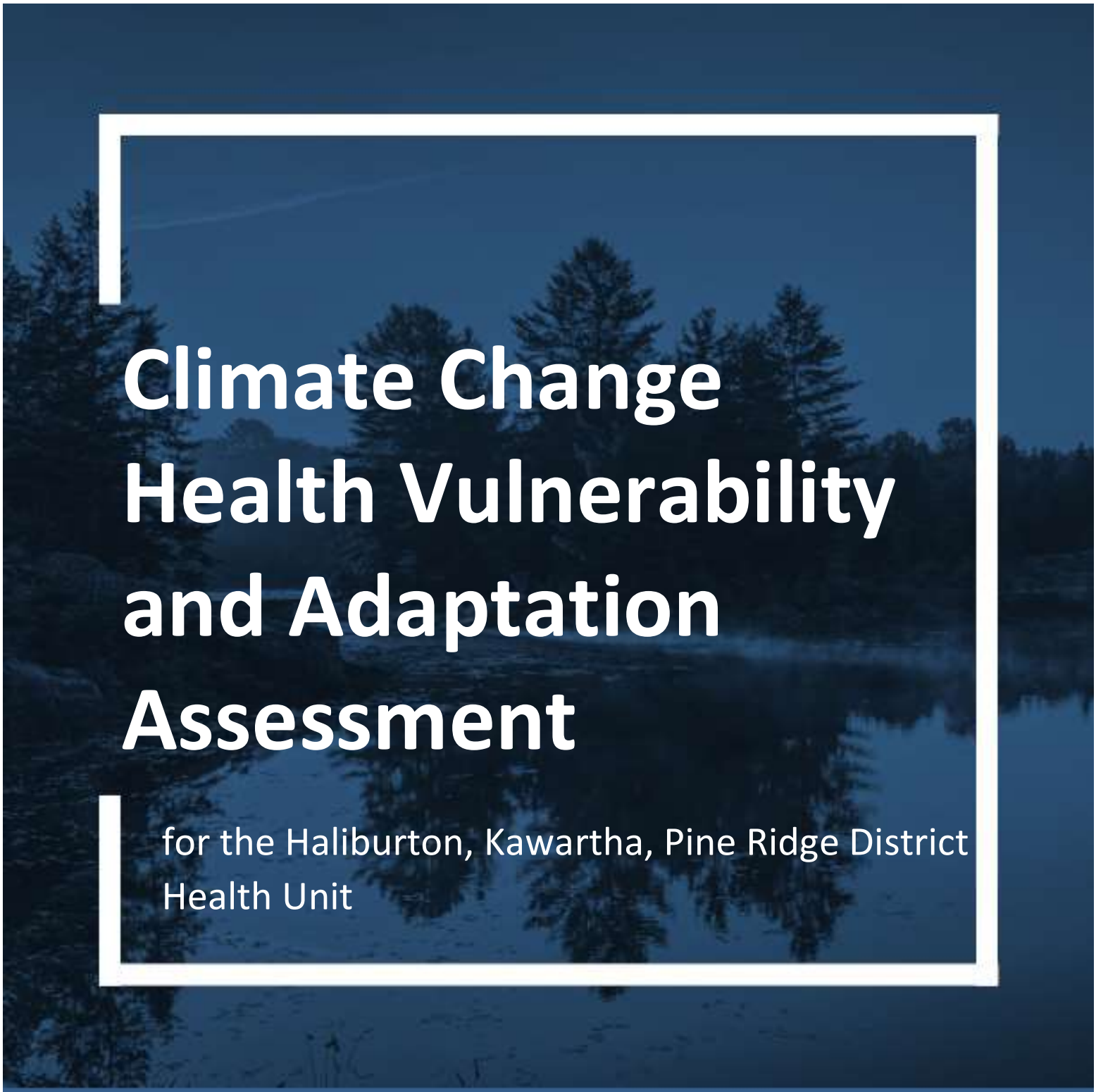

Climate Change Health Vulnerability and Adaptation Assessment

for the Haliburton, Kawartha, Pine Ridge District Health Unit

Haliburton, Kawartha, Pine Ridge District Health Unit

Full Report

Published May 2023

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Land Acknowledgement

The Haliburton, Kawartha, Pine Ridge District Health Unit (HKPR District Health Unit) is situated on the traditional territories of the Michi Saagiig and Chippewa Nations. This includes the territories of Treaty 20 and Williams Treaties. We respectfully acknowledge that these Nations are the stewards and caretakers of these lands and waters for all time and that they continue to maintain this responsibility to ensure their health and integrity for generations to come.

The Haliburton, Kawartha, Pine Ridge District Health Unit recognizes the many harms done to Indigenous peoples and our collective responsibility to right those wrongs. As an organization that is rooted in a colonial system, we are committed to change, to building meaningful relationships with Indigenous communities and in improving our understanding of local Indigenous peoples as we celebrate their cultures and traditions, serve their communities, and responsibly honour all our relations.

Report author:

Sue Shikaze, Health Promoter

Acknowledgements:

Work on this assessment started in 2018 and continued until early 2020, when it was interrupted for over two and a half years by the COVID-19 pandemic. Work resumed in late 2022 and this report completed in early 2023. The author wishes to acknowledge the contributions of Andrew Harris, Epidemiologist, for his work throughout this project sourcing and summarizing health data, and doing data visualization for numerous climate variables. Morgan Levison, former Health Promoter at the Simcoe Muskoka District Health Unit, provided invaluable guidance and support, especially during the early stages and generously shared her expertise and lessons learned. Many thanks also to the members of the HKPR Internal Climate Change Working Group for their input and support prior to the pandemic.

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1 Chapter 1: Climate Change and Health in HKPRDistrict Health Unit area – Introduction

1.1 Preamble

Climate change is affecting our lives and our health today, and it is necessary to take adaptive action now. But the term 'climate change' also implies a future-orientation. Further change is coming, and we are on an inevitable path unless as a global community we act to limit global average temperature rise to less than 2°C above pre-industrial levels.

The work that we do or do not do today will impact the lives of future generations. Thinking about what the climate might be like under different future scenarios, "the life of every child born today will be profoundly affected by climate change…without accelerated intervention, this new era will come to define the health of people at every stage of their lives."(1)

A baby born in 2020 will be 30 years old by 2050, and 60 years old by 2080, the time periods typically used in climate projections and used in this report. Imagining a year in the future is difficult – picturing a person is not. As you read this report, instead of thinking about the year, picture a baby or young child you know. A child. A grandchild. A niece, nephew or family friend. These are the people who will be living in these climate scenarios that the models project.

There is no doubt that climate change is affecting and will continue to affect human health. The measure of impact will be in our ability to take adaptive action and in the effectiveness of measures to stall the current climate trajectory. Without effective action, the children of today will face increased health risks and challenges from climate change.

This report is the first step in understanding how climate change affects health in Haliburton, Kawartha, Pine Ridge district, at present and in the future. The COVID-19 pandemic has taught us that some groups of people experience more severe impacts than others; the analogy often used being "in the same storm but different boats". The populations that have been most impacted by COVID-19 are also most vulnerable to climate change. This report provides a detailed assessment of how climate change is currently impacting and projected to impact the health of residents with a focus on those most vulnerable; what adaptation measures are currently in place and what needs are anticipated in the future.

We also learned through the pandemic that public health is a critical and respected voice for protecting the health of our communities. We need to use that voice to contribute to the greater dialogue on climate change, how it affects people, communities and our environment, and why we urgently need to act now.

1.2 Climate change and health

Climate change has been identified as the "biggest global health threat of the 21st century" by the *Lancet* Climate Change Commission.(2) Primary care providers are already seeing health impacts of climate factors such as hotter days, more pollution, longer allergy seasons. The Canadian Medical Association (CMA) and the Canadian Public Health Association joined with other health organizations to urge federal action on climate policy, with the president of the CMA stating that climate change is "…a reality that's already harming the physical and mental health of Canadians."(3)

> Global warming of 1.5°C to 2°C is identified by the Intergovernmental Panel on Climate Change (IPCC) as the 'tipping' point beyond which we will be unable to adapt to the worst effects of climate change.

The urgent need to take immediate action on climate change is emphasized in the Intergovernmental Panel on Climate Change Special Report 1.5. The report describes impacts of increased global temperatures, including impacts to health, stating, "Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C...Any increase in global warming is projected to affect human health, with primarily negative consequences."(4) This is the most recent report in a growing body of evidence that links climate change to negative impacts on human health and highlights the importance of strategies to mitigate greenhouse gas emissions in order to reduce the severity of future impacts on human health. Tackling climate change presents an important health threat and opportunity.

Climate change is a global phenomenon, but it is at the local and regional levels where people and communities face its impacts. Both mitigation and adaptation measures to address climate change are important; the focus of this assessment is on adaptation from a health perspective. Many jurisdictions are undertaking climate change health vulnerability and adaptation assessments (CCHVAA), intended to build our understanding of current and projected future health impacts of climate change, and to identify effective policies and programs for building resiliency and adaptive capacity. These range from large-scale national (e.g. "Health of Canadians in a Changing Climate: Advancing our Knowledge for Action."(5)) to local assessments (e.g. "A Changing Climate: Assessing health impacts & vulnerabilities due to climate change within Simcoe Muskoka"(6)). Effective health adaptation measures are key to addressing vulnerability.

Adaptation occurs at the community level, so local scale information is needed.(7) In Ontario, public health units are directed in the Ontario Public Health Standards (OPHS), to "monitor the impacts of climate change within their jurisdiction to inform local vulnerability plans…"(8) Because of this direction, the Haliburton, Kawartha, Pine Ridge District Health Unit (HKPRDHU)[1] undertook a CCHVAA to identify local needs and opportunities to increase adaptation in our district.

[1] Throughout this document, use of the acronym "HKPRDHU" refers to the Haliburton, Kawartha, Pine Ridge District Health Unit.

The assessment process began in 2018 and examines the following climate-related hazards and their health impacts:

- extreme temperatures
- extreme weather
- vector-borne diseases
- air quality
- safe food and water
- exposure to solar ultraviolet radiation

This assessment identifies how HKPRDHU programs and services currently contribute to climate change adaptation and examines opportunities to incorporate a climate change lens into our work to continue to build the adaptive capacity of our residents and communities. The assessment also looks at how municipalities and community organizations contribute to health adaptation to climate change.

1.2.1 Key Definitions

Adaptation

Adaptation is the process individuals, communities and societies go through to prepare for and cope with an uncertain future. Adapting to climate change means taking measures to reduce the negative effects of climate change – or take advantage of positive effects.(9)

Climate

Climate is the record and description of average daily and seasonal weather events and patterns that describe a region over a long period, typically 30 years.(10) Climate is relatively stable and predictable; for example, we can be sure that in Ontario it will be colder in February than in June. Changes to climate are gradual and long-term.(11)

Mitigation

In climate science, mitigation means human interventions to reduce greenhouse gases or increase carbon storage (sinks). This is different from the standard usage of the word in health and risk management, where mitigation refers to actions to reduce the severity or seriousness of an outcome.(9)

Resilience

Resilience describes the capacity of a system (or individual) to prepare and plan for, respond to and recover from a disturbance and still retain essentially the same function.(9) Having strong adaptive capacity contributes to greater resilience. Building community resilience can be an opportunity to make systems level changes to increase equity and promote health, for example, changing social, economic and political structures.(12) A more equitable community will be more resilient.

Risk

Risk in this report means the potential consequences of future changes in climate. It is generally described as the probability of occurrence of an adverse event multiplied by the expected severity of that event if it happens.

Social Determinants of Health

Social determinants of health are social, political and economic factors that contribute to a person's health. They include income and social status, social support networks, education, employment/working conditions, social and physical environments, personal health practices and coping skills, healthy child development, gender and culture.(13) The social determinants of health can increase an individual's vulnerability to climate change and amplify health threats.(14)

Vulnerability

Vulnerable populations experience disproportionate, multiple and complex risks to health and well-being due to climate change.(14) Throughout this assessment, the lens of vulnerability is used to identify and address the needs of target populations and what strategies will contribute most to building adaptive capacity and resiliency. Vulnerability is the tendency or predisposition of a person or group to be adversely affected by climate-related health effects. Three elements contribute to vulnerability: exposure, sensitivity, and the capacity to adapt. These three elements are discussed specific to each climate health hazard.

> *Exposure* is contact between a person and one or more biological, psychosocial, chemical, or physical stressors, including stressors affected by climate change (14)
>
> *Sensitivity* is the degree to which an individual, community or system is affected (positively or negatively) by climate change (9)
>
> *Adaptive capacity* is the ability of communities, institutions, or people to cope with climate change-related hazards and includes planning for, responding to and recovering from adverse events (15)

Weather

Weather is the state of the atmosphere at a specific time; the short-term or instantaneous variations of the atmosphere, or, how you would describe what it's like outside when you walk out your front door. Weather is vivid, immediate and sometimes rapidly changeable.(11)

1.2.2 Role of Public Health

Throughout this report, extensive references document the health threats presented by climate change. Public health professionals can and must play a role in addressing these issues. Public health is ideally positioned to educate, advocate and mobilize our communities around the health impacts of climate change. A great opportunity exists for public health to contribute to the climate change conversation by

making the links between climate change and health. As Dr. Theresa Tam states in her 2022 report, "It is clear, climate action is good for our health and public health systems have a critical role to play." She points to the importance of public health taking lessons learned from the pandemic and applying them to climate change work, showing leadership and working collaboratively with other sectors.(16)

Despite climate change featuring much more prominently in the media and public discourse, many people do not see how it impacts them personally. Taking a health perspective provides a personal connection and demonstrates climate change impacts that are close to home. Maibach et al state "…the public health community has an important perspective to share about climate change, a perspective that makes the problem more personally relevant, significant, and understandable to members of the public."(17)

Public health programs and services in Ontario focus in four domains: Social Determinants of Health, Healthy Behaviours, Healthy Communities and Population Health Assessment. In each of these domains there are links to climate change.

This CCHVAA enables us to link our expertise in evidence-based policy analysis and program development with on-the-ground work in our communities to build adaptive capacity to climate change. Public health is an essential bridge between government policy and action, population vulnerabilities and need. Building an understanding of how the climate is changing and how those changes may affect human health can inform decisions about climate change mitigation and identify priorities for protecting public health through increased adaptation.(14) Public health can provide leadership and critical perspective in local conversations about climate change and how it affects the health of our communities, now and in the future. Public health also seeks to reduce health inequities so that everyone can live to their fullest potential. Health inequities, such as living with low-income, contribute to increased exposure and vulnerability to the health impacts of climate change. Public health actions to understand and address health impacts of climate change will benefit all people, but these actions are especially important to more vulnerable populations. Table 1.1 provides examples of public health programs that address climate impacts in relation to essential public health functions.

Table 1.1 Essential Public Health Functions, Objectives, Program Examples and Climate Change

Essential Public Health Function	Objectives	Examples of Public Health Programs	Examples of Climate Impacts Addressed
Health Promotion	Work collaboratively with multiple sectors to improve health through healthy public policy, public participation, advocacy and action on determinants of health	Advocacy to address determinants of health (e.g. income-based solutions) Policy research for intersectoral action Leadership for healthy built environments (e.g. provision of shade in public outdoor spaces; policies for active transportation and walkable communities)	Stable income addresses many issues associated with vulnerability Extreme heat Climate change mitigation
Health Surveillance	Collect health data to track diseases, health	Mosquito and tick surveillance	Vector-borne diseases

	status, determinants of health and reduce impact of disease	Disease incidence monitoring (e.g. Lyme disease, West Nile virus, foodborne illnesses)	Foodborne illnesses
Health Protection	Protect population from Infectious diseases, environmental threats, unsafe food, water, air	Water testing and advisories after extreme events (e.g. floods) Food safety and security Emergency planning and preparedness	Safe water Safe Food Extreme weather and temperatures
Population Health Assessment	Understand the health of our communities to create effective services and policies	Climate change and health vulnerability assessments Community and place-based research and assessment that prioritizes other knowledge systems and lived experience (e.g. Indigenous knowledges)	All
Disease and Injury Prevention	Promote safe and healthy lifestyles to prevent/ reduce risk of illness and injury	Raising awareness of individual actions that reduce risk of illness/disease related to climate change (e.g. sun safety, heat safety) Working with partners to promote food security Mental health initiatives to address climate anxiety and stress	Vector borne diseases Extreme temperatures Exposure to solar UVR Food security
Emergency Preparedness and Response	Planning for and responding to disasters to minimize serious illness and death	Coordinate with partners on health-related emergency preparedness and response Providing public health advice, services and support to community during emergencies Community outreach and information sharing	Extreme temperatures Extreme weather

Adapted from: the Chief Public Health officer of Canada's Report on the State of Public health in Canada 2022 (16)

1.2.3 Health Impacts of Climate Change

Health is about more than just 'absence of disease'. It is about physical, social, emotional wellbeing, and a range of factors that influence all aspects of health.(18) This assessment considers both the physical and psychosocial impacts of climate change.

Climate change can affect health in two main ways. It can change the severity or frequency of health problems that are already affected by climate or environmental factors and/or it can create new health problems or threats in places where they have not previously occurred.(14) Changes in climate such as increased temperatures, more extreme precipitation and other weather events lead to health hazards such as extreme heat/cold, poorer air and water quality, and changes in infectious agents (vectors). Negative health outcomes associated with exposure to these hazards include heat/cold related illness, cardiopulmonary illness, food/water/vector-borne disease and mental health consequences. However, not all people are affected equally. Many social determinants of health will impact an individual's vulnerability to experiencing negative health outcomes. Chapters 3 to 8 provide detailed analysis of the health impacts of climate-related hazards and who is most vulnerable.

There is also a growing body of literature on the mental health impacts of climate change. Increased rates of depression, anxiety, post-traumatic stress and drug/alcohol usage are all linked to climate-related extreme weather events.(19) In addition, ecological grief, a sense of loss due to environmental change, is emerging as a mental health condition, as is eco-anxiety, the worry and sense of helplessness in the face of climate change.(19) Increasingly, public health programs will need to address adaptation for both physical and mental health in the face of a changing climate.

1.2.4 Objectives

The goal of this CCHVAA is to identify ways to increase adaptive capacity to climate change in the population of the HKPR District Health Unit area, especially those identified as most vulnerable, to minimize negative health outcomes. This report represents Phase 1, which is intended to:

- Build understanding of public health's role in adapting to climate change within the HKPR District Health Unit area and in the community.
- Identify current risks and vulnerabilities, including populations most vulnerable to the health impacts of climate change in the HKPR District Health Unit area.
- Identify and project future health risks due to climate change in the H District Health Unit area.
- Identify where and how HKPRDHU and community programs and services currently contribute to adaptation.
- Position the HKPR District Health Unit as a leading voice for climate change planning in our communities as it relates to health.

Phase 2 will build on the assessment and result in the development of a climate change health adaptation action plan for our district.

Over the long-term, the intended impacts of this project are to:

- Build adaptive capacity to address the health risks of climate change within the HKPR District Health Unit area.
- Include climate change adaptation as an integral consideration in the HKPR District Health Unit's planning, programs and services.
- Increase availability and accessibility to the HKPRDHU and community programs and services to build adaptive capacity and resiliency among vulnerable populations.
- Increase understanding among HKPR District Health Unit's staff and in the community about how climate change impacts human health in our communities.
- Build strong partnerships and collaborative relationships among the HKPR District Health Unit, municipalities, Alderville First Nation and others to strengthen climate change health adaptation.
- Position HKPR District Health Unit as a leader in our communities related to climate change and health.

1.2.5 How to Read This Report

This report is not intended to be a comprehensive literature review on climate change and health. The evidence of the health impacts of climate change is well-documented. More in-depth exploration on any topic can be done by going to key resources that have been listed below in the bibliography, For the purpose of this report, highlights of the evidence are included.

It is important to note that although review and discussion about climate-related health hazards have been separated into distinct sections, there are overlaps and interactions between the various climate impacts. For example, extreme heat also contributes to poor air quality and may lead to increased exposure to solar ultraviolet radiation. An extreme weather event such as a flood can impact availability of safe drinking water and contribute to increases in disease vectors such as mosquitoes because of an increase in standing water. The risk of food and water-borne illness can increase during extreme weather events if there is a power outage, or during heat waves. In the natural environment, all things are interconnected, and the divisions of topics are for ease of discussion for the purposes of this assessment. Efforts are made to address these interrelationships throughout the report.

1.3 Methodology

The Ministry of Health and Long-Term Care developed a toolkit for health units, "Ontario Climate Change and Health Vulnerability and Adaptation Assessment Guidelines", which guided the process for conducting this assessment. The toolkit outlines a six-step approach; this report covers steps 1 – 3, or Phase 1, as previously described.

1.3.1 Step 1: Frame and Scope the Assessment

The following priority climate health hazards were identified based on the toolkit, literature and local needs: extreme temperatures (heat and cold), extreme weather and natural events, vector-borne diseases, safe food and water, air quality and solar ultraviolet radiation. An internal working group was established, with representatives from all health unit divisions and several departments (emergency management, environmental health, infectious disease, health promotion, epidemiology, health equity, communications, evaluation/research). The purpose of the working group was to provide input and content expertise throughout the assessment process. Working group members also provided important links to community partners for their engagement. A workplan and communications/engagement plan were developed with input from the working group.

Geographic scope

Where data permit, analysis and reporting in this assessment has been separated into three sub-geographies, by upper-tier municipality: Northumberland County, Haliburton County and the City of Kawartha Lakes. Data specific to each upper-tier municipality provides important local context for future decision making.

Indicators

Climate and health indicators were determined based on suggestions from the ministry Toolkit, as well as from looking at similar assessments completed in other regions in Ontario.

Projecting climate in the future

Climate models are mathematical tools used by researchers to represent the climate system, incorporating external factors such as anthropogenic greenhouse gas emissions (GHGs). Individual models use different approaches and make different assumptions about the future. Using an ensemble of climate models helps to take natural climate variability and climate model uncertainty into account.(20) Generating mean values from multiple models emphasizes their common agreement about the direction and magnitude of change. (11)

Emissions scenarios are developed by climate scientists to describe different visions of future concentrations of anthropogenic greenhouse gases.(20) Representative Concentration Pathways (RCPs) are the scenarios currently in use. Each RCP defines a possible scenario, each with greater or lesser greenhouse gas concentrations in the atmosphere, depending on the degree to which human-activity changes. RCP8.5 is a high-carbon emissions scenario and is considered "business as usual" i.e. no change in human activity to reduce emissions. RCP2.6 is the lowest carbon scenario, which requires a high degree of reduction in human generated GHGs.(11) However, even in a best-case scenario such as RCP2.6, the concentrations of greenhouse gases already in the atmosphere mean that the trajectory of climate changes will continue, albeit to a lesser degree. This means that there is a need for adaptation efforts regardless.

For this assessment, most climate projection data are shown for both RCP2.6 and RCP8.5. RCP8.5 identifies high-end climate projections for which we need to be prepared. As of 2017, global efforts to reduce GHGs fall short of reductions required by 2030 to limit climate change to below a global average temperature rise of 2°C above pre-industrial levels (which require meeting RCP2.6 emission targets) as outlined in the Paris Agreement.(21) While it is prudent to prepare for the worst, it is also important to compare what the future could look like under a more optimistic emissions scenario, where there is success globally in dramatically reducing GHG emissions. Illustrating the difference may provide a visual that could help motivate further efforts to decrease GHGs globally and locally.

Averaging data over a 30-year period is a typical convention when looking at climate data. Taking the 30-year average helps ensure that what is being described is an aspect of the climate system and not the more variable experience of daily, weekly, monthly and annual weather. A 30-year average removes a lot of that variation and reveals common conditions across the time period. When changes can be seen between 30-year periods, "that difference is noteworthy because it represents a multi-year trajectory of change that's unlikely to be caused by short-term (seasonal, yearly, or even decadal) variability."(11)

Climate Timeframes and Data Sources

The climate periods used for this assessment and data sources are described in Table 1.2.

Table 1.2 Climate periods and data sources

Description	Timeframe	Data Source(s)

Baseline/Historical Reference	1986 – 2005	Ontario Climate Data Portal (OCDP) Climatedata.ca
Recent Past	2006 – 2018	Environment and Climate Change Canada, Historical weather station data
Projections -2050s	2040 – 2069	OCDP, climatedata.ca
Projections - 2080s	2070 – 2099	OCDP, climatedata.ca

The future time periods align with projection data available from the OCDP for the three municipalities in the HKPR District Health Unit area, as well as data provided in the Ontario Climate Change and Health Vulnerability Assessment Toolkit. The use of the 2050s and 2080s for describing future climate scenarios is consistent with the International Panel on Climate Change (IPCC) and most climate data developers.

Climate data for the past and future projections is presented from two sources. Most temperature data come from Environment Canada and Climate Change's (ECCC) website www.climatedata.ca. Where indicators required data that were not available from ECCC, the Ontario Climate Data Portal(22) (ODCP) operated by the Laboratory of Mathematical Parallel Systems (LAMPS), based at York University, was used. Both sources use an ensemble of climate models to generate projection data; however, the two sources differ in their approach to historic climate data. The OCDP generated data for the 20-year reference period (1986-2005) using observed weather station readings. Some practitioners would refer to this as 'climate normals' for the time period.(20) For data from ECCC, the reference period data was generated using climate model simulations. Temperature data for the recent past (2007-2017) was obtained from ECCC historical weather station data.(23) Data for projections of intensity-duration-frequency of heavy precipitation was obtained from the Ontario Climate Change Data Portal, the only source for this information.(24)

Health Data Sources

Where possible, health data is presented by municipality. In some cases, the data are only available at the health unit level. Local health data were sourced from

- intelliHEALTH ONTARIO (emergency department visits, hospitalizations, mortality)
- Integrated Public Health Information System (iPHIS)
- Public Health Ontario
- Statistics Canada Census data
- Population-based surveys (e.g., the Rapid Risk Factor Surveillance System)

1.3.2 Step 2: Describe Current Risks Including Vulnerabilities and Capacities

The current burden of illness associated with each climate-related health hazard was identified to establish a baseline. The relationship between illnesses and climate hazards was examined in the literature and provided the basis for anticipating future health impacts as the climate changes.

A review process to identify vulnerable populations in the HKPR district was completed using indicators provided in the Toolkit and local population-health data. Consultations were held with staff of each HKPRDHU department to identify how the impacts of climate change effect their clients and programs. Staff were also asked to describe how their current work contributes to climate change adaptation.

A small number of consultations were also held with community partners and agencies. This included six key informant interviews and three focus groups. Consultations asked participants about their organization's role related to climate change adaptation, who they saw as most vulnerable to health impacts of climate change, and what they saw being the role of public health. Key informants were identified and selected from across the district and included municipal staff (total of three), a health care professional, a community volunteer, and conservation authority staff (total of three). Focus groups were made up of individuals whose organizations work with the vulnerable sector, including families and people living with low-income, people who are homeless or precariously housed, older adults and people with disabilities. One focus group was held in each municipality. Most conversations were recorded, with recordings used to ensure accuracy of notes that were taken during the sessions. Recordings were deleted once the notes had been updated.

1.3.3 Step 3: Project Future Health Risks

Future health risks were assessed and discussed for each climate health hazard, based on projected changes to the climate and current burden of illness associated with each hazard. Summaries of current HKPRDHU and community programs and services that contribute to adaptation are included for each climate hazard.

1.3.4 Limitations

While climate projection modelling is common in climate science, such models are not readily available for projecting health impacts due to climate change. Disease burden projection tools exist, but using these requires expertise and resources beyond the scope of this project. Instead, the future local health impacts due to climate change are anticipated based on the relationships that are understood from the literature, current burden of illness, and projected changes in populations identified as most vulnerable. There is a degree of uncertainty regarding the climate-health relationship. Factors such as human behaviour, technological advances and socioeconomic adaptation will influence this relationship in the future.(25) However, data and analysis in this assessment offers a present and future picture of health impacts of climate change in the HKPR district and provides an evidence-informed approach for adaptation planning and action.

The community consultations did not capture all partners and agencies, therefore, the findings from the community should not be considered complete. However, they do provide an indication of some of the work taking place across the district that is building adaptive capacity.

Health data is sourced from emergency department visits and hospitalizations; detailed analysis of the impacts of climate change on the primary health care system was not included in the scope of this assessment.

The literature identifies Indigenous populations as being more vulnerable to climate impacts (see section 2.2.4). HKPRDHU is in the early stages of establishing formal relationships with Indigenous communities. We did not engage them in the development of this report. We recognize that an Indigenous perspective is critical to understanding the impacts of and solutions for addressing the health impacts of climate change. It is our intention to engage with Alderville First Nation and other local

Indigenous partners to strengthen our relationships, incorporate Indigenous knowledge and perspectives, and collaborate on adaptation strategies.

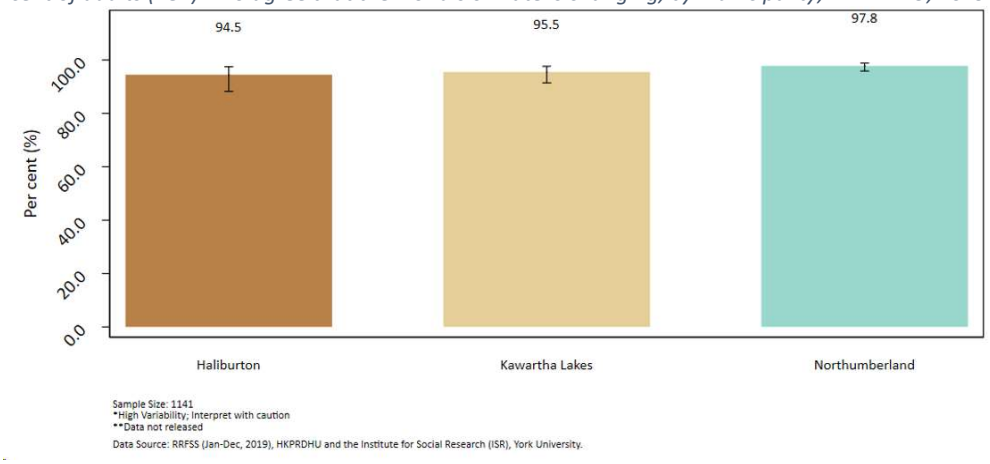
Work on this assessment was halted in March 2020 due to staff redeployment to support HKPR's COVID-19 pandemic response. The bulk of research and writing for this report was done in 2019 and early 2020, with the intent for completion in mid-2020. Some key references have been updated and where possible and feasible, data have been updated. The bulk of the report is presented as it was written in 2020, with the research and data that was available at that time. Despite an almost 3-year lapse in time, the information remains relevant. Climate change still has and will have an impact on the health of our communities, and taking adaptive action is key to reducing negative health outcomes.

1.4 Perceptions and Opinions about Climate Change in HKPR District

In 2019 as part of its Rapid Risk Factor Surveillance System (RRFSS) surveys, HKPRDHU included questions concerning public perceptions and opinions about climate change and its health impacts. The results are presented below, separated by municipality in Figures 1.1 to 1.7.

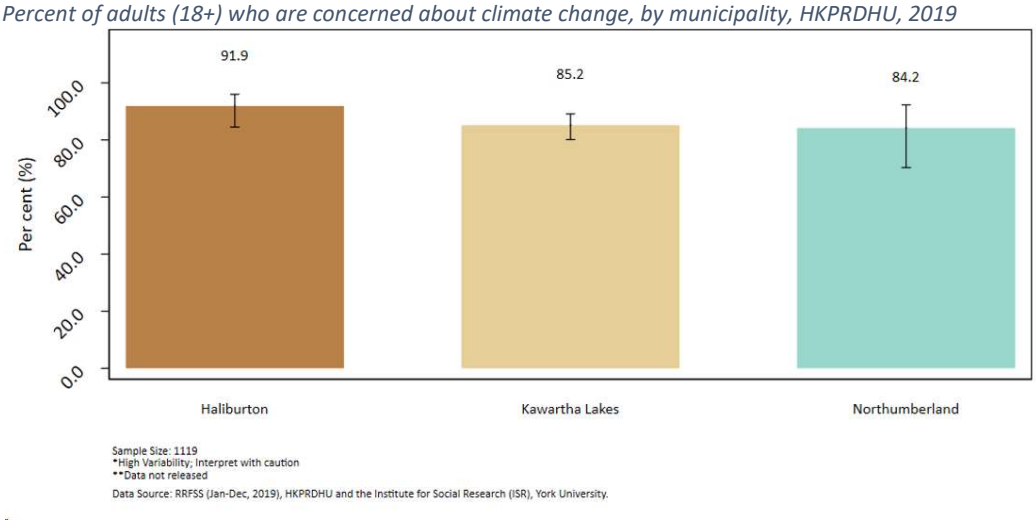
Regarding opinions, rate of agreement was similarly high across all municipalities at 94.5% or more.

Figure.1.1 Percent of adults (18+) who agree that the world's climate is changing, by municipality, HKPRDHU, 2019



Respondents were then asked to rate how concerned they were about climate change. Figure 1.2 shows those responses by municipality. A somewhat lower rate of respondents is concerned about climate change than agree that climate change is happening.

Figure 1.2 Percent of adults (18+) who are concerned about climate change, by municipality, HKPRDHU, 2019



Respondents were asked questions about climate change impacts on health, including whether they thought climate change was likely to lead to more insects carrying diseases (Figure 1.4), poor air quality (Figure 1.5), heatwaves (Figure 1.6) and extreme weather (Figure 1.7). There is relative consistency in thoughts about climate change impacts across the municipalities. The highest rates of agreement about climate change impacts were with respect to extreme weather and extreme heat and in almost all instances were higher than the percent of adults who think climate change has a negative effect on human health. This seems to indicate a disconnect between climate change impacts themselves and their link to human health.

Figure 1.3 Percent of adults (18+) who think climate change has a negative effect on human health, by municipality, HKPRDHU, 2019

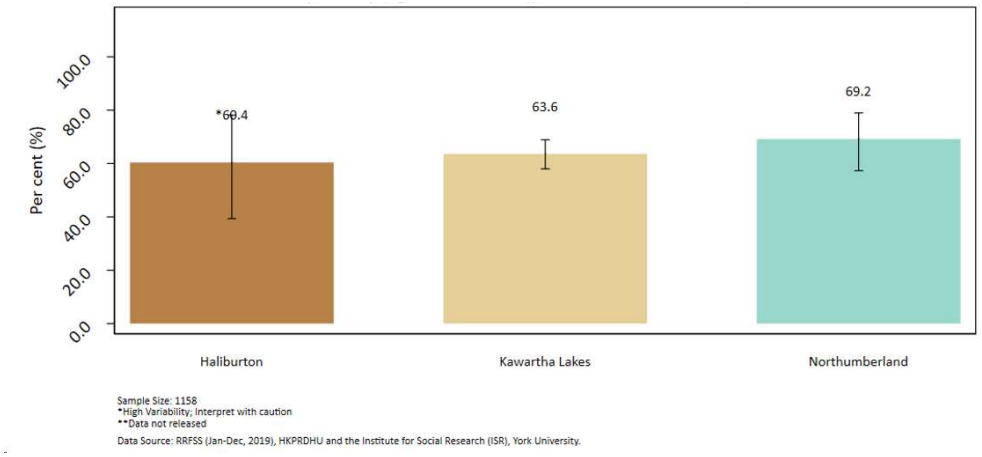


Figure 1.4 Percent of adults (18+) who think climate change is likely to result in more insects carrying diseases, by municipality, HKPRDHU, 2019

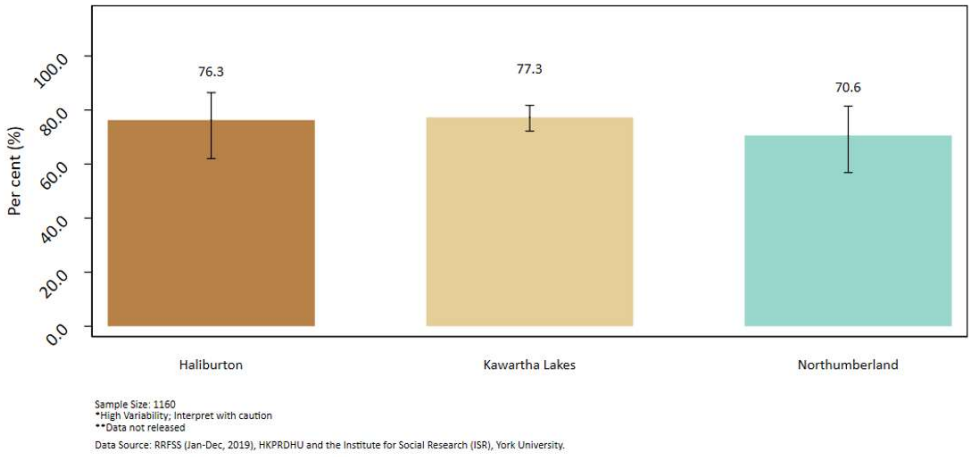


Figure 1.5 Percent of adults (18+) who think climate change is likely to result in poor air quality/more smog days, by municipality, HKPRDHU, 2019

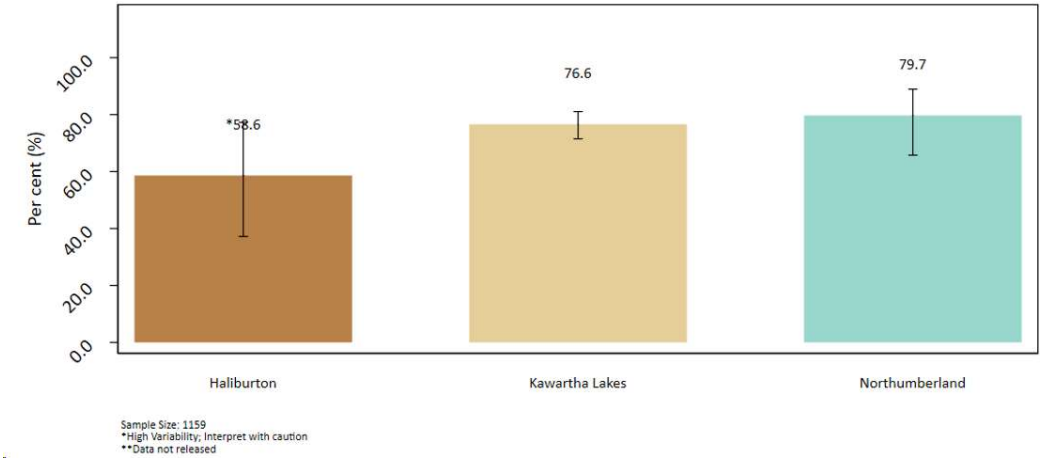


Figure 1.6 Percent of adults (18+) who think climate change is very likely to cause more frequent and severe heat waves, by municipality, HKPRDHU, 2019

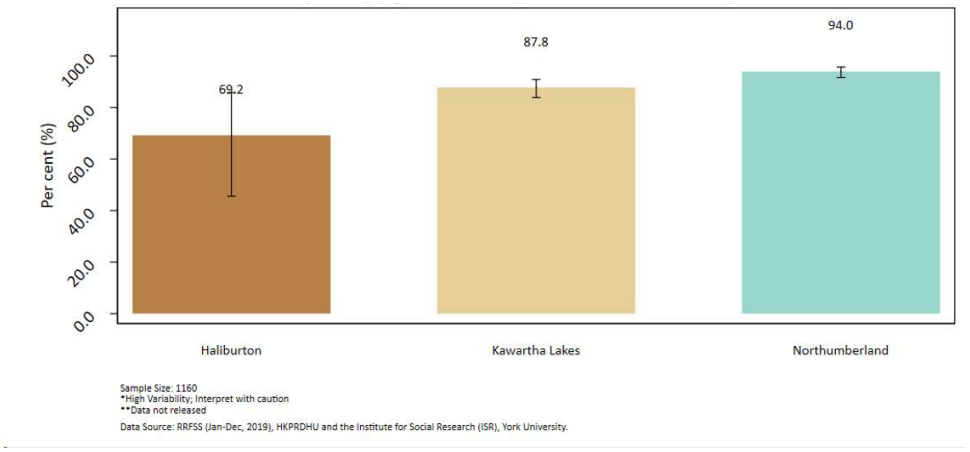
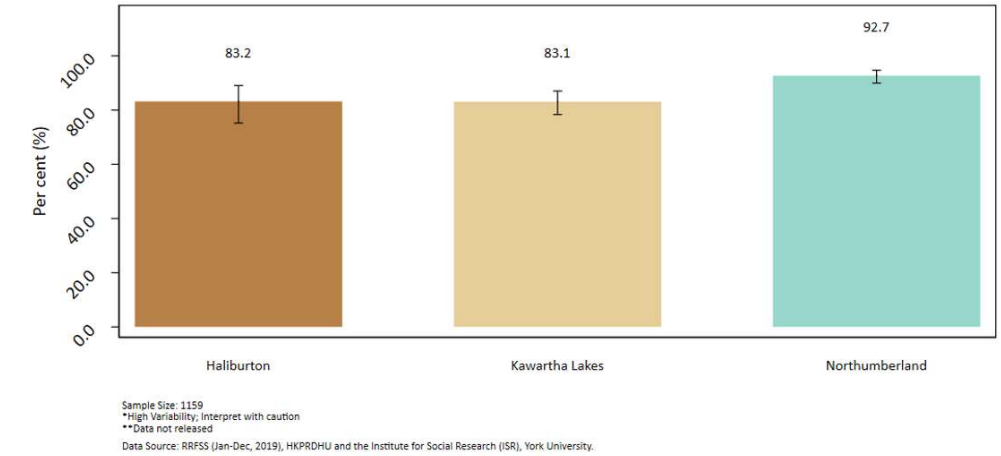


Figure 1.7 Percent of adults (18+) who think climate change is likely to cause more extreme weather locally, by municipality, HKPRDHU, 2019



The findings from the RRFSS data indicate that there is a high level of agreement across the district that the climate is changing, but less agreement that it will impact human health. There is varying opinion about climate change impacts locally in terms of causing poorer air quality, and more extreme heat, weather and insects carrying diseases. This presents an opportunity for HKPRDHU to raise awareness about climate change, how it affects health and the need for adaptation.

2 Chapter 2: Vulnerability in HKPR District

2.1. General Description

The Haliburton, Kawartha, Pine Ridge District Health Unit (HKPRDHU) serves Haliburton County, Northumberland County and the City of Kawartha Lakes (referred throughout this document as 'the municipalities'). The City of Kawartha Lakes (CKL) is a single-tier municipality, while the Counties of Northumberland and Haliburton are both upper-tier municipalities. Within the HKPRDHU, there are 11 lower-tier municipalities, seven in Northumberland and four in Haliburton. The HKPRDHU has an independent board of health which oversees the work of the organization and is accountable to its main funders, the Ministry of Health and the three municipalities.

2.1.1. Geography

The HKPR district is mostly rural and covers a large area (9,065 km^2) stretching from Lake Ontario to the southern base of Algonquin Park. Each of our local jurisdictions features small urban centres with greater population density and services, and large areas of rural, dispersed population. The City of Kawartha Lakes and Northumberland County are part of the Greater Golden Horseshoe and subject to planning requirements in the Growth Plan for this region.

As a small/rural health unit, the HKPR district features diverse characteristics that make it distinct from larger urban centres. There is a high seasonal population that includes cottagers, camps, and tourists which can place a high demand on acute health care services, especially in the summer. For example, in Haliburton County, it is estimated that the seasonal population is nearly three times the size of the permanent population.(26) The geography across the district varies greatly, and includes small urban centres (e.g. Cobourg, Port Hope, Lindsay), villages, rural/dispersed areas, Lake Ontario shoreline, and agricultural lands. The Oak Ridges Moraine is an ecologically significant and protected area that stretches into Northumberland County, ending just northeast of Cobourg. There are plentiful lakes, waterways, forests and wetlands. In some areas there are limited municipal services such as sewer, water and transit, and a high proportion of residents using private wells and septic systems. Infrastructure may be owned and managed by any one of four levels of government, for example, the Trent Severn Waterway (federal); highways (including highway 401 which runs through Northumberland County), provincial parks, crown land (provincial); roads, sewer, water, waste (upper or lower-tier municipality). This can make planning and development challenging and requires collaboration across all levels of government and community.

2.1.2. Population

According to Statistics Canada's 2021 Census of Population, there were a combined 189,183 residents within the three municipalities that form the boundaries of the HKPRDHU.(27) The population in 2016 increased by 3.88% over the count from the 2016 Census of Population (179,083). By 2036, the population is projected to grow by over 16%. Table 2.1 shows 2021 populations and projected increases by 2041.

Table 2.1 2021 Census population & 2014 projected population, HKPRDHU

Municipality	2021	2041	Projected Increase (# of residents)	% increase
Haliburton	20,571	23,706	3,135	15.2%
Kawartha Lakes	79,247	101,740	22,493	28.4%
Northumberland	89,365	109,431	20,066	22.5%
HKPR overall	189,183	234,877	45,694	24.2%

Data source: Ontario Ministry of Finance, distributed **by** Ontario Ministry of Health: IntelliHealth Ontario.

Table 2.2 shows the land area and population density of each municipality. Haliburton County covers the largest area and has the lowest population density in the district.

Table 2.2 Geographic characteristics of the municipalities within HKPRDHU

Indicator	Northumberland	Kawartha Lakes	Haliburton
Land Area (km^2)	1,905.2	3,084.4	4,076.1
Population Density	44.9/ km^2	24.5/ km^2	4.4/ km^2

Data source: Statistics Canada, 2017.

The language spoken most often at home is English (Haliburton County - 98.8% of population, CKL – 98.5%, Northumberland – 98.6%). Across HKPR district, less than 1% of the population speaks French most often at home and 1.2% speak another language. (28)

2.1.1. Primary health care services

The HKPR district is served by four hospitals (one has two sites), seven Family Health Teams and two Community Health Centres providing a wide scope of health services. Additional health care services that are provided by municipalities, Ontario Health, community agencies or private companies include paramedic services, mental health and addictions services, 20 long-term care homes, 20 retirement homes, Community Care (programs/services for seniors), outreach services (e.g. Green Wood Coalition) and in-home support (e.g. Victorian Order of Nurses, ParaMed). In addition, each municipality is serviced by numerous organizations that address health needs of children, youth, families, seniors, people with disabilities, people living with low-income and people with addictions.

2.2. Populations Vulnerable to Climate Change in HKPR District

Based on the literature and past research conducted at the HKPRDHU, key vulnerable populations of concern for this assessment were identified and include older adults, infants and children, people who are pregnant, people living with low-income, Indigenous peoples, people with chronic health conditions, people who work outdoors and people who are physically active outdoors. The detailed ways that climate change may impact these specific vulnerable groups are described in each climate change health hazard section.

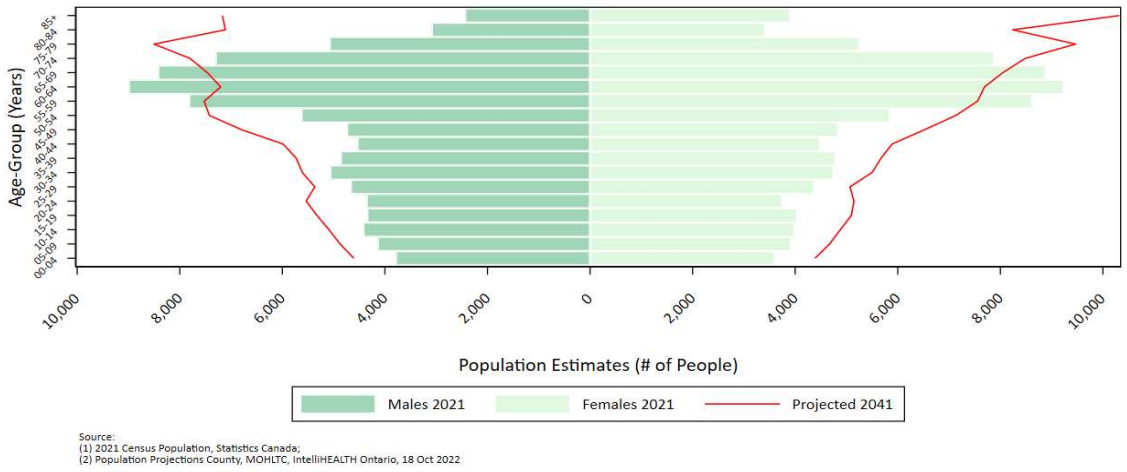
The literature also discusses the difference in vulnerabilities experienced in rural areas. Due to the rural, dispersed nature of much of the district, this report considers some of these unique characteristics that may add to vulnerability in the population. These include having more people employed in outdoor occupations, high reliance on private drinking water systems, a high population of older adults, a high incidence of chronic illnesses and limited access to services during extreme events.(29) Indigeneity, age, gender and socio-economic status are identified as key factors that influence both individual and community vulnerability in rural and remote areas.(30) In addition, many people have to travel significant distances (e.g. >25 km) to access essential services such as food, social supports and health care. Lack of affordable and accessible transportation is a barrier for many, as there are limited or no public transportation options across much of HKPR district.

As was defined in Chapter 1, the extent to which an individual or group is vulnerable to health impacts of climate change is a function of their exposure and sensitivity. Aspects of vulnerability in HKPR district are described in the following sections.

2.2.1. Age

Populations in all municipalities are projected to increase, and as Figure 2.1 illustrates, by 2041 the age distribution for all HKPR district is projected to skew heavily to the age groups 65+ years old. As the number of older adults continues to grow there is increased potential for negative climate change health impacts in our population. Older adults have increased vulnerability, especially if they are living with chronic health conditions (see section 2.2.6.) and/or living with low-income (section 2.2.3.). Older adults are at higher risk during emergencies such as floods because they may have difficulty accessing or responding to warnings, be reluctant to leave their homes or have limited financial capacity.(31)

Figure 2.8 2021 Census population and 2041 projected population, HKPRDHU



Trends for each specific municipality are similar.

Figure 2.9 Census population and 2041 project population, Haliburton County

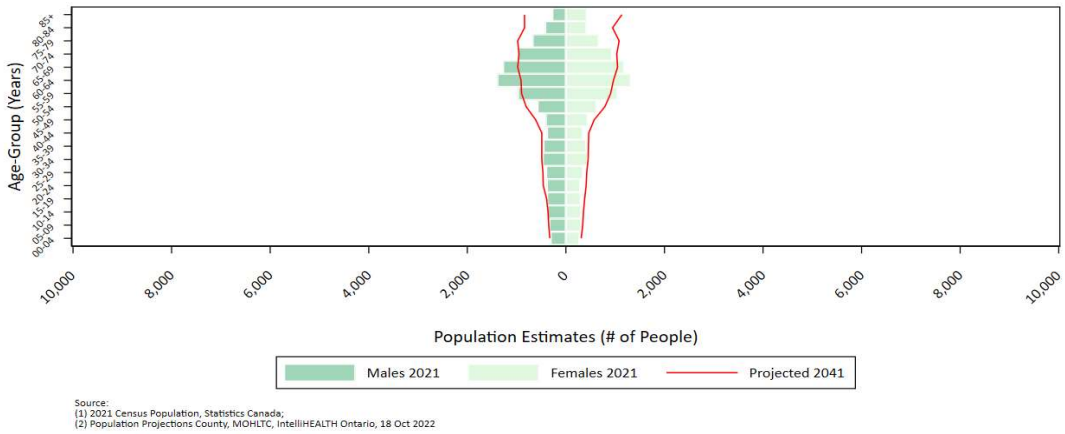


Figure 2.10 Census population and 2041 projected population, City of Kawartha Lakes

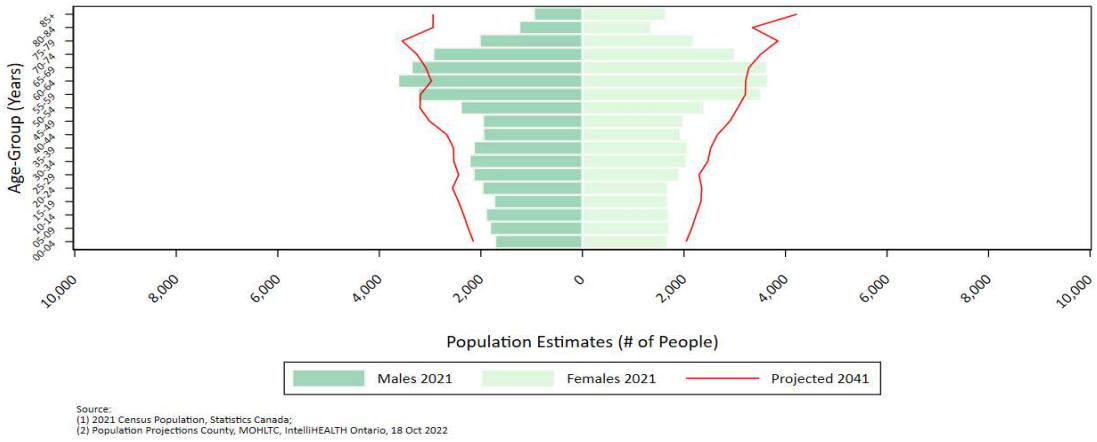
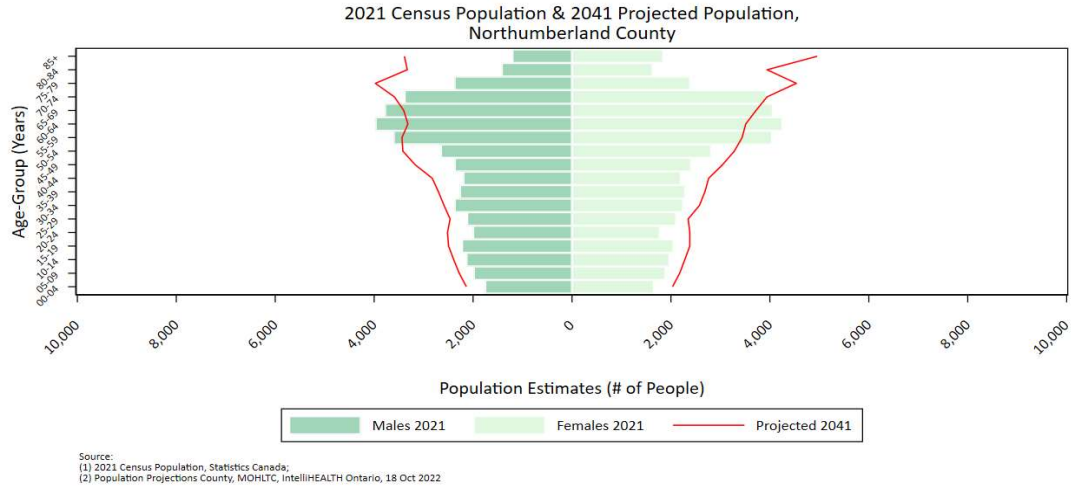
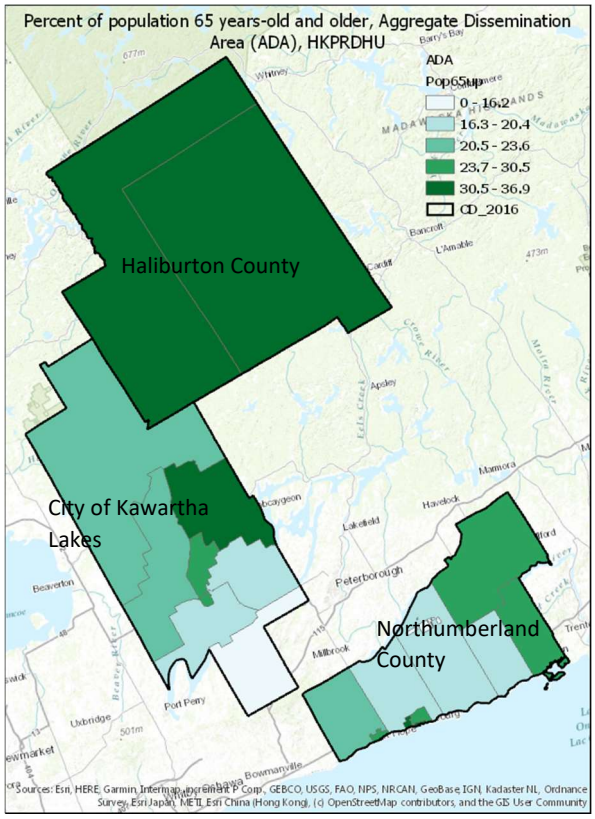


Figure 2.11 Census population & 2041 project population, Northumberland County



Although Haliburton County has the smallest population, it has the highest proportion of adults age 65+, as illustrated in Figure 2.5.

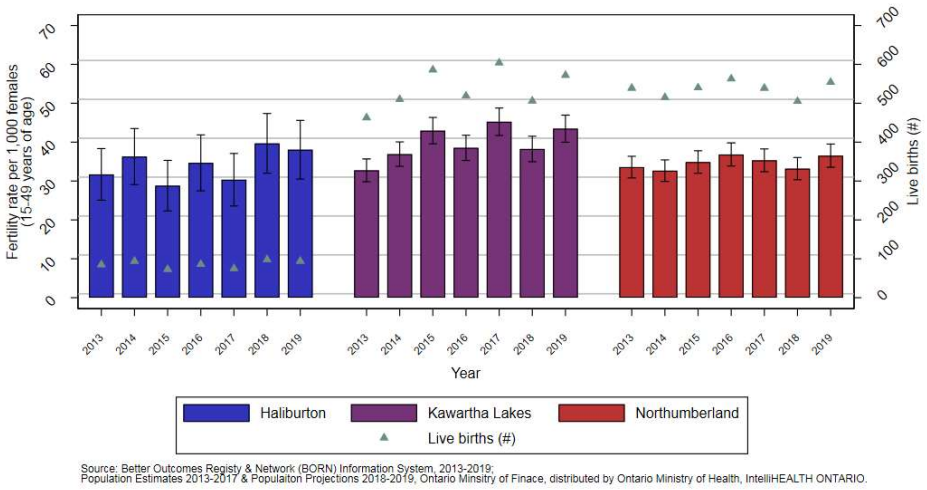
Figure 2.12 Percent of population age 65+ by Aggregate Dissemination Area



2.2.2. People who are pregnant

The number of pregnant individuals in the district is not monitored, however, fertility rate serves as a proxy indicator. Fertility rate is the number of live births per 1,000 individuals of reproductive age (15-49 years) and is shown for each municipality along with the number of live births. Haliburton has a low number of actual live births relative to the rate of individuals of reproductive age, while in both Kawartha Lakes and Northumberland, number of live births exceeds the fertility rate. Health risks for pregnant people that are associated with climate impacts include preterm births and adverse birth outcomes such as low birth weight and infant mortality from exposure to extreme heat.(32)

Figure 2.13 Fertility rate and number of live births in HKPR district, by municipality, 2013-2019

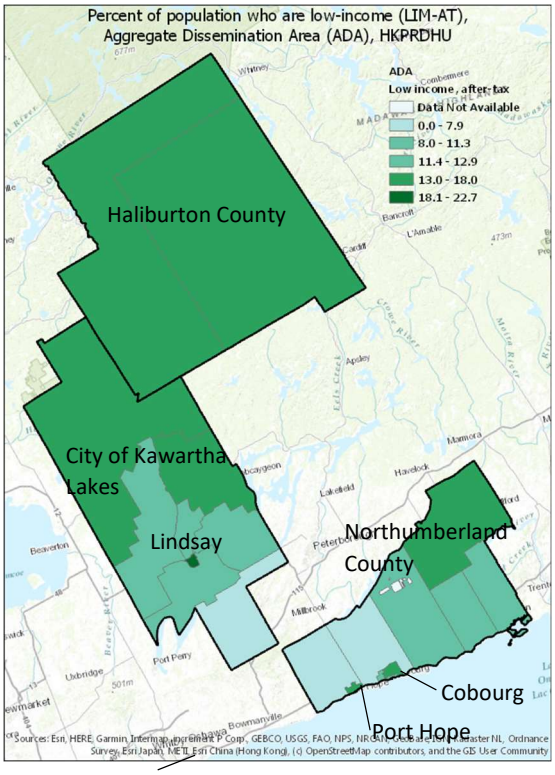


2.2.3. Income

Low-income was assessed using the Low-income measure, after tax (LIM-AT). The LIM-AT is half (50%) of the median household after-tax income of private households, after adjusting income by an equivalence scale (the square root of the number of persons in the household) which accounts for increased needs or a household as the number of household-members increases.(33) Of the population in private households, in Haliburton County, 17.2% (3,050 people) are considered low-income based on the LIM-AT. In the City of Kawartha Lakes, the rate is 13.1% (9,625) and in Northumberland County, the rate is 11.6% (9,590).(28) Looking at Figure 2.7 below, variations within Northumberland County and CKL are evident. The southern most area of Kawartha Lakes and the rural areas of western Northumberland are seen to have the lowest proportion of low-income households (0 – 7.9%), compared to Haliburton County, northern areas of Kawartha Lakes, northeast Northumberland, and more urban areas of Cobourg, Port Hope and Lindsay (13.0 – 18.0%).

People living with low-income experience vulnerability to climate change on several fronts. They are likely to have limited financial resources to take protective actions such as running an air conditioner, travel to public places for cooling or have a 72-hour emergency kit. This means they are more likely to experience heat-related illnesses, and greater exposure to unsafe food or water during an extreme weather event.

Figure 2.14 Percent of population who are low-income (LIM-AT), by aggregate dissemination area, HKPRDHU



2.2.4. Indigenous Peoples

There is one First Nations community in HKPR District. Alderville First Nation has a total membership of 1,373 individuals, with 307 registered individuals living on reserve, and 1,059 living off reserve. (34) According to the 2021 Statistics Canada Census of Population (35), the proportion of the HKPR district population that identifies as Indigenous[2] is similar to the whole of Ontario (2.9%). Of the total population living in private households, in Northumberland County 3.5% (3,905 individuals) identify as Indigenous, in the City of Kawartha Lakes the rate is 2.9% (2,210 individuals), and in Haliburton County 3.5% (700 individuals).

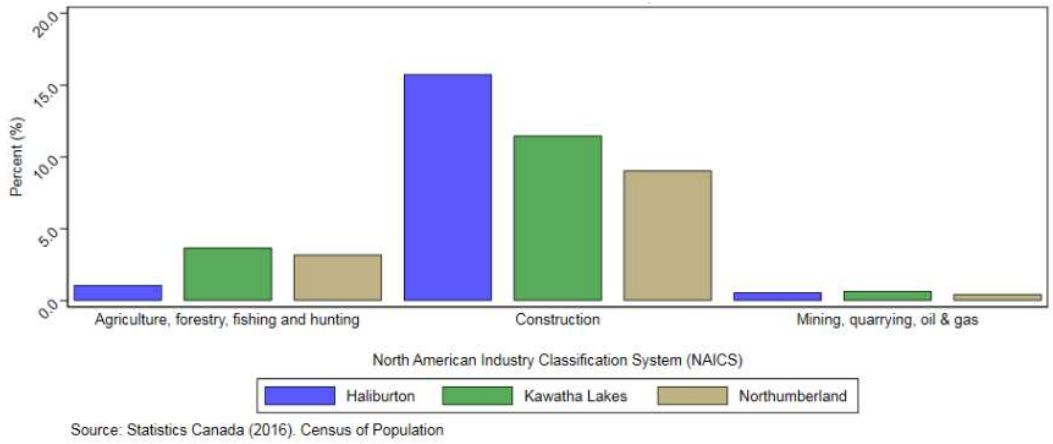
Climate impacts on Indigenous Peoples are magnified due inequities across a range of health determinants, most of which are linked to past and current colonial practices and policies. Systemic issues persist, and manifest in impacts such as substandard or overcrowded housing, high rates of poverty and unemployment, food and water insecurity and poorer access to quality health care, all of which increase vulnerability to negative health impacts of climate change. Climate change affects the physical, mental, social and cultural wellbeing of Indigenous Peoples, impacting traditional activities such as hunting, fishing, gathering; transportation; access to clean water and health and safety.(5)

[2] Includes persons who identify as First Nations (North American Indian), Métis and/or Inuk (Inuit) and/or those who report being Registered or Treaty Indians (that is, registered under the Indian Act of Canada), and/or those who report having membership in a First Nation or Indian band. (35)

2.2.5. Outdoor workers

The 2016 Census shows that there are workers in the HKPR district with occupations potentially exposed to climate impacts such as extreme temperatures, exposure to insects that carry diseases (vector-borne disease), solar UV exposure and poor air quality. Construction work is the largest group in each municipality, with smaller rates in agriculture, forestry, fishing and hunting. Mining, quarrying, oil and gas represent a small proportion of workers in the HKPR district. Many of the people who work in these categories will have increased exposure to immediate climate-related impacts such as heat-related illness, Lyme disease, West Nile virus and other emerging vector-borne diseases. Longer term exposure increases risk of developing skin cancer or respiratory illness.

Figure 2.15 Outside workforce potentially exposed to climate while employed, by North American Industry Classification System (NAICS) categories, HKPRDHU, 2016



In addition to those reported above, there are other workers with occupations within the district that are not reflected in this data that may also be exposed more frequently to climate variables. These include summer camp staff (25 summer camps within the HKPR district), people working in outdoor recreation/tourism (e.g. golf courses) and municipal roads and maintenance staff.

The tourism industry is a key economic driver in the HKPR district and is a vulnerable sector to changing weather conditions and increased weather variability, for example, shorter snow seasons for winter tourism.(36) This has implications for employment, further impacting income and vulnerability to climate change impacts. On the other hand, the tourism sector may benefit overall from a longer warm season.

2.2.6. Chronic health conditions

Chronic conditions such as diabetes, asthma, chronic obstructive pulmonary disorder (COPD), high blood pressure, cardiovascular disease, mental illness, obesity, and physical disability make people more vulnerable to the health impacts of climate change. For example, people with COPD are more sensitive to changes in air quality and diabetes, obesity, cardiovascular disease and some medications that treat mental illness can increase sensitivity to heat stress.(14) As noted previously, the population of seniors

in HKPR district (age 65+) is projected to increase significantly by 2041 which will increase the number of people with age-related chronic diseases. There is also growing understanding of the impacts of extreme heat on mental health, with increased violence, aggressive behaviour and suicide showing association with high heat events.(37, 38) Without significant adaptation measures, hospitalizations and mortality due to climate change will increase in the future.

Table 2.3 compares the rates of hospitalization in 2021 for several chronic diseases and injuries for HKPR district and Ontario. Compared to Ontario, rates in HKPR district were higher for all.

Table 2.3 Age standardized rates of hospitalization for select chronic diseases and injuries in HKPR district and Ontario, 2021

Disease/Injury	HKPR District Rate/100,000	Ontario Rate/100,000
Cardiovascular disease	833.2	807.9
Respiratory disease	421.3	355.3
Falls	318.5	281.9
Intentional self-harm	71.9	70.6
Chronic obstructive pulmonary disorder (COPD)	139.4	91.5
Diabetes	116.3	102
Ischemic heart disease	305.9	234.5

Source: Chronic Disease Hospitalization Snapshot | Public Health Ontario; Hospitalization for Injuries Snapshot | Public Health Ontario

Chronic disease mortality rates in 2015 were also higher in HKPR district than in Ontario, as shown in Table 2.4. (Note: this is the most recent mortality data available)

Table 2.4 Age standardized mortality rates for select chronic diseases and injuries in HKPR district and Ontario, 2015

Disease/Injury	HKPR District Rate/100,000	Ontario Rate/100,000
Cardiovascular disease	190.9	170
Respiratory disease	70.2	57.2
Chronic obstructive pulmonary disorder (COPD)	38.4	27.1
Intentional injuries	18.5	10.8

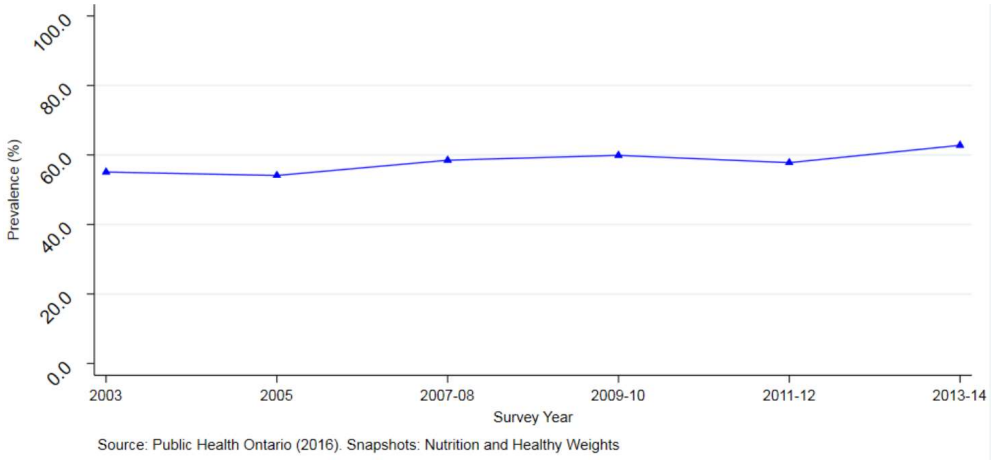
Source: https://www.publichealthontario.ca/en/Data-and-Analysis/Injuries-Data/Injury-Mortality

2.2.7. People who are physically active

People who are physically active outdoors can be more exposed to extreme heat, poor air quality and solar ultraviolet radiation. Depending on the type of activity, they may also be more exposed to ticks

and mosquitoes that carry Lyme disease, West Nile Virus or other vector borne diseases. Figure 2.9 shows self-reported rates of being active or moderately active during leisure time for HKPR district residents age 12+ years of age. The data does not differentiate between indoor and outdoor activity, however given that common forms of physical activity for adults include walking and use of parks/open spaces(39), it is likely that some of this reported activity takes place outdoors.

Figure 2.16 Self-reported rate of being active more moderately active during leisure time, HKPRDHU residents age 12+ years, 2003-2014



2.2.8. Mental Health

Climate change increases risks to the mental health of people who already experience increased vulnerability due to inequities that exist due to race, culture, gender, age, socio-economic status, ability or geographic location.(40) The mental health impacts of climate change are multi-dimensional.

Experiencing extreme weather events such as floods can result in a traumatic response, which can subside once the safety and security have been restored. But such events can also extend to longer-term impacts such as post-traumatic stress, anxiety and depression. The economic impacts related to things like job security and insurance for property damage can be especially stressful for people already experiencing socio-economic challenges. Extreme heat can worsen existing mental illness and increase risk of violence, aggression and suicide. In addition, some medications that treat mental conditions affect the body's ability to regulate temperature.(40)

In HKPR district, about one in 10 (10.7%) residents perceive their mental health to be poor. About one in 10 (9.3%) residents age 12 and older reported symptoms consistent with moderate to severe depression and about half (55.4%) of residents have symptoms consistent with minimal or mild depression.(41)

Concern about climate change can contribute to feelings of worry, sadness, loss (e.g. of sense of place, safety, identify), grief and depression. This is especially true for Indigenous Peoples, whose ways of life are disproportionately impacted(40), and for youth, who may experience significant distress as they recognize the potentially devastating impacts of climate change in their future.(42) Research on eco-anxiety and solostalgia (feeling homesick in one's home environment) is ongoing and emerging.

2.3 Conclusion

This chapter creates a picture of who is most likely to experience the health impacts of climate change in HKPR district. More detail is provided in the specific climate hazard chapters. Although vulnerabilities are separated in this chapter, it is important to note that people may be living with concurrent vulnerabilities that could magnify climate change impacts. For example, someone may be an older adult, living alone on a limited income, have a chronic illness and not speak English as a first language. Vulnerability is a function of exposure, sensitivity and adaptive capacity, which makes adaptation planning key to minimizing negative health outcomes.

3 Chapter 3: Extreme Temperatures

3.1. Chapter Overview

This chapter presents a picture of present and future extreme heat and cold in the HKPR district, using past and projected data for key temperature indicators. The relationship between extreme temperatures and health is discussed. Local data on heat- and cold-related illness is compared to average temperatures to provide an indication of how extreme temperatures impact health in the population.

3.1.1. Highlights

- Unless there is a significant and immediate reduction in global greenhouse gas emissions, by 2080 all municipalities in the HKPR district will experience an overall warming trend. There will be at least four times as many hot days (>30°C) compared to 2019, and almost no days colder than -15°C.
- Extreme heat can lead to heat injuries such as heat exhaustion and heat stroke, which can be life-threatening. Extreme heat can worsen chronic illnesses such as cardiovascular and respiratory diseases. Many medications can inhibit the body's ability to regulate temperature, increasing an individual's vulnerability.
- The HKPR district has a high proportion of older adults, people living with low-income and people who work and play outdoors. All these groups, as well as young children and pregnant people, are more vulnerable to negative health impacts of extreme temperatures.
- Extreme heat impacts mental health. More hot days may lead to more incidents of violent and aggressive behaviour, attempted suicide and other self-harm.
- As the number of hot days in HKPR district increases so does the rate of heat-related emergency visits. This trend should be expected to continue in the future.
- The overall trend in winter temperatures indicates a decrease in the number of cold days, which over time reduces exposure to cold events for residents of the HKPR district. However, there will be year-to-year variability which will continue to include extreme cold temperatures. There will continue to be risks to vulnerable populations, especially those experiencing homelessness or who work outdoors. People living with low-income may live in poor-quality housing or in households in need of repair (e.g. with poor insulation and windows) and may also have difficulty paying for heating.
- Preparing for and taking adaptive action is critical to reduce future burden of illness related to extreme temperatures. Building adaptive capacity to extreme temperatures should consider both physical and mental health impacts, and requires collaboration and partnership between public health, municipalities and community agencies.

Table 3.1 Summary of Potential Health Impacts of Extreme Temperatures

Climate Hazard	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts

Extreme Heat	More hot days (>30°C) More tropical nights (>20°C) More and longer heat waves	Older adults People living with low-income People experiencing homelessness Pregnant people Infants and children People with chronic physical and mental illnesses People who are physically active People who work outdoors	Heat-related illness and mortality (e.g. heat exhaustion, heat stroke) Dehydration Worsening of respiratory or cardiovascular illness Some medications inhibit thermoregulation Mental health impacts (e.g. aggression, violence, suicide) Pre-term birth, low birth weight, infant mortality
Extreme Cold	Decrease in heating degree days Decrease in days below -15°C	People living with low-income People experiencing homelessness People who work outdoors	Frostbite Hypothermia Potential decrease in cold-related morbity and mortality

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3.1. Extreme Heat

Climate change will lead to an increase in both average and extreme temperatures. There is strong evidence that climate change will increase the frequency, intensity and duration of heatwaves.(43) The warm season will start earlier and end later. Numerous analyses project that across Canada there will be more hot and fewer cold temperature extremes as global mean temperatures rise, and climate data projections show this to be the case across the Haliburton, Kawartha, and Pine Ridge (HKPR) district. More specifically, the Windsor to Quebec corridor and regions along Lake Ontario have been identified as among the places in Canada at highest risk for extreme heat.(29) Northumberland County is part of this corridor.

Temperature extremes can be defined by average, minimum or maximum daily temperatures. For heat, temperature reporting may also include Humidex value (combination of temperature and humidity). However, what is considered 'extreme heat' differs depending on the location. *Canada's Changing Climate Report 2019* (44) suggest a daily maximum temperature of ≥30°C as the threshold for defining an extremely hot day, and also recommends reporting the number of 'tropical nights'–when the daily minimum temperature (generally over-night temperature) is ≥20°C. Night-time cooling provides critical

relief from daytime heat, especially for vulnerable populations, so warm nights contribute to added heat stress. Both of these temperature indicators are used to describe extreme heat in the HKPR district.

High temperatures are also associated with poor air quality. Generally, higher temperatures, sunnier skies and lighter winds, which may all be associated with heatwaves, lead to higher ozone (0_3) concentrations.(45) The health impacts of air quality are discussed in more detail in Chapter 7. Heatwaves can also lead to drought and impact agriculture (discussed in Chapter 4) and affect food and water safety (Chapter 6).

3.1.1. Projections for Extreme Heat in HKPR District

Across the HKPR district, extreme hot temperatures are expected to become more frequent. All indicators show projections that temperatures will increase in all municipalities within the HKPR district. Using ECCC's climatedata.ca website, the largest population centre within each of the three municipalities within the HKPR district (Haliburton Village in Haliburton County; Lindsay in City of Kawartha Lakes; Cobourg in Northumberland County) was used to obtain climate data to be generalized across each of the respective municipalities.

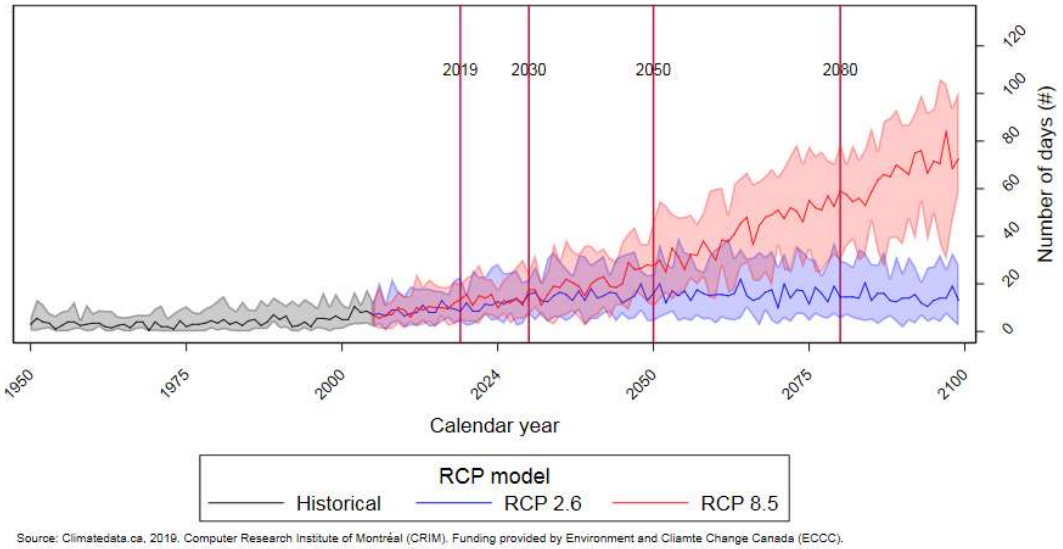
Annual number of days above 30°C - Projections

Figures 3.1 to 3.3 show the projected number of annual days above 30°C for each of HKPR's municipalities. On all figures, the black line on the left of the graph represents median values for 1950 to 2005, the blue line represents a low emissions scenario (RCP2.6[3]) and the red line a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile). Under RCP8.5, increases are projected in each municipality, the greatest being in Lindsay. For comparison, the projections for RCP2.6 are also shown, which project more stable numbers.

In Haliburton (Figure 3.1) for 2019, the models project a median value of 9 days (RCP2.6) and 14 days (RCP8.5) above 30°C. These values increase but stay fairly close together until about year 2030 (15 days, RCP2.6; 19 days RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of days above 30°C remains relatively stable (17 days by 2050; 14 days by 2080). However, under the high emissions scenario, there is a steady increase (28 days by 2050; 58 days by 2080).

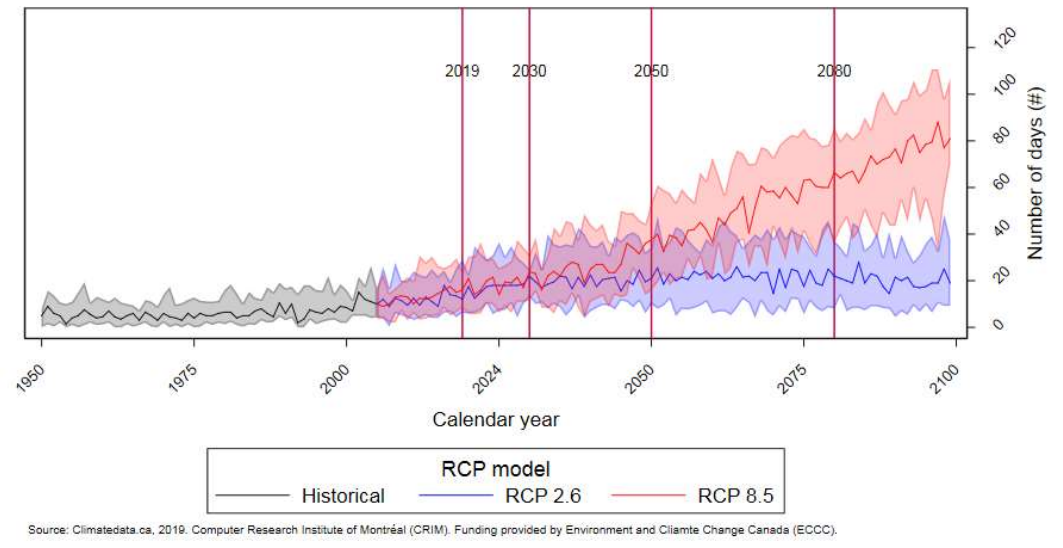
[3] For further detail on RCP scenarios, see Chapter 1-Section B, Methodology.

Figure 3.1 Projected number of days with a maximum temperature above 30 ℃ from years 1950 – 2100 in Haliburton (Haliburton County)



In Lindsay (Figure 3.2) for 2019, the models project a median value of 16 days (RCP2.6) and 16 days (RCP8.5) above 30°C. These values increase but stay fairly close together until about year 2030 (21 days, RCP2.6; 25 days RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of days above 30°C remains relatively stable from 2030 on (23 days by 2050; 22 days by 2080). However, under the high emissions scenario, there is a steady increase (38 days by 2050; 66 days by 2080).

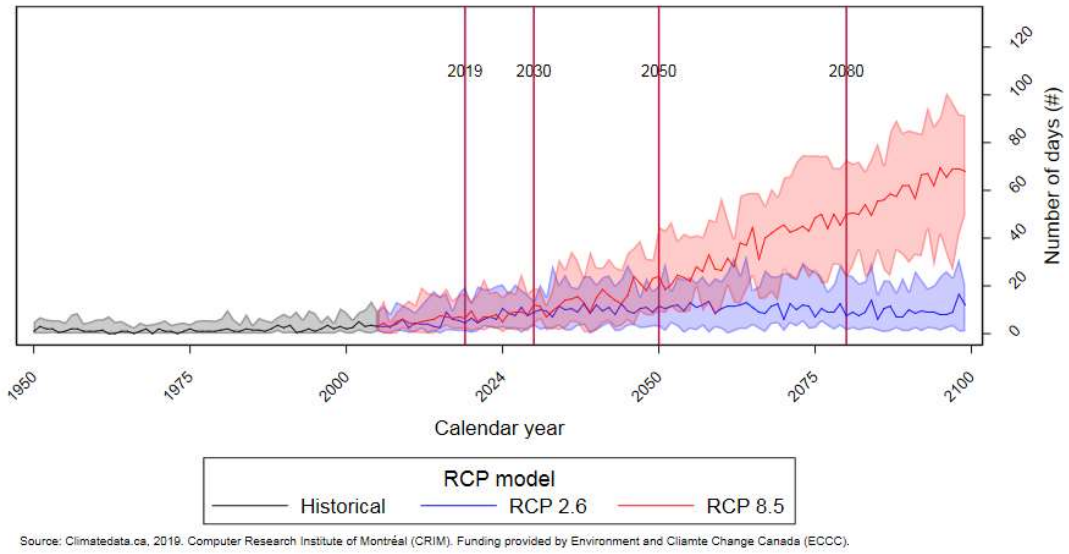
Figure 3.2 Projected number of days with a maximum temperature above 30 ℃ from years 1950 – 2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 3.3) for 2019, the models project a median value of 6 days (RCP2.6) and 7 days (RCP8.5) above 30°C. These values increase but stay fairly close together until about year 2030 (9 days, RCP2.6; 12 days, RCP8.5). After this time the red and blue lines begin to diverge. Under the low

emissions scenario, the median number of days above 30°C stays relatively stable and begins to gradually decrease beyond 2050 (12 days by 2050; 8 days by 2080). However, under the high emissions scenario, there is a steady increase (22 days by 2050; 50 days by 2080).

Figure 3.17 Projected number of days with a maximum temperature above 30 ℃ from years 1950 – 2100 in Cobourg (Northumberland County)



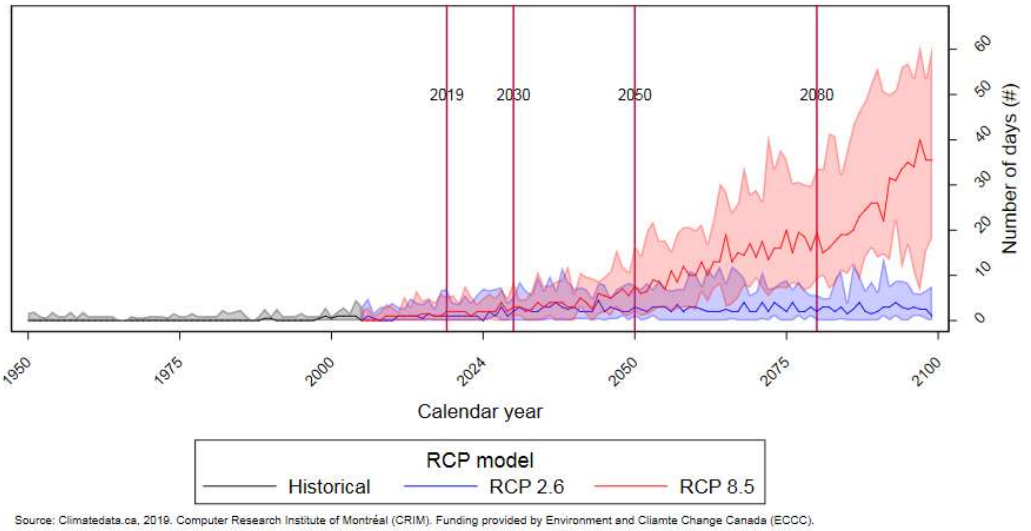
Annual Number of Tropical Nights - Projections

Tropical nights are defined as days when the minimum temperature (usually the overnight temperature) stays above 20°C. Tropical nights mean there is no relief from the heat through nighttime cooling. An increase in tropical nights leads to increase in heat stress, especially for vulnerable populations.

Figures 3.4 to 3.6 show the projected number of tropical nights for each of the HKPRDHU's municipalities. On all figures, the black line represents median values for 1950 to 2005, the blue line represents a low emissions scenario (RCP2.6) and the red line a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile). Under RCP8.5 increases are projected in each municipality. For comparison, the projections for RCP2.6 are also shown, which project more stable numbers.

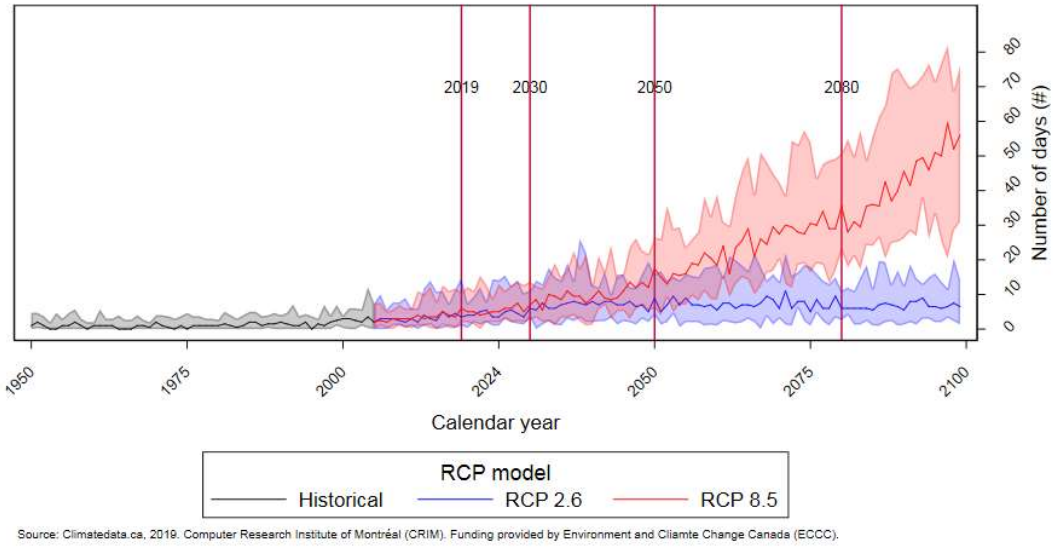
In Haliburton (Figure 3.4) for 2019, the models project a median value of 1 (RCP2.6) and 2 (RCP8.5) tropical nights. These values increase but stay fairly close together until about year 2030 (2 in RCP2.6; 3 in RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of tropical nights remains relatively stable (3 by 2050; 2 by 2080). However, under the high emissions scenario, there is a steady increase (7 by 2050; 21 by 2080).

Figure 3.4 Projected number of tropical nights (above 20 ℃) from years 1950 – 2100 in Haliburton (Haliburton County)



In Lindsay (Figure 3.5) for 2019, the models project a median value of 3 (RCP2.6) and 6 (RCP8.5) tropical nights. These values increase but stay fairly close together until about year 2030 (6 in RCP2.6; 7 in RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of tropical nights remains relatively stable (8 by 2050; 7 by 2080). However, under the high emissions scenario, there is a steady increase (16 by 2050; 36 by 2080).

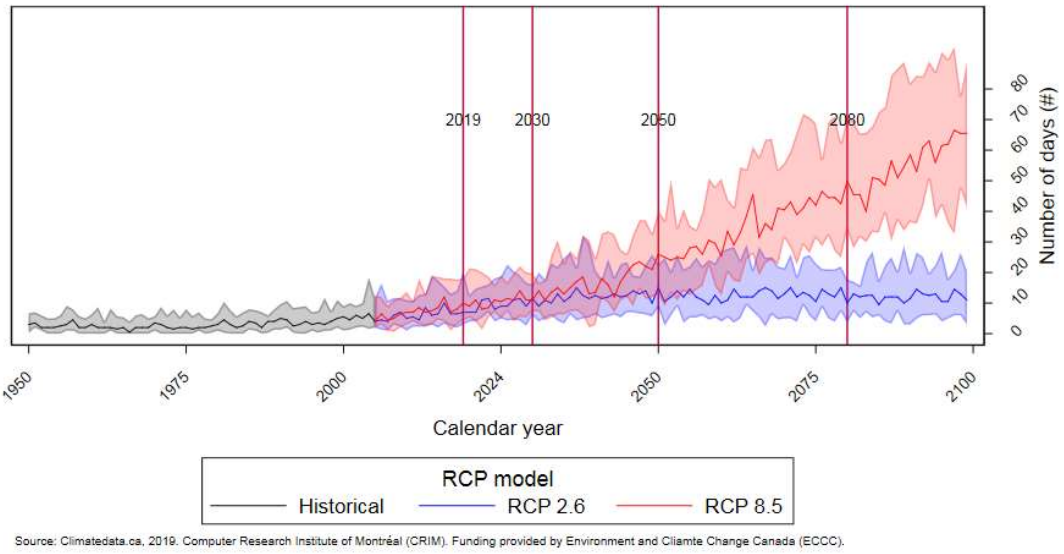
Figure 3.18 Projected number of tropical nights (above 20 ℃) from years 1950 – 2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 3.6) for 2019, the models project a median value of 7 (RCP2.6) and 10 (RCP8.5) tropical nights. These values increase but stay fairly close together until about year 2030 (11 in RCP2.6; 13 in RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of tropical nights continues to increase slightly and then starts to decline (15 by

2050; 10 by 2080). However, under the high emissions scenario, there is a steady increase (26 by 2050; 50 by 2080).

Figure 3.6 Projected number of tropical nights (above 20 ℃) from years 1950 – 2100 in Cobourg (Northumberland County)



Heatwaves

Reporting on heatwaves is challenging because there is no universal definition. A heatwave is usually measured relative to typical weather in an area and as such is location specific; temperatures that are considered normal in a hotter climate can be called a heatwave in a cooler area. The HKPRDHU issues heat notifications based on forecasts from Environment Canada and Climate Change's (ECCC) as part of the Harmonized Heat Warning and Information System for Ontario (HWIS). The HWIS is activated when "2 or more consecutive days of daytime maximum temperatures are expected to reach 31°C or warmer and nighttime minimum temperatures are expected to fall to 20°C or warmer. Or when 2 or more consecutive days of humidex values are expected to reach 40 or higher."(46, 47)

All temperature indicators project that all municipalities in the HKPR district will see increases in the number of days with extreme heat in the future under a scenario that sees minimal to no reductions in future greenhouse gas emissions (RCP8.5). With this comes increased risk of heat-related illnesses, especially for vulnerable people. The next section of this chapter discusses the burden of illness related to heat in the HKPR district.

3.1.2. Health Impacts of Extreme Heat in HKPR District

Exposure to extreme heat most directly affects health by overwhelming the body's ability to regulate its internal temperature and cool itself. Health risks of extreme heat include heat cramps, heat exhaustion and heat stroke, which can be life-threatening. Periods of extreme heat can also worsen a wide range of chronic illnesses such as cardiovascular and respiratory disease and diabetes.(48)

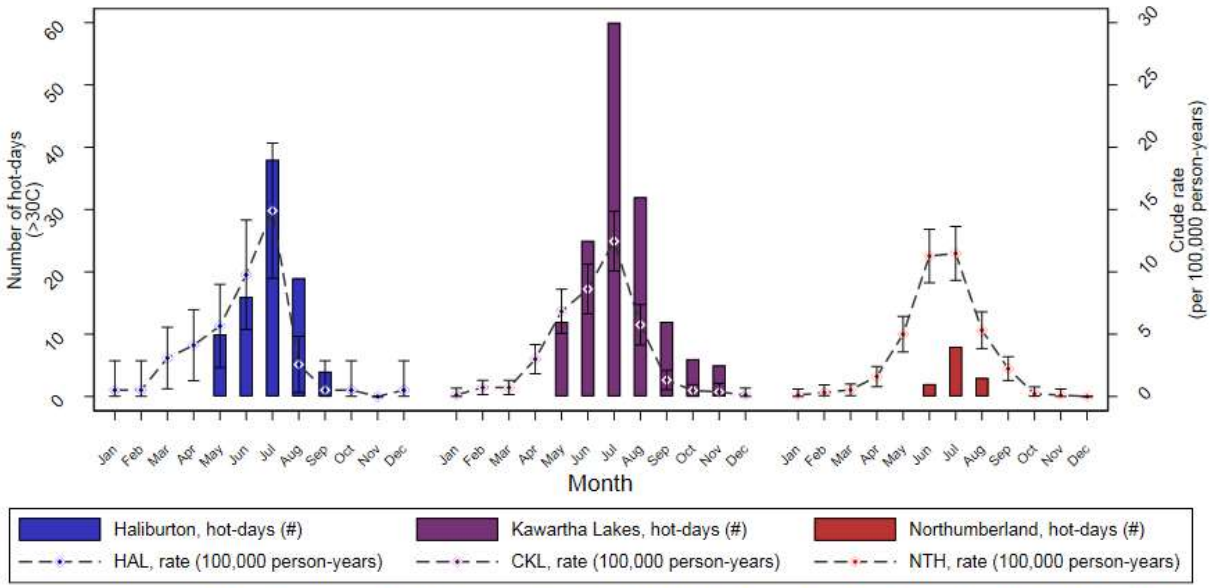
The thresholds that define heatwaves described previously in this chapter are not the only predictor of negative health outcomes due to extreme heat. Heat-related deaths begin to increase when

temperatures go above 25°C.(49, 50) A study done by Public Health Ontario and the Institute for Clinical Evaluative Sciences (ICES) found that even moderate changes in temperature had an impact on mortality. With every 5°C increase in temperature on hot days, there was a 2.5% increase in nonaccidental mortality, or 4 excess deaths per day in the summer months. Heat was most strongly linked with respiratory death.(51) These findings are important because they show that negative health outcomes increase in hot conditions even when the thresholds for activating heat warning/alert systems are not met.

Emergency department (ED) visits are coded using the International Classification of Diseases (ICD-10). Records do not include temperature at the time of admission, but by comparing ED visits that are coded for heat-related illnesses with hot days, a relationship can be seen. Heat-related ED visits reported for the HKPR district include heat and sunstroke, heat cramps, heat exhaustion and other effects of heat; and exposure to excessive natural heat.

Local temperature and health data show that the rate of heat-related emergency visits is higher in all three municipalities during months with more hot days, as illustrated in Figure 3.7, which shows the total number of hot-days and crude rate of heat-related illness for 2008-2018. Hot-days are days where the maximum temperature was greater than 30°C. With the number of hot days projected to increase, along with the portion of the population that is age 65+ years, hospitalizations would be expected to increase unless significant adaptation measures are put in place.

Figure 3.7 Total number of hot days (>30 ℃) and crude rate of heat-related emergency department visits, by month and municipality, 2008-2018

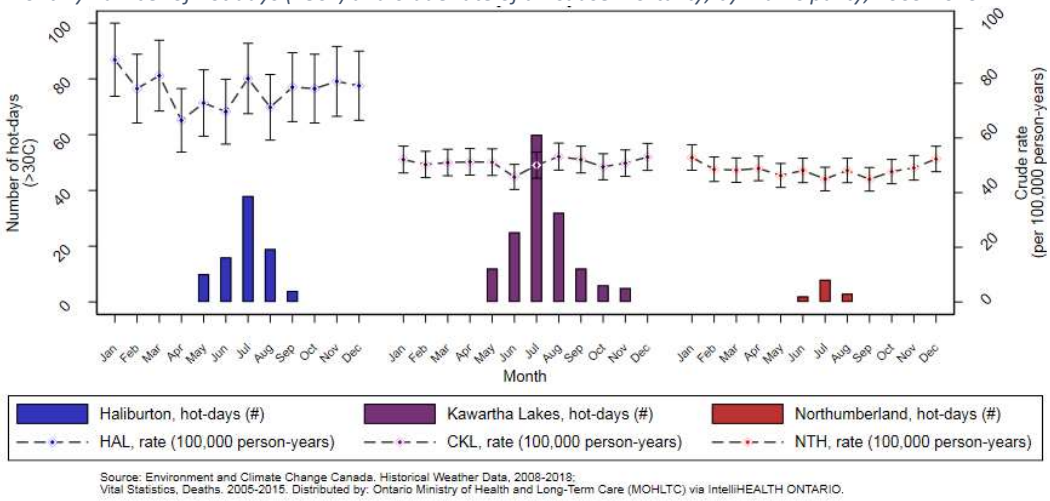


Source: Environment and Climate Change Canada. Historical Weather Data, 2008-2018; National Ambulatory Care Reporting System (NACRS), Canadian Institute for Health Information (CIHI). 2008-2018. Distributed by: Ontario Ministry of Health and Long-Term Care (MOHLTC) via IntelliHEALTH ONTARIO.

Another way to look at the health impacts of temperature is to relate the number of deaths to observed weather conditions. This statistical approach can show whether temperature was associated with increased death or illness.(32) All-cause mortality (death) rates for each municipality are reported in Figure 3.8, compared with monthly number of hot days. There is no apparent relationship between the

two, making it difficult to draw any conclusions about the degree to which hot weather has contributed to mortality in the recent past.

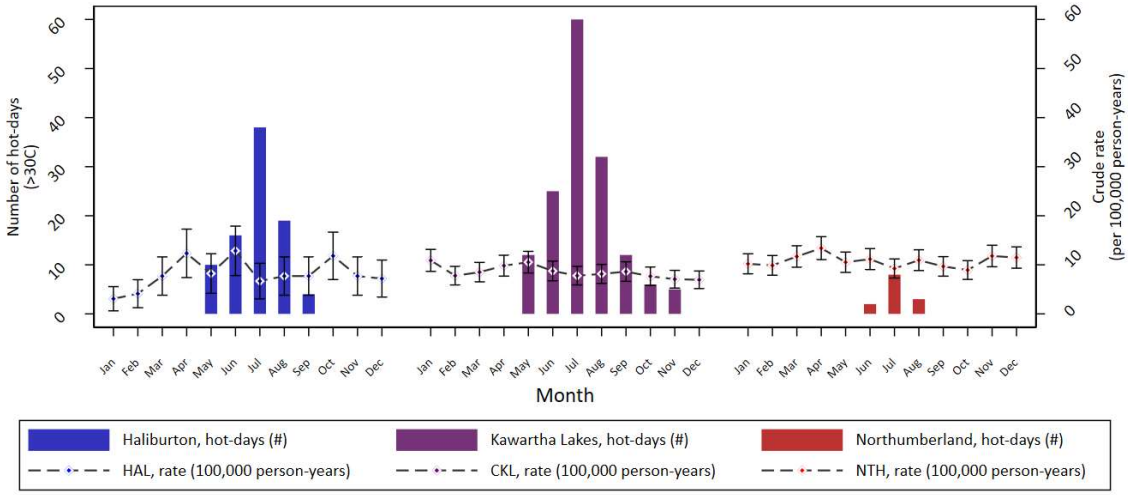
Figure 3.8 Monthly number of hot days (>30 °) and crude rate of all-cause mortality, by municipality, 2005-2015



There is emerging understanding of the impacts of extreme heat on mental health, with increased violence, aggressive behaviour and suicide showing association with high heat events.(37, 38) Hospital admissions among people with mental illness have been shown to increase due to extreme heat and humidity.(52) Public Health England notes higher rates of suicide observed during heatwaves in the United Kingdom(49) and a study from Stanford University found a linear relationship between temperature and suicide in the United States and Mexico; an increase of 1°C in average monthly temperature increased mean monthly rate of suicide by 0.68% in the U.S. and by 2.5% in Mexico between years 1990-2010.(38) While these studies demonstrate a relationship between heat and violent behaviour, they do not explain the mechanisms behind it; further research is needed.

The crude rate of ED visits for self-harm is compared to monthly number of hot days, Figure 3.9. There is no apparent relationship between the two, making it difficult to draw any conclusions about the degree to which hot weather has impacted self-harm in the recent past.

Figure 3.9 Monthly number of hot days (>30 °) and crude rate of self-harm-related emergency department visits, by municipality, 2008-2018



Source: Environment and Climate Change Canada. Historical Weather Data, 2008-2018; National Ambulatory Care Reporting System (NACRS), Canadian Institute for Health Information (CIHI). 2008-2018. Distributed by: Ontario Ministry of Health and Long-Term Care (MOHLTC) via IntelliHEALTH ONTARIO.

3.1.3. Exposure to Extreme Heat in HKPR district

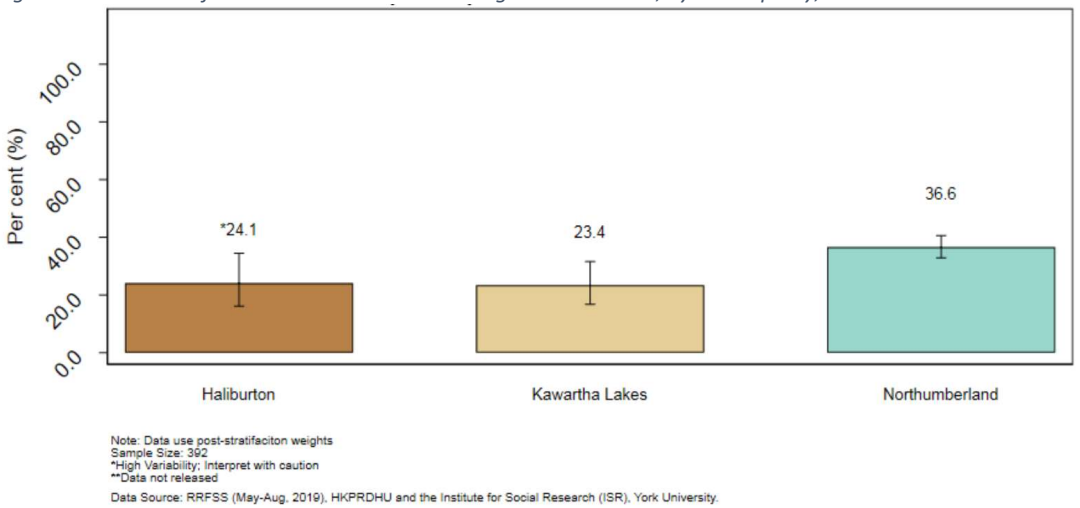
A person's exposure to extreme heat depends on location (e.g. do they live in an urban or rural area?) and indoor environment (e.g. do they have a heat pump or air conditioning?). Since most people spend much of their time indoors, housing conditions also play a role in exposure to heat.

The built environment has an impact on exposure to heat. Non-reflective surfaces such as roadways, parking lots and buildings absorb, retain and radiate heat during the day further increasing the surrounding temperature and diminishing cooling at night. This is known as the heat island effect and is most common in urban areas. Detailed mapping of urban heat islands in the HKPR district is not available to the HKPRDHU.

There is evidence the risk of heat-related mortality may be higher in rural areas. Contributing factors could be a higher proportion of older adults and people working in outdoor settings, less access to health care services and less access to air conditioning and transportation.(12)

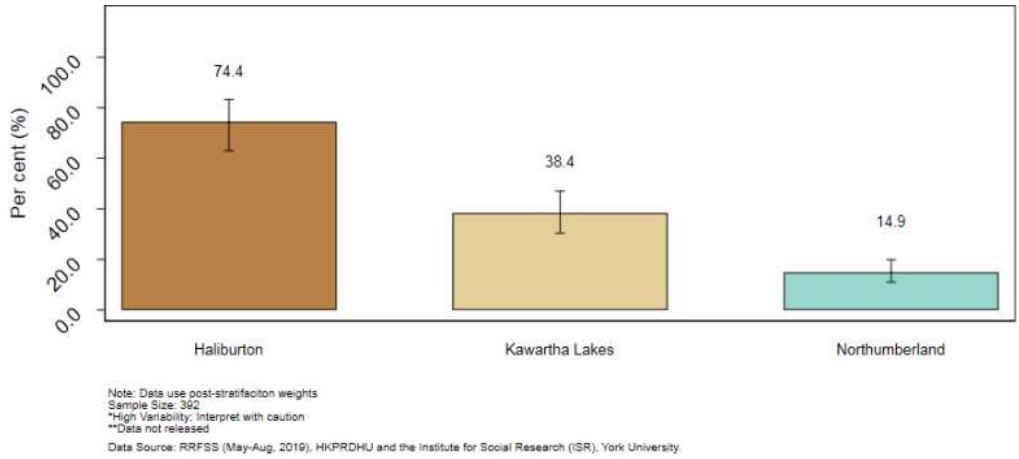
In the 2019 Rapid Risk Factor Surveillance System (RRFSS), HKPRDHU asked a set of questions about access to equipment that reduces exposure to heat: air conditioners, fans and access to locations that are cool. Heat pumps are now recommended as being preferable to traditional air conditioners because they contribute less to greenhouse gas emissions, however, the RRFSS module did not include heat pumps. Figure 3.10 shows the percentage of households without a working air conditioner, by municipality. The percentage of households without a fan was not reported due to small numbers.

Figure 3.10 Percent of households without a working air-conditioner, by municipality, 2019



Public spaces for people to go and get cool during hot weather are especially important for those who do not have air conditioning in their homes. Examples include indoor spaces such as malls, libraries and designated cooling centres. Outdoor spaces include shaded parks, beaches, splash pads and pools. Figure 3.11 shows the percent of adults who are not aware of places close to their home where they can go to get cool. A high percentage of respondents in Haliburton County are not aware of places close to their home (74.4%), compared with in the City of Kawartha Lakes (38.4%) and Northumberland County (14.9%). This may be a function of availability of cooling spaces, knowledge about such spaces, or both.

Figure 3.11 Percent of adults who are unaware of places close to their home where they can go to cool down during hot weather, by municipality, 2019



In the HKPR district, 6.9% of workers are in industries that require work outdoors such as forestry, agriculture and construction compared to 4.6% in Ontario overall (refer to Figure 2.8, Section 2.2.5.). People working outdoors are more exposed to environmental conditions and therefore more vulnerable to negative health impacts of extreme heat. Occupations such as agricultural workers, construction, utility workers and outdoor recreation workers are at increased risk for heat related illness, especially where jobs involve heavy exertion.(32) If workers are required to wear protective equipment this may also limit the body's ability to cool itself.

Across the HKPR district, outdoor activities such as cycling, hiking, and boating are promoted as tourist attractions and opportunities for residents and visitors to get physically active. More than half of HKPR residents report being active or moderately active (see Figure 2.9, Section 2.2.7.). People who are active outdoors in hot, and especially humid conditions are at increased risk of heat illness.(48) Exercising in hot weather increases core body temperature, putting people at risk of heat-related illness.(53) The HKPR district is also home to 25 residential summer camps that range from small (less than 100 staff and campers) to large (several hundred staff and campers). Both staff and campers are vulnerable during extreme heat, since they spend most of their time outside and are less likely to stay in accommodations that have air conditioning. Camps typically have on-site nurses or doctors, but instances of heat-related illness that require a visit to an emergency department or hospitalization place added demands on the health care system, especially in Haliburton County, where 19 camps are located and there is smaller capacity at emergency departments.

3.1.4. Sensitivity to Extreme Heat

Infants and children, older adults, people living on low income, people who have chronic illnesses or are on certain medications, and pregnant people are more vulnerable to extreme heat. (29, 32)

Children tend to be more active and produce more body heat during physical activity but have reduced sweating, making them particularly vulnerable during heat waves. Their body temperature increases more quickly when exposed to high heat due to greater surface-to-body ratio.(29) Children under 14 are also more likely to be dependent on caregivers to recognize heat impacts and take actions to keep them safe. This is true outdoors as well as in environments that lack air conditioning, including homes, schools, or cars. Children exposed to extreme heat may experience dehydration, electrolyte imbalance, fever, heat stress, and hyperthermia.(32)

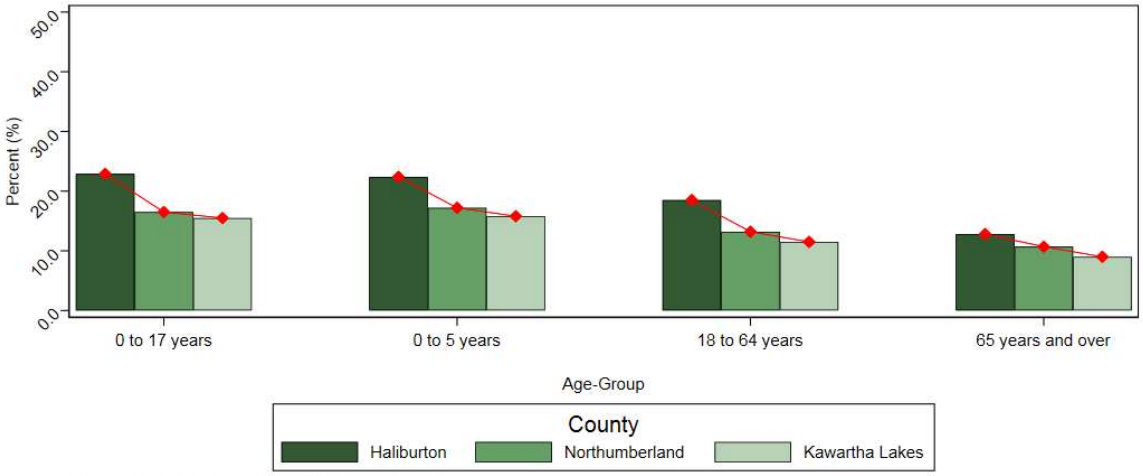
Older adults (65+) represent a large proportion of the population in the HKPR district (see Figure 2.1 in Section 2.2.1.) and this is projected to increase in the future. There is strong evidence of the relationship between increased temperatures and death in older adults.(32) People's physiology changes as they age which contributes to greater vulnerability to heat, including reduced ability to sweat and increased susceptibility to dehydration. Older adults may also have existing chronic conditions such as respiratory and cardiovascular illness that can be worsened by high heat. They may be taking certain medications that affect the body's ability to regulate heat (e.g., beta-blockers or diuretics)(32). People living alone are also more vulnerable to extreme heat as they may lack social connections that help ensure their safety during heatwaves.(54)

In the HKPR district, 14% of the population live on low income (low-income measure, after tax). The proportion is highest in Haliburton (17.2%), followed by CKL (13.1%), and Northumberland (11.6%).(28) People living on low income or those who are socially isolated may have limited financial resources to take protective actions. They may live in housing with no air conditioning or the cost of electricity may keep them from running an air conditioner or fan, even if it is available. The HKPR district is a large, rural, dispersed area with limited or no public transportation. Even though communities may have public places for cooling such as pools, beaches, malls or libraries, or offer designated cooling centres

during heatwaves, many people will have difficulty accessing them due to a lack of transportation options.

There are overlapping categories of vulnerability as well. Figure 3.12 shows the percentage of residents living with low-income. Among children 0 to 5 years of age, 22.4% in Haliburton County, 27.2% in City of Kawartha Lakes and 15.8% in Northumberland are low-income. Among seniors, age 65+, 12.8% in Haliburton County, 10.7% in City of Kawartha Lakes and 12% in Northumberland County are low-income.

Figure 3.12 Percent of Low Income Measure, After Tax (LIM-AT) residents, by age-group, by municipality, 2015



Source: Statisitics Canada. 2016 Census of Population.

Chronic conditions including diabetes, cardiovascular disease and mental illness make people more sensitive to adverse impacts of extreme heat.(32) Refer to Section 2.2.5 for details on the prevalence of chronic conditions in the HKPR district. There is growing understanding of the impacts of heatwaves on mental health. Specific illnesses impacted by heat include dementia, mood disorders, neurosis and stress, and substance abuse.(32) Many medications used to treat a range of mental health disorders (e.g. antidepressants, antipsychotics) can inhibit the body's ability to regulate temperature, thereby increasing one's vulnerability to heat.(32) More heatwaves may lead to increased demand on mental health services, paramedic services, emergency departments and social support services.

Exposure to high heat can impact pregnant people as it is associated with preterm births and adverse birth outcomes such as low birth weight and infant mortality.(32) See Fig. 2.6 in Section 2.2.2. for local fertility rates.

Extreme temperatures also include extreme cold. The next part of this chapter looks at cold using similar indicators for temperature and health and discusses who in the HKPR district is most likely to be exposed and sensitive to extreme cold.

3.2. Extreme Cold

Reporting on extreme cold can be challenging as, like extreme heat, definitions of extreme cold vary by geographical region. Environment Canada issues an extreme cold warning in southern Ontario when the temperature or wind chill is expected to reach -35°C for at least 2 hours.(47) However, local thresholds may differ. For example, Peterborough Public Health has a three-level warning system that starts with a

Frostbite Alert when the forecasted temperature or wind chill will be -27°C or colder. The same groups that are vulnerable to extreme heat are also vulnerable to extreme cold. People who are experiencing homelessness face greater risk of exposure and negative health impacts of cold temperatures.

3.2.1. Projections for Extreme Cold in HKPR District

In general, across the HKPR district a decline in number of days with extreme cold temperatures is expected in the future. However, some climate scientists also foresee that some parts of Ontario may experience increases in extreme cold events due to changes in the polar vortex that are impacted by global warming.(55) Therefore, preparing for extreme cold temperatures will continue to be important in the future even as average annual temperatures increase.

Using ECCC's climatedata.ca website, the largest population centre within each of the three municipalities within the HKPR district (Haliburton Village in Haliburton County; Lindsay in City of Kawartha Lakes; Cobourg in Northumberland County) was searched to obtain climate data to be generalized across each of the respective municipalities.

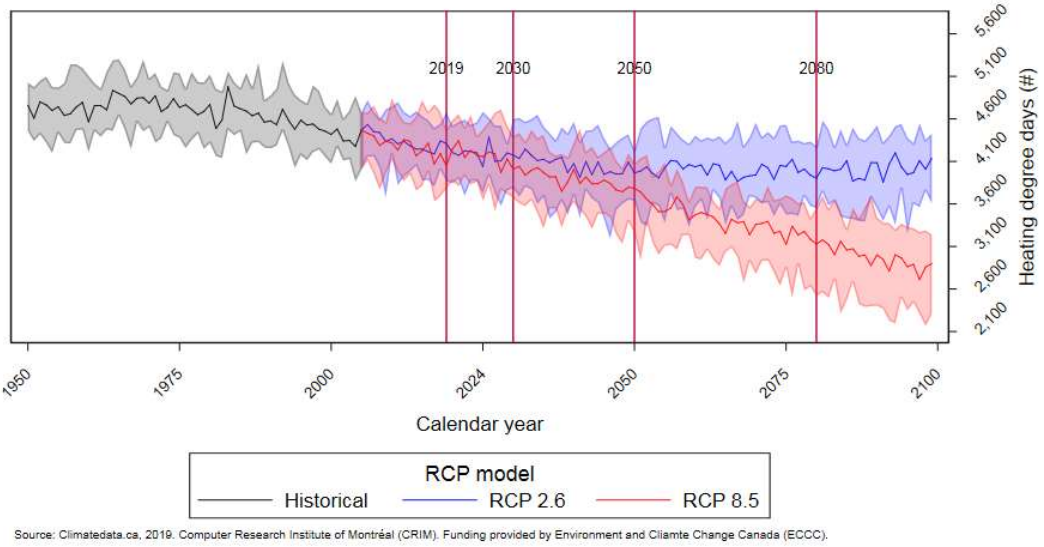
Annual number of heating degree days

The number of heating degree days (HDD) describes the amount of heating required to maintain comfortable indoor conditions during cooler months and therefore is an indicator of outdoor temperatures. Higher HDD values indicate colder outdoor temperatures. In this case, maintaining a baseline indoor temperature of 17°C is used. For any day that the outdoor mean temperature falls below 17°C, heating degree days are accrued, 1 HDD for each degree Celsius below 17°C. For example, if the outdoor daily mean temperature on a given day is 10°C, 7 HDDs are accrued that day. HDD values are totalled over the year.(22) As average winter temperatures warm, there will be a reduction in energy demand to heat buildings and number of HDDs per year decreases. A positive benefit of this is a potential reduction in the cost of home heating in the winter. In all municipalities, the number of HDDs is projected to decrease under emissions scenario RCP8.5.

On all figures, the black line represents median values for 1950 to 2005, the blue line represents a low emissions scenario (RCP2.6) and the red line a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile).

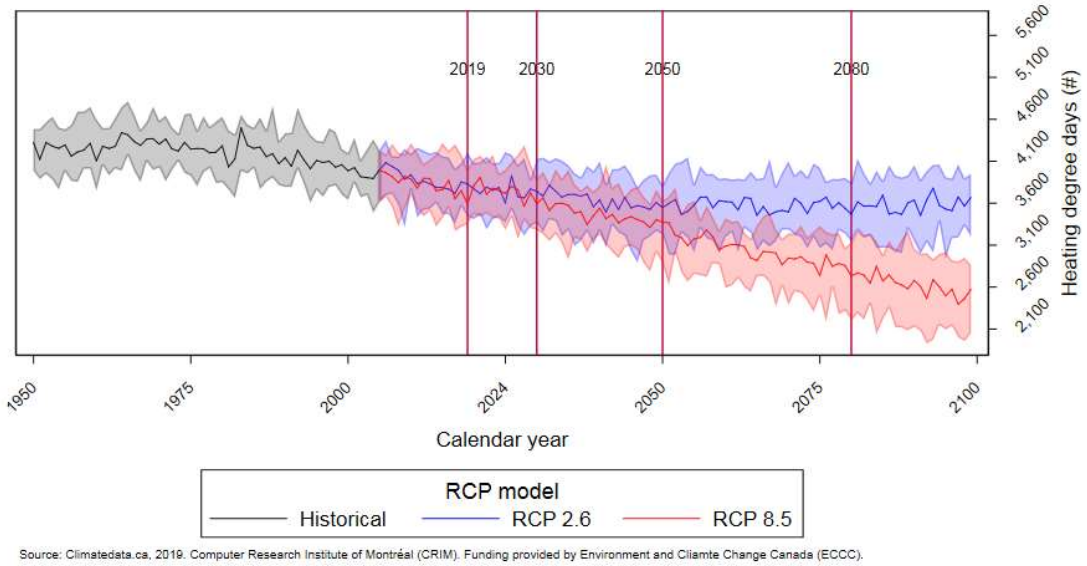
In Haliburton (Figure 3.13) for 2019, the models project a median value of 4,244 (RCP2.6) and 4,263 (RCP8.5) annual heating degree days. These values increase but stay fairly close together until about year 2030 (4,109 HDDs, RCP2.6; 3,999 HDDs, RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of HDDs stay relatively stable (4,001 by 2050; 3,995 by 2080). However, under the high emissions scenario, there is a steady decline (3,765 by 2050; 3,031 by 2080).

Figure 3.13 Projected annual number of heating degree days from 1950-2100 in Haliburton (Haliburton County)



In Lindsay (Figure 3.14) for 2019, the models project a median value of 3,793 (RCP2.6) and 3,832 (RCP8.5) annual heating degree days. These values increase but stay fairly close together until about year 2030 (3,702 HDDs, RCP2.6; 3,582 HDDs, RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of HDDs show a slight decline (3,586 by 2050; 3,526 by 2080). However, under the high emissions scenario, there is a steady decline (3,332 by 2050; 2,715 by 2080).

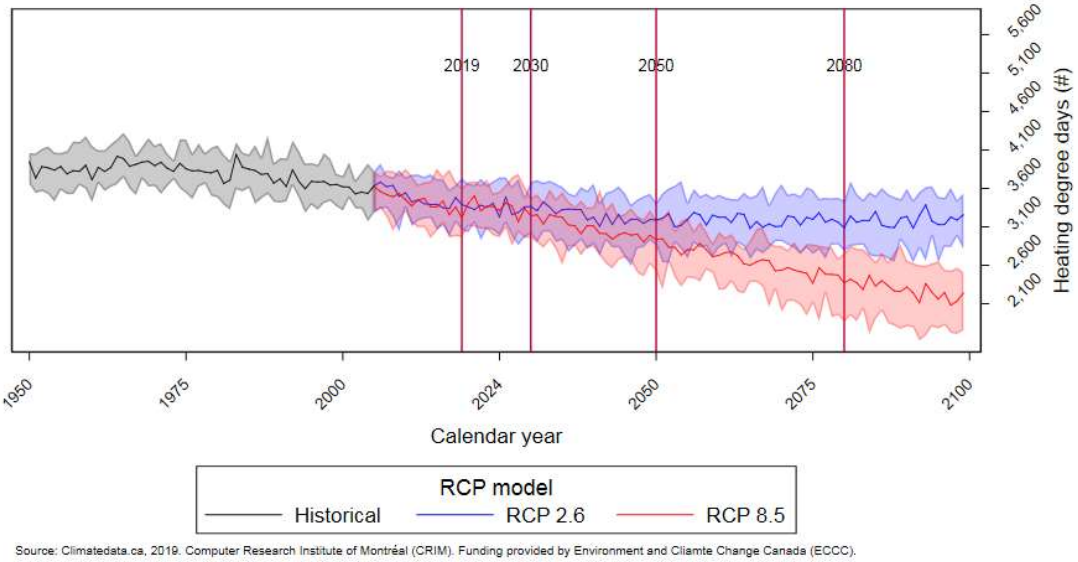
Figure 3.14 Projected annual number of heating degree days from 1950-2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 3.15) for 2019, the models project a median value of 3,377 (RCP2.6) and 3,417 (RCP8.5) annual heating degree days. These values increase but stay fairly close together until about year 2030 (3,340 HDDs, RCP2.6; 3,226 HDDs, RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario, the median number of HDDs show a slight decline (3,203 by

2050; 3,121 by 2080). However, under the high emissions scenario, there is a steady decline (2,912 by 2050; 2,344 by 2080).

Figure 3.15 Projected annual number of heating degree days from 1950-2100 in Cobourg (Northumberland County)

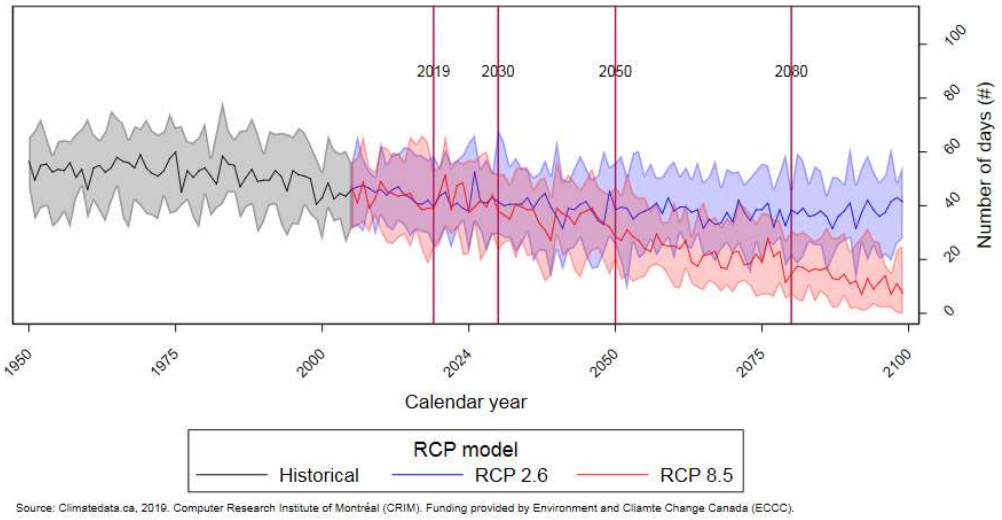


Annual number of days below minus 15°C

Temperature data is provided for cold days. On all figures, the black line represents median values for 1950 to 2005, the blue line represents a low emissions scenario (RCP2.6) and the red line a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile). For all municipalities, under a high emissions scenario (RCP8.5) the number of cold days (≤-15°C) is projected to decrease. For comparison, the projections for a low emissions scenario (RCP2.6) are also shown, which show a less dramatic decline.

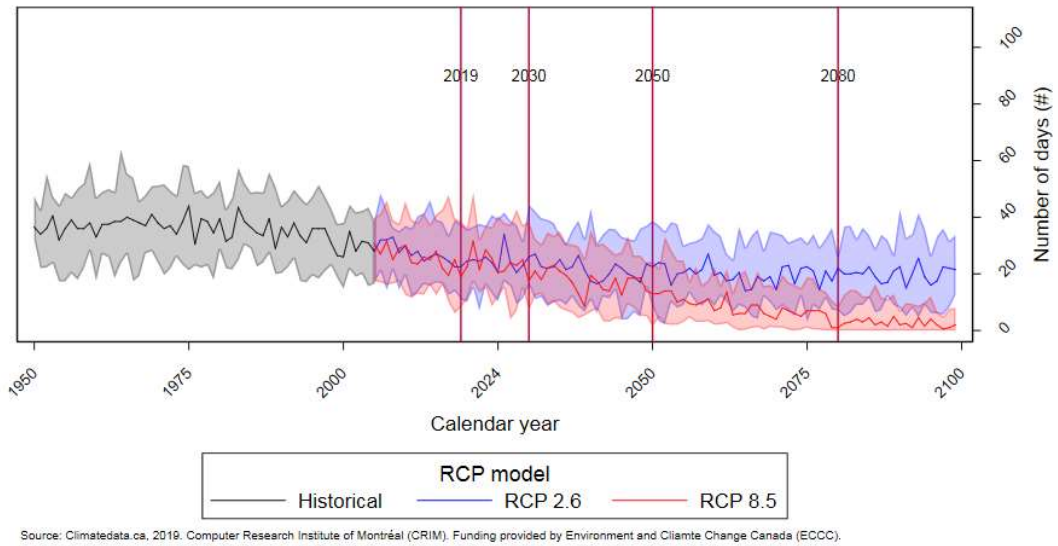
In Haliburton (Figure 3.19) for 2019, the models project a median value of 39 days (RCP2.6) or 41 days (RCP8.5) below -15°C. These values stay fairly consistent until year 2030 (40 days, RCP2.6; 37 days RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario (RCP2.6), the median number of days below -15°C remains relatively stable (41 days by 2050; 40 days by 2080). However, under the high emissions scenario (RCP8.5), there is a steady decrease (29 days by 2050; 15 days by 2080).

Figure 3.16 Projected number of days with a minimum temperature below -15 ℃ from 1950-2100 in Haliburton (Haliburton County)



In Lindsay (Figure 3.17) for 2019, the models project a median value of 24 days (RCP2.6) or 24 days (RCP8.5) below -15°C. These values stay fairly consistent until year 2030 (24 days, RCP2.6; 21 days RCP8.5). After this time the red and blue lines begin to diverge. Under the low emissions scenario (RCP2.6), the median number of days below -15°C remains relatively stable (24 days by 2050; 23 days by 2080). However, under the high emissions scenario (RCP8.5), there is a steady decrease (13 days by 2050; 1 day by 2080).

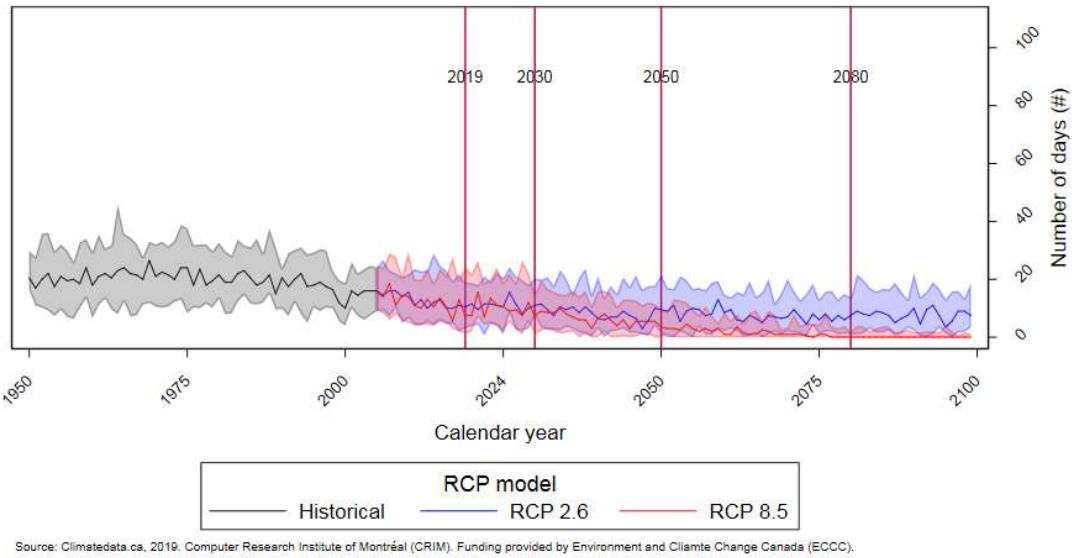
Figure 3.17 Projected number of days with a minimum temperature below -15 ℃ from 1950-2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 3.18) for 2019, the models project a median value of 11 days (RCP2.6) or 9 days (RCP8.5) below -15°C. These values stay consistent and fairly close together until about year 2030 (10 days, RCP2.6; 9 days RCP8.5). After this time the red and blue lines begin to diverge. Under the low

emissions scenario (RCP2.6), the median number of days below -15°C slightly declines and then remains relatively stable (10 days by 2050; 10 days by 2080). However, under the high emissions scenario (RCP8.5), there is a steady decrease (4 days by 2050; 0 days by 2080).

Figure 3.18 Projected number of days with a minimum temperature below -15 ℃ from 1950-2100 in Cobourg (Northumberland County)



Projections suggest that under emissions scenario RCP8.5, all municipalities will experience fewer cold temperatures as overall global annual average temperatures rise. However, there are still health implications of cold temperatures, discussed in the following sections.

3.2.2. Health Impacts of Extreme Cold in HKPR District

The main health risks of extreme cold are frostbite and hypothermia. An Ontario study found that for every 5°C decrease in temperature during cold months (Dec– Feb) there were approximately seven excess deaths per day. Cold was found to increase cardiovascular-related mortality in particular.(51)

Emergency department visits due to cold-related illnesses reported for residents of the HKPR district include: frostbite, hypothermia and exposure to excessive natural cold (as defined in the International Classification of Diseases, Tenth Edition (ICD-10)). Across the HKPR district, there appears to be a relationship between the number of cold days (below -15°C) in a year and the rate of emergency department visits for cold-related illness, with more visits in years with more cold days (Fig. 3.19). Cold-related ED visits are broken down by municipality in Fig. 3.20, showing a generally similar pattern.

Figure 3.19 Annual number of cold days (<15 ℃) and crude rate of cold-related emergency department visits, HKPRDHU, 2008-2018

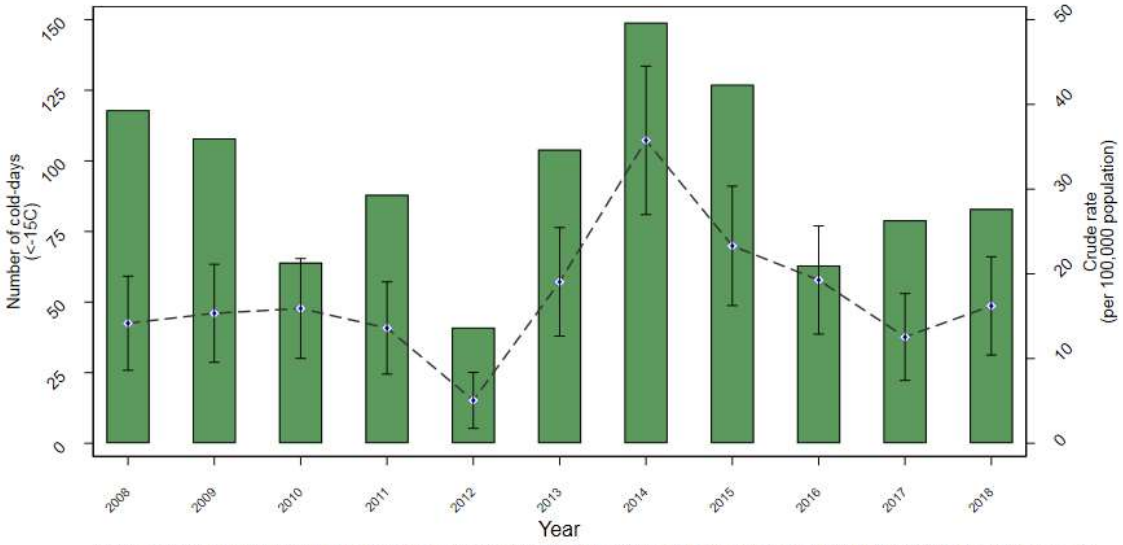
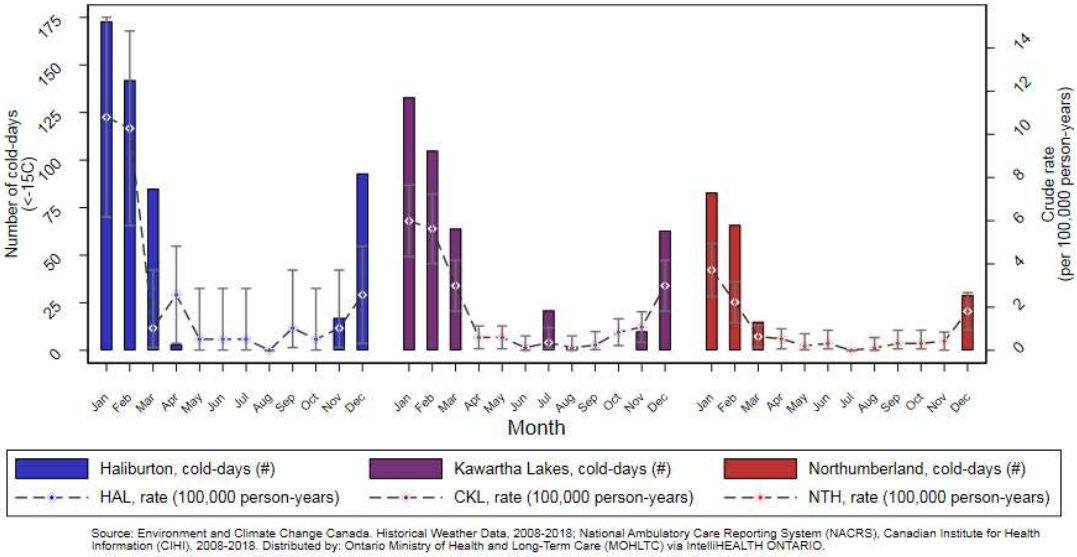


Figure 3.20 Total monthly number of cold days (<15 ℃) and crude rate of cold-related emergency department visits, by municipality, 2008-2018



3.2.3. Exposure and Sensitivity to Extreme Cold in HKPR District

The overall trend in winter temperatures indicates a decrease in the number of cold days, which over time reduces exposure to cold events for residents of HKPR district. However, there will continue to be year-to-year variability which will include extreme cold temperatures. There will still be risks to vulnerable people, in particular those who are experiencing homelessness or who work outdoors. People living with low-income may live in poor quality housing (e.g. with poor insulation and windows)

and may also have difficulty paying for heating. Considerations for adaptation to cold temperatures will continue to be important as the climate changes.

3.3. Building Adaptive Capacity to Extreme Temperatures in HKPR District

Given the projections of more extreme heat in the future and the impact of heat on health, the need to implement adaptation measures is clear. The populations most vulnerable to extreme temperatures in the HKPR district are diverse. Building adaptive capacity to extreme temperatures now and in the future requires partnership and collaboration between public health, municipalities and other community agencies.

The HKPRDHU plays a key role in communicating messages to the public and local partners during times of extreme heat and cold about how to stay safe, and to collaborate on community-level measures to address the needs of residents who are most vulnerable. A survey of community partners who receive HKPRDHU's heat alert response plan was conducted in 2019. Results indicate that HKPRDHU's email heat alerts meet the needs of most respondents very or extremely well. Several respondents forward the information to other staff and/or partners. Municipalities and other community partners are working to establish cooling and warming centres that can be made available during extreme temperature events. These facilities are important to building adaptive capacity in the community, especially for vulnerable populations.

The HKPRDHU works with municipalities and other institutions on the development of healthy policies. At a community level, planning policies and strategies can contribute to adaptation. For example, urban areas tend to be warmer than rural areas due to the density of buildings and pavement resulting in a heat island effect. Policies that increase shade, green space and trees in public places, and technologies such as green roofs can reduce this impact.(32)

At an individual level, the prevalence and use of air conditioning or heat pumps is a key strategy for adapting to extreme heat for individuals. However, some people are vulnerable to extreme heat because they may not be able to afford to own or operate these devices. This includes residents who are living with low-income or those living on a fixed income, such as seniors and people with disabilities. The HKPRDHU's work on issues of health equity related to income solutions (e.g. advocating for guaranteed basic income and living wages) contributes to reducing barriers of affordability for taking adaptive actions.

Having adaptation measures in place is important, even if a heat or cold alert has not been issued, because potential health risks still exist, especially for vulnerable populations such as those who are experiencing homelessness, living in substandard housing or unable to find a location to adequately cool down in the summer or warm-up in the winter.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

4 Chapter 4: Extreme Weather and Natural Events

4.1. Chapter Overview

Climate change will alter the frequency, intensity and geographic distribution of extreme weather and natural events such as heavy rain and storms, wildfires and droughts across Canada, (29) and HKPR district will experience these changes as well. This chapter offers a detailed picture of projected extreme weather events, with a particular focus on extreme precipitation. Health impacts are discussed related to exposure to extreme weather events and populations who are most vulnerable.

4.1.1. Highlights

- Intense storm risks in HKPR district include thunderstorms, lightning, snowstorms, freezing rain, hailstorms and tornadoes and can lead to widespread power outages which further their impacts. Floods are a primary concern; all municipalities in HKPR district have areas that are at risk of flooding. Projections of heavier precipitation, earlier snowmelt and more rain falling on snow may all contribute to more flooding in the spring. Recent floods in Minden (Haliburton County), Burnt River (City of Kawartha Lakes) and Brighton (Northumberland County) each provide examples of the effects that severe flooding has on individuals and communities from health, infrastructure and economic perspectives.
- Annual precipitation amounts are projected to increase across the HKPR district, with an increase in extreme heavy rainfall events expected. By 2080, rainfall on extremely wet days may increase by as much as 102% over historical norms. High intensity precipitation events (4+mm/hour for 24 hours) are projected to occur much more frequently, every 5 – 50 years instead of every 20 – 50 years, depending on municipality.
- Multiple immediate and long-term health impacts are associated with extreme weather events, including injuries, exposure to contaminated food and water and mental health impacts such as depression, anxiety and post-traumatic stress disorder. Repeated exposure to events like floods can have both immediate and long-term psychological impacts. Extreme events can also disrupt access to health care services.
- Groups more likely to experience negative health impacts of extreme weather events include infants and children, older adults, people living with low-income, people who have chronic illnesses or disabilities, and emergency service workers. People living with low-income are more likely to live in poor housing and have fewer financial resources to prepare for, respond to and recover from an extreme event.
- Public health contributions to building adaptive capacity include emergency planning and preparedness, addressing issues associated with age, disability, illness, income, medical/chemical dependence, isolation, language and housing, and working with partners to convey information in accessible and meaningful ways.

Table 4.1 Summary of Health Impacts of Extreme Weather

Climate Hazards	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts
Extreme precipitation Flooding Severe storms Wildfires Droughts	Power outages Property damage and loss Evacuation and relocation Damage to infrastructure (health care facilities, roads, water treatment, sewage) Poor air quality	Older adults People living with low-income Infants and children People with chronic physical and mental conditions/illnesses Emergency service workers	Physical injuries Death Infection Carbon monoxide poisoning Electrocution Food and water-borne illnesses Falls Anxiety, grief, post-traumatic stress disorder, depression, increased substance use

4.2. Extreme Weather in HKPR District

One indicator of extreme weather risk in the HKPR district is the list of hazards identified by local municipalities on their Hazard Identification and Risk Assessment (HIRA). Municipalities use HIRAs for their emergency planning, identifying hazard risk priorities based on historic events and weighing variables such as frequency, probability, potential consequences (e.g. to health, property, infrastructure, environment, financial) and changes in vulnerability. The HIRA process set out by Emergency Management Ontario identifies climate change as a consideration in the assessment process, stating that emergency management should ensure that, "…disaster risk reduction priorities drive emergency management programs with a clear understanding of the impact of climate change on natural hazards."(56)

A review of local HIRAs (2017) shows that extreme weather and weather-related events are among the top hazards of concern in all municipalities. Weather-related incidents, winter storms, windstorms, snowstorms, freezing rain and tornados appear among the top four hazards in various local HIRAs. Floods are identified among top hazard priorities in two municipalities. All municipalities identified energy emergencies as top risks in their HIRAs. Each of these hazards can present risks to public health, and these are described in this chapter.

Data is most readily available for precipitation and since incidents of flooding have been common in the HKPR district in recent years, most of the discussion about extreme weather in this chapter focuses on projected changes in precipitation and flood risk. Climate change is expected to increase flooding through increases in heavy precipitation, as well as earlier spring runoff and increased storm surges.(29)

4.2.1. Projections for Precipitation in HKPR district

For this chapter, indicators have been selected that provide a picture for what may be expected for mean precipitation amounts and extreme precipitation events in the HKPR district. Warmer annual temperatures lead to more water vapour in the atmosphere, which in turn leads to more precipitation. In colder months, there is likely to be more rain than snow.(57) An increase in number of days with freezing rain between December and February is also projected.(29)

Precipitation[4] indicators show increases in all municipalities within the HKPR district, summarized in Table 4.2. Trends are generally similar across municipalities, with Northumberland County showing the highest percentage increase in most categories. While annual precipitation amounts are projected to increase 10 – 12% by 2080 across the district under a high emissions scenario (RCP8.5), of greater significance are increases in precipitation projected on very wet days and extremely wet days. By 2080, rainfall on very wet days will increase by 44 – 51% above historical norms, and on extremely wet days by 89 – 102% depending on the municipality. This shows that precipitation increases will not be evenly spread out over the year; more will fall on very and extremely wet days. What this could look like is rainfall being concentrated over short periods of time, leading to water levels rising very quickly and potential flash floods. For example, in early May 2017, the Gull River system experienced rainfall of 60 – 75 mm in 24 – 48-hours with a further 50 – 60 mm possible in the following 3-days. For perspective, the average rainfall for Haliburton County during the month of May is 93 mm.(58) At the other end of the spectrum, there will be longer dry periods and greater risk of drought. Ontario's Special Advisor on Flooding stated that, "The most serious impacts of climate change are expected to be the changes in climate extremes".(59)

The local projections listed in Table 4.2 are consistent with those for Ontario overall, where annual mean precipitation by the 2050s is projected to increase by 6.6% in a high emissions scenario (RCP8.5), and by 17.3% (RCP8.5) by the 2080s. One-day precipitation extremes are also projected to increase, increasing the potential for rain-generated local flooding.(57)

[4] Precipitation measures include all forms of precipitation, as measured in water depth.

Table 4.2 Mean precipitation projections for historical reference period (1986-2005), 2050s and 2080s, by municipality, RCP8.5

Municipality	Precipitation Indicator	Reference (1981 – 2005)	2050s	% change (from reference)	2080s	% change (from reference)
Haliburton County	Very wet days[5]	207mm	+56mm	27% *	+92mm	44%
	Extremely wet days[6]	60mm	+32mm	53%	+54mm	90%
	Max 1 day[7]	38.1mm	+5.3mm	14%	+8.5mm	22%
	Total annual[8]	1013mm	+70mm	7%	+109mm	11%
City of Kawartha Lakes	Very wet days	190mm	+52mm	27%	+87mm	46%
	Extremely wet days	56mm	+28mm	50%	+50mm	89%
	Max 1 day	37.5mm	+4.9mm	13%	+7.5mm	20%
	Total annual	995mm	+66mm	7%	+101mm	10%
Northumberland County	Very wet days	194mm	+61mm	31%	+98mm	51%
	Extremely wet days	59mm	+35mm	59%	+60mm	102%
	Max 1 day	39.5mm	+5.8mm	15%	+9.1mm	23%
	Total annual	960mm	+75mm	8%	+112mm	12%

* All percentages rounded to nearest whole. Mean values are presented, within a range of 5% and 95% percentiles
Source: Ontario Climate Data Portal (OCDP).

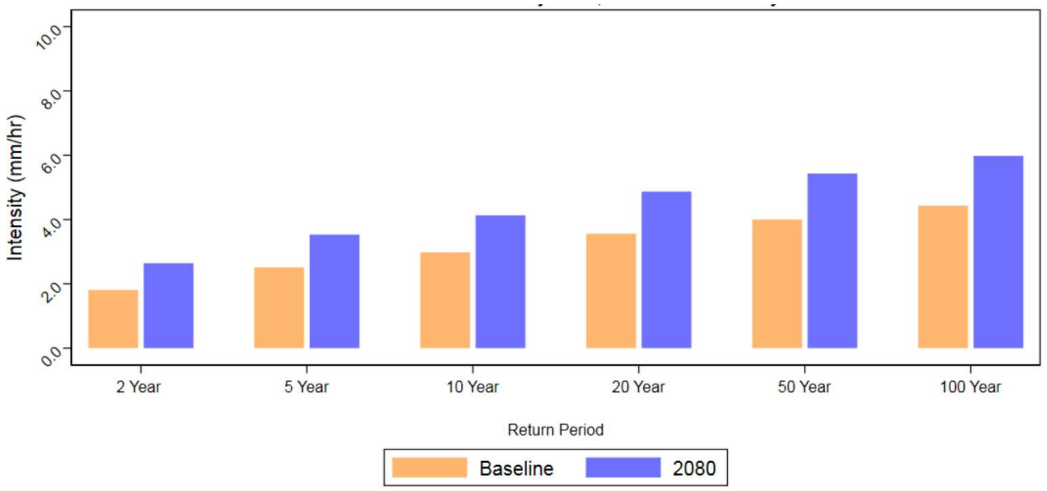
Another way to look at precipitation trends is through Intensity, Duration and Frequency (IDF) curves. IDF curves show the intensity of storms, measured in millimeters per hour; the duration, or length of time the precipitation falls and the frequency, or return period which is the average time between occurrences of a defined event. A low-level duration and intensity storm might return every two years, while one of high intensity and duration may return once every 50 years. IDF curves use analyses of past return periods to project changes in future return values of extreme rainfall events.(60) This approach does not account for climate change impacts on precipitation. Therefore, researchers at the Ontario Climate Change Data Portal used climate models to project how the intensity and duration of extreme rainfall events will be influenced by climate change.(61)

IDF data extracted from the Ontario Climate Change Data Portal(62) projects that under a high emissions scenario (RCP8.5), 24-hour heavy precipitation events that are expected at a given frequency today (e.g., every 20 years) will become more frequent in the future in all three municipalities.

[5] Total annual rainfall amount from days on which the total precipitation is more than the daily precipitation amount of the 5% of wettest days in the reference time period.
[6] Total annual rainfall amount from days on which the total precipitation is more than the daily precipitation amount of the 1% of wettest days in the reference time period.
[7] Maximum 1-day precipitation amount that occurs in a year.
[8] Total precipitation amount that falls over an area over 1 year.

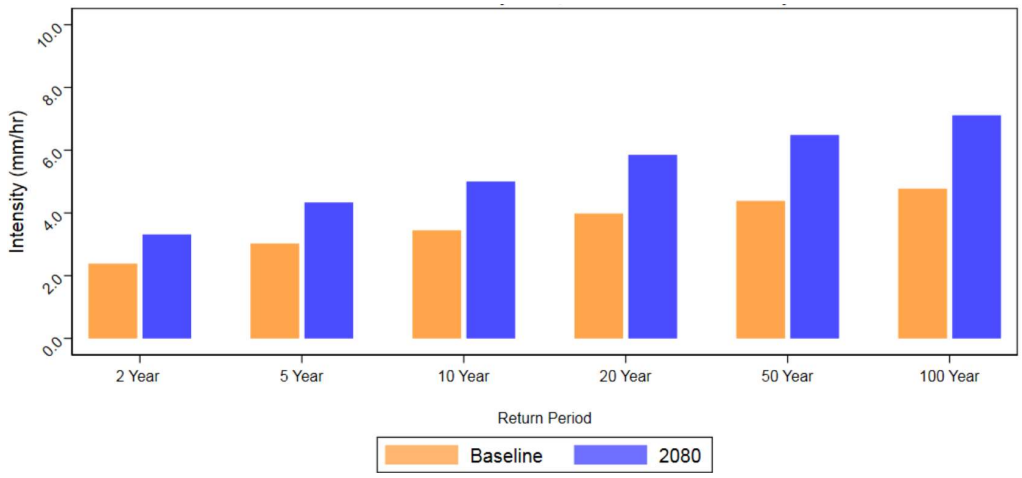
Under RCP8.5, all 24-hour rain events of a given frequency in Haliburton County are projected to increase in intensity by 2080 (blue bars taller than gold bars). The return period for high-intensity 24-hour rain events will also become shorter. For example, what is currently an event that occurs every 20 years will be expected every 5 years by 2080 (the 20 year gold bar is the same size as the 5 year blue bar).

Figure 4.1 24-hour precipitation interval, intensity-duration-frequency (IDF) values, baseline vs 2080 projections, RCP8.5, Haliburton County



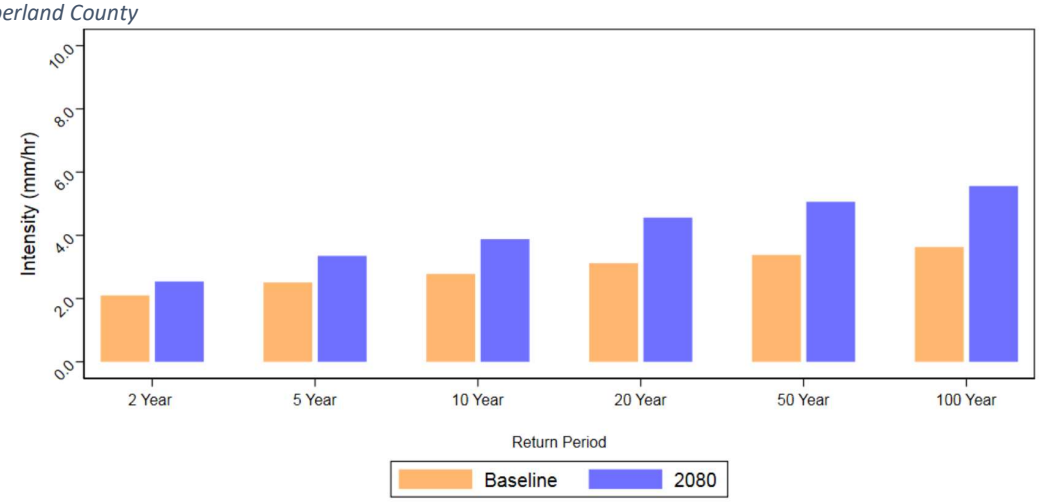
Under RCP8.5, all 24-hour rain events of a given frequency in the City of Kawartha Lakes are projected to increase in intensity by 2080 (blue bars taller than gold bars). The return period for high-intensity 24-hour rain events will also become shorter. For example, what is currently an event that occurs every 50 years will be expected every 5 years by 2080 (the 50 year gold bar is the same size as the 5 year blue bar).

Figure 4.2 24-hour precipitation interval, intensity-duration-frequency (IDF) values, baseline vs 2080 projections, RCP8.5, City of Kawartha Lakes



Under RCP8.5, all 24-hour rain events of a given frequency in Northumberland County are projected to increase in intensity by 2080 (blue bars taller than gold bars). The return period for high-intensity 24-hour rain events will also become shorter. For example, what is currently an event that occurs every 50 years will be expected every 5 years by 2080 (the 50 year gold bar is the same size as the 5 year blue bar).

Figure 4.3 24-hour precipitation interval, intensity-duration-frequency (IDF) values, baseline vs 2080 projections, RCP8.5, Northumberland County



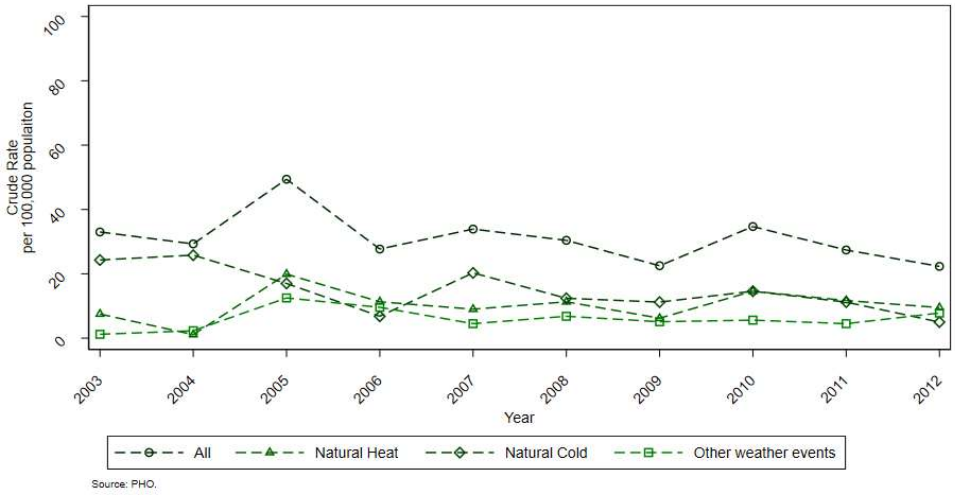
All the above precipitation indicators project increases in precipitation and changes in precipitation patterns. Days with heavy precipitation will be more frequent and intense, which will increase risk of flooding in flood-prone areas and have the potential to overload storm and wastewater management systems that may not be able to accommodate high volume water flow. This can lead to untreated water entering lakes, rivers and streams, threatening the safety of drinking and recreational water. The next section discusses the health impacts of floods and other climate-related events.

4.3. Health Impacts of Extreme Weather Events

Extreme weather events affect both physical and mental health. The impacts of some events, such as floods and wildfires, can be sustained over long periods as recovery time is typically required after the immediate or actual event has ended.

Direct health impacts of extreme weather can be difficult to measure. A Public Health Ontario study looked at rates of emergency department visits, hospitalizations and deaths attributable to extreme weather between 2003 and 2012. They state that “data do not capture the full direct and indirect impacts of extreme weather on health; in many cases, attributable health effects are not immediately known, understood or reliably documented.”(63) The findings from this study for the HKPR district are presented in Figure 4.4, which includes extreme heat, cold and other weather events.

Figure 4.4 Crude rate of emergency department visits attributed to extreme weather events, HKPR district, 2003-2012



Although the direct effects of extreme weather on physical and mental health are difficult to accurately measure, the literature identifies many potential impacts. Direct impacts to physical health can include injuries and death due to physical trauma,(64) as well as infection, accidents due to damage to transportation infrastructure, carbon monoxide poisoning from generators, electrocution, and illnesses related to food and water contamination.(29) Icy and slippery conditions associated with winter storms and freezing rain increase risk of injury from motor vehicle collisions, slips and falls. Experiencing an event such as a flood can lead to heart attacks and strokes due to exertion, and stress and rainstorms have been observed to make asthma worse.(29)

Research indicates that the mental health impacts of disasters exceed physical health implications.(65) Impacts related to mental health can be short-term or long-term, and include anxiety, grief, post-traumatic stress disorder, depression, aggression or increased substance use, brought about by issues such as property damage and loss, financial worries, family distress and disruption to daily life.(29) When events are recurring, such as in the case of floods, there can be a cumulative psychological toll. It should also be noted that there may also be positive mental health outcomes associated with climate events. Some researchers are exploring how experiencing an extreme event can build a sense of solidarity, connection, and contribution, and lead to beneficial changes they term 'post-traumatic growth'.(65) Further research is needed in this area.

Extreme weather events can also lead to power outages and damage infrastructure (e.g. roads, bridges), which may reduce access to healthcare facilities and services and delay emergency response.(64) Existing chronic diseases can be worsened if there is disruption in ongoing health services or reduced access to care. For example, the health of patients needing dialysis, routine laboratory testing or home care can be at increased risk.(29)

4.4. Exposure to Extreme Weather in the HKPR District

This section describes the likelihood of people and communities to be exposed to various extreme weather and natural events in the HKPR district.

4.4.1. Flooding

Floods are the most commonly occurring natural disaster in Canada and can result from extreme rainfall and rapid snow melt. Risk of flooding is increased by development on floodplains and urbanization, which generally reduces the capacity for the land to absorb stormwater run-off.(29) Extreme rainfall events can occur quickly and reduce time to get prepared. This is especially true in more urban areas, where more hard surfaces lead to greater runoff that can quickly overwhelm stormwater systems.

Within the HKPR district, there are areas in all three municipalities that are at risk of flooding, both along rivers and lakes. All three municipalities identify flooding as a common hazard in their HIRAs, recognizing the potential for significant impacts on community infrastructure, resources and health. The main causes of stream-flow related flooding are heavy precipitation, snowmelt, rain-on-snow events, ice jams or a combination of the above. There is high confidence that spring snowmelt will occur earlier due to warming temperatures, with higher winter and early spring flows, which may lead to more snowmelt-related floods.(66) This trend has been evident in the Township of Minden Hills where states of emergency have been declared three times in the past 7 years due to flooding or potential flooding (2013, 2017, 2019). In the Municipality of Trent Hills, communities along the Trent River, such as Campbellford, are risk areas for flooding.

High water levels in Lake Ontario also put shoreline communities in HKPR district at risk of flooding, erosion and property damage. Record high water levels in Lake Ontario in 2019 resulted in damage along shorelines in Cobourg and Brighton. In early May 2019, Lower Trent Conservation Authority issued a flood warning affecting Northumberland County which was not cancelled until October 10, 2019.(67) The image below shows flood prevention efforts in Brighton in 2019.

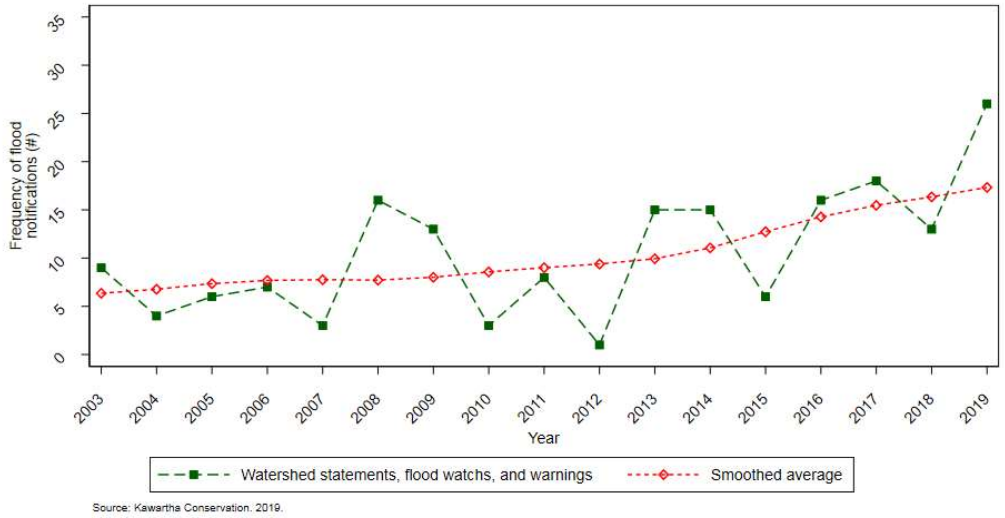
Photo: Bob Sine

Conservation authorities monitor water levels and issue flood watches and warnings (with warnings being the highest level of risk). The City of Kawartha Lakes is part of the Kawartha Conservation Authority's watershed. Northumberland County is covered by the Ganaraska Region Conservation

Authority and Lower Trent Conservation Authority. A small part of eastern Haliburton County is part of the Crowe Valley Conservation Authority, with the rest of the county's watershed overseen by the Ministry of Natural Resources and Forests. Haliburton County also includes the headwaters of the Trent Severn Waterway (TSW), managed by Parks Canada. A large portion of the TSW flows through and is fed by lakes and rivers across the HKPR district, including the Gull River, Burnt River, Kawartha Lakes and Rice Lake/Trent River watersheds.

Figure 4.5 shows a gradual trend towards more frequent flood alerts in the Kawartha Conservation watershed, which means residents in affected areas are increasingly exposed to potential health risks that come with floods.

Figure 4.5 Summary of flood notifications issued by Kawartha Conservation in recent past



Case Study: Burnt River Flood, 2013

The Burnt River has a well-documented history of flooding, usually during the spring months due to runoff generated by snowmelt in combination with rainfall. In 2013, the Burnt River started rising on April 13, and a state of emergency (SOE) was declared April 20. Burnt River was designated a disaster zone and the SOE remained in place until May 14. Circumstances that contributed to the flooding included significant snowpack, warm temperatures leading to rapid snow melt, an above average rain event (>70mm rain in 12 hours) in addition to already saturated ground and elevated water levels.

The return period for this flooding event was identified by Kawartha Conservation (KC) as one in one hundred years. However, KC identifies a likelihood rating of 5 (highest rating) that the "event is expected and may be triggered by conditions expected over a 30-year period".(68) This means that as increased rainfall combines with warmer temperatures that increase the pace at which the snow-pack melts, there is a high likelihood that a similar sized '100-year flood' will occur in the next 30-years.

The impact of this flood was extensive. Over 60 people were evacuated, and there was damage to private and municipal properties, local businesses and industries. The area experienced a reduction or loss of essential services due to the flood. A significant portion of the local population had limited access

to healthcare and community services. Sanitation and communication services and transportation infrastructure were also impacted.(68) Although the health impacts of this flood were not documented, based on the literature it is likely that there were both immediate impacts (e.g. due to reduced access to healthcare services) and long-term impacts (e.g. stress and anxiety due to relocation and loss of property).

Case Study: Minden, Gull River Floods, 2013 & 2017

The Village of Minden on the Gull River in the Township of Minden Hills has experienced two major floods in the past decade, in 2013 and 2017. Furthermore, there were 'near misses' in 2016, 2018 and 2019, when the river came close to overflowing its banks. States of emergency were declared in 2013, 2017 and 2019.

The 2013 flood took place between April 18 and May 15. A report on the 2013 flood by AECOM concluded that the rainfall event from April 17 to 19, consisting of 75 mm of precipitation falling in 48-hours, was the most severe rain event in the Gull River watershed in more than 50 years. This event had an associated return period of nearly 100 years. Water levels increased by as much as 30 cm overnight. The severe rainfall combined with the melting snowpack led to the severe flooding.(69)

On May 6, 2017, a state of emergency was declared by the municipality. Water levels rose over the next several days and peaked on May 11, approximately 5 cm below 2013 flood levels. The state of emergency ended on May 26, 2017. The township's response included developing an Incident Management System, a Continuity of Operations Plan and Public Education Supplements. Wellness checks were conducted by the Red Cross, Health Unit and Fire Department.(58)

Due to the frequency of floods and near-floods since 2013, it is very likely that there was and continues to be a toll on the mental health of people living on the Gull River. A 2018 study from the Intact Centre on Climate Adaptation found that three years after their home was flooded, people were still worried every time it rained, compared with only 3% of people who had never experienced a flood.(70) Flooded household members also experienced higher worry and stress than non-flooded household members.

4.4.2. Severe Storms

Severe storms can occur in the winter in the form of blizzards, ice storms and freezing rain, and in the summer as tornadoes, hailstorms and windstorms. Many of these extreme events are consider small-scale because they cover a relatively small spatial area. It is difficult to make projections of small-scale extreme events such as tornadoes and hailstorms. However, risk management strategies should assume that they will increase in frequency in the future.(60) Public Health Ontario reported 18 tornadoes (9 in Haliburton County & CKL; 9 in Northumberland County) from 2003 – 2012.(63)

Severe storms often disrupt medical care due to building, infrastructure, and medical vehicle damage, keeping people from accessing health and other social services.(29) Especially in rural areas of the district, downed trees from wind or freezing rain can block access, and travel can be unsafe due to ice, blowing snow or freezing rain.

Power outages are frequently associated with severe storms. Severe freezing rain events (lasting six hours per day or longer) are projected to increase in southern Ontario from average historic conditions

by 35% - 80%, depending on location, by the years 2081-2100.(60) As risk of ice storms and freezing rain increases, so does the risk of damage to energy infrastructure, as ice build-up can cause tree limbs to fall on equipment or cause conductors and poles to break (71) and lead to power outages.

Extended power outages create health risks that include exposure to unsafe water due to water treatment that is reliant on power, unsafe food due to lack of refrigeration, and risk of carbon monoxide poisoning through unsafe use of generators or other gas-powered equipment. Depending on the season, extended power outages can be life threatening if household heating systems cannot function and people are exposed to cold temperatures. Communication mechanisms (e.g. internet, phone lines) are often not functioning during a power outage, so informing people about how to keep safe is difficult or not possible.(72) People who rely on medical equipment requiring electricity are at risk. Power outages also have a significant impact on health care services, which rely heavily on electricity to run equipment and facilities.(72) Residents of multi-unit facilities such as long-term care homes, group homes and shelters may be at risk if the facility does not have generators. Temporary shelters may be required.

Fortunately, instances of extended power outages in the HKPR district have been minimal in recent years and providers are making efforts to reduce incidence. Hydro One Networks is the electricity provider for most of the HKPR district, including all of Haliburton County, City of Kawartha Lakes and most of Northumberland County. Lakefront Utility Services Inc. (LUSI) is the provider for Cobourg and Colborne and Veridian Connections Inc. is the provider for Port Hope. Hydro One reported an average number (province-wide) of power outages per year per customer of 2.21 for an average duration of 6.82 hours. Number and length of outages has decreased since 2014 due to Hydro One's increased frequency of trimming trees near hydro lines, replacement of aging infrastructure and improved planning and coordination.(73) LUSI reported that their average number of outages per year/customer was 1 or less, with an average length of 1 hour or less (2012-2017).(74) Veridian reported an average number of outages per customer of 1.26 in 2018, with an average length of 1.55 hours. Four days were classified as major weather event days.(75)

3.1.1. Wildfires

Combined changes in precipitation and temperature influence risk of wildfires that can result from hot, dry and windy conditions. Wildfires in much of Canada's forests are expected to increase.(29) Higher temperatures due to climate change will lead to drier fuels and increased fire risk which will not be offset by projected increases in precipitation.(57)

Although records from the Ministry of Natural Resources and Forests indicates minimal wildfire activity in the past within the HKPR district, because wildfire smoke can travel, residents of the HKPR district can be exposed to smoke depending on proximity of fires and wind direction. People near or even many miles downwind from a wildfire may be exposed to smoke that can contain various substances that present serious health risks, including carbon monoxide (CO), ozone (O3), toxic chemicals, and both fine and coarse particles. Exposure to smoke-related air pollutants from wildfires can worsen many chronic diseases such as asthma (especially in children), COPD, heart disease and other chronic lung diseases. This can lead to increased hospital and emergency department visits.(29) Infant mortality and low birth weight are also associated with wildfires.(29, 76) Wildfires can also affect water quality downstream due to changes in runoff and soil erosion.(76) Experiencing a wildfire also impacts mental health. Wildfires

typically persist over a long period of time, disrupting day-to-day routines and overall wellbeing. Many studies report mental health symptoms such as depression, anxiety, PTSD and psychological distress among both adults and children.(77)

3.1.2. Drought

Drought is a "sustained and regionally extensive occurrence of appreciably below-average natural water availability."(78) Drought conditions are associated with other climate hazards such as extreme heat. They also tend to reduce air quality and exacerbate respiratory illness due to soil drying and a loss of vegetation which increase airborne particulate matter, and can lead to conditions conducive for dust storms and wildfires.(76) Over the longer term, prolonged drought can decrease agricultural productivity leading to food shortages and higher costs, which can lead to suboptimal nutrition, especially for low income people. Droughts are also linked to increased stress and mental health issues among farmers.(29)

3.2. Sensitivity to Extreme Weather in HKPR District

Infants and children, older adults, people living on low income, people who have chronic illnesses and those on certain medications, and emergency service workers are more vulnerable to the negative health impacts of extreme weather events.

Children are at particular risk of adverse mental health impacts from extreme events and their response can be more severe than that of adults.(79) Depending on developmental stage of the child, potential impacts may include anxiety, depression, clinginess, aggression, social withdrawal or post-traumatic stress disorder (PTSD). Young children are more sensitive to the harmful effects of wildfire smoke, and they are dependent on their caregivers for protection from injury during extreme events.(14)

Older adults (age 65+) may have reduced mobility and strength and are more likely to have chronic medical conditions (e.g. hypertension, heart disease, cancer or dementia) and take medication that increases their sensitivity during an extreme weather event. Physical limitations may keep them from taking preventive measures e.g. sandbagging their home. Many older adults use assistive devices such as hearing aids, eyeglasses or dentures, and recovery from an event can be impeded if these are lost. Reliance on electrically powered medical equipment like ventilators and oxygen increases vulnerability during power outages.(76) Many older adults live on low or fixed-income and have limited financial resources for emergency preparation kits and to pay for repair of damages after an extreme event. In the case of flooding, this can lead to mould in the home which can worsen existing conditions such as COPD. Mental health can also be affected related to financial burdens of repair and recovery after an extreme event.

Older adults can also be more vulnerable because they may be less likely to leave their homes in an emergency due to prior experience with false alarms, fear that their homes will be looted, or possible disruption of medical or other routines.(29) They may also lack transportation to access supports or go to a safe location. Because many older adults also live alone, having someone to check on them is critical to ensure their health and safety during extreme weather events.

There are several health equity issues that mean that people living with low-income disproportionately experience the most negative health impacts of weather-related events. Poverty is a key factor. There are several reasons for this. People living with low-income are more likely to be uninsured and living in poor quality housing that may lack adequate insulation, heating and cooling. They may be forced to choose between spending money on food or heat/cooling or may be precariously housed or homeless. This population often experiences a higher prevalence of medical conditions due to health disparities, which can then be made worse during extreme events.(76) The stress of experiencing an extreme weather event adds to the existing stress of living on a limited income, increasing risk of negative mental health impacts.

People living with low-income are likely to have fewer financial resources to prepare for, respond to and recover from an extreme event. They may lack transportation to evacuate or relocate. For people struggling to pay for daily necessities such as food and shelter, purchasing items for being prepared in an emergency is not likely to be attainable. For example, having cash and a 72-hour supply of non-perishable food on-hand is probably not achievable or realistic for a family that struggles to put food on the table every day. They are less likely to have the financial resources to pay for repair and replacement of property due to an extreme event. Information on how to prepare for and respond in an emergency, and immediate information during an emergency may not reach people who do not have access to the internet, or do not have a phone. People may also have a hard time reading and understanding information that is presented at higher literacy levels.

Living with a medical condition also increases vulnerability to extreme events. People with chronic illnesses may require regular medication and if these become unavailable, experience negative health consequences. People with physical impairments may rely on mobility aids that could limit their independence during a flood; they may be unable to move themselves to safety. People with sensory impairments may be unable to communicate by modes typically used during emergencies. People with cognitive impairments may not be able to perceive or understand risk and how to respond. Individuals with existing mental health conditions may experience additional psychological trauma and disruption to health services and personal supports.(52)

People who work at the front line of response to extreme weather events, such as police, firefighters, EMS workers, health care and other support workers are at risk of short and long-term mental health consequences such as anxiety and depression. Being exposed to traumatic events, helping others in crisis, and working long hours can all contribute, especially if the injured are people they know.(29)

3.3. Building Adaptive Capacity to Extreme Weather in HKPR District

Building adaptive capacity to extreme weather events includes actions and initiatives that address helping individuals be ready for an event (planning and preparedness) and providing support during (response) and after an event (recovery).

For vulnerable individuals, building adaptive capacity means addressing issues associated with age, disability, illness, income, medical/chemical dependence, isolation, language and housing. Work being done at the HKPR District Health Unit on creating supportive policies related to poverty, income, food security and transportation address many of the root causes of vulnerability. Both HKPR staff and community partners identified a need to examine the messages communicated and how we

communicate them to ensure that information is relevant and accessible to the audience. Many sectors of the community have a role to play, and communication between them is key for effectively reaching and building adaptative capacity among vulnerable residents.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

5 Chapter 5: Vector-Borne Disease

5.1. Chapter Overview

This chapter examines the climate influences on two vector-borne diseases of public health significance, Lyme disease and West Nile virus (WNV), and the insects that transmit them, black-legged ticks and certain species of mosquitoes. Climate indicators are used to show how conditions are becoming increasingly more favourable for these insects to survive and reproduce across the HKPR district. Populations at greatest risk of exposure and greater sensitivity are discussed.

5.1.1. Highlights

- An earlier spring and later fall associated with warming temperatures due to climate change results in increased tick survival and activity, expanded geographic range of hosts that carry ticks such as mice and deer, and a longer season when humans may be exposed to ticks.
- Under a high emissions scenario (RCP8.5), cumulative degree days CDDs needed for black-legged tick reproduction will increase by about 25 – 30% in all municipalities. CDDs needed for mosquito reproduction will roughly quadruple in all municipalities under RCP8.5. Warmer temperatures and water pooling from increased precipitation contribute to mosquito population increases and usually result in more mosquitoes carrying WNV.
- All tick surveillance indicators suggest that the current geographic range of black-legged tick populations is expanding in southern Ontario and will likely continue to do so due to climate change. As of 2022, all of Northumberland County is identified as a risk area, and black-legged ticks can be encountered across the HKPR district. Confirmed cases of Lyme disease in the HKPR district went from one in 2006 to 54 in 2022.
- People who work and/or play outdoors are most likely to be exposed to vector-borne diseases (VBDs). There are many people in the HKPR district who work in outdoor occupations as well as residents and visitors who participate in outdoor recreation. A longer warm season may also encourage people to start outdoor activities earlier in the spring and continue later in the fall, increasing exposure to ticks and mosquitoes.
- Older adults make up a large proportion of the HKPR district's population. They are more vulnerable to Lyme disease and at higher risk for severe West Nile virus infection.
- Addressing the increasing risk of exposure to insects that carry VBDs requires adaptive actions at both individual and community levels. Public health activities that contribute to adaptation include monitoring, surveillance, assessing risk, education and awareness raising, partnering on policy development and clinical strategies such as early detection.

Table 5.1 Summary of Health Impacts of Vector-borne Diseases

Climate Hazard	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts

Vector borne diseases	Longer warm season (increase in degree days) Expanded range and increased survivability of black legged ticks and mosquitoes and their hosts Introduction of new vector insects due to favourable climate conditions Longer season for people to be outdoors	People who work or play outdoors Older adults Children under 9 years People with chronic health conditions People living on low income	Increased incidence and severity of Lyme disease Increased incidence and severity of West Nile virus Mental health impacts Emergent diseases e.g. Eastern Equine Encephalitis Virus, Zika virus, Powassan virus

5.2. Climate Influences on Vector-borne Disease in the HKPR District

Vector-borne diseases (VBDs) are illnesses that are transmitted by *vectors* that can carry viruses and bacteria which may then be transferred from one host to another. Mosquitoes and ticks are common disease vectors. For this assessment, the key VBDs of interest are Lyme disease, which is transmitted by black-legged ticks, and West Nile virus (WNV), which is transmitted by certain mosquito species.

It is widely accepted that climate change has contributed to an increase in the number, level of activity and distribution of black-legged ticks and their expansion into Ontario.(80) Increases in temperature, changing precipitation patterns and changes in seasonal weather patterns are all climate factors that affect the distribution and prevalence of ticks and mosquitoes as well as their survival and reproductive rates and cycles. Surveillance data indicates that black-legged ticks are spreading into Canada at a rate of 35 – 55 km per year. Similar studies have assessed the range expansion of West Nile virus.(29) Adaptation strategies play a key role in offsetting risk exposure.

5.2.1. Cumulative degree days and tick populations – Projections

All tick surveillance indicators suggest that the current geographic range of black-legged tick populations is expanding in southern Ontario and will likely continue to do so.(81)

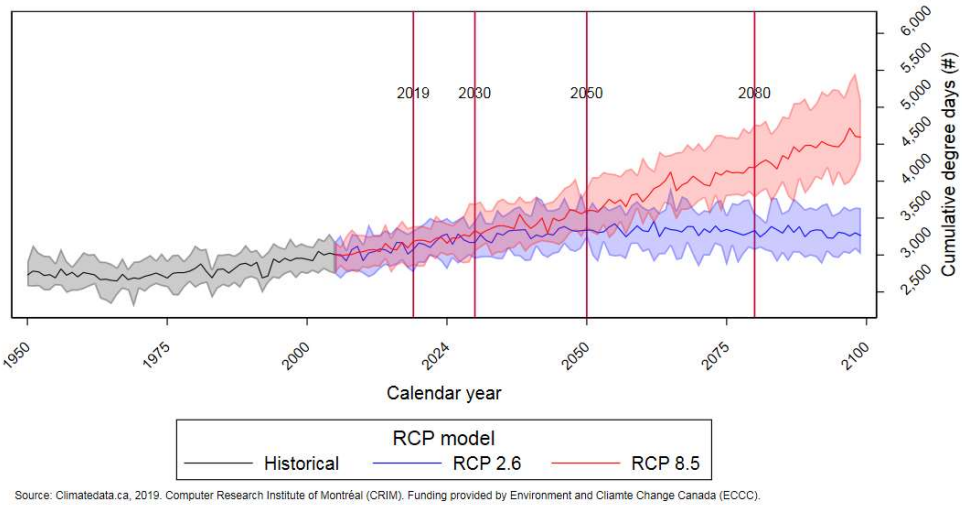
Human exposure to ticks is related to shorter winters. An earlier spring and later fall associated with warming temperatures due to climate change results in increased tick survival and activity, increases in the geographic range of tick hosts (e.g., mice and deer) and a longer season when humans may be exposed to ticks.(80)

Annual cumulative degree days (CDD) above 0°C is an indicator for blacklegged tick populations.(82) CDDs are calculated by adding average daily temperature over a defined time period (in this case, a year) for those days when the mean temperature exceeds 0°C. The warmer the weather, the more quickly species (in this case, black-legged ticks) can develop. A minimum of 2,800 degree-days above 0°C is required for tick survival.(83) Temperature is a driving factor, however, others such as suitable habitat and hosts for ticks are also essential for the spread of ticks at a regional level.(82)

Figures 5.1 to 5.3 show the projected number of CDDs above 0°C for each of the HKPR district's municipalities. On all figures, the black line represents median values for 1950 to 2005, the blue line represents median value for low emissions scenario (RCP2.6) and the red line median for a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile). As of 2019, all municipalities exceeded the minimum 2,800 CDDs needed for tick survival. Under RCP8.5 increases are projected in each municipality, meaning a longer season for ticks to propagate. For comparison, the projections under RCP2.6 are also shown, which project lower and more stable numbers. While still above the threshold of 2,800, fewer degree-days above 0°C means there would be a shorter period when conditions are favourable for ticks to survive and reproduce.

In Haliburton (Figure 5.1) for 2019, the models project a median value of 3,079 cumulative degree days above 0°C under RCP2.6 and 3,188 under RCP8.5. These values increase but stay fairly close together until about year 2030 (3,170 - RCP2.6; 3,329 - RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of cumulative degree-days above 0°C remains relatively stable (3,337 by 2050; 3,332 by 2080). However, under RCP8.5, there is a steady increase (3,600 by 2050; 4,183 by 2080).

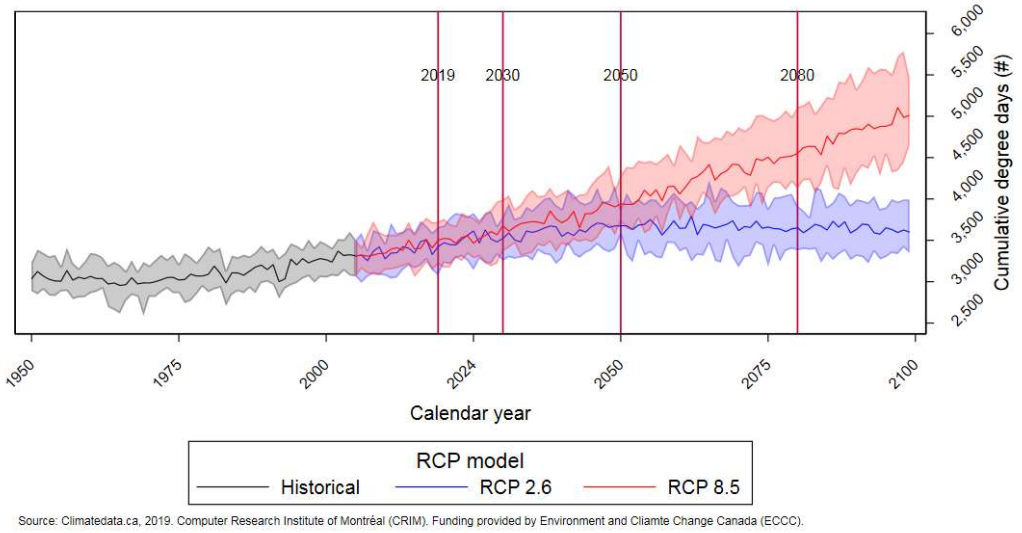
Figure 5.1 Projected cumulative degree-days above 0℃ from 1950-2100 in Haliburton (Haliburton County)



In Lindsay (Figure 5.2) for 2019, the models project a median value of 3,424 cumulative degree days above 0°C under RCP2.6 and 3,500 under RCP8.5. These values increase but stay fairly close together until about year 2030 (3,522 - RCP2.6; 3,676 - RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of cumulative degree-days above 0°C remains relatively

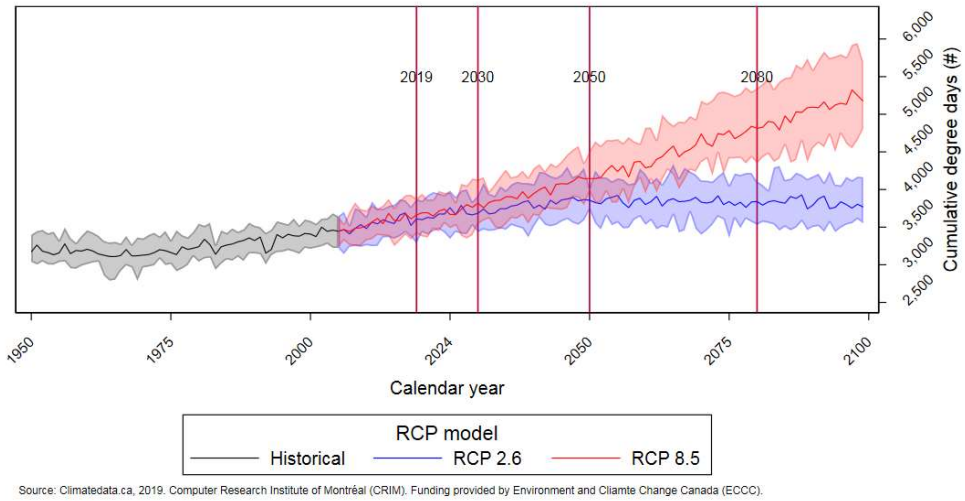
stable (3,676 by 2050; 3,651 by 2080). However, under RCP8.5, there is a steady increase (3,939 by 2050; 4,552 by 2080).

Figure 5.2 Projected cumulative degree-days above 0 ℃ from 1950-2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 5.3) for 2019, the models project a median value of 3,612 cumulative degree days above 0°C under RCP2.6 and 3,661 under RCP8.5. These values increase but stay fairly close together until about year 2030 (3,685 - RCP2.6; 3,820 - RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of cumulative degree-days above 0°C remains relatively stable (3,858 by 2050; 3,840 by 2080). However, under RCP8.5, there is a steady increase (4,145 by 2050; 4,813 by 2080).

Figure 5.3 Projected cumulative degree-days above 0 ℃ from 1950-2100 in Cobourg (Northumberland County)



5.2.2. Cumulative degree days and mosquito populations - projections

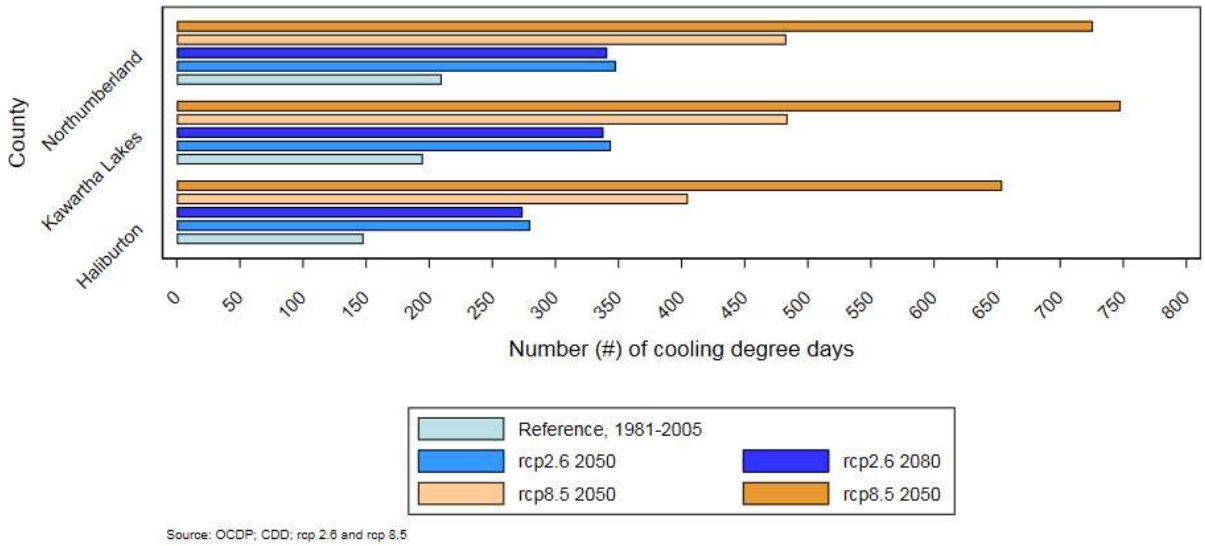
There are two types of mosquito vectors involved in the transmission cycle of West Nile Virus (WNV) to humans. Enzootic vectors feed primarily on birds, and bridge vectors feed on both birds and mammals, but primarily mammals. These species pick up the virus when they bite an infected bird and transfer it when they bite a mammal (e.g. human). *Culex pipiens* and *Culex restuans* are the main enzootic vectors responsible for amplifying WNV in bird populations.(84) *Cx. pipiens* also sometimes bite humans and can act as a bridge vector, as do several other mosquito species. It is the presence of *Culex* species populations that is the primary indicator of risk of WNV; when the *Culex* population is low there is limited risk of human infection (84) because there is little mechanism for the WNV to be passed from bird to bird.

Forecasting potential trends in mosquito populations due to climate change is difficult because there are many influencing factors. Climate change can affect mosquito life cycles and distribution of reservoir host populations. In general, warmer temperatures lead to higher mosquito reproductive rates and exponential population increases and usually result in more mosquitoes that may carry WNV (85). Increased precipitation and pooling left by flood-water increases the availability of standing water for mosquito breeding; however, heavy or violent precipitation can destroy eggs and flush larvae from habitats.(85) Projected temperature and precipitation trends are discussed in chapters 3 and 4.

An average daily field temperature of 18.3°C or higher is required for WNV to replicate in the *Culex* adult females. Accumulated degree days (ADDs) is an indicator that shows heat units. ADDs are calculated by adding average daily temperature over a defined time period (in this case, a year) for those days when the mean temperature exceeds 18°C. For example, a mean daily temperature of 21°C would give 3 ADDs. A model used by Public Health Ontario showed that 380 ADDs were required for 50% of infected *Culex* mosquitoes to test positive for WNV. According to this model, in 2018, there were not enough ADDs (225.2) in HKPR to amplify WNV in *Culex* mosquitoes.(84)

Figure 5.4 shows projections for ADDs above 18°C in the HKPR district, compared with the historical reference period (1981-2005). Under a low emissions scenario (RCP2.6, blue bars), ADDs stay below 380 by the years 2050 and 2080. However, under a high emissions scenario (RCP8.5, tan bars), all municipalities are projected to exceed the threshold by 2050 and 2080, indicating increasingly favourable conditions for *Culex* mosquitoes and therefore WNV across the HKPR district.

Figure 5.4 Annual average number of accumulated degree-days (>18 °), by municipality, RCP2.6 and RCP8.5, historical reference period (1981-2005), 2050 and 2080 projections



Cooling Degree Days defined by Ontario Climate Data Portal: number of degrees Celsius that the daily mean temperature is above 18 °C. Accumulated degree day values represent the annual average for the time period.

As average annual temperatures rise across the HKPR district, there will be an increase in accumulated degree-days, which create favourable conditions for both black-legged ticks and *Culex sp.* mosquitoes to survive and reproduce. The increased number of vectors along with an increased geographic coverage, means a greater risk of Lyme disease and West Nile Virus in the HKPR district.

5.3. Incidence of Vector-Borne Disease in the HKPR district

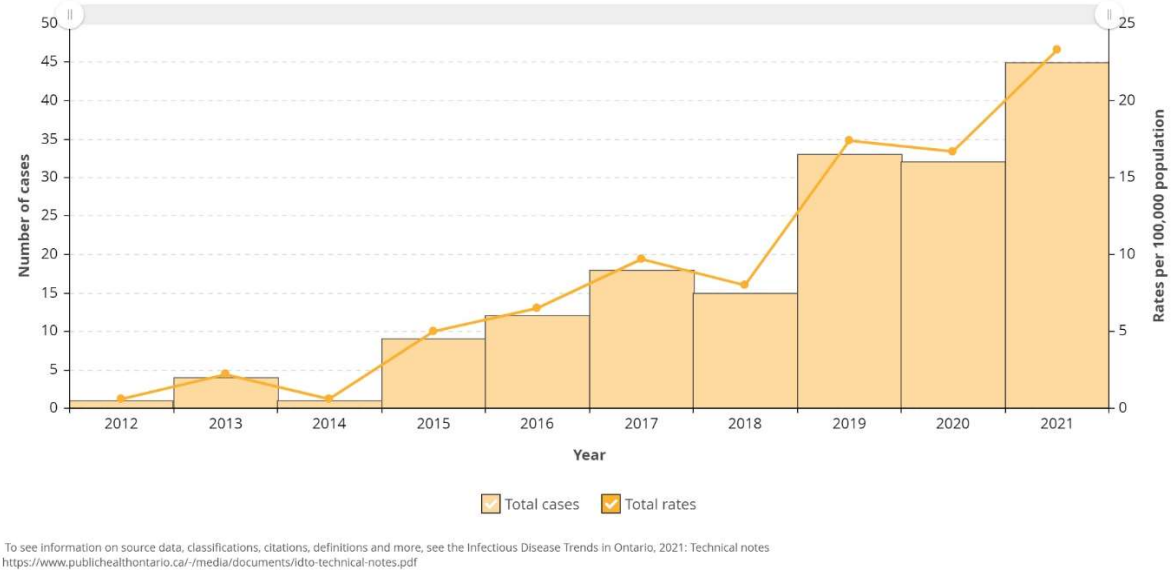
Both Lyme disease and West Nile virus are reportable public health diseases in Ontario and are tracked through the provincial Integrated Public Health Information System (iPHIS).

5.3.1. Lyme disease

Lyme disease is caused by a bacteria, *Borrelia burgdorferi,* and transmitted to humans through the bite of an infected black-legged tick, *Ixodes scapularis.* An infected tick must attach and feed on a human for 24 to 36 hours for the bacteria to travel to the host. Symptoms usually start within 3 days to one month after being bitten. The first sign of infection is a circular rash which occurs in 70 to 80 percent of those infected. Other initial symptoms may include fatigue, chills, fever, headache, muscle and joint pain and swollen lymph nodes. If untreated, longer-term symptoms can be heart palpitations, arthritic symptoms, extreme fatigue and neurological problems.(81)

Confirmed cases and rates of Lyme Disease in the HKPR district have increased since 2008, similar to the rest of Ontario.(86) The spread of black-legged ticks is a primary factor, however there may also have been under-reporting of cases earlier in the time period. Case counts only show known cases reported to public health units and recorded in iPHIS. Under-reporting of diseases such as Lyme disease could be due to factors such as disease awareness and clinical practice. Public and clinician education and outreach has increased awareness and likely enhanced the detection and reporting of Lyme disease in Ontario.(87) Confirmed cases of Lyme disease in HKPR district have been increasing since 2011.

Figure 5.5 Lyme disease rates and cases for all ages, all sexes, HKPRDHU, 2011-2021



5.3.2. West Nile virus

West Nile virus (WNV) is transmitted through the bite of an infected mosquito. Most people (70-80%) infected with WNV do not show symptoms. About 20% develop West Nile fever, with symptoms such as fever, head and body aches, mild rash and swollen lymph glands. First symptoms usually appear two to 15 days after infection. Fewer than 1 percent of people infected will develop severe disease with neurological symptoms that can include rapid onset of severe headache, high fever, convulsions, loss of consciousness and paralysis.(88) In general recovery for mild cases takes about a week. People with severe cases could experience health effects for many months or years. In the most severe cases, WNV can be fatal.(89)

Peak transmission of WNV is during summer season when mosquitoes are most active and temperatures are highest.(90) *Cx. pipiens* is primarily an urban mosquito; however, it is anticipated that WNV will increase in both rural and urban areas of Canada in the future.(85) From 2012-2018 there were 6 confirmed cases of WNV in HKPR district.(91) However, incidence is likely underestimated, since most WNV cases have no or mild symptoms and are likely not captured by surveillance.

5.4. Exposure to Vector-Borne Diseases in the HKPR District

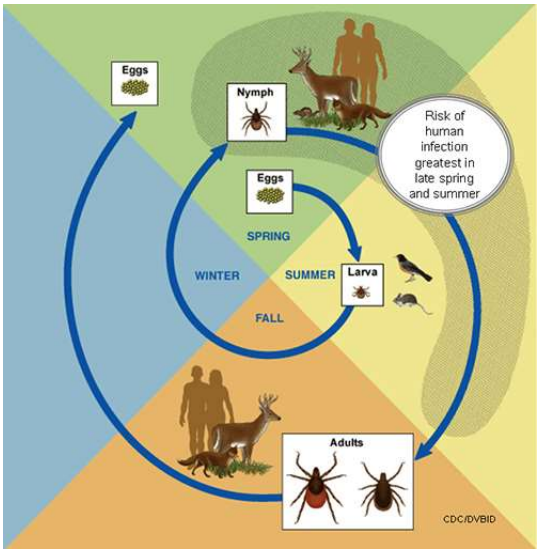
People most likely to be exposed to vector-borne diseases (VBDs) are those who work and/or play outdoors, especially in grassy and wooded areas, and those who live in or near endemic areas (areas where ticks are known to survive and reproduce). Outdoor occupations including farming, forestry, fishing and hunting are represented across the district. Figure 2.8 in Chapter 2 shows that in Haliburton County about 15% of the workforce is in construction. In the City of Kawartha Lakes the proportion is about 11% and in Northumberland County about 9%. These workers may spend a large portion of their day outside. There are also smaller portions of the workforce in other outdoor occupations including agriculture, forestry, fishing and hunting. All municipalities within the HKPR district promote outdoor recreation such as hiking, mountain biking, fishing, hunting and camping to both residents and visitors and these activities frequently take place in high exposure areas such as forests and trails. Staff and

campers at summer camps may also have an increased exposure to ticks and mosquitoes because they spend most of their time outdoors, often in wooded areas.

5.4.1. Lyme Disease

As the warm season gets longer, people may start outdoor activities earlier in the spring and continue later into the fall, which increases the exposure period to ticks.(80) Ticks can bite humans in their nymph stage or as adults. In the lifecycle of ticks, the nymph phase starts in the spring and goes through the summer. By fall, ticks are feeding as adults (see Figure 5.6). The risk of human infection is greatest in late spring and summer, in part because compared with adult black-legged ticks, nymphs are much smaller and more difficult to detect so are less likely to be noticed. This enables them to feed longer, leading to a greater risk of Lyme infection.(81)

Figure 5.6 Life cycle of blacklegged ticks(92)



In HKPR district, incidence of Lyme disease cases has been highest from June – August, which coincides with increased participation in outdoor activities and the feeding cycle of blacklegged tick nymphs.(93) Table 5.2 shows the total number of cases by month from 2016-2022.

Table 5.2 Total number of Lyme disease cases in HKPR district by month, 2016-2022*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2022	1	3	1	0	3	6	12	8	6	3	9	2	54
2021	0	0	0	1	4	5	15	7	2	4	5	1	44
2020	0	0	0	0	6	7	7	4	2	1	3	1	31
2019	0	0	1	1	1	8	12	6	1	1	1	1	33
2018	0	0	0	0	2	3	3	3	3	1	0	0	15
2017	0	0	1	0	0	2	8	4	2	0	1	0	18
2016	1	1	0	1	1	2	2	1	0	1	2	0	12

Total	2	4	3	3	17	33	59	33	16	11	21	5	207

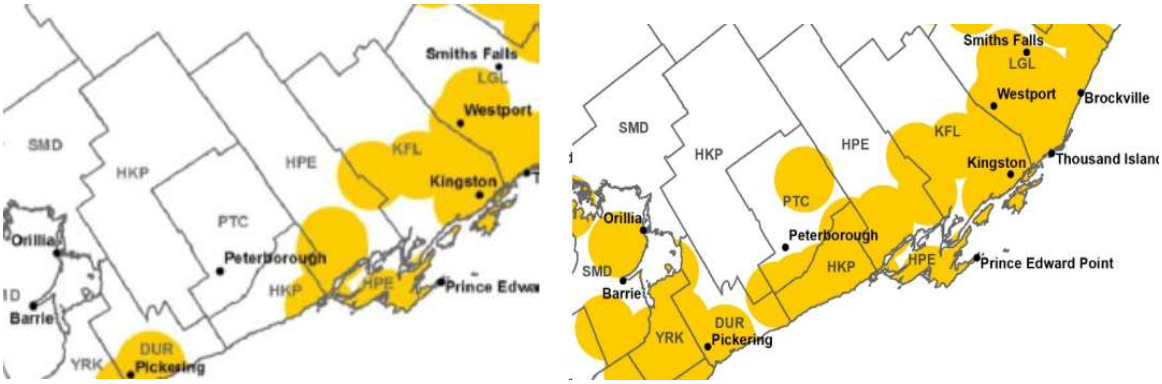
* Includes lab confirmed cases only; probable and suspect cases not included
Data source: HKPR Monthly reportable Disease Incidence Reports

The HKPRDHU conducts active surveillance of black-legged ticks by dragging for tick samples twice a year at various locations across the three municipalities. Ticks that are collected are sent to the National Microbiology Lab in Winnipeg where they are tested for the presence of *B. Burgdorferi.* All results are reported to Public Health Ontario, which develops local risk maps that help determine areas to concentrate future active surveillance within the district. Passive tick surveillance, where the public could drop off ticks at the health unit to be sent for testing for *B. burgdorferi*, ended in Ontario as of January 1st, 2020 due to resource constraints at the National Microbiology Laboratory.

The maps below show that the estimated risk areas for blacklegged ticks have been expanding. The estimated risk areas are locations where blacklegged ticks have been identified in both spring and fall through active surveillance. Risk areas are calculated as a 20 km radius from centre of location where blacklegged ticks are found through drag sampling. A study by Nelder et al concluded that expanding tick populations will increase both the frequency of encounters with blacklegged ticks and the percentage of ticks infected with *B. burgdorferi*.(82) By 2022, all of Northumberland County was identified as a risk area and it is likely that there will also be an increase in Lyme disease cases within the HKPR district in the future. Temperature is a driving factor, but so is availability of suitable habitat such as forested land,(82) which is plentiful across the HKPR district. Although Kawartha Lakes and Haliburton County have not yet been identified as risk areas through surveillance, it is still possible to encounter blacklegged ticks in these locations, partially because they can be transported by migratory birds.(86) All municipalities also have the number of degree days above 0°C (2800) required for ticks to survive (refer to Section 5.2.1), so there is potential for them to become established in all parts of the HKPR district.

Figure 5.7 Estimated risk areas for black-legged ticks in HKPR district, 2016 and 2022

2016 2022



Source: Public Health Ontario

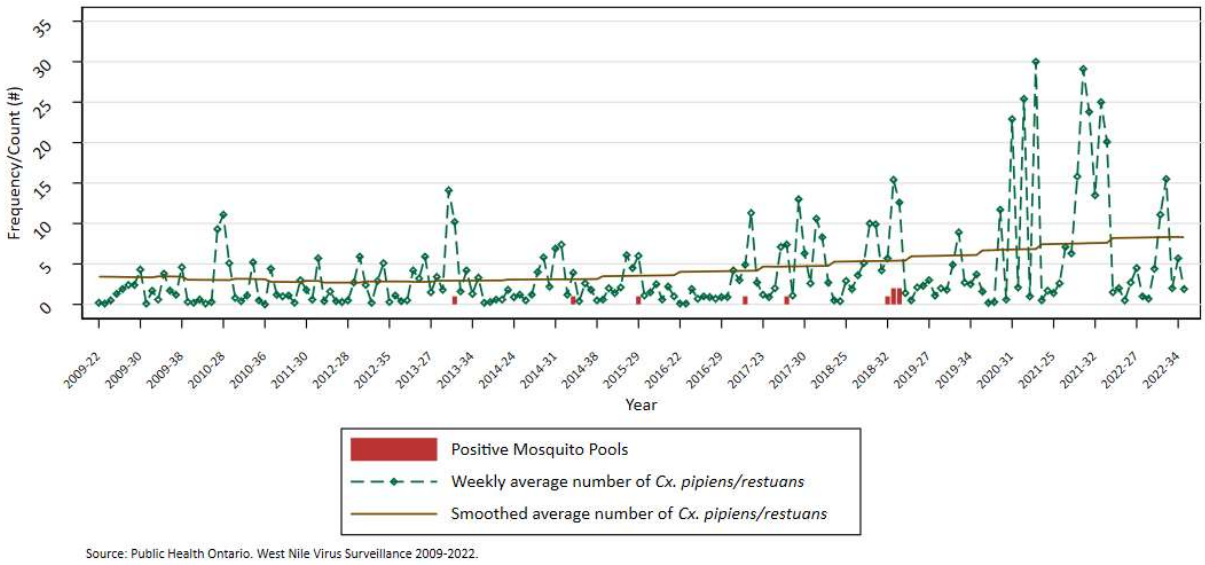
5.4.2. West Nile Virus

The HKPRDHU conducts surveillance and testing of mosquito pools for the presence of *Culex (sp.)* mosquitoes which transmit WNV in order to assess local risk of exposure. Studies have shown a strong

relationship between the number of WNV-positive mosquito pools and the number of confirmed human cases of WNV reported each year, so surveillance efforts contribute to early detection and risk monitoring.(94) Because *Culex pipiens* and *Culex restuans* are the main vectors for West Nile Virus, a greater number indicates a greater risk of human exposure to the disease.(84)

Figure 5.8 shows the results of weekly testing of mosquito pools for West Nile virus from 2009-2022. The number of pools with mosquitoes that tested positive for WNV are shown by the blue bars. In 2018 there were three weeks in which positive pools were identified. The green line shows the number of *Culex* mosquitoes that were found each week. A slight increase in smoothed average can be observed.

Figure 5.8 Weekly average of C. pipiens and C. restuans, West Nile Virus surveillance season, 2009-2022, HKPRDHU



Source: Public Health Ontario. West Nile Virus Surveillance 2009-2022.

The risk for WNV within the HKPR district has usually been low, except in 2018 when it was moderate.(84) Because WNV and its mosquito vectors are dependent on climatic conditions which vary from year to year, it is expected that there will be variable annual WNV and mosquito activity as well (95) and this is evident in the surveillance in HKPR district. However, as indicated previously, warmer temperatures and increased precipitation can create more favourable conditions for *Culex* mosquitoes to reproduce in the future, thereby increasing the potential exposure and risk.

5.4.3. VBDs of Emerging Interest

Eastern Equine Encephalitis Virus (EEEV) is a mosquito-borne virus that circulates between birds and mosquitoes, with bridge vectors transmitting the virus to humans and horses. The main enzootic mosquito vector is *Culiseta melanura.(84)* Most equine cases in Ontario occur in areas adjacent to swamps or flooded forests in rural areas, the primary habitat of *C. melanura*. This makes EEEV more of a rural health risk. Like WNV, EEEV is influenced by temperature and precipitation. EEEV is not a reportable disease in Ontario unless an infected person develops EEV-associated encephalitis. Only one human case has been recorded in Ontario (2016), although EEEV-positive horses have been reported in the province most years since 2002 when testing began.(95) The HKPRDHU mosquito surveillance

includes testing for EEEV. To date each year the HKPRDHU has been considered low risk for EEEV transmission to humans.(84) However, climate change will influence mosquito populations and it is anticipated that EEEV will increase in rural areas.(85)

Climate change is likely to create and expand suitable conditions for other mosquito species that transmit diseases such as dengue, chikungunya virus, Zika virus, and malaria.(96) As an example, the tropical mosquito *Aedes albopictus*, which is capable of transmitting Zika virus, was been identified in Windsor-Essex in 2016, and while cold winter temperatures prevent it from surviving, (97) climate change could lead to further northward expansion of this species.(98) A study using Chatham, Ontario as a model also showed increasing suitability for malaria transmission as temperature increases.(29)

In addition to Lyme disease, other tick-borne diseases are starting to emerge in other parts of Ontario and likely to increase due to climate change. These include anaplasmosis, babesiosis, Powassan virus and *Borrelia miyamotoi* disease.(80) Powassan virus is endemic to Canada and can cause encephalitis, meningitis and permanent neurological damage.(98) Furthermore, the lone star tick, *A. americanum*, whose bite can lead to an allergy to red meat, has also been found in Ontario. Though the lone-star tick does not appear to be established (reproducing) in Ontario at this time, the Public Health Agency of Canada is anticipating the possible expansion of the Lone Star tick into Canada from northern New York State (82, 99), just as climate change has contributed to the spread of black-legged ticks into Ontario.

5.5. Sensitivity to Vector-Borne Diseases in the HKPR District

Those who are very young (5-9 years of age) or older (55 years and older) are more at risk of tick-borne disease,(80) as their immune systems are underdeveloped or may be compromised. In the U.S., Lyme disease is reported most frequently among male children aged 5 to 9 years old.(14)

About 20% of people who are exposed to a mosquito-borne illness such as West Nile virus will develop acute clinical illness. People older than 70 years of age and those with chronic health conditions such as obesity, diabetes, hypertension and heart disease are at greater risk of severe illness, which could include meningitis, encephalitis or poliomyelitis.(100) The HKPRDHU has a high and growing proportion of older adults who will be increasingly affected by chronic illnesses as they continue to age. This means that public health efforts need to continue to address both infectious and chronic diseases.

People living with low- income are more likely to be in poorer health, live in substandard housing and experience food insecurity. They may have limited ability to take protective actions such as purchase effective insect repellent and clothing. Poorer health status may increase their health risks associated with vector-borne diseases.(100)

There is some evidence that vector-borne diseases can also impact mental health. For people with mental illness or existing mental health issues, VBDs may make these conditions worse by creating additional cognitive or neurological problems.(65) For example, studies have shown depression and personality changes following infection of Lyme disease or West Nile virus.(101) The literature identifies a need for further research in this area.

5.6. Building Adaptive Capacity to Vector-Borne Diseases in the HKPR District

Adaptive actions are key to reduce risk of exposure to and transmission of Lyme disease, West Nile virus and other vector-borne diseases. Adaptive actions can be both environmental and human (80) and require collaboration from a range of experts across public health, veterinary science, wildlife biology, landscape design and urban planning. For example, municipalities can keep grass short in parks, and veterinarians can monitor where ticks have been picked up on pets.(102) It should also be noted that strategies such as reducing shaded and woody areas in parks to decrease tick habitat can also be counter to climate change adaptation measures that aim to provide protection from heat and solar ultraviolet radiation.

Public health's roles include assessing and monitoring risks, ongoing surveillance, education and awareness raising about how to prevent insect bites, and clinical strategies such as early detection and patient education.(80) Ongoing surveillance enables annual comparison to observe and measure trends. Protective actions that are promoted by HKPR include encouraging people to: check selves and pets for ticks, wear light-coloured protective clothing (long pants, long shirts, closed toe shoes), wear a deet-containing repellant, provide medication to pets to prevent tick bites, yard maintenance and seek health care after sustaining a bite (e.g. prophylactic medication). Public health efforts need to ensure that people also understand the risks and be willing to act on these protective behaviours. Information to educate the public must also consider and support other public health messages that promote the benefits obeing physically active outdoors and in nature.

Public health work to address health inequities such as income and food insecurity are upstream measures that can reduce vulnerability by improving overall health in populations experiencing impacts of the social determinants of health.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

6 Chapter 6: Safe Food and Water

6.1. Chapter Overview

Previous chapters have presented projected increases in temperature, precipitation and extreme weather due to climate change. Although exposure pathways are indirect, the literature indicates an association between common foodborne illnesses and temperature. This chapter makes use of available climate and health data to discuss the relationships between climate change and food and water safety. Temperature indicators are compared with rates of food- and waterborne illnesses in the HKPR district. Projected changes in warm temperatures are presented and local data is given for populations who are more vulnerable to negative health outcomes regarding safe food and water. The potential climate impacts on the food system and how this could affect food security in the district are discussed.

6.1.1 Highlights

- Climate change will contribute to more warm days, more precipitation and more extreme weather in the HKPR district, which can all impact health by affecting water quality, food safety and food security.
- Without significant reductions in greenhouse gas emissions, the number of days with temperatures 25°C or higher is projected to more than double by 2080.More hot days and a longer warm season in the HKPR district mean more eating outdoors, higher risk of bacterial growth in food and a need to ensure safe food practices.
- Growing season length is used as an indicator of climate change impacts on the food system. All municipalities will have longer growing seasons in the future, which may be positive for agriculture, but may also change pests that affect crops and increase risk of food spoilage.
- Increased precipitation and warmer temperatures expected in the HKPR district can affect drinking and recreational water quality. 55% of residents in HKPR district use private wells for drinking water which are more susceptible to contamination during extreme weather events. Beach water is at increased risk of algal blooms due to higher temperatures and increased runoff.
- Extreme weather events such as floods, severe storms and power outages increase risk of food spoilage, water contamination and interruption to food supplies. An increasingly unpredictable climate affects food production, availability, delivery and safety.
- People with weakened immune systems, such as older and younger people and those with chronic illnesses, are more vulnerable to food- and waterborne illness. Potential impacts to the food systems in the future will hit people living with low-income harder. Over 10% of households in the HKPR district cited lack of money as a reason for not having enough to eat.
- Public health will continue to play an important role in monitoring and education about safe practices related to food and water. Public health work on poverty reduction is critical for addressing root causes of vulnerability such as food insecurity that are likely to be compounded by climate change.

Table 6.1 Summary of Health Impacts Related to Safe Food and Water

Climate Hazard	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts

Warmer temperatures	Increased survival of food-borne pathogens People doing more outdoor cooking and eating Change in growing season length More algal blooms	People who cook and eat outdoors; people attending outdoor events where food is provided People with weakened immune systems Older adults People with chronic illness People who are pregnant	Increase in food-borne illnesses e.g. Salmonella, Campylobacter and e.Coli Complications of food/waterborne illness Adverse pregnancy outcomes (preterm birth, pregnancy loss) Contamination of recreational and drinking water and risk of waterborne illness from drinking/rec water
Increased precipitation	Disruptions to food systems More algal blooms (cyanobacteria) Overload of stormwater management systems	People living on low income Children	Food insecurity Vomiting, diarrhea, skin rash, fever, headache Contamination of recreational and drinking water and risk of waterborne illness from drinking/rec water
Extreme weather events	Disruptions to food systems Power outages	People living on low income	Food insecurity Food spoilage may cause illness if consumed

6.2. Climate Influences on Safe Food and Water in HKPR District

Many food and waterborne pathogens are known to be sensitive to changes in temperature and precipitation.(103)

6.2.1. Foodborne illness

The climate factors of temperature, precipitation and extreme weather, and how these are projected to change in the HKPR district, are discussed in detail in Chapters 3 and 4. This chapter will discuss the relationships between these climate factors and risks to food and water safety and food security.

Common foodborne diseases affected by temperature include *Salmonella*, *Campylobacter*, and Escherichia Coli (*E.coli)* 0157, with peaks occurring during warm summer months.(104, 105) A strong association has been shown between these bacteria and ambient air temperature.(104) There are two contributing factors. Pathogens that cause illness are better able to survive and reproduce in warmer

temperatures (29), and people's eating behaviour changes in warmer weather, with increased outdoor cooking and eating (barbeques, picnics), where risk is higher because there is less control over cooking temperatures, food refrigeration and washing facilities.(105)

6.2.2. Waterborne illness

Temperature also impacts water quality. Cyanobacteria that are associated with algal blooms produce harmful toxins that threaten water quality. Algal blooms are more likely to form within water where there are sufficient nutrient levels, calm conditions and when air temperatures are 20°C or higher for an extended period of time. Increasing temperatures associated with climate change are likely to increase occurrence of cyanoblooms.(106)

Another climate factor is water runoff due to extreme precipitation that can transport contaminants and organic pollutants to water sources, which increases likelihood of algal blooms and contamination of recreational and drinking water.(29, 107) Extreme precipitation events are linked to increased presence of pathogens such as *Cryptosporidium* spp. in treated drinking water supplies.(107) In Canada, waterborne disease outbreaks have been linked to increasing temperatures and weather events, particularly heavy rains and drought.(29)

6.2.3. Food systems and security

The pathways through which climate change impacts human health via the food system and food security are complex and not well-documented in the literature. There is understanding that climate change will have an impact on all stages of the food system, including production, processing, preparation and consumption.(108)

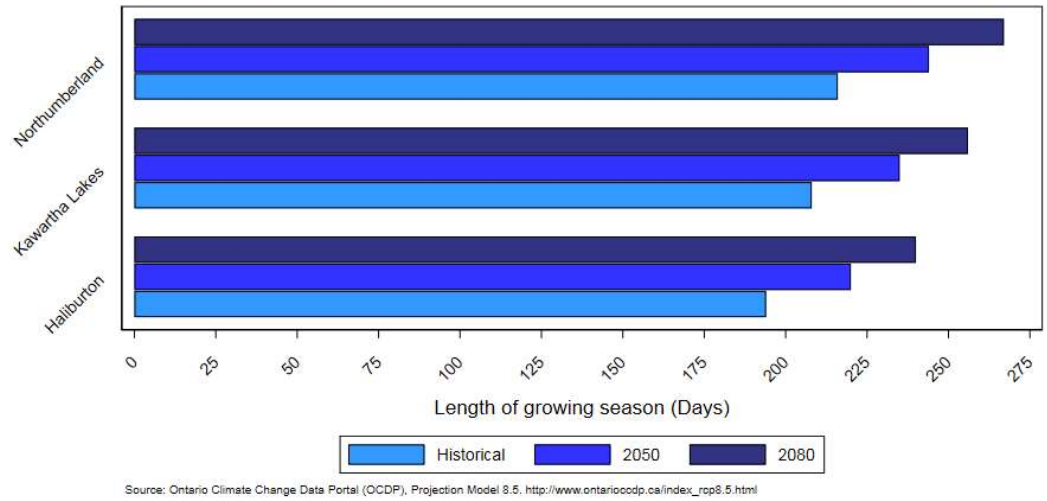
Production

More temperature extremes and weather variability lead to reduced agricultural productivity and yield. Projected increases in precipitation and higher intensity storms may make it more difficult to complete spring planting and increases in summer temperatures could reduce water availability.(109) Warmer and longer growing seasons may enable different types of crops to be grown further north than they are currently. However, food producers will need to adapt their choice of crops and timing of planting (e.g. seeding earlier in order to decrease exposure to drier late summer conditions) to take advantage of these opportunities. There may be increased risks of losses from invasive pests, heat waves and other extreme events which will also need to be addressed.(36)

Growing season length (GSL) is defined as the number of days when plant growth takes place. GSL is impacted by many factors, including air temperature, rainfall, frost days and daylight hours and is counted as starting with the first span of at least 6 days with daily mean temperature >5°C and ending with the first span after July 1 of 6 consecutive days with daily mean temperature <5°C.(22)

Figure 6.1 shows the projected increase in growing season length (GSL) by number of days, under emissions scenario RCP8.5. In Northumberland, GSL is projected to increase from 216 days (historical reference period) to 267 days by the 2080's. GSL in the City of Kawartha Lakes, is projected to increase from 208 days to 256 days by the 2080's and in Haliburton County, the projected increase is from 194 days to 240 days.

Figure 6.1 Projected changes in annual growing season length by number of days, by municipality, emissions scenario RCP8.5, for historical reference period (1986-2005), 2050s, 2080s



Distribution

Projected increases in extreme weather events will present risks to transportation systems that move food from source, to processing, to consumer, disrupting food distribution and potentially limiting access to safe and nutritious food. The risk for food spoilage and contamination also increases, especially if there is a power outage, which is often linked to increases in illness.(105)

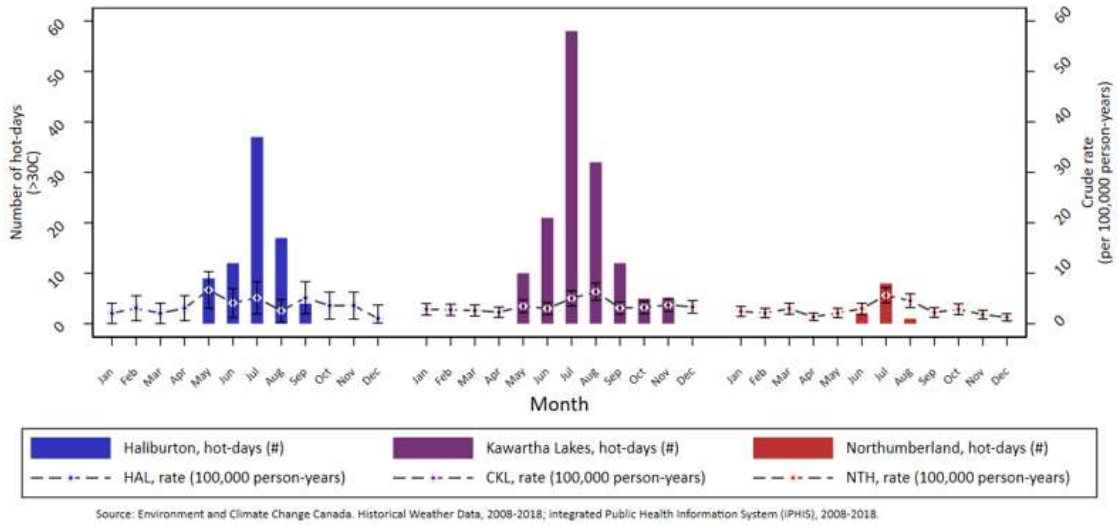
Preparation and consumption

Increased carbon dioxide in the atmosphere reduces the concentration of protein and essential minerals in many crops, which lowers the nutritional value of food. (108) As noted in section 6.2.1, increasing temperatures create more favourable conditions for foodborne pathogens, and outdoor food preparation and consumption.

6.3. Incidence of Food- and Waterborne Illnesses in HKPR District

Figure 6.2 shows number of hot days by month for a 10-year period and the incidence of foodborne illnesses as reported in iPHIS. Crude rates tend to be higher during the months with more hot days.

Figure 6.2 Monthly number of hot days (>30 °) and crude rate of lab-confirmed cases of Campylobacter enteritis, food poisoning (all causes), and Salmonellosis, 2008-2018, by municipality



6.4. Exposure – Safe Food and Water in HKPR District

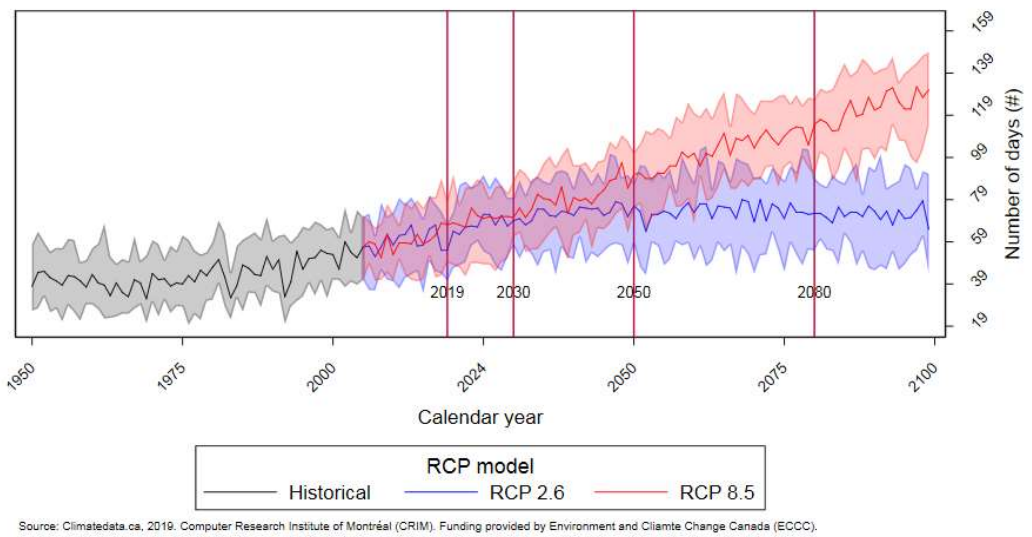
6.4.1. Foodborne illness – summer days

The lengthening of the warm season is likely to increase outdoor eating activity and there are also several large outdoor events held in the district during the summer, many of which have food vendors on site. Warmer temperatures increase potential exposure of food to pathogens and risk of foodborne illness, unless people and food operators are well-informed and follow safe food practices. Using Environment Canada and Climate Change's (ECCC) climatedata.ca website, the largest population centre within each of the three municipalities within the HKPR district (Haliburton Village in Haliburton County; Lindsay in City of Kawartha Lakes; Cobourg in Northumberland County) was searched to obtain climate data to be generalized across each of the respective municipalities.

Figures 6.3 to 6.5 show the projected annual number of days >25°C for each of the municipalities within the HKPR district. On all figures, the black line represents median values for 1950 to 2005, the blue line represents a low emissions scenario (RCP2.6) and the red line a high emissions scenario (RCP8.5). Shaded areas show the range in values of the climate model ensemble (defined as the 10th and 90th percentile). Under RCP8.5 increases are projected in each municipality. For comparison, the projections for RCP2.6 are also shown, which project more stable numbers.

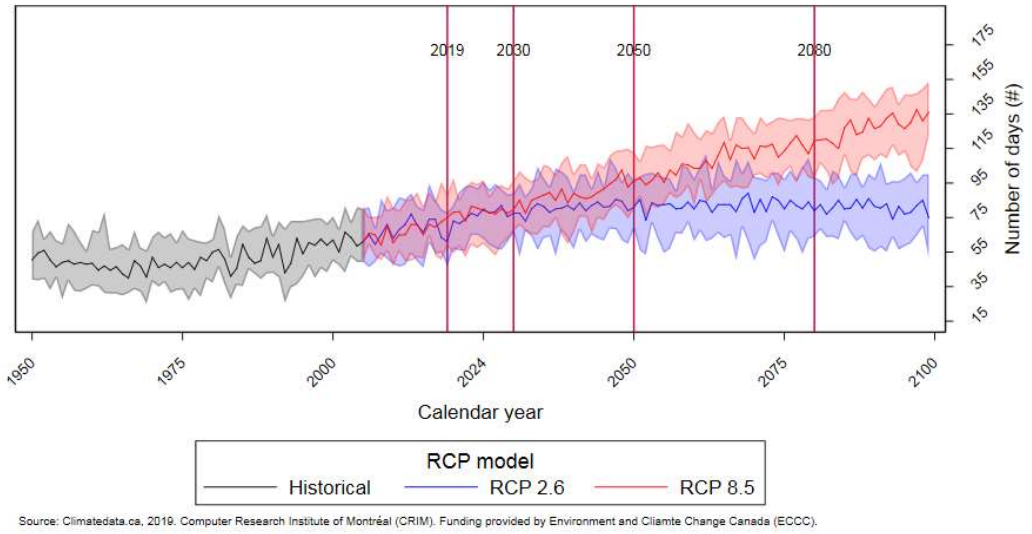
In Haliburton (Figure 6.3) for 2019, the models project a median value of 58 days (RCP2.6) and 67 days (RCP8.5) above 25°C. These values increase but stay fairly close together until about year 2030 (69 days, RCP2.6; 72 days RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of days above 25°C slightly increases and then remains relatively stable (74 days by 2050; 73 days by 2080). However, under RCP8.5, there is a steady increase (91 days by 2050; 115 days by 2080).

Figure 6.3 Projected annual number of summer days (>25 ℃) for years 1950-2100 in Haliburton (Haliburton County)



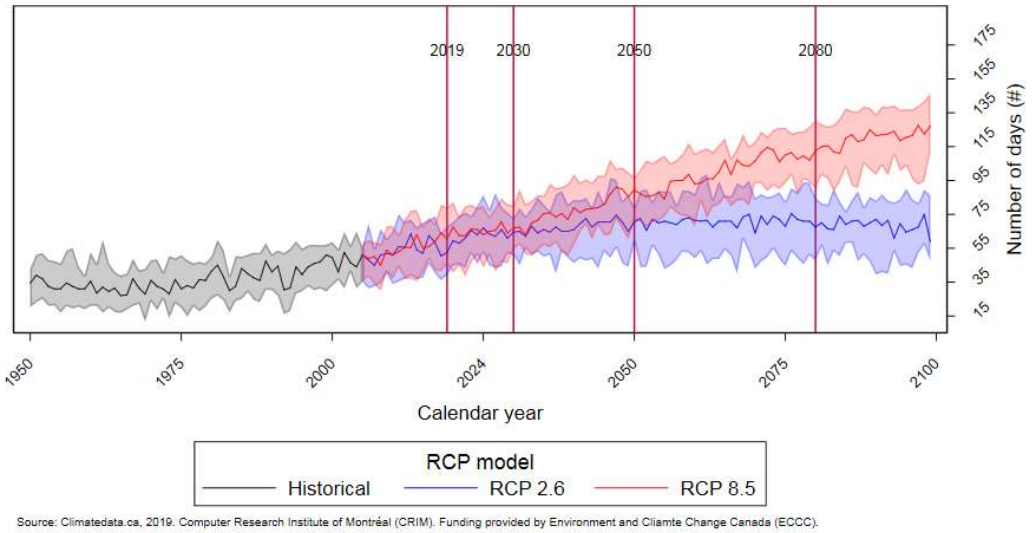
In Lindsay (Figure 6.4) for 2019, the models project a median value of 66 days (RCP2.6) and 75 days (RCP8.5) above 25°C. These values increase but stay fairly close together until about year 2030 (77 days, RCP2.6; 82 days RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of days above 25°C slightly increases and then remains relatively stable (82 days by 2050; 80 days by 2080). However, under RCP8.5, there is a steady increase (97 days by 2050; 120 days by 2080).

Figure 6.4 Projected annual number of summer days (>25 ℃) for years 1950-2100 in Lindsay (City of Kawartha Lakes)



In Cobourg (Figure 6.5) for 2019, the models project a median value of 56 days (RCP2.6) and 61 days (RCP8.5) above 25°C. These values increase but stay fairly close together until about year 2030 (65 days, RCP2.6; 68 days RCP8.5). After this time the red and blue lines begin to diverge. Under RCP2.6, the median number of days above 25°C slightly increases and then remains relatively stable (71 days by 2050; 69 days by 2080). However, under RCP8.5, there is a steady increase (90 days by 2050; 115 days by 2080).

Figure 6.5 Projected annual number of summer days (>25 ℃) for years 1950-2100 in Cobourg (Northumberland County)



6.4.2. Power outages

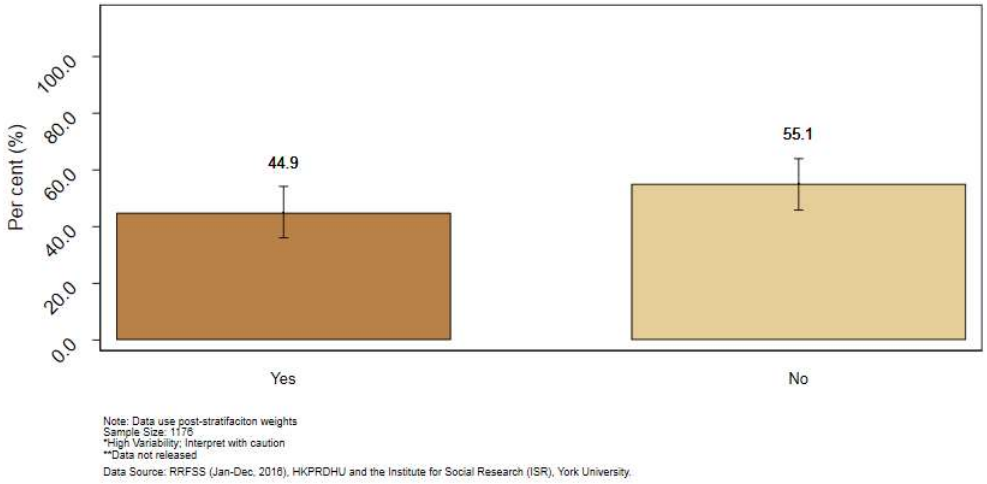
Another exposure factor that affects food safety is power outages, which can occur during extreme weather events such as tornadoes, windstorms, ice storms and floods. Seven municipalities identified energy emergencies or prolonged power failure among their top hazards in their municipal hazard risk assessments. Extended periods of time without electricity have the potential to impact health in several ways, including increased risk of food spoilage. Food in an unopened refrigerator will be kept cold for about 4 hours, and a full freezer will maintain temperature for about 48 hours. Longer than this, and perishable foods such as meat, poultry, seafood, milk and eggs may cause illness if consumed.(110)

6.4.3. Waterborne illness – drinking water

Municipal and in-home water treatment systems are critical to ensure the safety of drinking water. There are 35 large and small municipal residential drinking water systems in the HKPR district, and 34 non-municipal year-round residential drinking water systems (e.g. condo developments, year-round mobile home parks) which are monitored by the Ministry of Environment, Conservation and Parks. With more frequent and severe extreme precipitation projected in the future, drinking water infrastructure may be at greater risk of disruption or failure due to damage or exceedance of system capacity.(107) Heavy precipitation can also overload stormwater management systems, resulting in more frequent sewer passes directing untreated water into lakes and streams impacting drinking water down stream and recreational water quality.

As a largely rural area, many households across the HKPR district have private wells, which are the responsibility of the property owner to test. Private water sources tend to be more susceptible to contamination during extreme weather events such as heavy precipitation.(111) Figure 6.6 shows RRFSS data from 2016 indicating approximately 45% of households in the district get their tap water from municipal systems, while the remaining 55% draw from private wells, communal wells, natural non-well water sources, cisterns, or other systems.

Figure 6.6 Percent of households supplied with municipal water, HKPRDHU, 2016



About 43% of households in the City of Kawartha Lakes and 54.5% in Northumberland County get tap water from municipal systems. In Haliburton County, there is municipal water supply in the village of Minden and Cardiff townsite (~850 households); all other residential and seasonal dwellings draw from private wells or other water sources.

Municipal and other small drinking water systems require regular testing by their operators to ensure water safety. However, households that have a private well or water source require the homeowner to submit a water sample for testing. With more than half of households in the HKPR district drawing tap water from a non-municipal water source, many residents may be at risk of contracting a waterborne illness if appropriate follow up actions to test and clean their water supply are not taken after flooding, heavy precipitation or extended power outages.

6.4.4. Waterborne illness – recreational water

Exposure to toxins produced by cyanobacteria can occur by drinking contaminated water or through skin contact during swimming. Short-term effects can include vomiting, diarrhea, skin irritation, rash, fever or headaches. Children tend to be more susceptible because of their lower body weight.(112) Frequent use of lakes in the HKPR district for recreational purposes, including at summer camps, means the potential for increased risk of exposure to cyanobacteria as climate change creates more favourable conditions for algae growth.

Ten algal blooms have been recorded within the HKPR district by the Ministry of Environment, Conservation and Parks (MECP) since 2011, as listed in Table 6.2. This list only includes incidents where a suspected bloom was reported to MECP and a sample was confirmed as indicative of a blue-green algal bloom. It does not include blooms that were not reported to MECP or ones that were reported but no sample collected.

Table 6.2 Algal blooms reported by Ministry of Environment, Conservation and Parks (MECP)

Year	Waterbody name	Additional location info

2011	Sturgeon Lake	Kawartha Lakes
2011	Katchewanooka Lake	Kawartha Lakes
2011	Clear Lake (Peterborough Cty)	Kawartha Lakes
2011	Lower Buckhorn Lake	Kawartha Lakes
2012	Sturgeon Lake	Kawartha Lakes
2015	Canal Lake	Kawartha Lakes
2018	Big Brother Lake	Algonquin Highlands, Haliburton County
2018	Sturgeon Lake	Kawartha Lakes
2018	Dark Lake	Highlands East, Haliburton County

As extremely hot days become more common, public beaches will be increasingly more important resources for people to cool off, especially people who don't have air conditioning or other options to stay cool. They may then be at increased risk of contracting a waterborne illness if water quality declines.

The HKPRDHU conducts beach water surveillance from June to September each year. In 2019, 47 beaches were regularly tested across the district (Northumberland – 13, CKL – 15, Haliburton – 19). Samples are tested for *E. coli,* which is used as an indicator of bacterial contamination. A minimum of 5 samples are collected per beach each day when the beach water is sampled. When the geometric mean of the bacteria level of the samples is greater than 200 *E. coli* per 100 mL, or when any one sample exceeds 400 *E. coli* per 100 mL, the beach water is considered adverse and the beach will be posted to advise the public that there is a greater risk of becoming ill. In 2022 there was a total of 31 adverse water events. In 2021 there were 32, in 2020 there were 26 and in 2019 there were 36. It should be noted that some beaches had more than one adverse result.

6.4.5. Food systems and security

Climate change has the potential to affect all aspects of the food system, from farm to table.

As an industry, farming relies on year-to-year predictability of seasonal weather to facilitate crop selection and infrastructure investments. Farms and farmers are vulnerable to extreme weather events and unpredictable weather conditions which could negatively affect production (36) which then reduces availability to consumers. For example, an unprecedented heat wave in Ontario in March 2012 caused fruit trees to blossom five weeks earlier than usual, and subsequent frosts in April destroyed approximately 80% of apple blossoms.(36) Heavy precipitation and flooding can wash contaminants onto food crops, and because vegetables and fruit are often consumed raw, people can be exposed to harmful bacteria if foods are not properly washed before eating.(113) Climate change may affect the availability of some foods, and potentially lead to increased food costs and reduced accessibility for people with low incomes or living in isolated communities.(29)

6.5. Sensitivity - Safe Food and Water in HKPR District

6.5.1. Food- and waterborne illness

People with weakened immune systems are at greater risk of contracting food and waterborne illness and of developing serious complications as a result. This includes older adults (aged 65+). The growing proportion of older adults across the HKPR district (refer to Figure 2.2 in chapter 2) means an increasing proportion of the population will be more vulnerable to both food- and waterborne illness. People with certain chronic diseases (e.g., diabetes, liver or kidney disease, HIV/AIDS or receiving chemo or radiation therapy due to cancer) also have weakened immune systems, and infants and young children are at risk because their immune systems are still developing. Also, children swallow roughly twice as much water as adults while swimming and have higher risk of exposure to waterborne pathogens if the water at beaches is contaminated.(107) Pregnant people are more likely to get sick from foodborne pathogens and are at risk of adverse pregnancy outcomes such as pregnancy loss and preterm birth.(107, 114, 115)

6.5.2. Food Systems and Food Insecurity

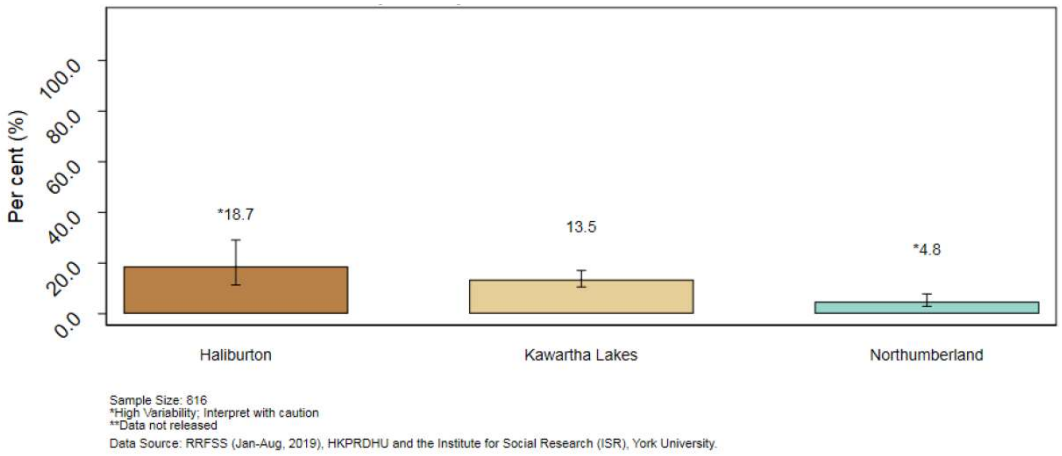
When people do not have or are unable to acquire enough food to meet the needs of all members of their household because they do not have enough money, they experience food insecurity.(116) Impacts on the food system from climate change are likely to be more strongly felt by those who are already food insecure. Some studies have identified the potential for crop prices to rise in the future as production falls due to extreme weather events that are predicted with climate change.(117) Rural areas that have limited capacity to store and/or produce food will be particularly vulnerable to disruptions in the transportation of food.(108)

People experiencing food insecurity are more likely to have chronic illnesses such as type 2 diabetes, heart disease, high blood pressure and mental health issues. In addition, food insecurity is associated with increased risk of birth defects among pregnant people, and with poorer health and development in children.(118)

The populations most vulnerable to food insecurity are people living on low income, which can include seniors. Infants and young children are vulnerable because they rely on adults for their basic needs such as shelter and food. Without successful efforts to address poverty, the number of households within the HKPR region that experience food insecurity may increase.

The percentage of low-income (low-income measure-after-tax, LIM-AT) households within the HKPRDHU is 12.8%.(119) In 2019, 10.7% of households in the HKPR district reported that, because of lack of money, they were worried that there would not be enough to eat, didn't have enough food to eat, or didn't eat the quality or variety of foods that they wanted to eat. (RRFSS, 2019) This is further broken down by municipality in Figure 5.7, which shows that Haliburton County had the highest percentage of households reporting food insecurity (18.7%), followed by the City of Kawartha Lakes (13.5%) and Northumberland County (4.8%).

Figure 5.7 Percent of households that, because of lack of money, worried that there would not be enough to eat or didn't have enough food to eat or didn't eat the quality or variety of foods that they wanted eat, by municipality, HKPRDHU, 2019



Each year HKPRDHU completes the Nutritious Food Basket (NFB), a specific protocol that provides a cost for healthy eating in each municipality. Putting the NFB in context with income illustrates the challenges that individuals and families living with low-income currently experience to have a healthy diet. Many people must compromise by eating less expensive and less healthy food in order to make ends meet. Table 6.3 shows the cost for a family of four (2 adults, 2 children) living in a low-income household.

Table 6.3 Cost of rent and healthy eating for a family of four living on Ontario Works or with one full-time wage earner, by municipality, 2022

	Haliburton County	City of Kawartha Lakes	N'land County	Haliburton County	City of Kawartha Lakes	N'land County
	Ontario Works[1]			One full-time minimum wage earner[2]		
Total monthly income	$2,760	$2,760	$2,760	$3,973	$3,973	$3,973
Avg market rent[3]	$2,500	$2.290	$1,559	$2,500	$2,290	$1,559
Monthly cost of NFB[4]	$1,103	$1,103	$1,103	$1,103	$1,103	$1,103
Total rent/food	$3,603	$3,393	$2,662	$3,603	$3,393	$2,662
% income spent on rent	91%	83%	56%	63%	58%	39%
% income spent on healthy food	40%	40%	40%	28%	28%	28%

[1] Including credits and benefits

[2] Including credits and benefits

[3] Average monthly rent may or may not include utilities

[4] Haliburton, Kawartha, Pine Ridge, District Health Unit. Addressing Food Insecurity and Poverty in the County of Haliburton, City of Kawartha Lakes and Northumberland County 2022 (January 2023)

Climate impacts that lead to increased food prices will further magnify existing health inequities, making people living with low-income even less able to access food for a healthy diet, and increasing their risk of chronic health conditions associated with poor nutrition (e.g., cardiovascular disease, type 2 diabetes,

and obesity). Vulnerable groups are also less likely to be able to access safe and nutritious food after disruptions associated with extreme weather events. (105)

6.6. Building Adaptive Capacity for Safe Food and Water in HKPR District

Public health will continue to play an important role in minimizing the incidence of food and waterborne diseases as the climate changes. This will include ensuring that residents know how to maintain food safety when preparing food and eating outdoors, since behavioural factors are known to affect risk of contracting a foodborne illness. Similarly, with many residents getting drinking water from private wells, public health plays an important role in helping people understand how to make sure their well water is safe to drink after an extreme weather event such as a flood.

Public health action and multi-sectoral collaboration on poverty reduction initiatives are key approaches for addressing existing issues such as food insecurity that may be compounded due to factors associated with climate change. Vulnerable groups such as people living with low-income and seniors who may already experience food insecurity, are more likely to feel the impacts of climate change on the broader food system, things such as the availability and cost of healthy and fresh food.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

7 Chapter 7: Air Quality

7.1. Chapter Overview

Air pollution is widely recognized as a major health risk. The relationship between temperature and air quality is well-documented in the literature. Projected temperature changes in the HKPR district are discussed in chapter 3. This chapter discusses how these changes may impact air quality in the future, and what this means to the health of our population. Three types of air pollutants and their risks to health are examined. Recent air quality data for HKPR district is presented, as well as health data for respiratory illnesses that are sensitive to air pollution. Rates of the population that live close to busy roads and highways are given.

7.1.1. Highlights

- Warmer annual temperatures expected in HKPR due to climate change will contribute to increased concentrations of air pollutants such as ozone (O_3), fine particulate matter ($PM_{2.5}$) and pollen. The growing season will get about 23% longer by 2080, meaning a longer season for plant growth and allergies.
- Breathing in air pollutants can worsen existing allergies and respiratory illnesses such as asthma and chronic obstructive pulmonary disorder (COPD) and increase risk of premature mortality from heart disease and stroke. Lung cancer is strongly associated with air pollution. $PM_{2.5}$ is third on the list of top environmental carcinogens in Ontario.
- Exposure to heat and air pollution together can result in compounded health impacts, as both can worsen respiratory and cardiac function. Outdoor air quality also impacts indoor air quality. Air pollutants can get into indoor spaces, and although concentrations will be lower than outside, people are still be exposed to them when indoors and subject to potential health impacts.
- Overall air quality in HKPR district is fairly good, however about 20% of the population lives within a traffic-related air pollution (TRAP) zone, including 40% of elementary schools and 50% of long-term care facilities. Young children and older adults are more vulnerable to adverse health effects of air pollution. Vehicular traffic is a key source of $PM_{2.5}$ and people living with a TRAP zone are more likely to experience negative health impacts such as development or worsening of asthma and chronic obstructive pulmonary disorder (COPD).
- Public health work on healthy community design has many co-benefits that can protect health, reduce air pollution and act as climate change mitigation strategies. Examples include advocating for policies that encourage more active transportation and greenspace. For individuals, the Air Quality Health Index (AQHI) is a resource that provides information about how to protect health when the air quality is poor.

Table 7.1 Summary of Health Impacts of Air Quality

Climate Hazard	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts

Air Quality Extreme Heat Wildfires	Higher levels of O_3 Increased level of Particulate Matter (PM_2) Longer growing season – increase in aeroallergens Poor indoor air quality Combined effect of air pollution and heat	Young children Older adults People with cardio or respiratory illnesses People with allergies People who work or play outside People living near TRAP zones	Premature death from heart disease, stroke, lung cancer Worsening of: asthma symptoms, other respiratory /cardiovascular illnesses, allergies/allergic responses Increased hospital visits Increased risk of lung cancer Inflammation of respiratory system

7.2. Climate Change and Air Pollutants

Ozone (O_3) occurs naturally in the earth's atmosphere and is also formed by human activities. In the stratosphere, ozone prevents harmful solar ultraviolet radiation from reaching the earth's surface. However, when found at ground level and breathed in, it is damaging to our lungs. O_3 is a key component of smog and is formed by chemical reactions that happen more easily when it is warm.(120) Climate change is expected to increase O_3 pollution, in part due to higher temperatures and more frequent stagnant air conditions.(45) Poor air quality is frequently associated with large, slow-moving high pressure systems that bring hot and dry conditions.(121)

Particulate matter is also a key component of smog and is categorized as coarse ($PM_{10-2.5}$), fine ($PM_{2.5}$) and ultrafine ($PM_{0.1}$). Evidence shows significant harm from fine particulate matter.(29) Due to its small size, it can be inhaled deeply into the lungs. Vehicular traffic is a key source of particulate matter ($PM_{2.5}$).(122) Other sources include industrial facilities (e.g., smelters), wildfires and wood and waste burning.(122) In terms of the impact of climate change, increased humidity and stagnant air events are likely to increase $PM_{2.5}$ levels, while increased precipitation may decrease levels. Wildfires are likely to be more frequent in Canada in the future and present a significant risk to air quality. The health burden of wildfire smoke is expected to increase.(121) Wildfire smoke can spread over large areas; even if the fire is not within HKPR district, our communities can still experience the impact on air quality.

Aeroallergens are substances such as pollen or mould that are present in the air and stimulate an allergic response in some people. Warmer annual temperatures associated with climate change have resulted in a longer growing season for pollen-producing plants, increased quantity of pollen, expanded pollen distribution and increased allergenicity (how much particular allergens affect people).(45) In other words, there will be more pollen, for longer periods of time, over a larger area and it will affect people more strongly. The growing season starts when there are six consecutive days with daily mean temperature above 5°C in spring/summer and ends when this condition fails to be met later in the year.(44)

7.3. Health Impacts of Air Pollutants

Air pollution is widely recognized as a health risk, with exposure increasing risk of premature mortality from heart disease, stroke and lung cancer.(123) Health impacts of exposure to ozone (O_3) include respiratory and asthma symptoms, such as throat irritation, coughing, shortness of breath and reduced lung function. O_3 causes inflammation in the respiratory system, resulting in what's often called "sunburn on your lungs".(11) O_3 exposure can also make asthma and chronic lung diseases worse (124) and has been associated with cardiovascular effects such as arrhythmias and heart rate variability.(125) Respiratory emergency room and hospital visits are also associated with short-term exposure to O_3.(29)

Fine particulate matter ($PM_{2.5}$) is a mix of metals, carbons and other compounds that are small enough to be inhaled (<2.5 micrometres in diameter) and are associated with serious chronic and acute health effects, including lung cancer, chronic obstructive pulmonary disease (COPD), cardiovascular disease, and asthma development and exacerbation, which can all result in increased emergency room visits, hospitalization and premature mortality.(29) A study done by Public Health Ontario and Cancer Care Ontario identified $PM_{2.5}$ as the third-most significant environmental carcinogen in Ontario (after solar ultraviolet radiation and radon), responsible for an estimated 560 new cancer cases per year. Lung cancer is associated most strongly with outdoor air pollution.(126) New research suggests that these particles could also make their way into the brain and contribute to psychological, behavioural and neurological problems such as anxiety, depression, and dementia.(127) A recent study completed by the Health Effects Institute found evidence to support a relationship between non-accidental mortality and long-term exposure to low $PM_{2.5}$ concentrations.(128) This means that risks to health may exist even with $PM_{2.5}$ concentrations below current identified thresholds, especially among vulnerable populations.

Aeroallergens are air-borne substances that when inhaled can trigger allergic responses in some people. Increased aeroallergen formation has been associated with worsening of respiratory diseases such as asthma and COPD, leading to increased hospital admissions.(29) Other allergic responses can include hay fever, sinusitis, conjunctivitis, hives, eczema and anaphylaxis.(45)

Climate change could also impact indoor air quality. Increased concentrations of outdoor air pollutants contribute to increased concentrations indoors, and while these would typically be lower, generally people spend most of their time indoors, so much of their exposure to air pollutants will come from particles inhaled indoors.(45) In addition, heavy precipitation and flooding could create moisture in buildings and lead to growth of biological contaminants such as mould and bacteria that pose health risks if inhaled.(29)

Air pollution levels and high temperatures often occur together, and evidence suggests that combined exposures result in compounded impacts to health. For example, air pollution can worsen respiratory and cardiac function, which will impair capacity to cope with heat stress.(48, 125)

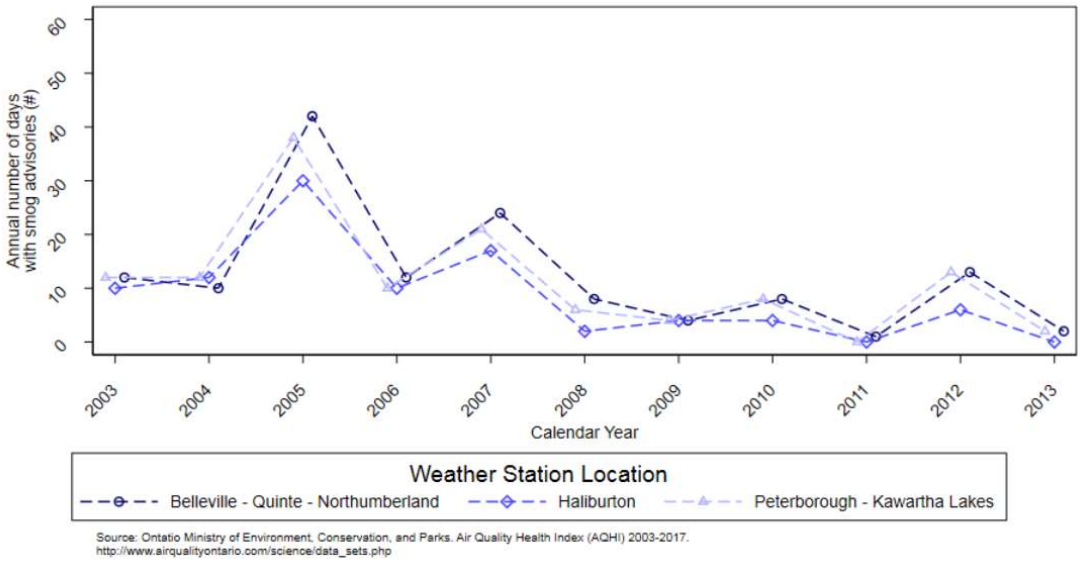
7.4. Exposure to Poor Air Quality in the HKPR District

People who work or are physically active outside are more exposed to air pollution. In the HKPR district, 6.9% of workers are in industries that generally require work outdoors such as forestry, agriculture and construction, compared to 4.6% in Ontario overall (Refer to Figure 2.8, Section 2.2.5). Occupations such as agricultural workers, construction, utility workers and outdoor recreation workers are at increased

risk of negative health outcomes due to poor air quality, especially where jobs involve heavy exertion.(32)

In general, in Ontario, air quality has been improving over the past ten years due to a substantial reduction in pollutants, especially $PM_{2.5}$. One significant action was the phase-out of coal-fired generating stations and regulation of industrial emissions.(129) Figure 7.1 uses weather station data from municipalities in or near the HKPR district and shows that the number of days with smog advisories has gradually decreased.

Figure 7.1 Annual number of days with smog advisories, 2003-2013, select weather stations in or near HKPR district



7.4.1. Ozone

Figure 7.2 shows average monthly concentrations of O_3 from the Peterborough monitoring station, which is the closest station to the HKPR district, and from the station located in Dorset, in the northern part of Haliburton County. The Ontario Ambient Air Quality Criteria (AAQC) has a maximum concentration of 80 parts per billion (ppb) over one hour as an indicator of O_3 concentrations that have a negative impact on health.(130) Average monthly values of O_3 in both locations were below this threshold. In terms of future exposure, Table 7.4 shows the projected number of days that will exceed ozone concentrations of greater than 80 ppb, with a slight increase shown by 2050.(131)

Figure 7.2 Monthly average concentration of ground-level ozone (O_3), Dorset and Peterborough monitoring stations, 2003-2017

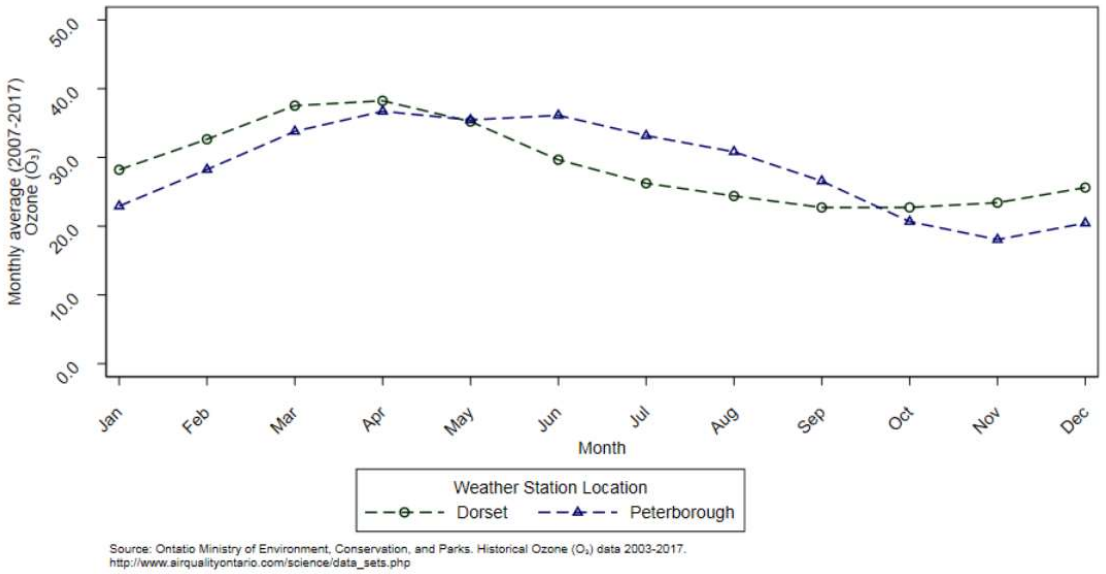


Table 7.2 Changes in number of exceedances of ozone (<80ppb) count (days per year) for HKPRDHU for baseline period (1971-2000), 2050s and 2080s

	Days above 80ppb* (1971-2000)	Days above 80ppb (2050s)	Days above 80ppb (2080s)
HKPR District Health Unit	4	5	5

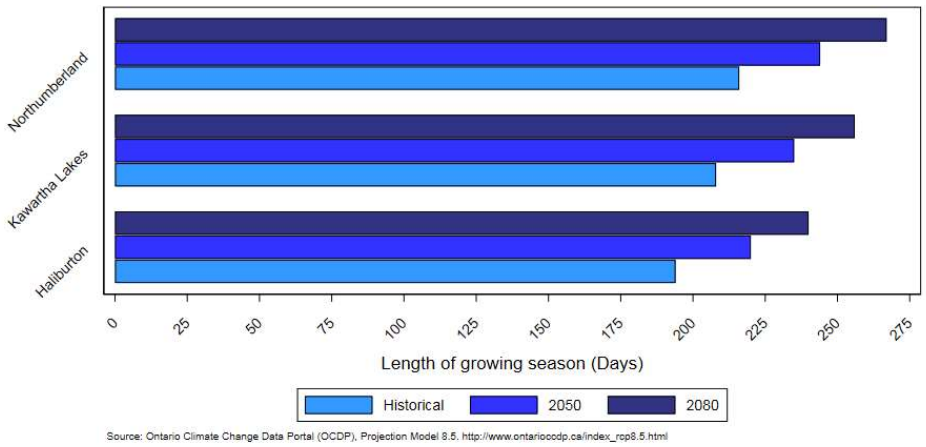
***** parts per billion
Data source: Ontario Climate change and Health Modelling Study. Ministry of Health and Long-Term Care, 2016.

7.4.2. Aeroallergens

Due to climate change, people with allergies will be exposed to more allergens, for longer periods of time, and across a larger area. The incidence and prevalence of respiratory allergies and asthma are projected to increase in Canada.(121) For example, ragweed season is becoming longer and in some parts of Canada has increased by 27 days between 1995 and 2009.(29) As the frost season grows shorter, the length of pollen season increases.

Figure 7.3 shows the projected increase in growing season length (GSL, number of days) across the HKPR district under emissions scenario RCP8.5. A longer growing season will mean extended exposures to aeroallergens, especially from plants (e.g., pollen). In Northumberland, GSL is projected to be 267 days by the 2080's, an increase from 216 in the historical reference period (23.6% longer). The GSL in the City of Kawartha Lakes is projected to increase from 208 days to 256 days by the 2080's (23.1% longer) and in Haliburton County, projected to increase from 194 days to 240 days (23.7.% longer).

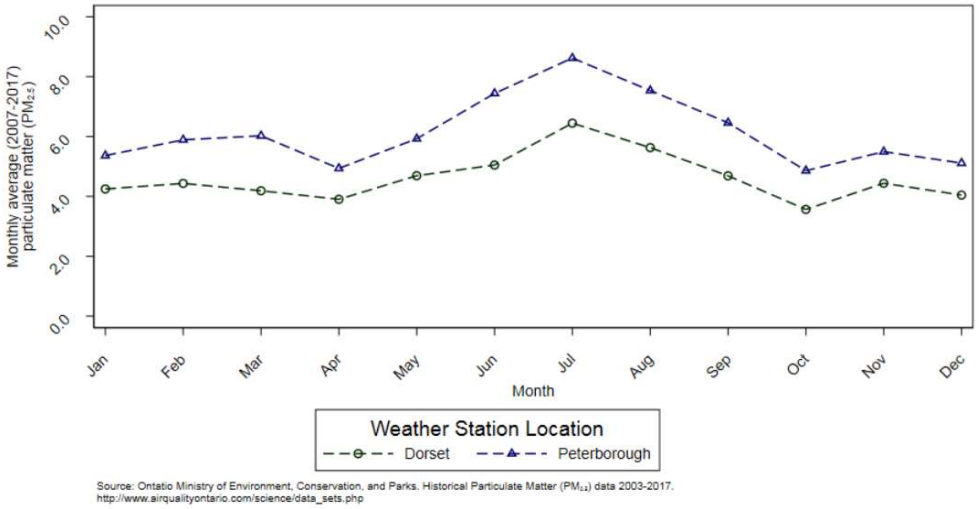
Figure 7.3 Annual growing season length by number of days, by municipality, emissions scenario RCP8.5, historical reference period (1981-2005), 2050s, 2080s



7.4.3. Particulate Matter

Figure 7.4 shows average monthly concentrations of fine particulate matter ($PM_{2.5}$) from the Peterborough monitoring station, which is the closest station to the HKPR district, and from the station located in Dorset, in the northern part of Haliburton County. According to the AAQC, a maximum concentration of 30 micrograms/metre cubed ($\mu g/m^3$) over 24-hours is an indicator of $PM_{2.5}$ concentrations that have a negative impact on health. Average monthly values in both locations were well below this threshold, although there is a peak in concentrations in the summer months (June – August).

Figure 7.4 Monthly average concentration of atmospheric fine particulate matter ($PM_{2.5}$), Dorset and Peterborough monitoring stations, 2003-2017

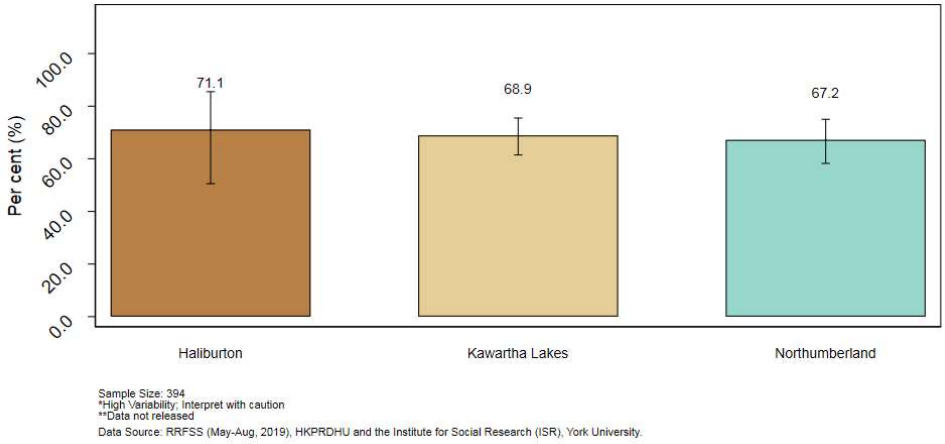


7.4.4. Air Quality Health Index

The Air Quality Health Index (AQHI) is an online tool where people can get local information to help make informed decisions about reducing their exposure to air pollution. There are also tailored messages for vulnerable groups such as parents with children and infants, seniors and those with cardiovascular and respiratory diseases.(29)

Results from the 2019 Rapid Risk Factor Surveillance System (RRFSS) survey conducted by HKPRDHU and the Institute for Social Research (ISR), York University indicate that most adults (67.2 % - 71.1%) in the district are aware of the AQHI. This is positive in that many people know that there is a resource where they can go to get local information on air quality. However, the survey did not ask respondents how frequently they used the AQHI, or what action they took.

Figure 7.5 Percent of adults familiar with the Air Quality Health Index, by municipality, HKPRDHU, 2019



7.4.5. Indoor Air Quality

People of lower socioeconomic status and those living in poor housing conditions may be more likely to be exposed to indoor allergens such as mould, which is more likely to occur in damp conditions from outdoor humidity or heavy precipitation events.(45) Pollutants that are outside also eventually work their way inside, so outdoor air quality affects indoor air quality. Although the concentrations will be lower indoors, because most people spend about 90% of their time in indoor environments, much of their exposure to air pollutants happens inside.(45) Thus, even people who spend little time outside can still be exposed to air pollutants generated by traffic and other sources, with the potential for negative health outcomes.

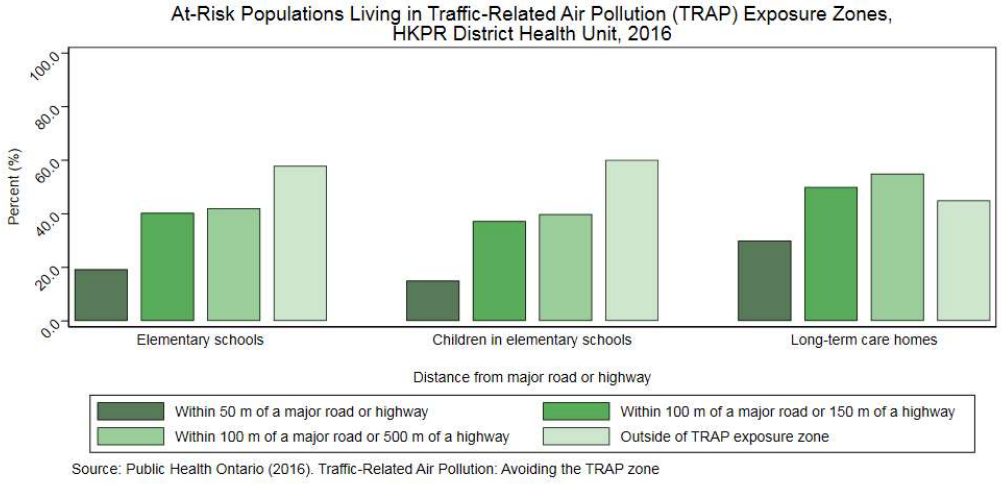
7.5. Sensitivity to Air Quality in the HKPR District

Certain population groups are particularly susceptible to adverse effects of exposure to $PM_{2.5}$ and O_3. These include both healthy and asthmatic children; older adults, especially those with pre-existing respiratory or cardiac conditions.(29) Children can be particularly susceptible to allergens because their respiratory and immune systems are still developing.(45) Exposure to air pollutants while pregnant increases risk of having a low birth-weight baby.(120)

Public Health Ontario identifies facilities in the HKPR district that serve children and older adults and their location in relation to traffic-related air pollution (TRAP) exposure zones. This information provides an indication of the exposure risk of two population groups that are most sensitive and vulnerable to the health risks of air pollution. The zone within 300-500 metres of a major road is the area most affected by traffic emissions.(132) Figure 7.6 shows that about 40% of elementary schools in the HKPR district are

located within 100m of a major road or 500 m of a highway[9]. About 50% of long-term care homes in the HKPR district are similarly located. In the HKPR district, roadways in this category include provincial Highways 401, 2, 7, 35, 115, 118, as well as numerous local municipal roads that function as arterial thoroughfares. While the average annual traffic volume may be lower than a major highway, some of these roads may carry a high volume of industrial vehicles which contribute diesel-related pollutants and coarse particulate matter.(132)

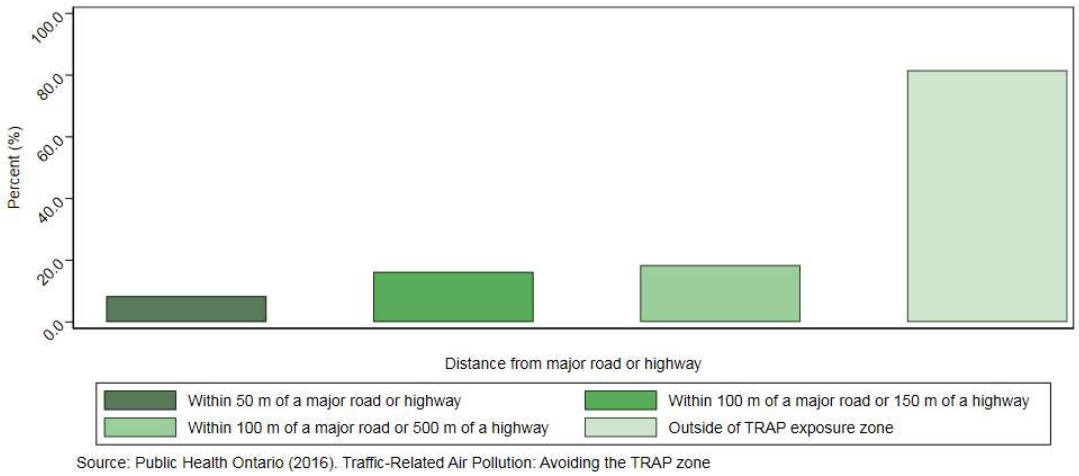
Figure 7.6 At-risk populations living in traffic-related air pollution (TRAP) exposure zones, HKPRDHU, 2016



Research indicates that children living in low-income areas, immigrants, and racialized groups are more likely to be exposed to air pollution than children in higher income areas.(121) In terms of overall population, just under 20% of HKPRDHU's population lives within TRAP exposure zones, shown in Figure 7.7. Further mapping needs to be done to determine whether these zones include low-income and other at-risk groups.

Figure 7.7 Population living traffic-related air pollution (TRAP) exposure zones, HKPRDHU, 2016

[9] Public Health Ontario definition of major roads and highways: "A major road includes road classes defined in the Ontario Road Network (ORN) as: 1) Arterial: a major thoroughfare with medium to large traffic capacity, or 2) Expressway highway: a high-speed thoroughfare with a combination of controlled access and intersections at grade level. †A highway is the road class defined in the ORN as a: 1) Freeway: An unimpeded, high-speed controlled-access thoroughfare for through traffic with typically no at-grade intersections, usually with no property access or direct access and which is accessed by a ramp"



Figures 7.8 and 7.9 show the rates of hospitalization and emergency department visits for asthma and COPD in the HKPR district. These rates provide an indication of the portion of residents with the highest risk of negative health impacts due to air pollution. Despite the overall air quality in HKPR district being fairly good, as illustrated in Figure 7.4, there are still annual hospitalizations and ED visits due to respiratory illnesses. Increases in levels of ozone, particulate matter or aeroallergens may result in increased need for those with respiratory illnesses to access primary health care.

Figure 7.8 Age-standardized rate of hospitalizations for asthma and COPD, HKPRDHU, 2008-2020

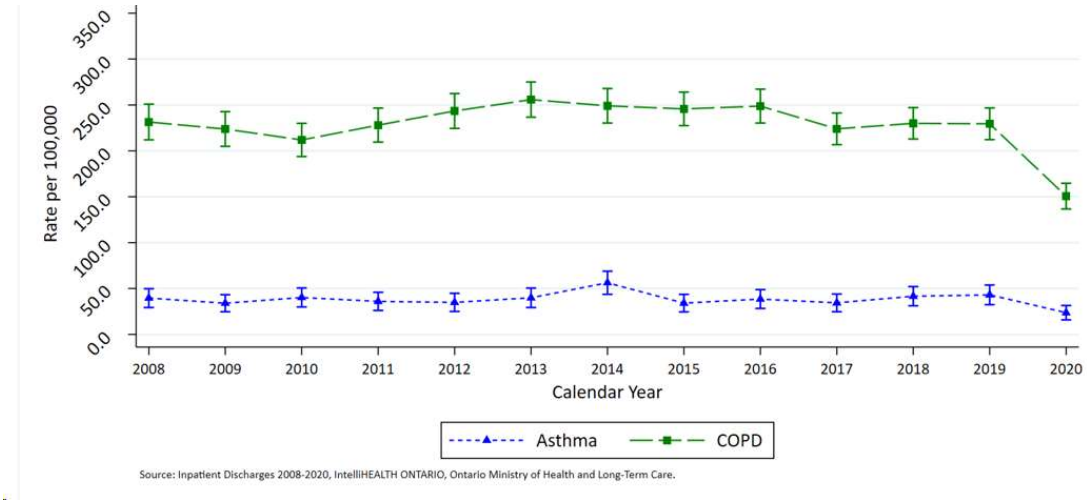
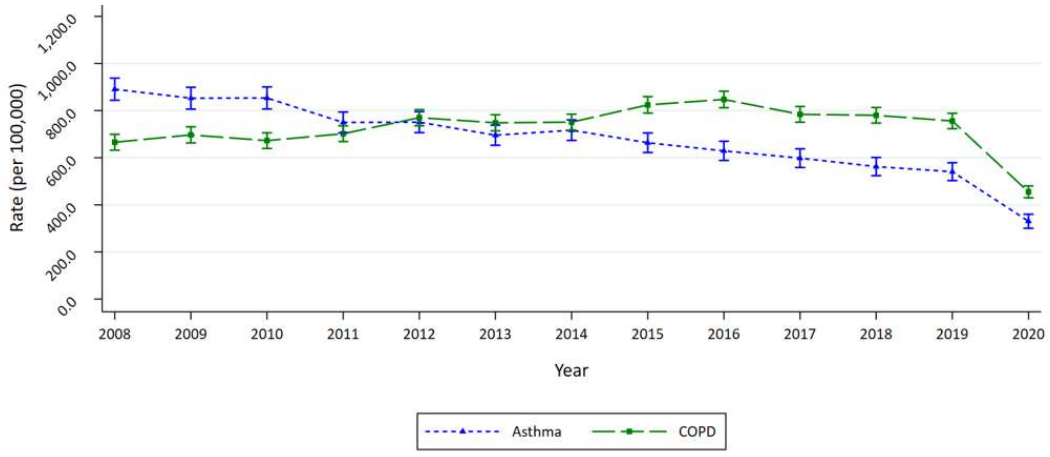


Figure 7.9 Age-standardized rate of COPD and Asthma-related emergency department visits, HKPRDHU, 2008-2020



7.6. Building Adaptive Capacity to Air Quality in HKPR District

Recent air quality data from the AQHI indicates that in general, air quality in the HKPR district tends to be fairly good, with most readings at low risk levels as illustrated in Figure 7.1. However, there are key vulnerable populations who are served by facilities located in proximity to major roads that generate traffic-related air pollution. Reducing exposure to air pollution reduces the risk of cancer. Improved emission standards and traffic reduction strategies are two ways to improve air quality.(126)

Since increased air pollution is often accompanied by high temperatures, adaptation measures need to consider both factors, and the compounded impacts that some populations may experience. Individuals and communities need to be aware of the health risks of both extreme heat and poor air quality, tools that are available (i.e. AQHI) and how to protect themselves. Integrated adaptation messages should be developed.

Public health action and advocacy for healthy community design has many co-benefits that can protect people from air pollution and extreme heat. For example, developing parks and greenspace to provide shade and dissipate heat through evaporation and transpiration reduces ambient temperatures and encourages more physical activity if walking and biking paths are also included. More people using active transportation reduces air pollution and increases physical activity levels, both of which are associated with positive health outcomes.(48) Increasing active transportation and reducing vehicle trips is also a climate change mitigation strategy, by contributing to reduction in greenhouse gas emissions. Equitable healthy community design also means that people and neighbourhoods of all incomes, abilities and race have access to greenspace and are protected from traffic-related air pollution.

The projected increases in heat across the HKPR district will also have an impact on future levels of air pollutants, so although the present health burden may be minimal, there is a need to plan for adaptation in the future related to air quality.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

8 Chapter 8: Exposure to Solar Ultraviolet Radiation

8.1. Chapter Overview

Previous chapters have discussed projected climate changes related to temperature (Chapter 3) and extreme weather (Chapter 4). These two climate factors will also have an impact on solar ultraviolet radiation (UVR) exposure. This chapter discusses the relationship between exposure to solar UVR and health, presents recent health data for the HKPR district on rates of skin cancer and provides projections for how this may change in the future. The percent of residents who took steps to protect themselves in the sun is given.

8.1.1. Highlights

- In HKPR district, climate models project more warm summer days, a longer warm season and extended dry periods. These are likely to increase people's exposure to solar ultraviolet radiation (UVR), as conditions become more favourable for spending time outdoors. Rates of basal and squamous cell carcinoma are projected to increase in the HKPR district.
- Solar UVR is the number one environmental cause of cancer in Ontario. It is known to cause several different skin cancers and can also lead to development of cataracts. Most skin cancer occurs after many years of exposure. Taking protective action early in life is the key to reduce exposure and skin cancer prevention.
- Populations that have increased exposure to solar UVR in the HKPR district include people who work outdoors and people who pursue outdoor activities. Across the district, outdoor activities are promoted to both tourists and residents, and there are hundreds of adults and children who attend 26 residential camps.
- In HKPR district, about 50% of youth ages 12-17 years and 68% of youth ages 13-24 years took steps for sun protection. People ages 24 years and under were less likely to take steps for sun protection than those over age 25 years. This is important because total lifetime exposure increases cancer risk. Children/youth with a history of sunburns are at greater risk of developing skin cancer later in life. Males were also less likely to protect themselves from the sun than females.
- Developing skin cancer due to UVR exposure is largely preventable. Public health can raise awareness of taking personal protective actions such as using sunscreen and wearing long clothing. Community-level initiatives include advocating for community design measures such as provision of shade through trees or structures. These initiatives have co-benefits; they can also improve air quality and reduce exposure to extreme heat.

Table 8.1 Summary of Health Impacts of Exposure to Solar Radiation

Climate Hazard	Projected Climate Impacts	Vulnerable Populations	Potential Health Impacts
Longer warm season	Increased exposure to solar radiation	Young children	Increased risk of developing cataracts

More hot days		People who work or play outside	Increased risk and mortality from skin cancer

8.2. Climate Change and Solar Ultraviolet Radiation

Increases in annual number of hot days mean a longer warm season and changes in precipitation patterns indicate more extreme wet and dry periods. As our summers become longer, warmer and drier, people will be likely to spend more time outdoors and be exposed to more solar radiation (29), and therefore more at risk of skin cancer, unless adaptive actions are taken. There is evidence that at higher temperatures sunlight is more carcinogenic, however predicting the health impacts of UVR from climate change remains a challenge.(29)

8.3. Health Impacts of Solar UVR

There are three main types of skin cancer: basal cell carcinoma, where there is uncontrolled growth in the basal cells, the deepest layer of skin; squamous cell carcinoma, uncontrolled growth in squamous cells, the upper layers of skin; and malignant melanoma, the most serious and fatal form of skin cancer. Although they are less fatal than melanoma, basal and squamous cell carcinomas can cause substantial morbidity and impact on the health care system.(126)

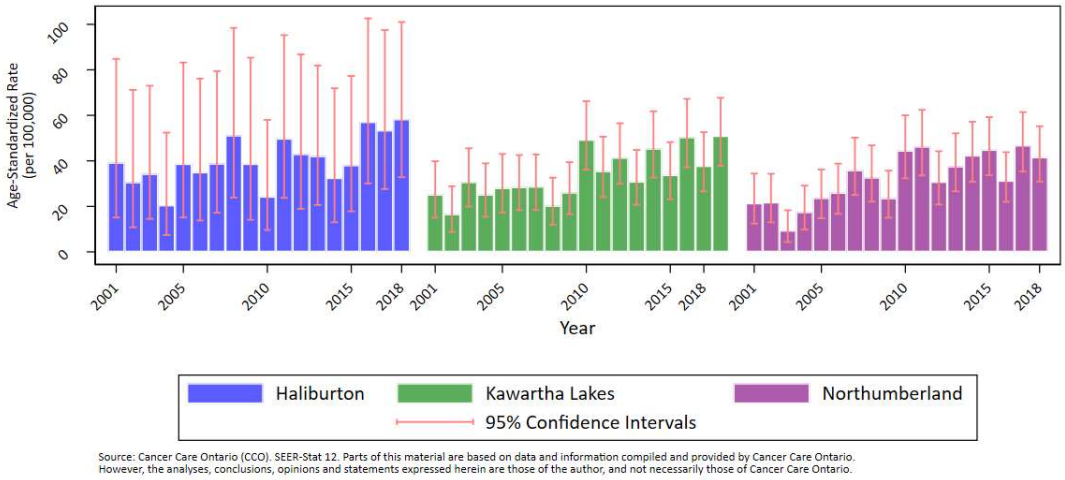
Most skin cancers arise later in life after many years of exposure to solar UVR, so its impacts are not immediately apparent, nor is the link with climate change as easily recognized. However, the association between ultraviolet radiation (UVR) exposure from the sun with skin cancer has long been recognized. Ultraviolet-B-radiation (UV-B) is well-known to cause non-melanoma skin cancers.(131) UVR exposure can also have harmful effects on the eyes, for example development of cataracts.(133)

Public Health Ontario identified solar UVR as the number one environmental carcinogen in Ontario, resulting in 2090 to 2990 (mean 2540) new cancer cases (specifically, melanoma) per year. The study only included melanoma, the most fatal form of skin cancer, because non-melanoma skin cancers are not reliably reported in the province. In Canada non-melanoma skin cancers are about 12 times as common as melanoma; including these cases would result in a much greater estimated disease burden from solar UV exposure.(126)

In addition to skin cancer, short-term health effects of UVR exposure can include DNA damage and immune suppression. A positive health benefit of UV exposure is stimulation of vitamin D production.(29)

Figure 8.1 shows the age-standardized rate of malignant melanoma in each census division, from 2001 – 2018. Rates have gradually been increasing in City of Kawartha Lakes and Northumberland County and have remained fairly consistent in Haliburton County. Data has not been separated by gender because Haliburton data is not stratified by sex for 13 of the 15 reporting years. Overall (2001-2018 combined) males had a higher rate of malignant melanoma and other non-epithelial skin cancers.

Figure 8.1 Age-standardized incidence rate of malignant melanoma and other non-epithelial skin cancers, by municipality, HKPRDHU, 2001-2018



Source: Cancer Care Ontario (CCO). SEER-Stat 12. Parts of this material are based on data and information compiled and provided by Cancer Care Ontario. However, the analyses, conclusions, opinions and statements expressed herein are those of the author, and not necessarily those of Cancer Care Ontario.

A study using mice found that the cancer-inducing effects of UV light increased by 5% for each degree centigrade of increased temperature.(134) A study cited in the Ontario Climate Change and Health Modelling Study showed that basal and squamous cell carcinomas increased by 2.9% and 5.5% respectively per degree Celsius increase in summer temperature.(131) Based on this relationship, the projected increase in HKPR District of basal cell carcinoma is 13.1% by the 2080s and of squamous cell carcinoma of 24.8% (Table 8.2). These potential increases underscore the importance of ensuring that our population is aware of how to protect themselves from UVR exposure.

Table 8.2 Projected percentage increase in basal cell and squamous cell carcinoma for 2050s and 2080s over the baseline period (1971-2000), HKPRDHU(131)

	% increase in basal cell carcinoma (2050s)	% increase in basal cell carcinoma (2080s)	% increase in squamous cell carcinoma (2050s)	% increase in squamous cell carcinoma (2080s)
HKPR District Health Unit	7.8	13.1	14.7	24.8

8.4. Exposure to Solar UVR in the HKPR District

Ambient ultraviolet radiation levels vary by location, season, time of day, altitude, cloud cover, and atmospheric pollution.(29) Generally UVR is most intense at areas closest to the equator, during the summer months and between the hours of 10 am and 3 pm.(135)

People working outdoors and people who pursue outdoor activities have increased exposure to solar UVR. Figure 2.8 in Chapter 2 shows that in Haliburton County about 15% of the workforce is in construction. In the City of Kawartha Lakes, it is about 11% and in Northumberland County about 9%. These workers may spend a large portion of their day outside. There are also smaller portions of the workforce in other outdoor occupations including agriculture, forestry, fishing and hunting. Other

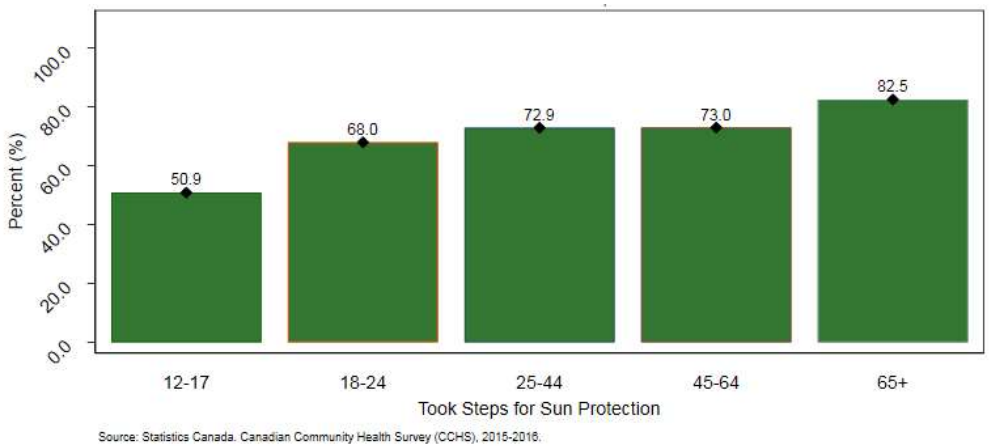
workers not captured in the census data, but who are likely to be exposed to solar UVR include people working in outdoor recreation/tourism (e.g., golf courses) and municipal roads and maintenance staff.

Across HKPR region, outdoor activities such as cycling, hiking, and boating are promoted as tourist attractions and opportunities for residents and visitors to get physically active. More than half of HKPR residents report being active or moderately active (Figure 2.9, Chapter 2). People who are active outdoors will be more exposed to solar UVR. Sports such as football and soccer are typically played on open fields with limited shade, making players more exposed. HKPR district is also home to 26 residential camps that range from small (less than 100 staff and campers) to large (several hundred staff and campers). Both staff and campers spend most of the day outside and exposed to solar UVR.

Data from the Canadian Community Health Survey (2015-16) in Figures 8.2 and 8.3 provides an indication of exposure risk by age and gender in HKPR district based on people reporting taking the following protective actions when in the sun: Typically spending fewer than 30 minutes in the sun during peak hours (10 am to 4 pm); spending 30 minutes or more in the sun and always/often doing at least one of the following: seeking shade and avoiding the sun, wearing protective clothing and a hat; and wearing sunscreen SPF ≥15 on face and body.

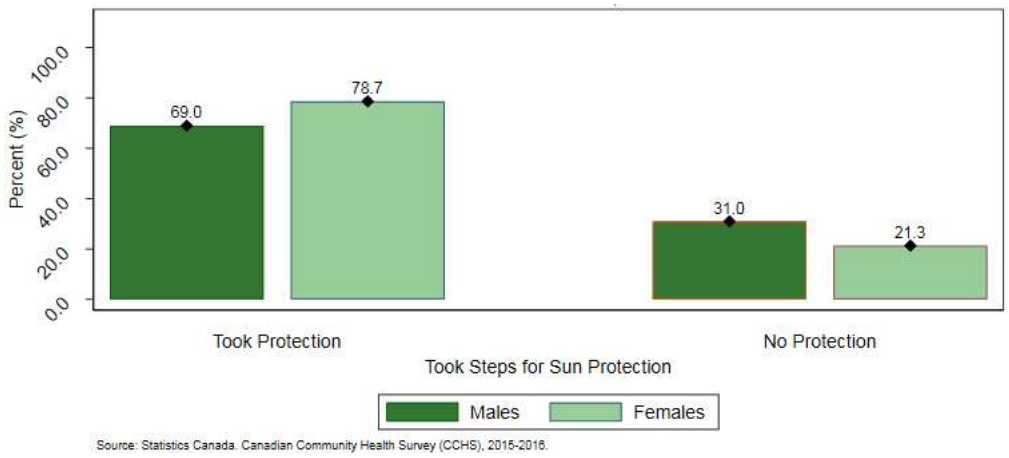
People age 65+ had the highest rate of sun protective behaviour at 82.5%. People in the youngest age-group, 12-17 years, had the lowest rate at 50.9%, meaning that almost half of people this age were exposed to solar UVR. Over 30% of people ages 18-24 do not take steps to protect themselves. This is important because total lifetime exposure increases cancer risk. Development of melanoma, the most fatal type of skin cancer is related to a history of sunburns, especially if exposure has been during childhood or adolescence.(126)

Figure 8.2 Percent of residents, by age-group, aged 12 and over who took steps to protect themselves from the sun, HKPRDHU, 2015-16



Separated by gender, almost 10% more females than males took steps to protect themselves from the sun.

Figure 8.3 Percent of residents, by gender, aged 12 and over who took steps to protect themselves from the sun, HKPRDHU, 2015-16



8.5. Sensitivity to Solar UVR in the HKPR District

People who have fair skin, light eyes and light or red hair tend to sunburn more easily and are at increased risk of all types of skin cancer. Children have thinner skin that is more sensitive and can burn after even a short time outdoors. Children can have three times the annual sun exposure of adults; most of a person's lifetime sun exposure happens during childhood. Children and adolescents who develop a history of sunburns, especially short, intense exposures are at greater risk of melanoma later in life.(136)

8.6. Building Adaptive Capacity to Solar UVR in the HKPR District

Developing skin cancer due to solar UVR exposure is largely preventable; reducing exposure is the key, especially in children and youth. Adaptive actions can take place at a personal level, for example, personal sun protection (using sunscreen, wearing a hat and long clothing), reducing time spent outdoors during peak UV hours; or community level (provision of shade through structures, tree coverage)(122)

UV index was created in 1992 by scientists at Environment and Climate Change Canada as a tool to help Canadians understand exposure risk to UVR. It has since been adopted as a global standard and is used around the world. The forecast gives the maximum amount of UV expected for the day, at noon, when the sun is highest in the sky.(137) The UV Index provides a straightforward way for people to assess risk and take protective measures.

UV categories	UV index range (rounded values)
Extreme	11 or higher
Very high	8 to 10
High	6 to 7
Moderate	3 to 5
Low	2 or less

It is unknown at this time what the level of public awareness is about the UV Index and to what extent people in HKPR district act on it. There may be opportunity to build awareness of the UV Index, what it means and what protective actions to take. Additionally, ensuring that the public is aware of the risks of solar UV exposure as it relates to climate change will be important.

A list of current and potential activities that contribute to adaptation at HKPRDHU and in the community can be found in Chapter 9.

9 Chapter 9: Conclusion – From Vulnerability to Adaptation

The data presented in this assessment shows that residents in the HKPR district are already experiencing many health impacts of climate change, and that there will continue to be climate change impacts in the future. There is a need for adaptive action now and in the future to address projected impacts so that the health burden of climate change is minimized. Many sectors play a role in building adaptive capacity, because many important health-related adaptation options fall under the purview of decision makers outside of the health sector, for example land use and transportation planning, infrastructure and water management.(5) A health lens also strengthens the case for sustainable policies in these areas (138) and public health can and must provide this perspective. Health adaptation planning must also include participation and engagement of those most at-risk.

The climate projection data shows that the HKPR district will experience more hot temperatures, a longer warm season and more extreme precipitation events, with potential increases to heat-related illnesses, worsening of chronic conditions and threats to mental health. These changes in weather patterns will also affect the survival and viability of disease-carrying insects and food and water pathogens, increasing the population's risk of infectious diseases such as Lyme disease, West Nile virus, and food- and water-borne illnesses. Our projected climate future will also affect air quality and exposure to solar ultraviolet radiation, increasing risks of respiratory illness and skin cancer.

Climate change is often described as a threat multiplier and there are several population groups in the HKPR district that are more vulnerable to its negative health outcomes. These include older adults, infants and young children, people living on low income, people with existing medical conditions, Indigenous Peoples, pregnant people and people who work or are active outdoors. The degree to which each of these groups is vulnerable depends on their exposure to a specific climate hazard, their sensitivity to it and how readily they can adapt. Reducing vulnerability requires actions that increase the adaptive capacity of populations that are most likely to be at risk.

9.1. Public Health's Role in Climate Change Adaptation

Public health plays a critical role in building adaptive capacity to address the vulnerabilities many people experience. At HKPRDHU, current work to address vulnerability to climate change occurs at multiple levels. This work includes:

- Communications with the general public and specific populations to increase awareness about actions to take to protect themselves from solar UVR exposure, from ticks and mosquitoes, during periods of extreme heat or poor air quality, and for being prepared in case of a weather emergency. Specific audiences include families, schools, daycares, summer camps and outdoors organizations.
- Collaborating with and supporting community partners so they are climate-ready from a health perspective e.g. emergency planning and response, heat response, maintaining food and water safety
- Engaging with municipalities and working with partners to advocate for local actions and policies that improve the built environment for health and contribute to adaptation e.g. shade in parks

and public spaces, provision of warming/cooling centres, separation of uses (e.g. schools and busy roads), protection of water quality, development of green infrastructure
- Engaging with municipalities and working with partners to advocate for local actions and policies that contribute to climate change mitigation, such as planning for and investing in active transportation, complete streets, and healthy community design
- Working with partners to address poverty as a root cause of vulnerability through advocacy for basic income guarantee and living wage, affordable housing, public transportation
- On-going surveillance and monitoring of diseases of public health interest that are impacted by climate change e.g. Lyme disease, West Nile virus, food and water-borne illnesses
- Knowledge-building with health care providers and health teaching with patients on treatment of vector-, food- and waterborne diseases

Although climate change adaptation may not be the primary focus of much of this work, climate change health impacts are key reasons to continue to build on and strengthen public health work in these areas.

9.2. Public Health Strengths

Public health offers several strengths in efforts to address climate change. One strength identified by both HKPR staff and community partners is working collaboratively with partners from many different sectors to achieve public health objectives. Public health is recognized as a 'convener', having the ability to identify and bring together organizations and individuals around a common issue. Community partners also identified public health as being a reliable, trusted source of health information; indeed, a key role for public health in the climate change conversation is communicating clear, fact-based information. These comments demonstrate that public health plays an important role in addressing climate change and conveying the message that climate change affects us directly by showing how it impacts our physical and mental health.

Communication is an important part of public health work. The data presented in this report provides the basis for evidence-based information to share with the community. Health is personal and highlighting how climate change impacts health helps 'bring the message home', making climate change more real and a less distant, intangible threat. This in turn supports efforts by municipalities and others to reduce greenhouse gas emissions; people are more likely to see the benefits of mitigation measures when they see how climate change is affecting them directly.(139)

Emergency management is a core public health function, and the COVID-19 pandemic has shone a spotlight of public health's important and multi-faceted role in this area. Public health is an important partner in responding to climate-related emergencies such as floods, extreme weather events, and extreme temperatures. Mental health is also a public health priority. Because of the growing evidence of climate change impacts on mental health, public health can contribute to and participate in initiatives that seek to build resilience in the community's mental health.

Public health also provides an important voice on health equity. There is a known relationship between income and health; the less money you have, the less healthy you are likely to be. Living with low-income is identified as a vulnerability throughout this report and climate change will magnify existing health challenges faced by people who live in poverty. Public health has an important role to play to ensure that health equity and the needs of those who are most vulnerable are considered in all climate

change planning, both within our own organization and in the community. Addressing health inequities due to the social determinants of health is required to increase climate change resilience. Otherwise, efforts may benefit only part of the population and worsen existing inequities.(5)

9.3. Public Health's Role in Climate Change Mitigation

While the purpose of this report has been to focus on public health action related to adaptation, there is also a strong case to be made for public health to also focus action on climate change mitigation. When it comes to climate change, mitigation is an upstream action while adaptation is more downstream. Dr. Theresa Tam, Canada's Chief Medical Officer of Health states in her 2022 report on the state of public health in Canada that, "…A key focus for upstream public health attention is climate change mitigation."(16)

Adaptation is only part of the equation related to protecting health. Given the current 'business as usual' emissions trajectory, without significant mitigation efforts, even robust adaptation measures will not be enough to protect human health.(140) Public health should continue to focus on adaptation, but there needs to be a concurrent focus and efforts on reducing greenhouse gas emissions.(5) As this report illustrates, the health of our population is already being impacted by climate change and the greater the change the greater the threats to health.

Potential climate change mitigation actions that HKPRDHU could take include:

- assess our CO_2 emissions as an organization and plan for ways to reduce them
- assess other environmental impacts such as use of single-use plastic and other items, energy consumption, and plan for ways to address them
- increase staff's knowledge about climate change, its impacts on health, and strategies for adaptation and mitigation
- continue and strengthen advocacy for community design that supports mitigation such as reducing motor vehicle travel, supporting active and public transportation, increasing greenspace, improving access to local food (141)
- advocate for and support local climate change action plans
- advocate for local, provincial and federal policies that will reduce CO_2 emissions
- recognize and communicate that all public health work to keep people healthy contributes to climate change mitigation because it reduces demand for primary care; the health care system is a significant contributor to CO_2 emissions. Keeping people out of the health care system thus reduces this system's climate impact.(142)

9.4. Considerations from Consultations

Both HKPRDHU staff and community partners recognized a range of ways that climate change impacts the health of vulnerable populations. A recurring theme was a disconnect among vulnerable populations with information put out by the health unit. There need to be improvements in our communication when it comes to taking protective actions in the face of climate change. Factors identified that create barriers include information written at a high literacy level, people not having the resources needed to be prepared/adapt, not using the communication channels typically used by the health unit and being focused on meeting daily needs such as food and housing. All of these factors amplify vulnerability,

because the people who need it most are not getting the information and support they need to protect their health and safety.

Too often, information provided by HKPRDHU is not accessible or relevant to the people who are most vulnerable and might need it the most. Making information accessible means that it is written in plain-language, understandable for the intended audience and available where and when those who need it can get it. This benefits all audiences, including those who have literacy challenges. Relevant means that the information is practical and useful for the audience and takes into consideration the unique needs and perspectives of those it is intended to reach. This means using communication channels beyond typical methods. For example, information can be shared with front-line workers who have regular contact with vulnerable groups; it does not always have to come directly from public health.

It was noted that stigma and fear of judgment can be a barrier to people accessing potential supports. The term 'vulnerability' itself can be stigmatizing and can perpetuate a narrative of victimization.(5) The words 'vulnerable' and 'vulnerability' are used throughout this report; it is important to communicate that the purpose is not to label specific populations, but to explore how health equity and determinants of health contribute to exposure, sensitivity and adaptive capacity and shape vulnerability to climate change.(5)

A key recommendation is to consult with people with lived experience in the development of the adaptation plan. Systems in place tend to be geared to the general population, which leaves some people behind. To meet the needs of the people who are most vulnerable, we need to ask them what adaptation strategies are most appropriate, what language to use, how to make information useful and the most effective ways to get it to them. It is also important to take a strength-based approach and identify assets that exist and ask these groups to share their solutions.

Similarly, further adaptation planning must include engagement with Indigenous communities. We have an opportunity to learn from Indigenous partners how their traditions and practices can strengthen adaptation to climate change and reduce our environmental footprint.

Some additional considerations were provided by HKPRDHU staff and community partners for communicating links between climate change and health:

- Package information into simple, 'bite-sized' pieces. This benefits everyone, not just harder-to-reach people.
- Tell stories. Dramatic stories elicit an emotional response that can be more powerful than numbers in changing behaviour.
- Adaptation messages are a way to get people's attention by illustrating what changes are to come.
- Look for ways to integrate climate change and health messages into other public health work already being done.
- Work with community partners to get information to vulnerable and harder-to-reach populations.
- Engage schools; youth are very engaged with climate change.

9.5. Climate Change Will Impact Public Health Work

HKPRDHU staff identified several ways in which climate change directly impacts their work, and how it will continue to do so in the future. Staff who work outdoors will face greater exposure to extreme heat, solar UVR, vector-borne diseases and poor air quality. Extreme and unpredictable weather events can lead to hazardous road conditions that threaten the safety of staff and clients, or cancellation and postponement of clinics, home visits, workshops and group meetings. Residents may miss out on vaccines, testing, treatment, consultation, and information, and in the case of groups, social interaction.

Staff also spoke to the need to integrate a climate change lens into all areas of work, in the same way that health equity and emergency planning are considerations in all public health programs and services. They also raised the need for HKPRDHU to develop our own climate action plan that identifies how we can reduce our environmental footprint e.g. through reducing waste, energy consumption and use of single-use plastic. As an organization, HKPRDHU needs to consider how we can contribute to climate change mitigation to reduce the severity of future impacts on human health.

9.6. Next Steps

A communication plan will be developed to share key findings from this Phase 1 report with HKPRDHU staff and the community.

The next phase of this project is the development of an adaptation action plan, which will be informed by the findings contained in this report. The adaptation plan will identify gaps and further develop opportunities to ensure positive health outcomes in the face of climate change. Considerations listed above will be incorporated into the Phase 2 plan.

Objectives for Phase 2 are to develop a Climate Change Health Adaptation Action Plan that identifies:

- Effective ways to integrate climate change adaptation into existing HKPR programs
- Gaps in HKPR's current climate change adaptation actions, and assets and opportunities to address these gaps
- How HKPR can support and work with partners and people with lived experience to increase adaptive capacity in the community related to health impacts of climate change
- Ways to continue to strengthen partnerships between HKPR, municipalities and community partners related to climate change adaptation and mitigation
- A strategy for evaluation and monitoring progress and effectiveness

Community engagement will be a key piece of Phase 2. Key groups identified for engagement

- People with lived/living experience
    - How do they see climate change impacting their health?
    - How can public health support their health around climate change?
- Indigenous communities
    - What can we learn from Indigenous ways of knowing the land and our relationships to it?
    - How do Indigenous peoples in HKPR district see climate change impacting their health?

    - How can public health support Indigenous health around climate change?
- Community partners, including municipalities, community agencies, health care, community interest groups

A key resource to be used as a starting point for HKPRDHU's adaptation action plan is a report prepared by Simcoe Muskoka DHU, Cambium Indigenous Professional Services and the Public Health Agency of Canada, "Two Approaches, One shared Learning Journey to support Climate-health Adaptation Planning" , December 2020

This Vulnerability Assessment is the first step in building our understanding at HKPRDHU of the current and potential climate change impacts on health in our population and integrating this into our work. Climate change is a threat to human health, so it is critical that our programs and services address climate change impacts. Climate change also presents another opportunity for us to work with community partners to protect the health of our communities, today and in the future.

9.7 Current Adaptation Strategies

The following tables summarize the current programs and services offered by HKPRDHU (Table 9.1) and in the community (Table 9.2) that contribute to climate change health adaptation. Tables 9.3 and 9.4 list gaps and opportunities at HKPRDHU and in the community. The activities were identified through focus groups and key informant interviews held in 2019 and reflect work that was being done at that time. Not all groups in the community were directly consulted, therefore community lists may not present a complete picture of all relevant programs. An update will be needed for the adaptation action plan. Table 9.5 identifies climate change impacts on HKPRDHU programs and services.

Table 9.1: ***Current work at HKPR that contributes to climate change adaptation***

The table below lists current ways that HKPR programs address climate health risks. The activities were identified through focus groups held in 2019 with HKPR departments and reflect work that was being done at that time. An update will be needed for the adaptation plan.

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Population Assessment	Yearly RRFSS modules including: General attitudes about climate change; extreme heat; VBD; UVR exposure; drinking water; food safety; food security; behaviour during air quality warnings	Foundational Standards	All	General public		
	Annual Community Health Status reports	Foundational Standards	All			
	Census summaries	Foundational Standards	All			
	Reports on reportable vector borne diseases	Foundational Standards	VBD			
	CCHS data – food insecurity, sun safety practices	Foundational Standards	Food Security Solar UVR			
	Monitoring cost of healthy eating through Nutritious Food Basket	Community Nutrition	Food Security			

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Surveillance	Tracking of number of heat alerts sent out	Emergency Management	Extreme Temperatures			
	Monitor/track number of policy recommendations that address exposure to heat (e.g. shade policies)	Healthy Communities	Extreme Temperatures			
	Calls and actions related to an emergency documented in Hedgehog – review/debrief after	Environmental Health	Extreme Weather			
	Receive and share extreme weather notifications internally	Environmental Health	Extreme Weather			
	Active surveillance – tick dragging, mosquito pool testing	Environmental Health	VBD			
	Surveillance of actual cases through iPHIS	Infectious Disease Foundation Standards	VBD			
	Monitor public beaches and sample beach water. Receive all adverse water quality test results and observations from drinking water system operators	Env'tal Health	Waterborne illness – rec water Waterborne illness – drinking water	General public Operators of SDWS	municipalities	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
	Surveillance at facilities and at source (e.g. where food is grown, harvested, prepared)	Env'tal Health	Foodborne illness			
	Reportable diseases reported in iPHIS and case investigations and enhanced surveillance as required	Infectious Diseases	Foodborne illness			
Health Promotion	Education/information sharing through family home visits, Intake line, parenting groups, clinics, prenatal classes re: coping with heat, emergency preparedness, sun protection/sun safety kit	Family Health	Extreme Temperatures, Extreme Weather Solar UVR	Pregnant people, young families, low-income	Local community agencies	
	Health teaching: During power outages and other extreme events, nurses call families to give information e.g. ensuring safe water, preparing safe formula, heat. Important for people who are isolated due to lack of transportation. Contact clients when notification of extreme heat/weather to discuss how to be prepared – real time preparation. Often communicate by text	Family Health	Extreme Temperatures Extreme Weather	Pregnant people, young families, low-income		

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion	Supporting community partners on establishment of 'comfort' centres for warming, cooling, bathrooms	Health Equity Emergency Management	Extreme temperatures, extreme weather	Low-income, pp exp homelessness	Municipalities Agencies that support vulnerable groups	
	Support municipality in development of vulnerable sector plan	Health Equity Emergency Mgmt	Potentially all	Low-income, pp exp homelessness	Northumberland county	
	Municipal engagement and advocacy for healthy municipal policies (including land-use, shade, Age-friendly planning, active transportation, community design, food policy, food systems)	Healthy Communities Community Nutrition	Extreme Temperatures Extreme Weather Food Security Air Quality	Whole community Older adults People living on low income	Municipalities	GGH mitigation Chronic disease and injury prevention
	Partner with agencies who work with vulnerable people on ways to get information out that is practical and useful	Emerg Mgmt Health Equity	Extreme Temperatures Extreme Weather	Older adults People living on low income	Local community agencies	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion				People exp. homelessness		
	Policy and partnership work to address the social determinants of health – issues related to income (living wage, basic income guarantee), housing, transportation, food security	Community Nutrition Health Equity Healthy Communities	All	People living on low income People experiencing homelessness	Local community agencies	
	Presentations on how to be prepared for an emergency, especially with groups that may have special needs/considerations	Emergency Mgmt	Extreme Temperatures Extreme Weather	Groups with special needs e.g. brain injury groups	Local community agencies Volunteers	
	Provide support to school boards as requested on policies and procedures related to health e.g. safe practices in heat, cold; nutrition; medical health management	School Health	Extreme Temperatures Solar UVR	Children and youth	Schools School boards	
	Held contest to promote Emergency Preparedness (2019)	Emergency Mgmt	Extreme Weather	General public		
	Promotion of Emergency Preparedness Week	Emergency Mgmt	Extreme Weather	General public		

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion	Make presentations on emergency planning and preparedness as requested	Emergency Mgmt	Extreme Weather	variable		
	High and low risk areas for Lyme Disease posted on website	Communications	VBD	General public		
	Provide education and communication about VBDs on protection and prevention. Strategies include presentations, home shows info booths, print/online information. Distribution of tick keys.	Env'tal Health School Health Inf Diseases Family Health Communications	VBD	community groups, schools, parents, general public, summer camps	Schools Community groups Municipalities Camps	
	Promote eTick website	Env'tal Health Communications	VBD	General public		
	Food literacy and food skills training, including food safety when it's hot	Community Nutrition	Foodborne Illness			
	General public food safety information (fact sheets on safe BBQing)	Env'tal Health Communications	Foodborne Illness	General public		
	Local food systems planning, promotion and policy development; awareness	Community Nutrition	Food Security	People living on low income	Local Food Coalitions Municipalities	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion	raising; building a sustainable food system					
	Promoting community gardens, grow-a-row	Community Nutrition	Food Security			Chronic disease prevention
	Food literacy projects – building food/nutrition knowledge, cooking skills, understanding food systems, reducing food waste e.g. Apple sauce project	Community Nutrition	Food Security		Community Agencies	Chronic disease prevention
	Piloting farm to school programs – using local produce to increase access to fresh fruit and vegetables in schools	Community Nutrition	Food Security		Schools	Chronic Disease prevention
	Promotion of breastfeeding – always safe, available, affordable	Family Health Community Nutrition	Food/waterborne Illness Food Security	Parents of infants	Community Agencies	
	Work with schools on comprehensive school health has included sun protection in schoolyard Ongoing promotion of sun safety e.g. through school newsletters	School Health	Solar UVR	Students Parents School Staff	Schools School boards	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion	General messages in summer and if going south through social media	Communications	Solar UVR	General public		
	Low income housing is often located near environmental hazards and/or far from services. This can increase exposure to environmental hazards or if walking, exposure to heat, sun and poor air quality. Potential to review site plans for housing development with this in mind.	Healthy Communities Health Equity Environmental Health	Air Quality Solar UVR Extreme Temperatures	People living on low income	municipalities	
Health Protection	Heat Alert Response Program	Emergency Mgmt	Extreme Temperatures	General public	Municipalities Local community agencies	
	Extreme weather notifications (e.g. precipitation, flooding)	Emergency Mgmt Communications	Extreme Weather	General public	Municipalities Local comm agencies	
	Receive general calls during hot weather asking if there is legislation re: working outside in high temperatures. Referred to EH.	Communications Environmental Health	Extreme Temperatures	General public		

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Protection	Provide support as requested by LTC/retirement facilities on how to balance Ministry of Labour regulations and infection control re: staff having access to drinking water when it is hot	Infectious Diseases	Extreme Temperatures	Workers	LTC homes Retirement homes	
	Partnered with Kawartha Conservation on social media campaign on Harmful Algae blooms (blue green algae)	Environmental Health	Waterborne Illness	General public Waterfront property owners	Kawartha Conservation Cottage associations	
	Provide education during recovery phase of emergency (e.g. well disinfection, dealing with mould); may go door to door if applicable Provide fact sheets to municipalities to post on their websites	Environmental Health Communications	Extreme Weather	People impacted by emergency	Municipalities	
	Inspect emergency shelters (in event of evacuation)	Environmental health	Extreme Weather		Municipalities	
	Encourage agencies and individuals to pick up harm reduction supplies in advance of severe weather so that they are prepared	Harm Reduction	Extreme Weather	People who are substance users	Harm reduction partners	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Protection	Ensure safety of overdose medication and vaccine – i.e. maintaining proper storage temperatures Contingency plans for vaccine storage and handling in event of power outage	Harm Reduction Vaccine Preventable Diseases	Extreme Weather			
	Provide vaccine clinics in local communities to reduce travel, address health inequity	Vaccine Preventable Diseases	Extreme Weather	Older adults and others with transportation barriers	Municipalities Health Care partners	Reduce GGH emissions with less travel
	Flexible to meet needs of clients if a clinic is cancelled due to weather e.g. make alternative appointment, travel to see client, meet by phone	Sexual health	Extreme Weather			
	Participate on municipal control groups and contribute input, evidence and discussion on HIRA priorities. Raise awareness of health impacts and role of public health	Emergency Mgmt	Extreme Weather		Municipalities	
	Promote 72-hour emergency preparedness kit	Emergency Mgmt	Extreme Weather	General public	Municipalities	
	Working with primary health care providers on poverty assessment tool, to	Health Equity	Extreme Weather	People on low income	Health Care providers	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Protection	assess income so they can provide support					
	Work with health care sector on planning for meeting needs of vulnerable sector during emergency e.g. people in home receiving home nursing, palliative care – make sure municipalities know who to notify	Emergency Mgmt	Extreme Weather	People who are homebound	Municipalities Community Paramedicine Primary Care	
	Participate in municipal emergency 'exercises'; review health unit role and process	Emergency Mgmt	Extreme Weather		Municipalities	
	Case follow up on Lyme Disease – health teaching and resource sharing	Infectious Disease	VBD	People infected with Lyme		
	Communication with health care providers about VBDs to help ensure timely diagnosis and treatment	Infectious Disease	VBD	Health Care providers	Health Care providers	
	Provide public Information: Lyme and WNV e.g. reducing standing water from heavy rain and flooding	VBD working group	VBD	General public		
	Respond to inquiries about dealing with standing water and risk of VBD (WNV)	Env'tal Health	VBD	General public		

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Protection	Safe food handler training	Env'tal Health	Foodborne Illness	Workers Food premises		
	Disclose/post all drinking water advisories and provide direction to users of the drinking water on what measure to take not to get ill Promote owners of private wells to test their wells.	Env'tal Health	Waterborne Illness	Property owners		
	Inspect small drinking water systems to ensure compliance with applicable regulations. Issue boil water orders/advisories for adverse water quality and observations.	Env'tal Health	Waterborne Illness	Property owners		
	Work with food operators to ensure food safety during and after power outage	Env'tal Health	Foodborne Illness		Food operators	
	Inspection of food premises, including mobile vendors Review and conduct risk assessments of special event applications, provide education to vendors / organizers and	Env'tal Health	Foodborne Illness		Food operators	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
	conduct inspections of special events as required.					
	Inspect/investigate/educate about risks to drinking water due to flooding, heavy rain and measures to take Interpret drinking water samples for private well owners. Outdoor pool inspections – UV can affect water chemistry	Env'tal Health	Waterborne Illness	General public People exposed to flooding Property owners	Municipalities	
	Work with municipalities regarding beach postings and remediation strategies	Env'tal Health	Waterborne Illness		Municipalities	
Health Protection	Case investigations and health teaching with individuals for safe food handling etc for reportable diseases. Investigate food-related outbreaks	Infectious Diseases	Foodborne Illness			
	Provide information to summer camps on sun safety	Infectious Diseases	Solar UVR	Campers and staff	Camps	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
	Respond to/investigate complaints about indoor air quality e.g. mould due to flooding	Env'tal health	Air Quality	People living in poor housing, exposed to flooding	Municipal Bylaw	

Table 9.2: ***Current work in the community that contributes to climate change adaptation***

The table below lists current programs and services in the community that address climate health risks. The activities were identified through focus groups and key informant interviews held in 2019 and reflect work that was being done at that time. Not all groups in the community were directly consulted, therefore this list may not present a complete picture of all relevant programs. An update will be needed for the adaptation plan.

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Developing/completed Climate Change Action Plans for municipality	NLD County, CKL, Haliburton County Community groups	All	Community-at-large	CC mitigation
Subsidies for people at risk of having no heat (Enbridge, Ontario Hydro subsidy program, OESP, LEAP, Housing Helps, Municipal Community and Social Services)	John Howard Society HELP Centre Municipal social services Habitat for Humanity	Extreme Temperatures	People living on low income	
Funding: Subsidy programs to help people with housing repairs (e.g. Renovates Program)	Community agencies	Extreme Temperatures Extreme Weather	People living on low income	CC mitigation

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Housing Corporation – new builds have AC, all units include heat and hydro, consider longevity of materials e.g. steel vs asphalt roof Older buildings – have common area that will be AC'd to be a cooling centre Have generators at facility	Hal/CKL Housing Corporation	Extreme Temperatures Extreme Weather	People living on low income	CC mitigation
CKL Healthy Environment Plan (2019) recommends developing and implementing a response program for vulnerable populations to protect residents from climate-related risks and create a system to communicate messages to help them prepare for and respond to climate events (143)	City of Kawartha lakes	Extreme Temperatures Extreme Weather	Vulnerable populations	
All municipalities required to have Energy Conservation and Demand Management Plan, to reduce energy demand in buildings	Municipalities	Extreme Temperatures		CC mitigation
Wellness checks of people at risk – member of public can call to ask for a family member to get checked CKL community care incorporates wellness checks with Meals on Wheels	Police Services Paramedics Community Care	Extreme Temperatures	Older Adults Other at-risk populations	
Vulnerable Sector Planning	Northumberland County	All	Vulnerable populations	
Identify and promote cooling /warming centres	Municipalities Libraries (NLD Cty)	Extreme Temperatures	People without home air conditioning	
Operate splash pads, pools. New water Park @ Boys and Girls Club	Lindsay B and G Club, municipalities, YMCA	Extreme temperatures	Children, youth, families	

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Enable access to green space for cooling, mental health benefits	Kawartha Conservation	Extreme Temperatures	General public	CC mitigation
Tree planting programs– helps with cooling GIS mapping of heat islands to identify where to plant trees Promoting forests as places for natural cooling	Northumberland County Kawartha Conservation	Extreme Temperatures	General public	CC mitigation
At client support groups, talk about climate related topics e.g. how to prevent falls in winter, coping with heat	Local community agencies	Extreme Temperatures Extreme Weather	Client groups including: older adults, vulnerable families	
Plan in advance for extreme weather – cancel programs if buses are cancelled Adapt program schedule e.g. hold during better weather to make travel easier; trade-off is that it can be winter when people need programs the most to reduce isolation	Local community agencies	Extreme Weather	Client groups including: older adults, vulnerable families	
Have Emergency Response Plan to ensure staff coverage at facility	Shelters, LTC homes	Extreme Weather		
Grant for $ to give out free cleats for traction in winter	Aging Well Ctte	Extreme Weather	Older adults	
Flood plain mapping	Conservation authorities Haliburton County	Extreme Weather	People living on flood plains	
Upgrading weather gauge stations to gather more accurate local data	Kawartha Conservation	Extreme Weather		
Cross-sectoral partnerships to plan for flood mitigation and adaptation (e.g. Upper Trent Watershed Management Partnership)	Haliburton County	Extreme Weather		
Issue flood warnings/alerts	Conservation Authorities	Extreme Weather	General public	

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Have green infrastructure demonstration sites	Kawartha Conservation	Extreme weather Waterborne Illness	General public	CC mitigation
Citizen science initiatives to monitor temperature and precipitation	Kawartha Conservation	Extreme Temperatures Extreme Weather Waterborne illness	General public	
Communication: Use strategies to "follow the line of relationship" to be aware of and check on vulnerable people Think about how to get message out – less paper, more instant messaging, social media Asking people their preferred way to get info Provide info on website for ways to ensure people who can't hear can still receive critical info Messages to remind people to check on each other	Local community agencies Hearing Society	Extreme Temperatures Extreme Weather	Vulnerable groups People who are harder to reach	
Designate or hire an Emergency Management Coordinator, have Municipal Control Groups to plan for emergencies, develop Emergency Response Plans, hold mock exercises, complete Hazard Identification Risk Assessment (HIRA)	Municipalities	Extreme Temperatures Extreme Weather		
Low Water Response Program – initiated during periods of drought	Conservation authorities	Extreme Temperatures Extreme Weather		
Education about Lyme disease in general, and in relation to pets	Ontario Parks Conservation authorities	VBD	General public People who work outside	

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Shoreline protection bylaws	Municipalities	Waterborne illness	Waterfront property owners	CC mitigation
Recreational water improvement (e.g. Blue Flag designation)	Municipalities	Waterborne illness	General public	
Establish Community gardens e.g. Crayola garden. Gardens practice mulching to reduce water use. Provide sun shelter.	Crayola, United Way, Fleming, Food Source CKL Food Security WG Community Gardens network, HKPRDHU	Food Security		Chronic disease prevention: Access to health food, physical activity
CKL council reduced speed limits to 40 km/hr across the city in 2020. Will improve safety and encourage more people to walk, cycle for transportation.	CKL	Air quality	General public	CC mitigation Chronic disease prevention
Bicycle and active transportation planning	municipalities	Air quality	General public	CC mitigation Chronic disease prevention
Install electric vehicle charging infrastructure	Municipalities	Air quality	General public	CC mitigation

Table 9.3: *Opportunities for future work on adaptation – HKPR*

The table below lists future opportunities for HKPR programs to address climate health risks. These were identified through focus groups held in 2019 with HKPR departments and will be further explored in the development of the adaptation plan.

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Population Assessment	None identified					
Surveillance	Annual summary of Hedgehog data related to emergency response	Environmental Health	Extreme Weather			
	Strengthen relationships with veterinarians who test ticks on animals and get faster results, to enhance our surveillance data	Environmental Health	VBD		Veterinarians	
	Formalize annual tracking of beachwater testing results	Environmental health	Waterborne illness			
Health Promotion	Potential in Injury Prevention to promote heat and cold alerts, providing information to public on adaptive actions during extreme temperatures Cross promotion of messages on social media pages When work was more topic based Physical activity promotion used to include messages about outdoor activity in heat and cold. Not currently done	Healthy Communities Healthy Families Communications	Extreme Temperatures	Families Older adults People living on low income People who work or are active outdoors	Sports Councils	
	Share messages with schools, parents, workplaces, day cares about protective actions	Healthy Schools Environmental Health	All	Children and youth Parents People who work outdoors	School boards Schools Day cares Chambers of Commerce Rec camps	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Promotion	Engage with people with lived/living experience to determine most effective way to get information out to them. Healthy Babies Healthy Children staff work with vulnerable, at-risk families and could be good conduit for information and for input.	Healthy Families Climate Change Lead	All	People experiencing vulnerability to climate change	Local community agencies Volunteers	
	Engage with health care professionals regarding their role in climate change health adaptation & impact on health care system	CC Lead	All	Health care professionals	Health services Family Health Teams Comm Health Centre Mental Health and Addictions support	
	Engage with Indigenous community in development of adaptation plan	CC Lead Health Equity	All	Indigenous community		
	Review and revise messaging to ensure it is literacy-friendly (e.g. emergency preparedness, heat safety, protection from VBD, sun safety, air quality)	Health Equity Emergency Mgmt Env'tal Health School Health Family Health CC Lead	All	People with low literacy General public		
	Consider how to identify families/people at risk that are not part of our case load to ensure their safety and provide. Connect	Family Health	Extreme Weather	Families and others at-risk or hard to reach	Local community agencies e.g. SIRCH	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
	with other community agencies who work with them. Could increase health teaching about how to be prepared for emergencies for families at risk					
Health Promotion	Improve collaborations / connections with community and volunteer-based groups that put on free meal programs	Community Nutrition	Food Security	People living on low income	Community agencies	
	Look at ways to reduce food waste in food programs and food system	Community Nutrition	Food Security		Env'tal committees CKL Food rescue.ca	CC mitigation
	Increase/improve messaging with schools, parents, workplaces, day cares about protective actions	School Health Communications CC lead	All	Students Parents workers	Schools Day cares Workplaces	
	Partner with community groups to distribute sunscreen, protective clothing to vulnerable groups e.g. at warming /cooling centres	Health Equity	Solar UVR	People experiencing homelessness	Shelters	
Health Protection	Advocate for policies that identify indoor temperature thresholds for heat/cold (e.g. LTC/retirement facilities, workplaces)	Environmental Health	Extreme Temperatures	Older adults Workers	LTC homes Retirement homes	
	Consider adding to LTC/retirement facility profile whether or not they have air conditioning. Find out about legislation re: temperature thresholds and requirements to maintain	Infectious Diseases Environmental Health (?)	Extreme Temperatures	Older adults	LTC homes Retirement homes	

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Health Protection	Assist LTC/retirement facilities with problem solving on dealing with extreme heat, developing heat response plan	Infectious Diseases EH? Emergency Mgmt	Extreme Temperatures	Older adults	LTC homes Retirement homes	
	Support development of policy and best practice for designating a municipal cooling centre	Environmental Health	Extreme Temperatures	People exp homelessness	Municipalities Emergency Housing providers	
	Develop protocol for HKPR response during an extreme event, and clarify role within municipal response	Emergency Mgmt Env'tal Health	Extreme Weather		Municipalities	
	Develop Cold Alert Response program (in process)	Emergency Mgmt	Extreme Temperatures	People exp homelessness	Municipalities	
	More/stronger collaboration with Ontario Health teams for more integrated service and response during an emergency	?	Extreme Weather		OHTs	
	Advocate to municipalities to install water refill stations and water fountains	Healthy Communities	Extreme Temperatures	General public	Municipalities	
	Have water bottle fill stations, bug spray and sunscreen available at HKPR offices as well as reminder signs to drink water when it's hot	Corporate Services	Extreme Temperatures	HKPR clients		
	Continue efforts with messages in hospitals re: VBD prevalence	Infectious Disease Env'tal Health	VBD	Health care providers General public	Health Care providers Hospitals	
	Issue messaging about what to do in case of poor air quality due to wildfire smoke	Emergency Mgmt	Air Quality	General public		

Public Health Role	Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
	Promote Air Quality Health Index					

Table 9.4: Opportunities for future work on adaptation – Community

The table below lists future opportunities for community initiatives to address climate health risks. These were identified through focus groups held in 2019 with select partners and will be further explored in the development of the adaptation plan.

Activities	Who is Involved	Climate Change Hazards Addressed	Target population(s)	Climate change or public health co-benefits
Building social housing to be climate resilient (Passive House Standard) – train local contractors in those modes of construction	Northumberland County	Extreme Temperatures Extreme Weather	People living on low income	CC mitigation
Potential to look at libraries as cooling centres especially in smaller communities	Municipalities (other than NLD)	Extreme Temperatures	People without air conditioning	
Develop Low Impact Development Initiatives to demonstrate what people could do on their property e.g. to control runoff	Kawartha Conservation			CC mitigation
Develop Green infrastructure plan	Municipalities			CC mitigation

Table 9.5: Implications for HKPR Staff and Programs

Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
Staff working outside are exposed to heat/sun e.g. working a booth at an outdoor event. Pop up tents are available.	Emergency Management Occ H&S Committee	Extreme Temperatures Extreme Weather Solar UVR			

Activities	Department / Teams involved in work	Climate Change Hazard Addressed	Target population(s)	Partners	Climate change or public health co-benefits
HKPR Joint Health and Safety Committee identifies and addresses health risks and exposures. Procedures and protective equipment provided e.g. sunscreen, hats,					
Winter storms result in cancellation of clinics (including school clinics for oral health, vision, sexual health, vaccines). Travel safety considerations for staff and clients. Required to reschedule school clinics but could run out of time in school year.	School Health Oral Health VPD	Extreme Weather		Schools Clinic clients	

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