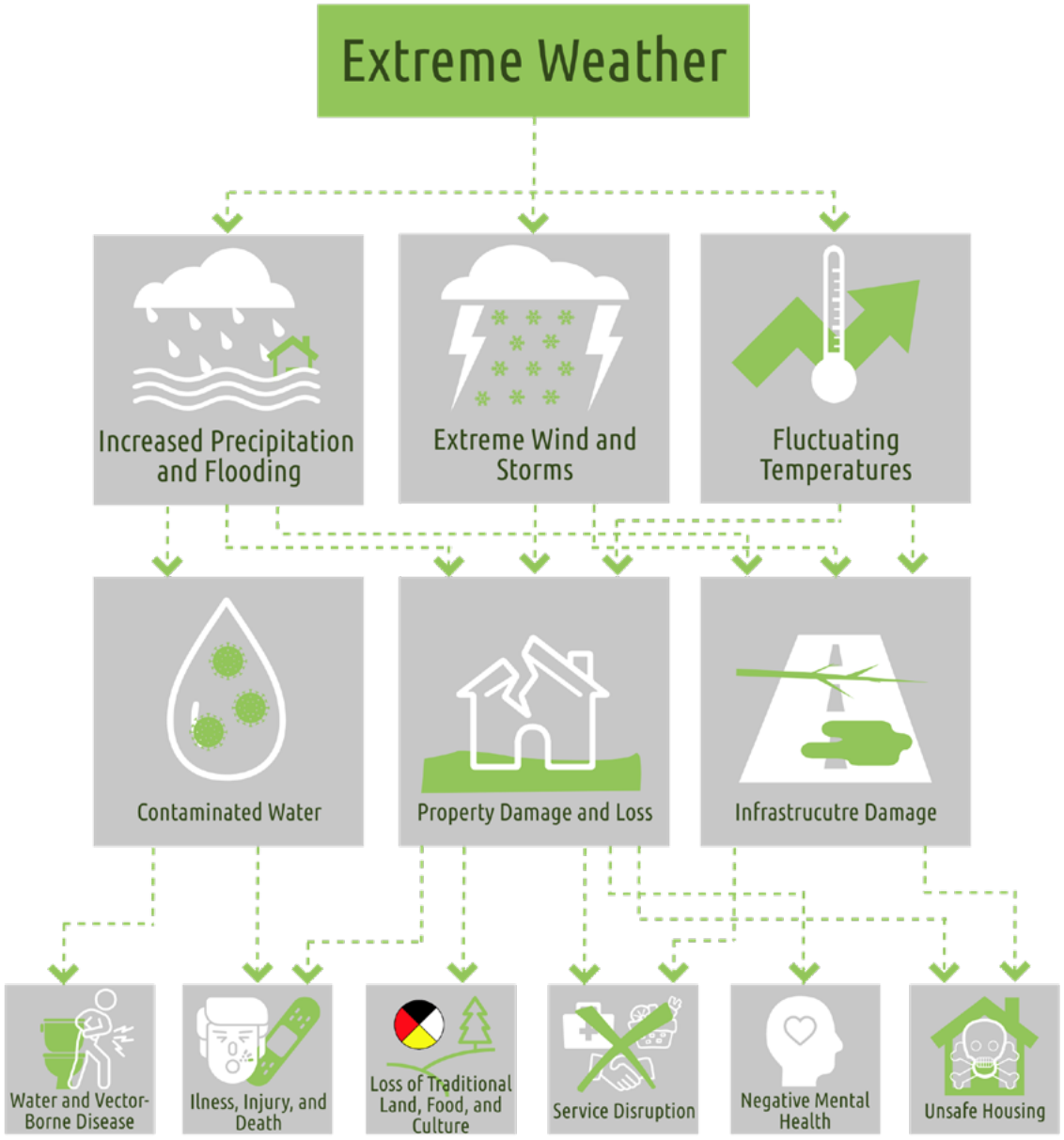
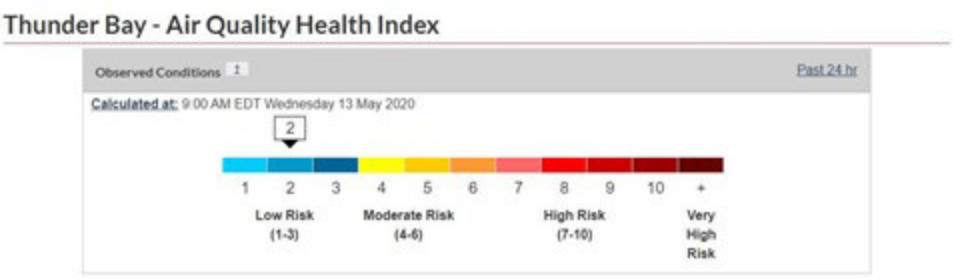


Figure 20: Impact pathways from extreme weather events related to flooding and storms.

Wildfire and Air Quality

By 2030 incidences of wildfire within northern Ontario are projected to increase by 25%. Climate change is creating drier summers which leads to favourable conditions for wildfire proliferation. This includes increased lightning storms, whose lightning strikes ignite over half of the wildfires in northern Ontario and dry, windy weather which can bolster the spread of flames. Rising temperatures work to quickly dry out brush and trees even after periods of precipitation. These rising temperatures are also more favourable for creating storms capable of producing lightning. Once the wildfire has been lit, windy weather not only spreads the flames but also makes them more difficult to extinguish. Climate change is also lengthening the fire season by causing earlier snow melts and later fall frosts, extending the fire season in the region.



Wildfires produce gas, smoke, ash and particulate matter, all of which create potential impacts to health, specifically respiratory health.[81] In addition, the symptoms of pre-existing respiratory illnesses such as asthma or chronic obstructive pulmonary disorder can be exacerbated by these by-products. Within northern Ontario wildfires and the resulting poor air quality can create the need for evacuation and displacement, moving entire remote communities into temporarily safer, more urban centres. Being removed from your home community, the familiarity of your environment and sometimes your culture, as well as the uncertainty of the safety of your home, belongings and land, can have significant impacts on the physical and mental health of individuals.

In addition, increased periods of warmer temperatures contribute to lengthened seasons, during which plants and trees which produce allergenic pollens have a longer window to thrive.[82] Within Canada pollen levels have been rising over the past decade and in parts of the country the duration of the pollen season has increased by over four weeks. In addition to warmer temperatures, increased levels of CO2 in the atmosphere are contributing to the rising allergen levels.

Sensitivity

Population Center Sensitivity

All population centers are more sensitive to extreme weather impacts related to heavy precipitation; however, they differ in the potential risks present. In urban settings infrastructure development (e.g., roads, buildings) contributes to urban storm-water runoff because much of the ground is covered with impermeable surfaces. This increases the transport efficiency of drainage to, and overwhelms, rivers leading to severe flooding. Furthermore, urban storm-water runoff can lead to overloading of storm drainage systems and water treatment plants which can lead to water contamination as well as residential flooding if not appropriately prepared for. In rural settings, road access and remote settings heavy precipitation events can lead to road wash outs and the destruction of power, gas and water lines. In the spring season intense precipitation and natural ice thawing can result in significant ice jams along river-ways resulting in large floods, forcing communities to evacuate. The land within many northern communities remains frozen for much of the spring, resulting in snow and ice melt being unable to penetrate the ground and accumulating, which adds to the impact of flooding.

Rural, road access and particularly remote communities are also dramatically impacted by frequent wildfires. As fires spread across northern Ontario, amplified by warmer, drier summers, many communities who live on and close to the land are impacted. These communities are at a greater risk to experience impacts ranging from property damage and forced evacuation to mental health trauma and physical injury from smoke inhalation.

Physiological and Social Sensitivity

Older adults, infants and children, those with existing health challenges and chronic conditions, and outdoor workers may be more impacted by extreme weather events. In particular those with mobility limitations, as well as pre-existing respiratory disorders such as asthma and chronic obstructive pulmonary disease, are at a high risk.

Adaptation

The impacts of extreme weather events will impact populations across northern Ontario. Public health units and partners can reduce these impacts and protect health:

Within the PHU

- Health equity impact assessments to identify populations/communities at risk
- Collect and consolidate data on extreme weather event events
- Air quality alerts
- Coordinated emergency response planning
- Educational campaigns surrounding protective individual action communities can take

Outside of the PHU

- Community connection - Community programs to help establish community connection and increase resiliency when faced with challenge
- Educational awareness – Increase community knowledge and skills in recognizing and responding
- Infrastructure – Environmental design to maximize energy usage
- Partnership – Emergency preparedness collaboration, evacuation coordination and communication

Food and Water - Contamination and Availability

Hazards

Food Insecurity

Food insecurity is the uncertainty or inability to geographically or financially access or consume an adequate diet quality or quantity in socially and culturally acceptable ways, or the uncertainty that one will be able to do so.[83] Food security is influenced by four dimensions including: (a) the availability or quantity and quality of food supply; (b) access or the ability for individuals to acquire food necessary for healthy, active living; (c) use or the ability to effectively use, consume and benefit from food; and (d) the long-term security and availability, access and utilization.[71] There are many ways that food systems and factors influencing food insecurity are being worsened by climate change and in turn impacting health.[69,71,84,85]

Climate change is creating instability in the availability of food as acute and long-term climate events are increasing the precarity of growing conditions and disrupting food distribution. For example, temperature extremes are creating unpredictable growing seasons with extreme heat events leading to an earlier season, and extreme cold causing sudden frost during summer seasons which damages and kills crops.[86] The infrastructure required for food production and distribution, including agricultural land, supply chain resources and roads for food transportation can also be negatively impacted by a changing and unpredictable climate.[71]

Remote populations in northern Ontario also face the added challenge of transporting food to their communities.[87] Several communities rely primarily on winter roads to import their food supply and with temperatures warming unpredictably this method of acquiring health food is becoming more precarious.[31,71] Canada is part of a global food system and although the severity and frequency of certain climate events that negatively impact food availability such as drought are much lower in northern Ontario, these climate events occurring in other locations will have implications for food security in the region.[71]

Northern Ontario is also facing negative impacts of climate change with the availability and quality of traditional foods, further contributing to the observed dietary shift in Indigenous populations from traditional foods to Western market foods.[71,91] Northern Ontario's Indigenous hunting and gathering and traditional food storage practices are challenged by climate hazards that reduce the duration and thickness of ice, cause permafrost thaw, shorten winter seasons, lengthen summers and create conditions of unpredictable weather.[71,92] For example, climate change has contributed to changes in the abundance and geographic distribution of traditionally hunted caribou. Regions that are rural or remote often have a lowered capacity to produce or store their own food products locally which creates a vulnerable dependence on food that is not always accessible.[71,88,92]

Foodborne Illness

Food systems are also being impacted by climate change through the increased prevalence of foodborne illnesses resulting from climate change creating ideal conditions that favour pathogen growth and survival.[93,94] For example, climate change has led to longer pathogen survival times, the migration of flora and fauna that create new contaminants at the food source, and incidences following acute weather events where power and water supply, which are critical in proper storage and preparation of food, are lost.[95,96] Warmer weather and increased rainfall in northern Ontario create a warm, humid environment which is an optimal environment for pathogen proliferation[95]. Additionally, food that has come into contact with flood water is not safe for consumption.[97] Climate change also has the food-related social impact of creating ideal, warmer weather conditions for outdoor gatherings such as barbeques. During these times, individuals often bring food to prepare, but are unable to maintain proper safe storage, resulting in foodborne illness.

Water Contamination

Climate change is creating optimal conditions for the spread of bacteria and algae within water sources in northern Ontario. Cycles of drier conditions followed by intense rainfall, which are increasing as a result of climate change, create greater amounts of runoff contaminants and nutrients that enter water sources. Drier conditions also increase dust-borne contaminants that can enter water sources. The increased frequency and intensity of rainfall can also overload water treatment and storm water managements systems, which then contributes to contamination of water, as well as a lack of water availability. One health impact related to water contamination of particular relevance to northern Ontario is the increased incidence of blue-green algae blooms.

These blooms have been increasing in Ontario since 1994, with average temperatures rising in northern areas creating longer periods of ideal bacterial growth. Warmer temperatures also result in an increase in water recreation activities such as swimming, which increase exposure to these blooms. Surface contact with blue-green algae blooms can result in respiratory and allergic reactions, while ingestion can result in headache, fever, or gastrointestinal trauma.

Availability of Safe Drinking Water

Communities in northern Ontario, who can be dependent on natural water sources for their drinking water, are often living under water boil advisories due to lack of clean, safe water. Warming summer temperatures, with heavy precipitation events leads to favourable conditions for blue-green algae formation and severely compromises the integrity of these water sources. These factors, in addition to industrial pollution from resource extraction operations, have reduced the safety and security of water sources throughout northern Ontario.

Sensitivity

While any individual can be impacted by food and water insecurity, some individuals may be at greater risk of life-threatening consequences. Individuals with pre-existing health challenges, older adults, financially insecure people, and those living close to the land are comparatively at a greater risk. These impacts are disproportionally experienced, predominantly in remote communities as food prices, food availability and water quality are unstable, and are often dependent on external resources and aid.

Hazard

Tick-borne illness

Lyme disease is the most prevalent vector-borne disease in northern Ontario and has seen dramatic increases within the past 10 years, driven in part by increased environmental suitability and elevated surveillance of Ixodes scapularis, commonly referred to as the blacklegged tick. [56,98–101]

The principal hazard posed by blacklegged ticks is their ability to carry and spread infectious agents of disease. [54,102] Feeding on the blood of a host organism, ticks can act as vectors transmitting a number of infectious pathogens, including Lyme disease. [55] Reported cases of Lyme disease in Canada have increased over the past decade, with the majority of cases experienced in Ontario. [55,99,101] Further intensification of Lyme disease is expected as warming temperatures increase tick maturation leading to the expansion of estimated risk areas. [101,103]

Public Health Ontario releases an annual map estimating areas of risk for Lyme disease, classified based on locations within a 20 km radius where “blacklegged ticks have been identified or are known to occur and where humans have the potential to come into contact with infective ticks”.[104] Risk areas in northwestern Ontario have continually expanded, which has led to communities such as Thunder Bay and Kenora being declared as endemic.

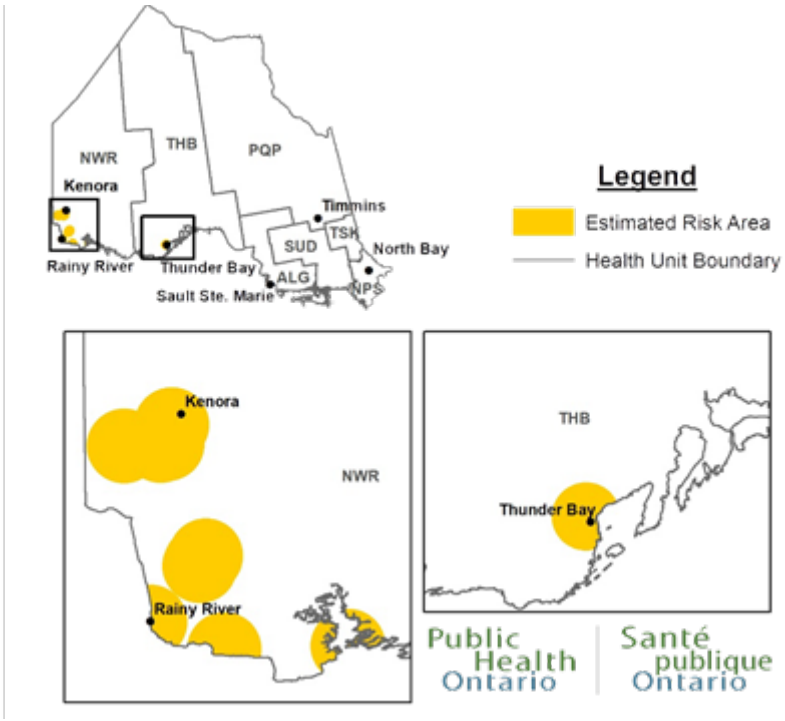


Figure 21: The 2021 Public Health Ontario Lyme disease estimated risk area map.[105]

There are many environmental, educational and lifestyle risk factors associated with exposure to ticks and thus the potential for contracting tick-borne disease.[56] One such risk factor is the species of tick that bites an individual. Different species of ticks transmit different diseases and some diseases are exclusive to one type of tick.[102] As well, geographic location varies among individual species of ticks, with optimal environmental suitability resulting from warm, wet climates. [52] The risk of infection for tick-borne disease is also dependent on individual awareness and understanding.[106] Action taken to enhance vigilance and minimize skin exposure will lower risk and chance of infection. Public knowledge to engage in preventative action, or to act appropriately and in a timely manner when there is contact with ticks, minimizes the risk of being infected and contracting a potentially chronic disease. [107]

Mosquito-borne illness

In Canada, over 80 different species of mosquitos naturally exist; however only very few are capable of carrying pathogens of disease. West Nile virus (WNV) is carried by infected mosquitoes. Eighty percent of individuals infected with WNV are asymptomatic, while 20% of infected individuals develop West Nile fever which consists of fever, tiredness, headache, muscle aches, rash and/or swollen glands. Approximately one in 150 people infected with the virus will develop life-threatening encephalitis, i.e., swelling of the brain. Symptoms of West Nile encephalitis include fever, headache, stiff neck, disorientation, tremors, muscle weakness, paralysis and/or coma. West Nile encephalitis is more common among, but not restricted to, individuals over 50 years of age. The severity of the disease increases with age. From 4% to 14% of people with West Nile encephalitis die as a result of their infection; others may experience long-lasting, debilitating problems ranging from memory loss to muscle weakness.

Vulnerability

Individuals with outdoor occupations, or those who spend an extended amount of time in wilderness settings, increase their exposure to vector-borne diseases. While research has investigated the use of biological and chemical agents as a means of controlling tick populations and the transmission of Lyme disease, the evidence is inconclusive and many of the control methods have significant negative health impacts to non-target organisms making the interventions non-viable. Public health interventions therefore focus on education and preventative approaches [108].

Mental Health

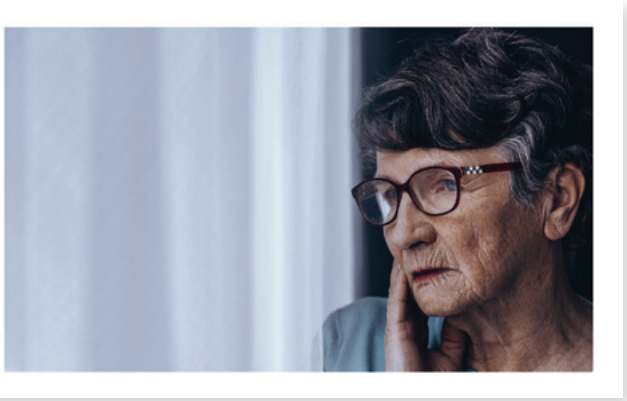
The World Health Organization defines mental health as a state of well-being in which an individual realizes their own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to their community.[109] Mental health is a universal and individual experience and as such, quite complex in nature. Everyone experiences mental health, but what these experiences look like, or the factors that influence where an individual's mental health falls on the continuum of mental illness to wellness vary greatly from person to person. While the relationship between climate change hazards and mental health outcomes is understudied compared to climate change and physical health, research has shown negative mental health outcomes in response to acute and long-term and projected climate events.

Hazards

Impacts of Acute Hazards

The current literature on climate change and mental health focuses predominantly on the impact of acute climate hazards such as extreme heat events, extreme cold events, flooding and wildfires. Unlike the physical health impacts that result from specific acute hazards such as heat stroke from extreme heat, mental health impacts can be experienced after any acute hazard. As such, the discussion of these impacts will be approached differently. Rather than listing the specific hazards that are often uniquely associated with an acute hazard this report will discuss some of the mental health impacts through examples and data relevant to northern Ontario.

One of the first impacts associated with acute climate change hazards is the onset or exacerbation of mental illness, specifically mood and behavioural disorders. Symptoms of major depressive disorder, post-traumatic stress disorder, fear and anxiety have all been shown to develop or worsen following an acute climate hazard. With the increasing intensity and frequency of acute climate hazards people are being more frequently exposed to events such as danger, injury and death which may spark the onset or exacerbation of these mental illnesses. Incidences of extreme heat have been linked to greater levels of aggressive or criminal behaviour and increased rates of hospitalization for those with mood or behavioural disorders such as dementia or anxiety. Flooding has also been shown to exacerbate pre-existing mental illness and provoke new symptoms, with psychological distress prevalent in 8.5% to 53% of populations who experience flooding one-year post-flood.



Another mental health impact that is pervasive throughout all acute climate hazards is trauma, which can foster complex emotional and behavioural reactions. Trauma can be understood as a normal response to an abnormal situation. Trauma becomes abnormal when responses persists even when safety has been re-established and the stressor is no longer present. Trauma can result directly from acute hazards where the high level of threat and stress leads to a trauma response that persists long past the danger passing, or indirectly from experiences of the physical health impacts of acute climate hazards. Extreme weather events are the most common climate hazard resulting in trauma in northern Ontario. Residents experience direct trauma with high levels of threats to their individual or communal safety, such as injury, illness, or death. Individuals can also experience indirect trauma through loss of property, belongings, traditions, or culture.

Other mental health impacts relevant to northern Ontario are the loss of livelihood and sense of place associated with displacement. Wildfires and floods cause displacement, where individuals or communities are required to leave their homes due to a risk of harm or mortality. Within northern Ontario, evacuation and displacement due to

wildfires has been shown to increase levels of stress, fear and long-term emotional trauma.

Impacts of Slow Creeping Hazards

Slow creeping hazards refers to climate change impacts that occur gradually but consistently over time. One example especially relevant to those residing in northern Ontario is the rising heat levels. Studies examining North America have found relationships between higher daily temperatures and rates of mental illness. The mental health impacts associated with slow creeping hazards are often not instant, but rather seen in building intensity of anxiety, grief, depression, anger and helplessness. The term solastalgia has become prominent in the climate change mental health literature, used to describe the profound sense of loss felt by those losing their connection to the environment they know, often incorporating the previously listed emotions. It is a lasting sense of distress that cannot easily be overcome.

Similar to the impacts of acute hazards, slow creeping hazards can also lead to a loss of sense of place as well as culture and identity. Within northern Ontario in particular many Indigenous peoples value a close connection to the land as part of their identity, cultural practices and livelihood. When this connection is threatened or harmed by climate hazards Indigenous populations can lose the positive benefits of their connection to the land including their sense of identity, self-worth, strengthened interpersonal relationships and cultural practises. Rising temperatures and increased snow and ice melt impede individuals' connection to place and the land, fostering poor mental health outcomes such as substance misuse, distress, depression and suicide.

Sensitivity

Population Center Sensitivity

Remote, road access and some rural population centres are likely to be more sensitive to the mental health impacts of climate change due to the lack of mental health services and supports. Hospitals that provide psychiatric services tend to be situated in urban population centres, requiring those wanting to seek psychiatric services to travel in from their home community, leaving their supports behind and incurring a substantial financial cost. In some instances, residents of these population centres can access mental health services through telemedicine or temporarily assigned mental health workers but limited infrastructure means this is not always possible.

Physiological and Social Sensitivity

As noted mental health is something that everyone experiences and as such, everyone is susceptible to the mental health impacts of climate change. However, there are some population groups who experience an increased sensitivity to the climate hazards.

Indigenous peoples

Indigenous populations in northern Ontario continue to experience health inequities resulting from an inequitable, colonial and marginalizing health system. As such Indigenous peoples experience an increased sensitivity to the mental health impacts of climate change. Climate hazards are negatively impacting Indigenous identity by destroying their connection to the land. Many elements of the Indigenous culture and traditions centre on the connection to the land as it is used for ceremonies and subsistence. As acute and slow-creeping climate hazards negatively impact the health of the environment, Indigenous peoples are seeing the lasting impacts of this damage to their mental health and cultural identity, including increased rates and severity of mental illness, substance misuse and suicidal ideation.[110,111] Intergenerational knowledge sharing is also being lost as a result of climate change, negatively impacting the culturally relevant tradition of knowledge sharing between elders and youth, both populations who are already at an increased sensitivity due to their age and physiological characteristics.

Children/youth

Some mental health impacts are being seen among children and youth which are not seen in older adults, highlighting them as a population who are particularly sensitive to the mental health impacts of climate change. One element that makes children and youth particularly sensitive is their age since they are the population who will experience a worsening climate crisis. Children and youth have expressed feelings of hopelessness and anxiety at the long-term prospect of losing not only the environment but also their futures. Studies have also shown increased rates of post-traumatic stress

disorder in children following acute climate events. Children are additionally sensitive to the impacts of climate change because they rely on others, often caregivers, to support their emotional wellbeing. Children are still cognitively developing and can lack the skills to effectively handle the stress associated with experiencing acute climate events.

Occupational groups

There are two occupational categories that have been shown to experience greater sensitivity to the mental health impacts of climate change. Outdoor and agricultural workers are heavily dependent on the land, and climate events are creating negative mental health impacts associated with loss of livelihood including stress, anxiety and depression. First responders can experience vicarious trauma, leading to the development of post-traumatic stress disorder when involved in immediately responding to, as well as supporting, the aftermath of climate events.

Individuals with pre-existing mental health conditions

Individuals with pre-existing mental health challenges experience an increased sensitivity to the mental health impacts of climate change because acute and slow-creeping climate events often exacerbate the symptoms of existing mental health challenges. Furthermore, experiencing a mental health challenge increases the risk of developing a comorbidity. As climate hazards increase the chance of onset for many mood and behavioural disorders, living with a mental health disorder and experiencing an acute climate event may spark the onset of an additional, comorbid disorder.

Conclusion

This report provides an overview of climate change and health issues relevant to northern Ontario to enable public health units and partner agencies in the region to undertake climate change and health vulnerability and adaptation assessments.

By first providing background information on the region of northern Ontario, the science of climate change, and the relationship between climate change and health, this report laid out the foundational knowledge required to recognize and understand the many complex ways that climate change is, and will continue to, impact the health of northern Ontarians.

This report then explored some of the more specific ways that climate change will impact health, including through temperature and weather extremes, contamination and availability of food and water, vector-borne disease and negative mental health. Through these impact groupings, we are able to gain a greater understanding of the complex and interconnected ways that climate change is having an immediate and lasting impact on human health. However, we are also able to gain valuable insight into how we can best continue to address the climate health crisis. Through identifying specific climate change hazards relevant to northern Ontario, those who will be most sensitive to the impacts, and the current best approaches to adapt, this report provides insight to inform policy, guide future programming, and inspire effective action.

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