DURHAM REGION
HEALTH DEPARTMENT

2024

CLIMATE CHANGE *and* HEALTH *in* DURHAM REGION

Assessing the impact of extreme heat

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The Region of Durham exists on lands that the Michi Saagiig Anishinaabeg inhabited for thousands of years prior to European colonization. These lands are the traditional and treaty territories of the Nations covered under the Williams Treaties, including the Mississaugas of Scugog Island First Nation, Alderville First Nation, Hiawatha First Nation, Curve Lake First Nation, and the Chippewa Nations of Georgina Island, Beausoleil and Rama.

We honour, recognize, and respect Indigenous Peoples as rights holders and stewards of the lands and waters on which we have the privilege to live. In our efforts towards reconciliation, we continue to build and strengthen relationships with First Nations, as well as the large Métis community and growing Inuit community here in Durham. We commit to learning from Indigenous values and knowledge, building opportunities for collaboration, and recognizing that we are all connected.

CLIMATE CHANGE AND HEALTH IN DURHAM REGION:

Assessing the impact of extreme heat

REPORT | July 2024

durham.ca/ClimateAndHealth

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ACKNOWLEDGEMENTS

We would like to thank the Mississaugas of Scugog Island First Nation (MSIFN) for their support and guidance. MSIFN identified important gaps in our climate change and health vulnerability assessments, including a holistic approach to Indigenous health, and made recommendations for strengthening the reports.

We would also like to express our gratitude to the dedicated team members and advisors listed below. Their support and commitment to excellence have been instrumental and this report would not have been possible without their collective efforts. We appreciate their contributions and extend our genuine thanks to each of them.

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This document is available in its entirety in electronic format (PDF) on the Durham Region Health Department website at: www.durham.ca/ClimateAndHealth

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About this report

This extreme heat report is the first in a series of Durham Region Health Department climate change and health vulnerability assessments.

Climate change is projected to increase the number, intensity and duration of climate hazards such as extreme heat, wildfires and flooding. Significant action is required to both mitigate and adapt to climate change to protect the livability of our planet and the places we call home.

In Canada, federal and provincial vulnerability assessments have been completed to determine the impact of climate change on health. Less is known about local health risks and vulnerabilities faced by Ontario municipalities. To fill this knowledge gap, the Durham Region Health Department (DRHD) initiated a series of climate change and health vulnerability assessments (CCHVA) to determine current and future impacts of climate hazards on the health and wellbeing of Durham's residents. Each vulnerability assessment focuses on a specific climate hazard and has been written as a stand-alone report. **This vulnerability assessment explores current and projected health impacts of extreme heat in Durham Region**.

The DRHD's extreme heat and health vulnerability assessment will help our region to:

- Better understand local health risks due to extreme heat, including those who may be most affected.
- Develop place-based strategies for protecting residents from extreme heat. Examples include surveillance and warning systems and training of health professionals on extreme heat-related health impacts.
- Champion health equity by prioritizing measures to reduce impacts to equity-deserving people and groups.
- Improve public engagement and local knowledge on how to prepare for and respond to the health risks of extreme heat.
- Ensure a health lens is applied to broader regional climate action planning, policy and program development.
- Promote community partnership development, including meaningful engagement with priority populations to understand barriers to climate-adaptation measures as well as potential harms or unintended consequences of adaption plans.
- Establish health indicators and metrics of community climate resilience to extreme heat.
- Identify intersectional adaptation interventions that offer numerous health co-benefits.
- Find opportunities for working across municipal sectors to deliver health benefits to Durham Region residents.

Detailed information about the CCHVA process, Durham Region's diverse environment and communities, and a high-level summary of the causes and impacts of our changing climate can be found in the previously published report: Climate Change and Health in Durham Region: Understanding the local health impacts of climate change, available at:
durham.ca/ClimateAndHealth

Executive Summary

This vulnerability assessment explores current and future local health impacts of extreme heat due to climate change. Findings will be used to support evidence-informed adaptation plans, policies and programs to protect the health of Durham Region residents.

Extreme heat and health

Extreme heat events are the deadliest weather-related events in Canada, but they do not affect everyone equally.

- Extreme heat is associated with illness, pregnancy complications, hospitalization and death.
- Durham Region data demonstrate increased health burden and emergency room visits associated with maximum temperatures above 30°Celcius.
- The local burden of heat-related illness in Durham Region is underestimated and underreported, particularly among older adults.
- Some people are at greater risk of harm from heat than others and vulnerability is determined by three main factors: exposure, sensitivity, and adaptive capacity.
- Our understanding of heat health risk is still evolving, but in general, priority populations include the following groups (see **Table 4.1**):
    - older adults 60 years of age and older;
    - infants and young children;
    - pregnant individuals;
    - Indigenous Peoples;
    - people with chronic health conditions (e.g., chronic illnesses, disabilities, obesity, cognitive and mental health challenges and substance use challenges);
    - socially and materially disadvantaged people;
    - newcomers and transient populations such as tourists; and
    - people who work or are physically active outdoors.
- It is possible to prevent heat-related illness and death in Durham Region by reducing heat exposure, prioritizing those most sensitive to negative health impacts and supporting local capacity for taking preventive and protective measures.
- As residents experience increasing exposure to extreme heat, so will the natural environment that residents depend on. This connection is crucial, and emphasizes the need for heat tolerant nature-based solutions that mitigate heat and increase heat resilience.

Extreme heat exposure in Durham Region

All Durham Region residents can expect greater future exposure to extreme heat. Negative health impacts may be greatest among Durham's seven priority neighbourhoods (PN).

- Heat waves in the region are projected to more than double between 2050 and 2080.
- The northern municipalities of Brock, Uxbridge and Scugog are projected to experience a greater increase in extreme heat days than southern municipalities.
- The annual number of tropical nights in Durham Region is projected to increase by almost a month and a half by the end of the century.
- The number of urban heat islands in Durham Region is expected to increase.
- Residents living in urban heat islands of Pickering, Ajax, Whitby and Oshawa may be more exposed to higher than projected extreme temperatures.
- The negative health impacts of urban heat islands may be greatest in Durham Region's seven priority neighbourhoods.
- Prioritizing people who live in homes at greater risk of high indoor temperatures could reduce the risk of heat-related illness and death in Durham Region.

Extreme heat sensitivity in Durham Region

Some people are more sensitive to heat than others and there is strong evidence of a social gradient of heat-related health impacts.

- Durham Region has a rapidly growing older adult population.
- Prioritizing healthy indoor temperatures for older adults who live alone, have a low income and/or are dependent on a caregiver can help prevent heat-related illness and mortality.
- Oshawa and Brock have the highest proportion of older adults with low incomes as well as the highest proportion that live alone.
- Some children in Durham Region face a disproportionate risk of poor health outcomes from heat due to health and socioeconomic disparities such as asthma and low income.
- Health promotion and heat-adaptation strategies, with an emphasis on priority neighbourhoods may help prevent heat-related health burdens among children.
- In Durham Region, pregnant individuals experiencing mental, financial, social or housing stress are at greater risk of heat-related pregnancy complications than those without these challenges.
- Targeted prenatal health promotion and adaptation strategies to reduce heat exposure may help reduce the risk of heat-related pregnancy complications.
- The prevalence of some chronic health conditions and associated heat vulnerability is higher in Durham Region than the Ontario average. Targeted heat health strategies may help to reduce heat risks and poor health outcomes, particularly among those with a chronic health condition and who live alone, are experiencing low income or are dependent on a caregiver.
- Upstream interventions that address individual and neighbourhood level deprivation are important to preventing heat-related illness and death in Durham Region.
- Some Durham residents experience financial hardship, inadequate housing, food insecurity and a lack of support. These factors increase their risk of harm during extreme heat events.
- As a general category, newcomers are not uniquely sensitive to extreme heat but may face barriers to protections. A better understanding of needs and barriers among this rapidly growing population is essential for reducing local heat-related health burdens.
- With the growing frequency, intensity and duration of extreme heat, protections are essential for those who work outdoors.

Adaptive capacity to extreme heat in Durham Region

It is essential that all Durham Region residents have equal ability to avoid harmful heat.

Building local adaptive capacity requires, but is not limited to:

- A better understanding of heat-related health burdens in Durham Region.
- Improved local knowledge of households without cooling systems and their heat-coping barriers and needs.
- Increased community awareness about who is at risk and which protective actions to take.
- Methods for identifying and reaching isolated individuals during extreme heat events.
- Improved local data and understanding of Durham Region residents living with disabilities.
- Improved understanding of the distribution, accessibility and use of cooling centres.
- Identification of high-need community spaces in need of shade, green space and/or water features.
- Strategic urban planning to maintain and restore forested ecosystems, wetlands and grasslands.

Current local strengths to protect residents from extreme heat include:

- Existing forested ecosystems, wetlands and grasslands that are crucial to extreme heat mitigation and resilience.
- A rapidly growing subscribership to Durham Region's Heat Warning and Information System (HWIS). Evidence shows that the implementation of the Ontario HWIS system was associated with a decline in emergency department visits for heat-related illness in some subpopulations. [1]
- The Region-wide Durham Greener Homes Program, which includes an income-qualified incentive for air-source heat pumps that can provide cooling to low-income households.
- Advancement of the Region's energy efficiency and resilience strategy for the Durham Regional Local Housing Corporation (DRLHC) multi-unit seniors building portfolio that includes in-home cooling.
- Tree planting incentive programs. For example, Regional collaboration with local municipalities to promote and subsidize the LEAF backyard tree planting program for residents in Pickering, Ajax, Whitby, Oshawa, Clarington, Brock, and Scugog.
- Some Durham Region municipalities have shade policies. For example Ajax was identified as one of only four Ontario municipalities with strong shade policies.[1]

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1 Ontario Health Prevention System Quality Index available at: https://www.ontariohealth.ca/sites/ontariohealth/files/PSQI_2023_Report_English.pdf

Next steps and priorities

This assessment helps residents and decision-makers to better understand current and future health risks of extreme heat to Durham Region's community. It supports adaptation planning to protect all community members, especially those worst affected and least protected. Next steps include exploring three main adaptation action areas to protect and promote heat health in Durham Region:

1. **Local knowledge and data** such as monitoring and reporting local extreme heat events and associated health impacts on people and health systems.
2. **Health promotion and education** to help Durham Region residents assess the risk to themselves and those they care for and take appropriate action.
3. **Heat health policies, programs and services** to help residents avoid or escape from extreme heat. Plans may include tenant protections, cool building policies, green infrastructure, public transportation, health services, public health programming, services and outreach, community outreach programs and accessible cooling spaces.

A list of potential activities is provided in **Table 5.12, "Examples of Heat Health Adaptation Initiatives."**

These are illustrative examples only and have yet to be assessed for feasibility or priority.

1. Why prioritize and prepare for extreme heat?

Extreme heat events are on the rise and have become the deadliest weather-related events in Canada.

Climate change is expected to be the most challenging public health issue of the 21st century, and health-care systems will be impacted by climate-driven emergencies, including extreme heat. Extreme heat events (EHEs) are now the deadliest weather-related events in Canada. [2]

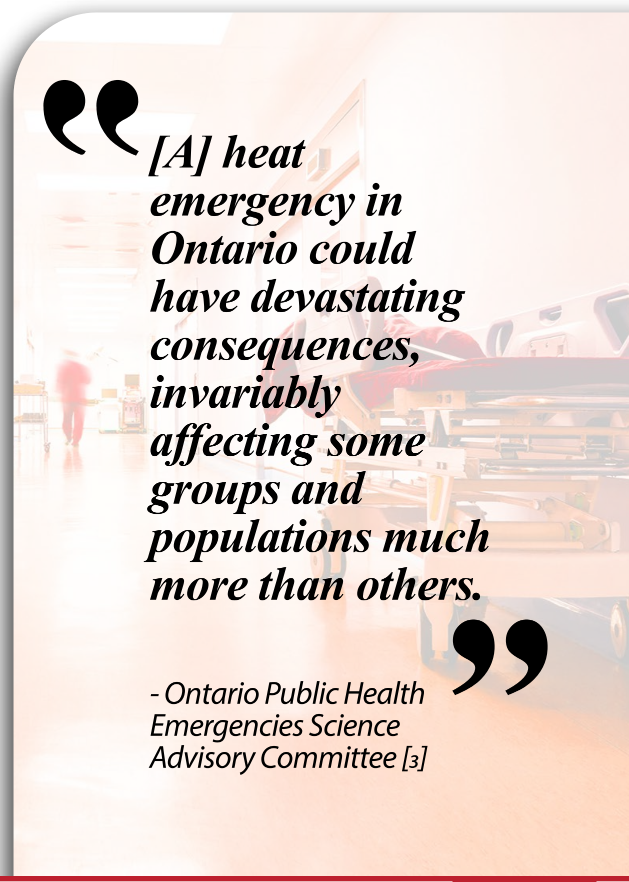
In July 2023, the Ontario Public Health Emergencies Science Advisory Committee released interim recommendations for Ontario's Heat Alert and Response System. These recommendations are based on the understanding that extreme heat poses a serious health threat to Ontarians. [3]

Evidence from other Canadian provinces demonstrates that extreme heat events can be sudden, result in severe illness and death and disproportionately harm some people more than others. In 2021, British Columbia (BC) experienced a record-setting heat dome that led to an estimated 740 excess deaths (a 440 per cent increase in community deaths). [4] Almost all heat-related deaths occurred indoors and were among older adults with chronic health conditions, people with higher material and social deprivation, and those with cognitive or mental health conditions. [3]

EHEs can overwhelm health systems. An Ontario study showed that each 5°C increase in daily summer temperature was associated with a 2.5 per cent increase in death. [5] Another Toronto-based study found that on average, for every one degree increase in daily maximum temperature (°C) there was a 29 per cent increase in ambulance response calls for heat-related illness. [6] During the 2021 BC heat dome event, paramedics received more than 900 calls for heat stroke; many patients had to wait hours, and some died before help could arrive. [2]

Looking into the future, higher greenhouse gas emissions are expected to result in a more than 17 per cent net increase in heat-related mortality in Canada from 2090 to 2099, with the highest net increase observed among people aged 65 and over. [7] A 2023 Ontario Provincial Climate Change Impact Assessment projected that by the 2080s, Southwest, Central and Eastern Ontario may experience an average of 60 extreme heat days per year. [8]

As climate change intensifies, there is a need to prepare for EHEs and heat emergencies[2] . Action is needed to prevent illness and death and protect those most affected by and least protected from extreme heat.



"[A] heat emergency in Ontario could have devastating consequences, invariably affecting some groups and populations much more than others."

- Ontario Public Health Emergencies Science Advisory Committee [3]

2 Environment and Climate Change Canada (ECCC) issues a heat warning for Durham Region when two consecutive days are forecasted to have a daytime high that is greater or equal to 31°C and a nighttime temperature greater or equal to 20°C, or a humidex greater than 40.

2. What is the purpose of this assessment?

Findings will be used to support evidence-informed adaptation plans, policies, and programs to protect Durham Region residents from extreme heat.

The purpose and objectives of this vulnerability assessment are outlined in **Figure 2.1**. The assessment will also support the climate change and extreme heat planning and adaptation processes for our community and municipal partners.

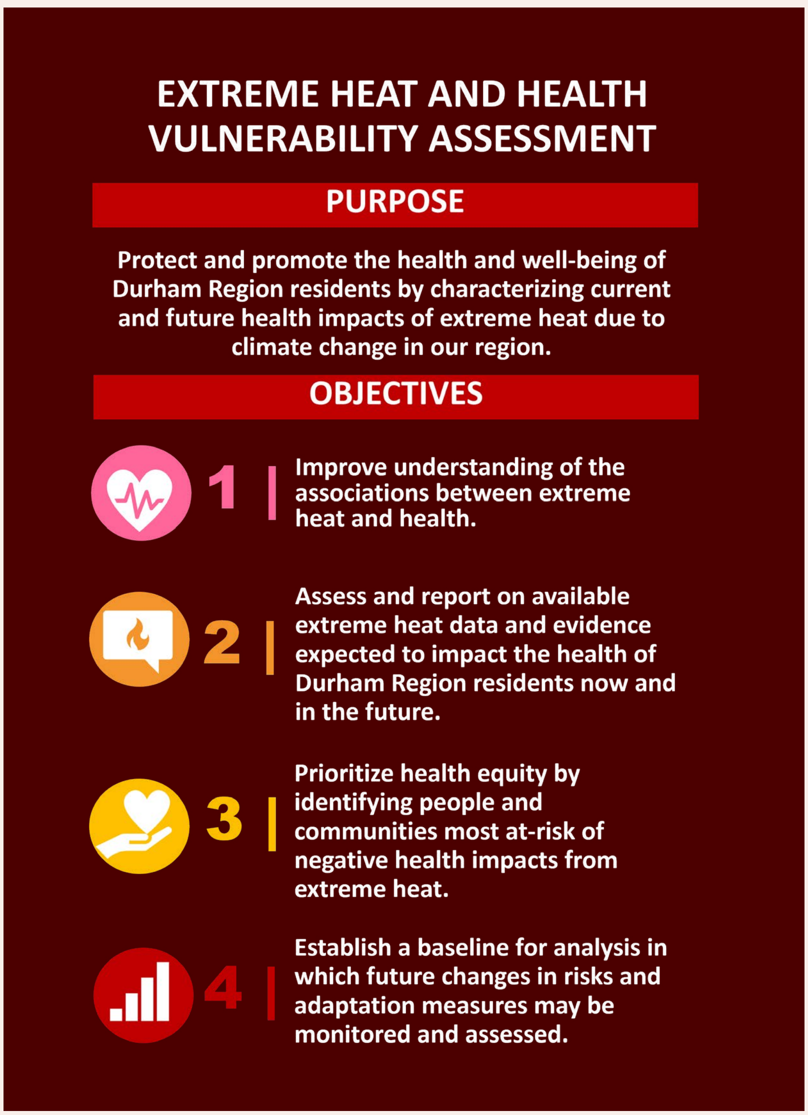


Figure 2.1 | Purpose and objectives of DRHD's extreme heat and health vulnerability assessment

3. What determines heat vulnerability?

Health impacts are influenced by exposure, sensitivity and adaptive capacity.

Figure 3.1[3] illustrates three main factors of heat vulnerability: (1) **exposure** to heat (for example, a person living in a densely urbanized area or a person who works outdoors may have greater heat exposure); (2) **sensitivity** to heat influenced by factors such as age, genetics, health status or community health disparities (for example, older adults and people with certain health conditions may be more sensitive to heat due to a decreased ability to regulate body temperature); and (3) **adaptive capacity** to take protective measures to avoid extreme heat (for example, a person with limited financial resources or limited mobility may have a reduced capacity to access cool spaces during an EHE).

Heat vulnerability is influenced by upstream factors such as land use planning, building codes and regulations, transportation planning and energy use planning. It is also influenced by a person's ability to earn sufficient income, access health care, find safe and stable housing; and live in a healthy, supportive community. Although factors of vulnerability are important for assessing health risk, the term "vulnerable" as a label for people can be stigmatizing and harmful and should be avoided.

> *"The concept of vulnerability can be highly stigmatizing, so it is important to recognize that climate vulnerability is not a label for communities or populations."*
>
> *- Chief Public Health Officer of Canada's Report on the State of Public Health in Canada 2022 [74]*

3 For a more detailed overview of this framework, please refer to the DRHD primer report: Climate Change and Health in Durham Region, available at www.durham.ca/ClimateAndHealth

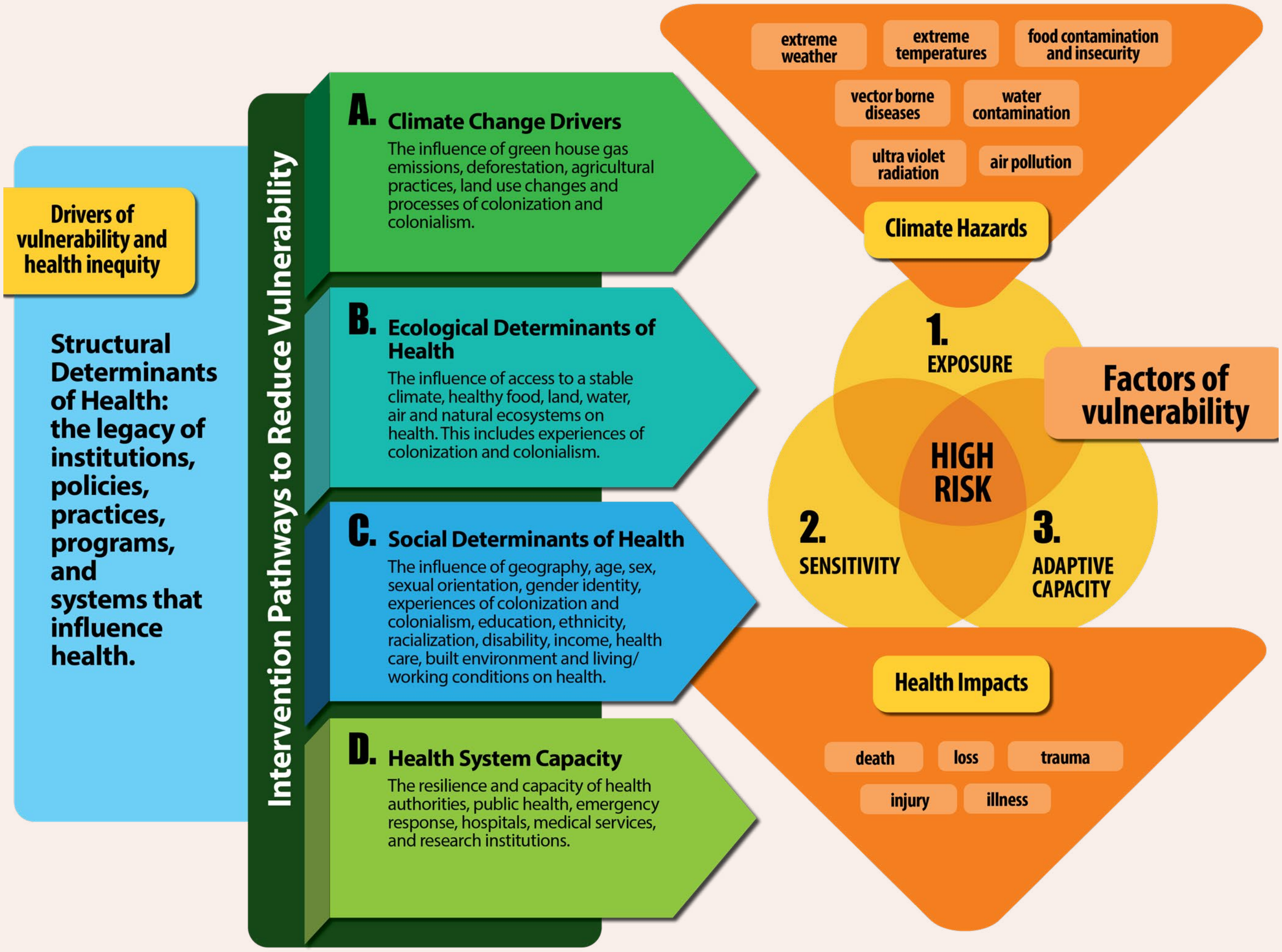


Figure 3.1 | Climate Change and Health Vulnerability Adaptation Framework (Developed under guidance of Schnitter et al. 2022) [92]

4. How does extreme heat impact health?

Extreme heat is associated with illness, pregnancy complications, hospitalization and death.

Heat-related illness (HRI) can range from mild to severe and includes heat stroke, heat exhaustion, heat rash, edema and dehydration. [9] The link between heat exposure and adverse cardiovascular health outcomes is well documented and a 1°C increase in temperature is positively associated with cardiovascular disease-related illness and death. [10]

An Ontario-based study showed that each 5°C increase in daily mean temperature was associated with a 2.5 per cent increase in mortality and was strongly related to an increase in respiratory- and cardiovascular-related deaths. The study also showed that risk of death increases as outdoor temperature increases (approximately 4 to 5% increase in mortality at 30°C). [5] Psychosocial impacts have also been associated with extreme heat including worsened mental health conditions and increased risk of distress, aggression, violence and even suicide. [11]

Illness and death can also occur below extreme heat temperatures. Mortality curves relative to temperature indicates relative death rates can begin to rise even at daily average temperatures as low as 20˚C. [12, 13] **Figure 4.1** summarizes the direct physical health outcomes associated with extreme heat. [14]

Indirect health impacts of extreme heat are beyond the scope of this assessment but include crop failures, food and water contamination and shortages, and livestock illness and death. They also include the destruction and loss of many traditional Indigenous foods. [15]

Extreme heat days (EHDs):

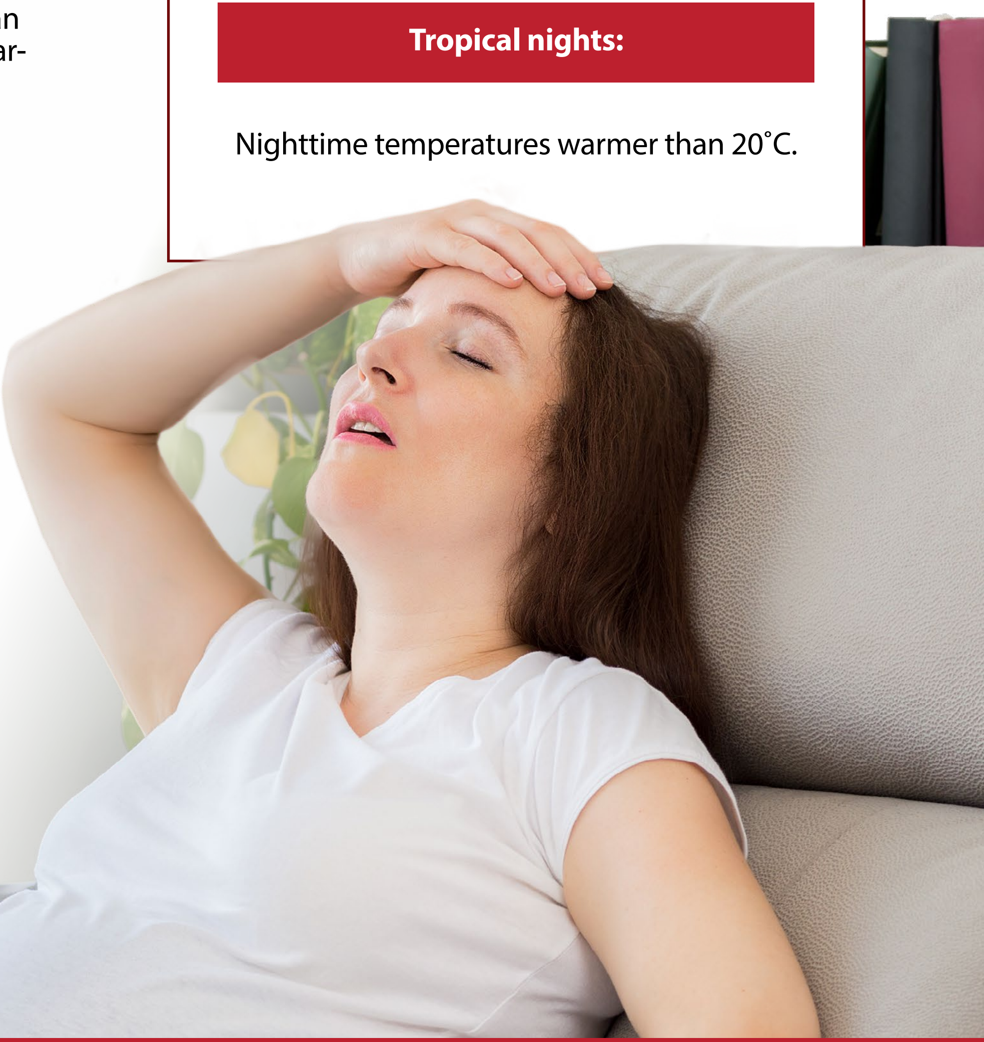
Temperatures of 30˚C or higher with potential to negatively impact health. [28, 23, 9]

Extreme Heat Events (EHEs):

Multi-day temperatures and/or humidex values that are unusually high for a region and can result in negative health effects. [72, 68, 9, 28]

Tropical nights:

Nighttime temperatures warmer than 20˚C.



Extreme temperatures

- Hospitalization
- Death
- Pregnancy complications

Hospitalization and emergency department (ED) visits: Extreme heat is associated with increased ED visit rates among individuals with heart and lung diseases [111, 112, 113, 114] and those experiencing severe symptoms of schizophrenia, mood disorders, and neurotic disorders. [115, 116]

Mortality: Extreme heat is associated with increased mortality rates from all causes [109, 110] including mortality rates for heart and lung diseases. [111, 112, 113, 114] Evidence shows that mortality rates increase as the intensity and duration of the heat wave or event increases. [110]

Perinatal effects: Perinatal complications are dependent on which trimester the extreme heat exposure occurred. [53, 54, 55, 52] Exposure during the first trimester is associated with increased rates of miscarriage [52] and congenital complications. [54, 55] Exposure to extreme heat during the third trimester is associated with premature birth and early delivery. [53]

Figure 4.1 | Direct negative health outcomes associated with extreme heat in Canada

Although extreme heat can harm everyone, some people are at greater risk of life-threatening outcomes due to multiple and compounded health risks and socioeconomic barriers.

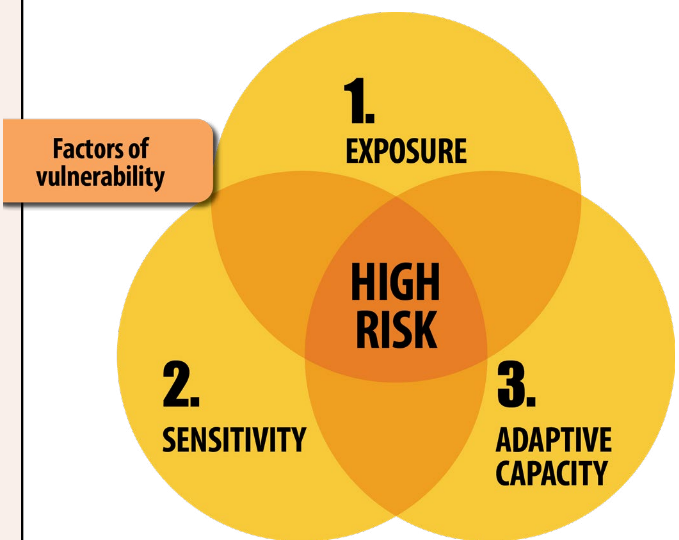
Our understanding of heat vulnerability is incomplete and evolving. **Table 4.1** outlines factors of heat vulnerability and at-risk groups. These groups are not distinct and risk categories often overlap. For example, older adults living alone with a health condition represented most heat-related deaths during the 2021 BC heat event. [16]

Heat vulnerability depends on the level of heat within the environment combined with individual and community risk factors. Those who experience all three factors of heat vulnerability are at greatest risk of negative health outcomes from heat exposure. These priority populations experience greater exposure and sensitivity to heat as well as barriers that limit their capacity to protect themselves.

> *"People who are already marginalized or underserved are among those who are most at risk from extreme heat; they will require additional support to counter these existing inequalities."*
>
> *- Irreversible Extreme Heat: Protecting Canadians and Communities from a Lethal Future [15]*

Table 4.1 | Factors of heat vulnerability and at-risk populations [14, 9]

Factors of heat vulnerability	Priority populations*


Exposure: The degree to which an individual or community is exposed to extreme heat. It is influenced by underlying social and economic conditions that result in some individuals or communities experiencing more exposure to extreme heat than others.
 	
Sensitivity: The degree to which an individual or community is affected by extreme heat. This can be influenced by age, genetics, health status or community health disparities.
 	
Adaptive Capacity: The ability of an individual or community to respond to and protect against the health impacts of extreme heat. Capacity may include access to informational, social, financial and institutional supports.
	• **Older adults,** 60 years of age and older
	• Infants and young **children**
	• **Pregnant** individuals
	• **Indigenous** Populations
	• People with **chronic health challenges** including:
	  o chronic illnesses
	  o disabilities
	  o obesity
	  o cognitive and mental health challenges
	  o substance use challenges
	• Socially and materially **disadvantaged** individuals and communities
	• **Newcomers** to Canada and transient populations such as tourists
	• People who **work** or are physically active **outdoors**
	
	** Those who experience all three factors of heat vulnerability are at greatest risk of negative health outcomes from heat exposure.*

Timing and setting influences risk of HRI and death.

Heat is often thought of as an outdoor health risk, yet most heat-related deaths in Canada have occurred indoors in settings where mechanical cooling was not available. [17] The highest risk for heat-related mortality occurs in the spring and early summer months when people have not yet acclimatized to warmer temperatures. Relentless overnight heat exposure (tropical nights), built-up urban settings and a lack of local green space can also increase the risk of HRI and death. [18, 19, 20, 21, 22]

Durham Region data demonstrate increased health burden and emergency room visits associated with maximum temperature above 30°C.

Heat-related emergency room visits correlate with the number of days with maximum temperatures above 30°C. Analysis from 2005 to 2017 found that the years with six or more maximum temperature days had higher rates of heat-related emergency room visits (**Figure 4.2**). As the number of days above 30°C increases, the number of individuals requiring medical attention due to heat-related illness is expected to increase.

> ***People don't die because it is hot outside; they die because it is hot inside.***
>
> *- Dr. Sarah Henderson, Surviving the heat: The impacts of the 2021 western heat dome in Canada [22]*

For years with less than 5 days with a daily maximum ≥ 30°C:
HRI visit rate of 6.3 per 100,000 (95% CI: 5.5 to 7.1).

For years with 5 or more days with a daily maximum ≥ 30°C:
HRI visit rate of 9.1 per 100,000 (95 % CI: 8.2 to 10.0).

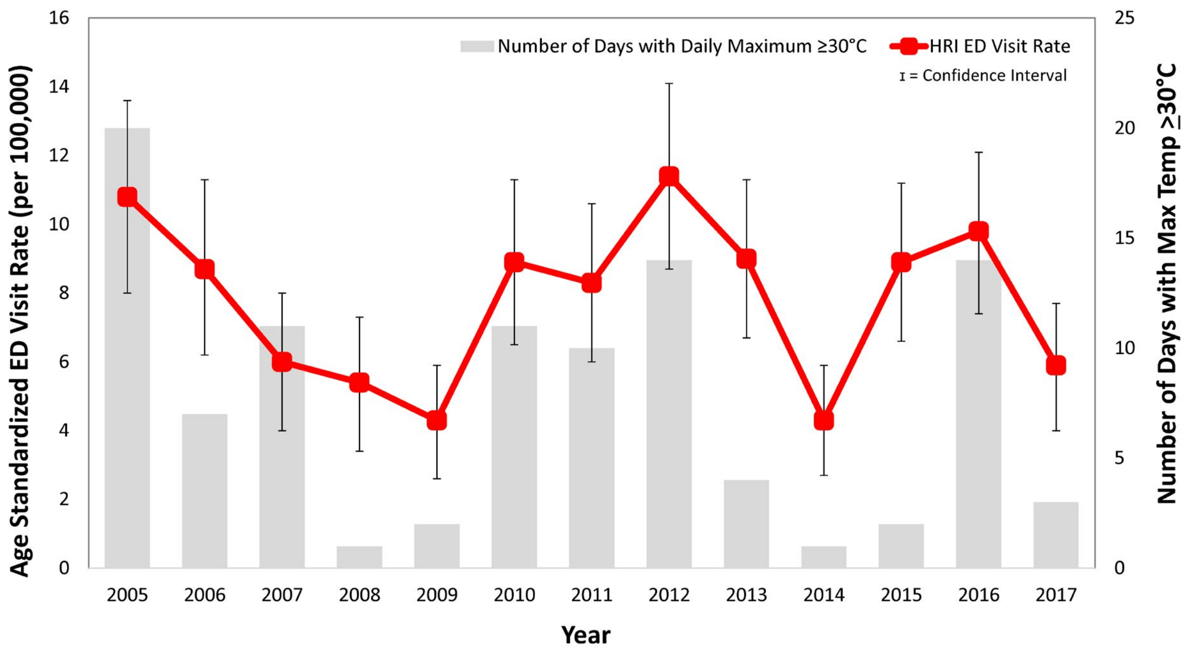


Figure 4.2 | Annual trends in Durham Region heat-related illness emergency department visit rate (per 100,000) and number of days with daily maximum temperature above or equal to 30˚C, from 2005 to 2017

The local burden of heat-related illness in Durham Region is not well understood and may be underreported, particularly among older adults.

It is recognized that without a systematic approach to identifying heat-related deaths and illness underreporting may result. [4, 23] For example, data from the Acute Care Enhanced Surveillance (ACES) system was used to identify potential heat-related ED visits and hospital admissions for Durham Region residents in 2019. ACES is a syndromic surveillance system, which groups pre-diagnostic health data into syndromes for analysis. In this case, a syndrome refers to a group of symptoms, clinical signs or laboratory test results that are associated with a particular health event, exposure or outcome. Syndromes of interest were those known to be exacerbated by heat including asthma, chronic obstructive pulmonary disease, dehydration and environmental syndrome (**Table 4.2**). Environmental syndrome included cases of heat exhaustion, heat syncope and heat stroke. From May 1 to September 30, 2019, there were 3,818 visits to Durham Region hospital emergency departments for these syndromes. Asthma contributed to the most emergency department visits, resulting in a total of 3,739 cases. From May to September 2019, there were a total of 33 environmental-related visits to the emergency department by Durham Region residents. Increased risk of heat-related illness is associated with older age, yet most emergency department visits attributed to environmental syndrome were in the 25-to-44-year age group, followed by the 18–24-year age group. It is suspected that environmental illness such as heat exhaustion, heat syncope and heat stroke is more likely attributed to younger individuals where the illness cannot be explained by another health condition. This also suggests that heat exhaustion, heat syncope and heat stroke among older adults may be under-reported and highlights the need for a systematic approach to understanding the burden of HRI in Ontario. [24]

Table 4.2 | Emergency department visits and hospital admissions for syndromes related to heat exposures in Durham Region, 2019

ACES Syndrome	Count
Asthma	3,739
Chronic obstructive pulmonary disease	12
Dehydration	30
Environmental	33
Total	**3,814**

Source: Acute Care Enhanced Surveillance (ACES) System, Durham Region Health Department (Data extracted: July 2020).

The mental, emotional and spiritual health impacts of extreme heat require deeper attention, and can be guided by Indigenous knowledge systems.

Most heat health surveillance focuses on heat related illnesses and death. The Mississaugas of Scugog Island (MSIFN) remind us that it is essential to also explore and respond to how extreme heat significantly affects the emotional, spiritual, mental, and cultural wellbeing of Indigenous and non-Indigenous peoples. Extreme heat can lead to severe harm and loss of healthy ecosystems that we depend on for food, water, refuge, physical activity, stress reduction, cultural celebrations, relationship building, community connection, knowledge sharing, collective wellbeing and more.

For example, extreme heat contributes to water insecurity. Several studies across Canada demonstrate that water insecurity is linked to mental and psychosocial distress among Indigenous Peoples, underscoring the relationship between Indigenous water sovereignty and health. Indigenous knowledge and perspectives are uniquely suited to guide and inform approaches for understanding the broader health impacts of extreme heat. Indigenous knowledge systems, in general, offer direct, extensive, multi-generational and long-term insight into the biological, physical, cultural and spiritual impacts of climate change, including extreme heat.[4]

Extreme heat can overwhelm and disrupt health systems.

Health system impacts include power outages, increased demand for emergency response and paramedics, increased patient admission and decreased health care staffing, disruption or closure of specialty departments or procedures, patient transfers, increased mortality and strain on morgue use. [15] Heat events often coincide with other climate hazards leading to compounded health risks and further strain on the health-care system. [25] Extreme heat often coincides with poor air quality and may result in cumulative negative health effects. Overlapping climate hazards may result in a diminished or failed capacity to provide emergency health services to local communities. [25] For example, during the 2021 BC heat dome both the electricity infrastructure and health facilities were "pushed to the limit" with health-care costs estimated at 12 million Canadian dollars. [26]

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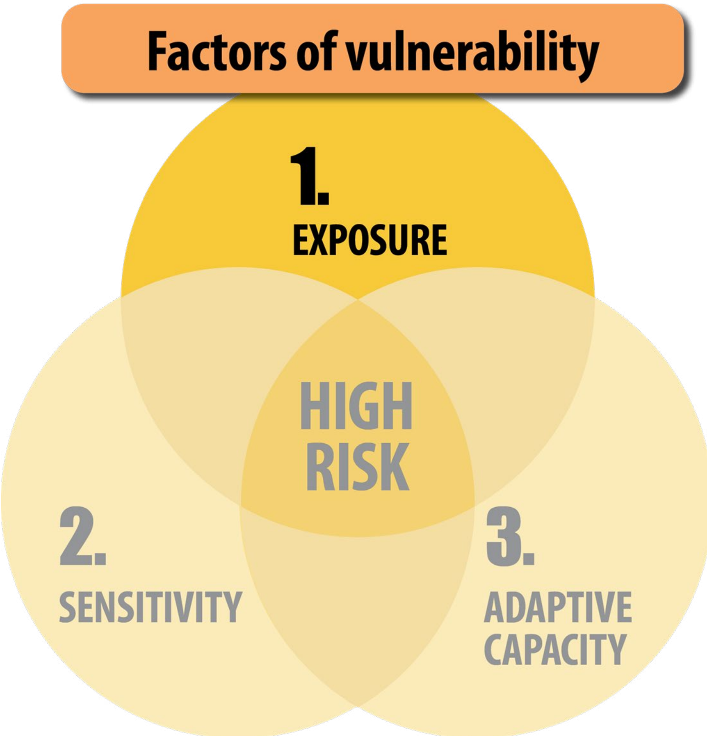
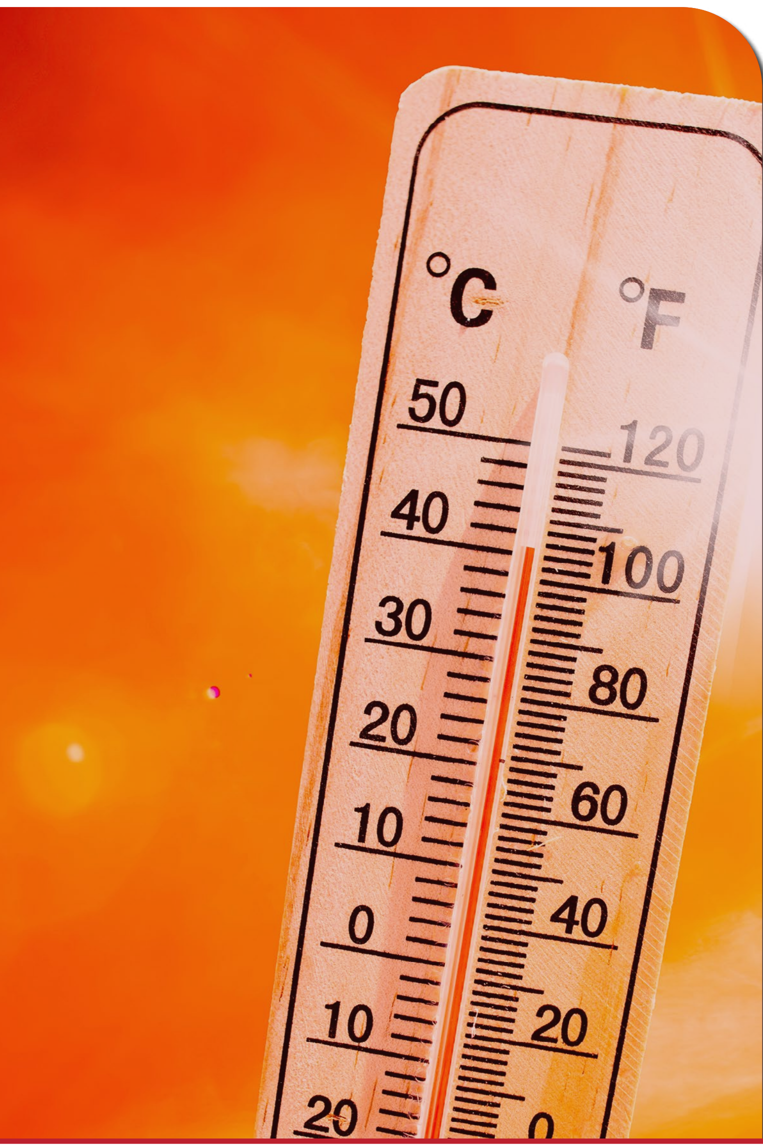
4 To learn more see: Climate Change and Indigenous Peoples' Health in Canada, available at: https://www.nccih.ca/Publications/Lists/Publications/Attachments/10367/Climate_Change_and_Indigenous_Peoples_Health_EN_Web_2022-03-22.pdf

5. Understanding heat vulnerability in Durham Region

It is possible to prevent heat-related illness and death in Durham Region by reducing heat exposure, prioritizing those most sensitive to negative health impacts and supporting local capacity for taking preventive and protective measures.





5.1 Heat exposure in Durham Region[5]

All Durham Region residents can expect greater future exposure to extreme heat due to an increase in EHDs, EHEs, tropical nights and longer summer seasons.

Climate change has already increased average annual temperatures and EHDs in Durham Region. By the 2050s, Durham Region is expected to experience an average of 27 EHDs and by 2080 almost 47 EHDs–a 40-day increase compared to the historical average. [27]

Heat will be experienced differently across the municipalities.

Although increased rates of EHDs are projected for all of Durham Region (**Figure 5.1.1**), these increases are projected to vary across municipalities. The greatest increases in average annual number of EHDs by 2100 are expected in Brock, Uxbridge and Scugog. These municipalities are projected to experience an increase of at least 16 EHDs, whereas the southern municipalities range from 6.6 days to 13 days (**Figure 5.1.2**). [6][27]

5 This section focuses on extreme temperature projections. Please see Appendix E for more detailed information on all temperature projections for Durham Region.

6 These projections do not account for local urban heat islands which may result in higher than projected EHDs and temperatures in densely urbanized neighbourhoods of southern municipalities.

Extreme heat days

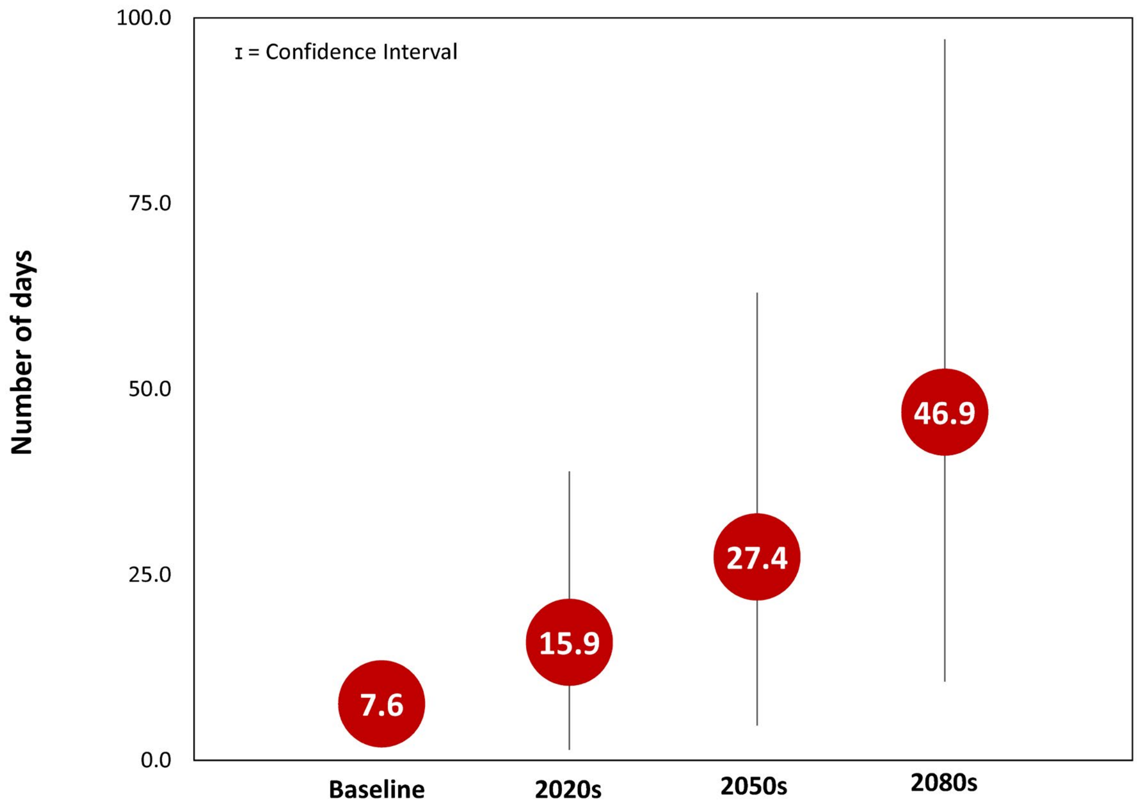


Figure 5.1.1 I Projected number of EHDs in Durham Region based on the RCP 8.5 climate scenario

EHDs refer to the total number of days each year when the daily maximum air temperature is greater than 30˚C.

The line on each estimate represents the 10th and 90th percentile.

Data Source: Delaney et al 2020. [27]

Representative Concentration Pathways (RCPs) 8.5 represents a "business-as-usual" scenario or the highest emission scenario where carbon dioxide emissions continue to rise throughout the rest of the century. [75]

Municipal increases in extreme heat days

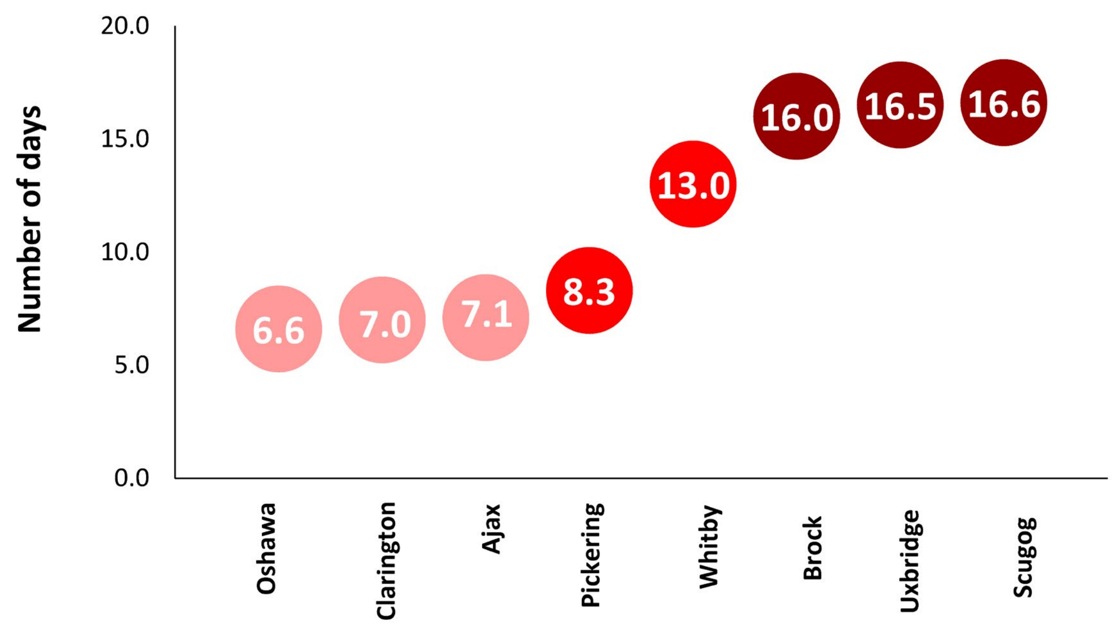


Figure 5.1.2 | Projected increases in average annual number of EHDs by 2100 for Durham Region municipalities based on the RCP 8.5 climate scenario[7]

Municipalities are ranked in increasing order. These values reflect a comparison to the historical number of EHDs of 7.6.

Data Source: Delaney et al 2020. [27]

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7 These projections do not account for local urban heat islands which may result in higher than projected EHDs and temperatures in densely urbanized neighbourhoods of southern municipalities.

Longer summers are expected for Durham Region as well as increased heat waves that are projected to more than double between 2050 and 2080.

The Ontario Climate Change and Health Modelling Study defined a heatwave based on criteria established by the Ontario Ministry of Labour, Immigration, Training and Skills Development and refers to a period of at least three consecutive days where air temperatures exceed 32˚C. [28] According to their study, Durham Region is expected to experience 1.2 EHEs per year by the 2050s and this number is projected to increase to 2.9 by the 2080s. [29]

By the end of the century, summers are anticipated to be 58 days (almost two months) longer than the historical average. The northern municipalities of Scugog, Brock and Uxbridge will likely experience a longer summer each year compared to southern municipalities (**Figure 5.1.3**). The number of summer days experienced annually in these communities may rise by approximately 63 days by the 2080s.

Increased summer length

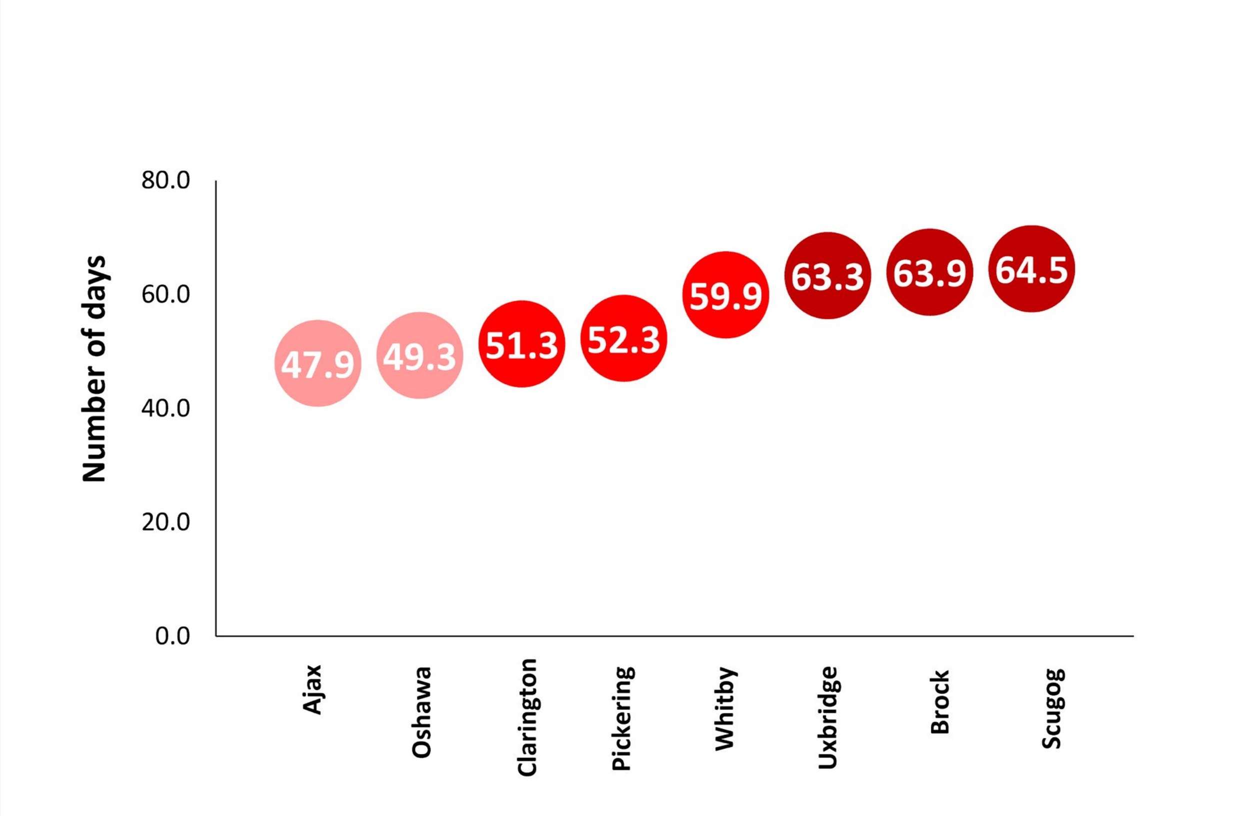


Figure 5.1.3 I Projected increases in average annual number of summer days by 2100 for Durham Region municipalities based on the RCP 8.5 climate scenario

Municipalities are ranked in order to increased days compared to the historical # of summer days of 42.1.

Summer days refer to the total number of days each year when the daily maximum air temperature is greater than 25˚C.

The annual number of tropical nights in Durham Region is projected to increase by almost a month and a half by the end of the century, with northern municipalities experiencing them the most frequently. [27]

Tropical nights occur when evening air temperature does not drop below 20˚C. The annual number of tropical nights in Durham Region is projected to increase up to 148 days by the 2080s. Changes in the number of tropical nights may vary substantially across the various municipalities with the northern municipalities of Scugog, Brock, and Uxbridge expected to experience a greater number compared to municipalities in the south (**Figure 5.1.4**). [27]

Tropical night increases by municipality

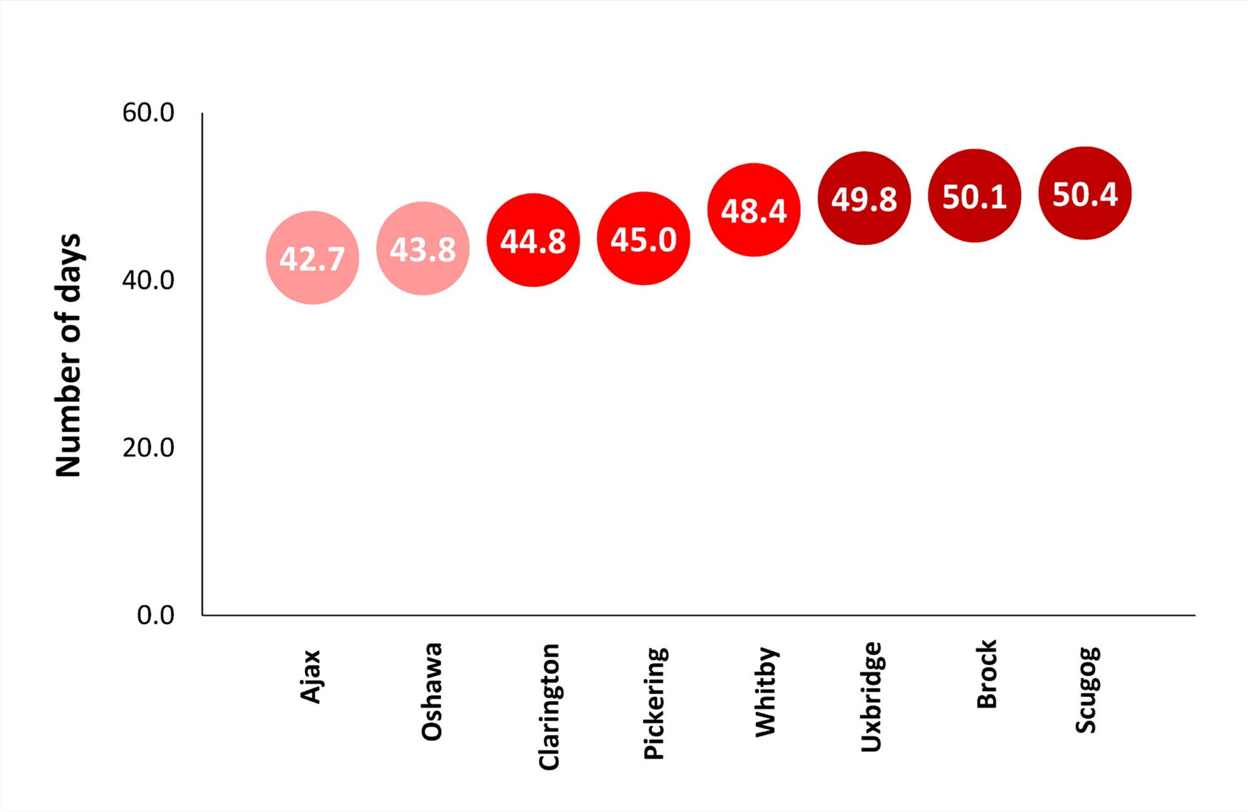


Figure 5.1.4 I Projected increases in average annual number of tropical nights by 2100 for Durham Region municipalities based on the RCP 8.5 climate scenario

Municipalities are ranked in increasing order. Increases are compared to the historical average of 100.6 per year (1971 to 2000).

Data Source: Delaney et al 2020. [27]

Residents living in urban heat islands of Pickering, Ajax, Whitby and Oshawa may be more exposed to higher than projected extreme temperatures.

During extreme heat days, some Durham Region neighbourhoods will experience greater heat exposure than others due to urban heat islands (UHIs). UHIs can increase land surface temperature (LST) by 10 to 15 degrees Celsius due to a high density of buildings and heat-generating infrastructure, combined with poor air flow and heat dispersion, and limited shade and green space. Building materials in UHIs absorb heat during the day and release it at night, preventing overnight cooling in the vicinity. As a result, UHIs increase the intensity and duration of heat exposure and risk of HRI and death.

Based on 2017 data, the highest LST in Durham Region are experienced in urban cores within the municipalities of Pickering, Ajax, Whitby and Oshawa (**Figure 5.1.5**). In contrast, cooler LST are seen in the rural areas of Uxbridge, Scugog and northern Clarington. This variation in temperature suggests residents of urban areas within Durham Region have a greater risk of exposure to extreme heat compared to residents of rural areas due to the UHI effect. It is also important to note high LST are spreading into the more rural areas of Brock and Clarington because of urban sprawl with low-density residential housing.

> ***"It's super-hot, there are trails with no trees, it's not walkable."***
>
> *- Ajax SNAP Resident*
> *Ajax Sustainable Neighbourhood Action Program (SNAP) is a program of Toronto and Region Conservation Authority, in collaboration with Town of Ajax and Durham Region*

Urban heat islands in Durham Region

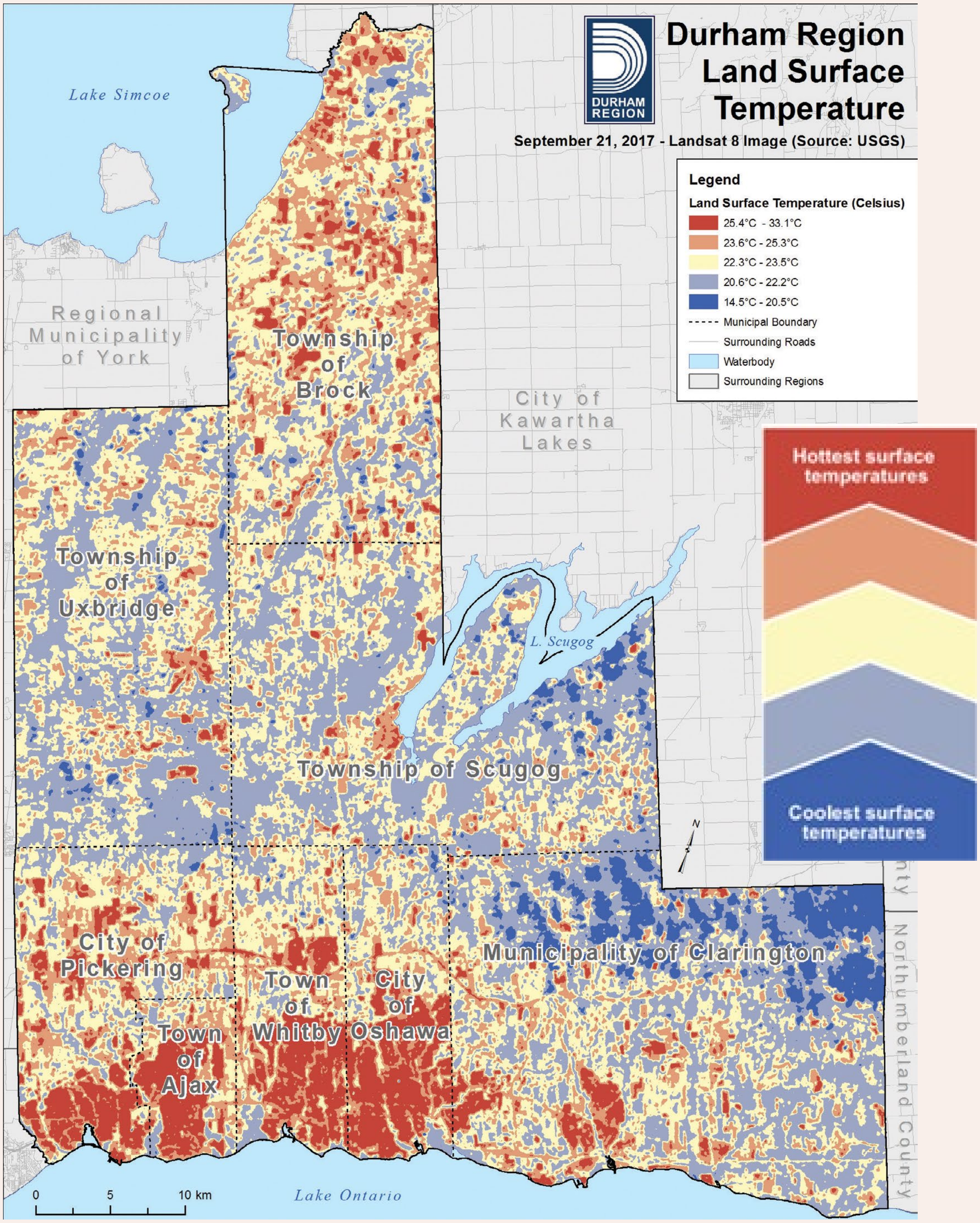


Figure 5.1.5 | Land surface temperatures across Durham Region as measured on September 21, 2017

The hottest locations are illustrated in red, and the coldest locations are illustrated in blue.

Data Source: USGS, Durham Region, 2017.

The number of urban heat islands in Durham Region is expected to increase.

Population growth has led to a corresponding increase in land surface temperature in Durham Region due to land use change and urbanization. By 2051 Durham Region's population is expected to reach 1.3 million, approximately double its 2021 population. [118] It is expected that increased density in housing and infrastructure to accommodate this growth will result in an increase in urban heat islands and an intensification of heat exposure during EHDs. [30]

The negative health impacts of urban heat islands may be greatest in Durham Region's seven priority neighbourhoods.

Durham Region Health Department has identified seven priority neighbourhoods (PN) based on health and wellness indicators (**Figure 5.1.6**). Residents of these seven neighbourhoods may be particularly susceptible to the negative health effects of extreme heat and urban heat islands due to pre-existing health inequalities that can increase the risk of HRI. In these seven neighbourhoods, hospital emergency visit rates for asthma in children and cardiovascular disease in adults aged 45 to 64 are higher than the other 43 neighbourhoods in Durham Region. [30]

Durham Region Priority Neighbourhoods

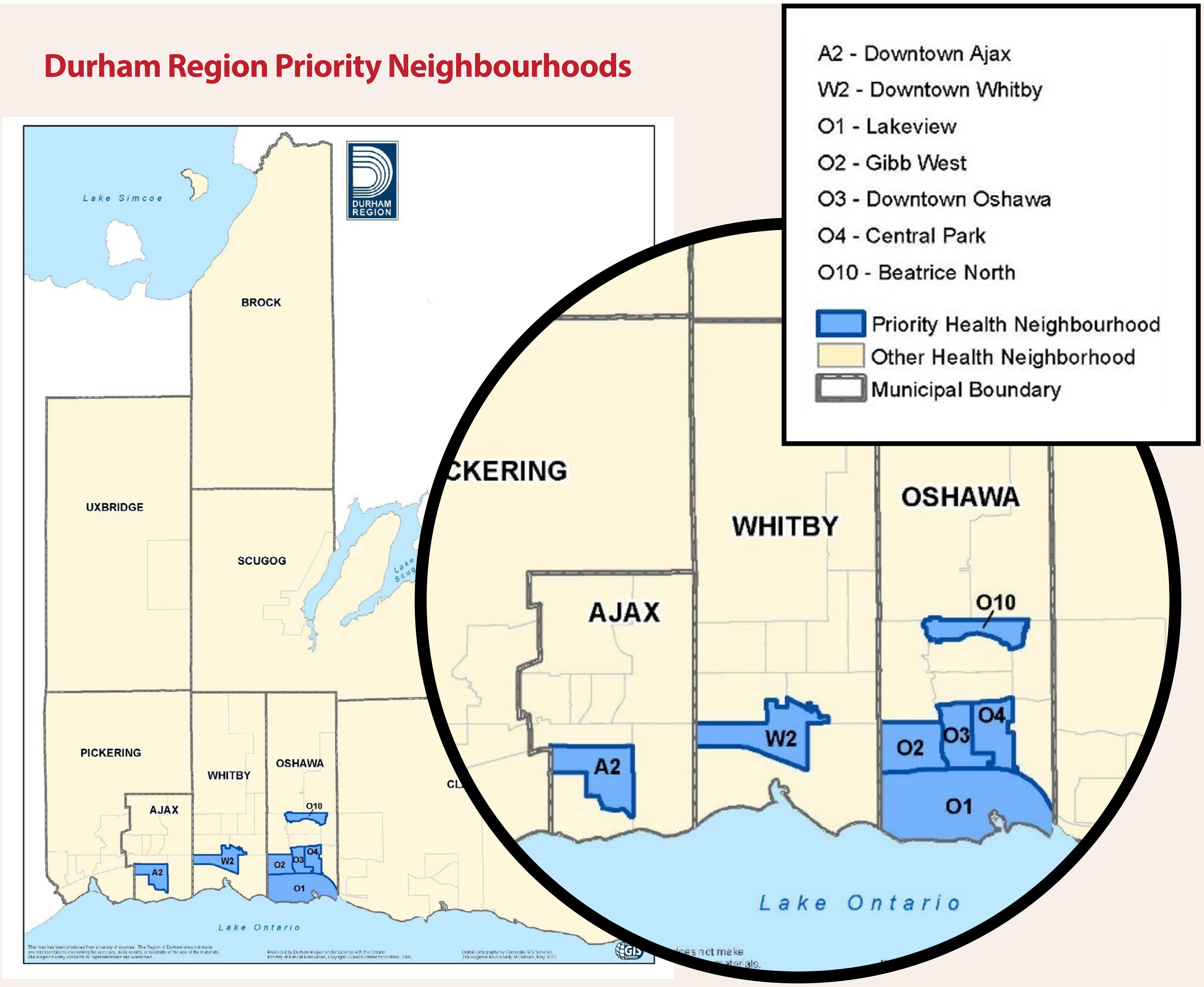


Figure 5.1.6 | Map of the seven priority neighbourhoods of Durham Region

Data Source: The Guide to Health Neighbourhoods, Durham Region, 2022

Surface temperature maps and heat-relevant demographic data for all seven PNs have been included in the Durham Region report: **Keeping Our Cool: Managing Urban Heat Islands in Durham Region (2018)**. [30] The maps contained in the report denote landmarks frequented by at-risk residents including seniors' residences, childcare centres, social housing and hospitals. [30] **Figure 5.1.7** is an example from the City of Oshawa. In the map, the PN boundaries are indicated with yellow lines. These maps can help support decision making on priority areas that require more heat-mitigation strategies to reduce heat exposure and risk of HRI. For example, development of cooling infrastructure and community engagement to better understand local needs and barriers to avoiding extreme heat.

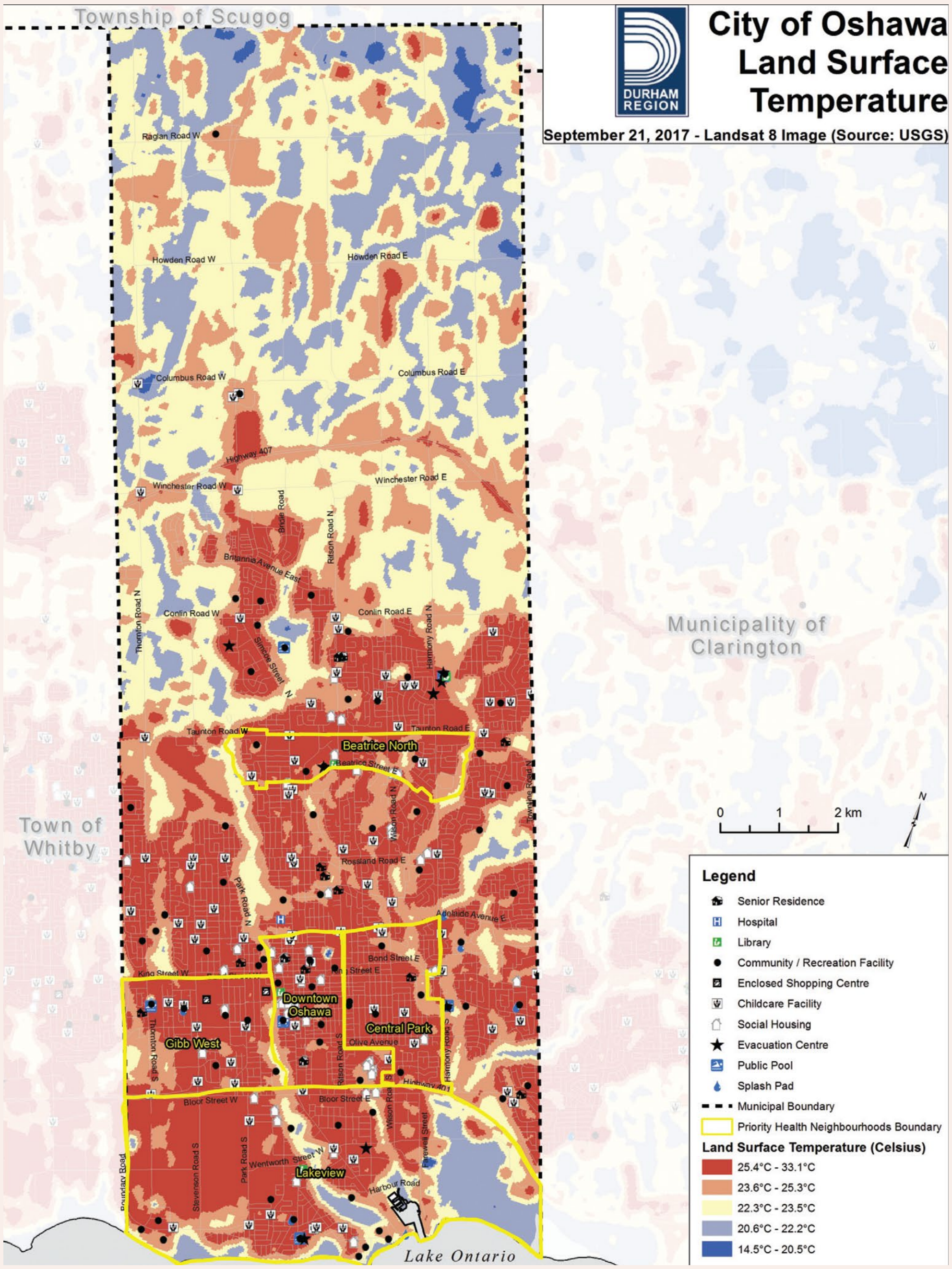


Figure 5.1.7 | City of Oshawa land surface temperature map

Data Source: USGS, Durham Region, 2017.

Prioritizing people who live in homes at greater risk of high indoor temperatures could reduce the risk of heat-related illness and death in Durham Region.

Most heat-related deaths in Canada have occurred indoors where mechanical cooling was not available. [15] Growing evidence that indoor temperatures above 26°C is associated with increases in emergency calls and death suggests that an indoor temperature limit of 26°C would significantly reduce the risk of heat-related mortality (**Figure 5.1.8**). [31] Lower temperatures are required for heat-vulnerable groups, for example, older adults with chronic health conditions. [32]

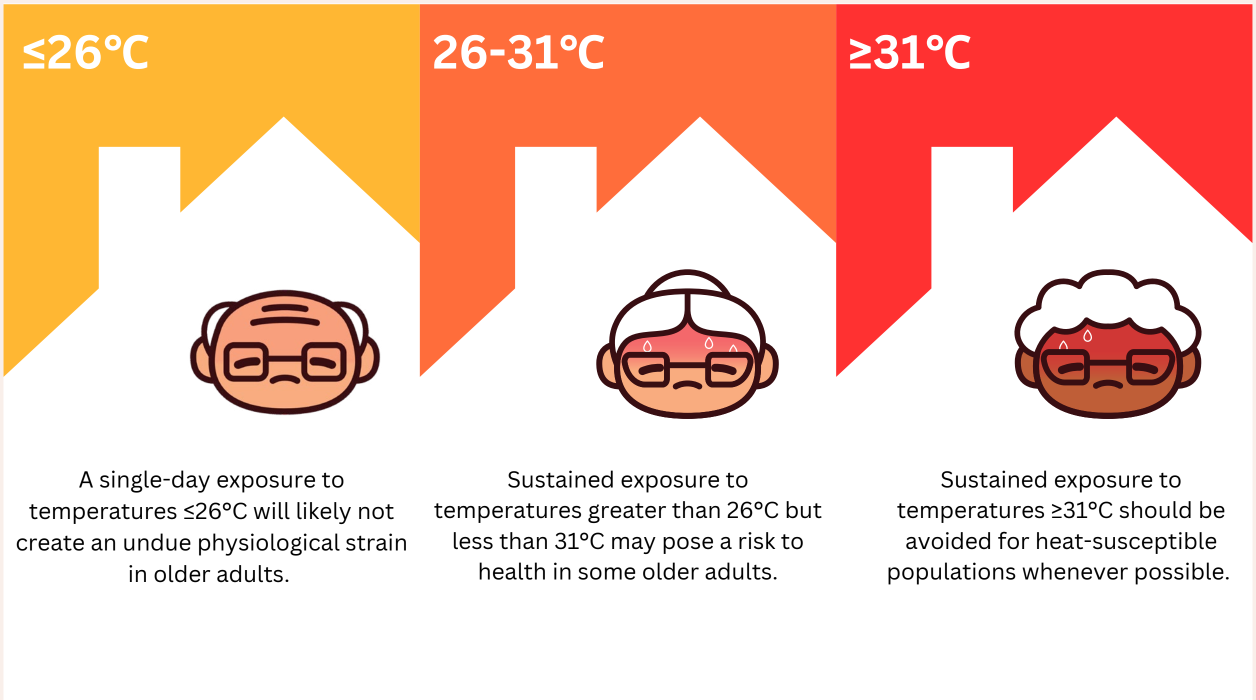
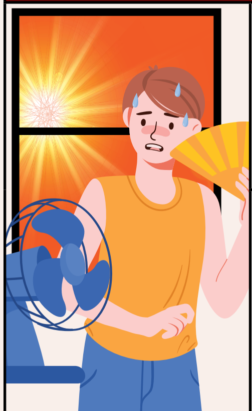
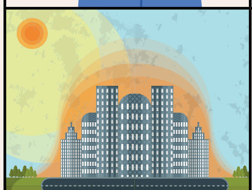
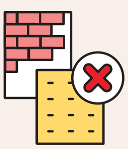
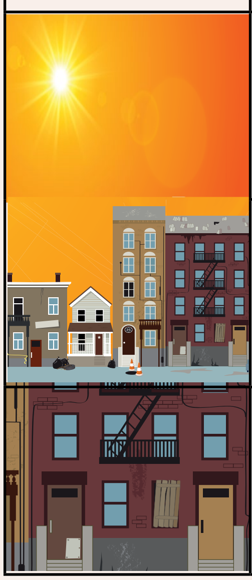


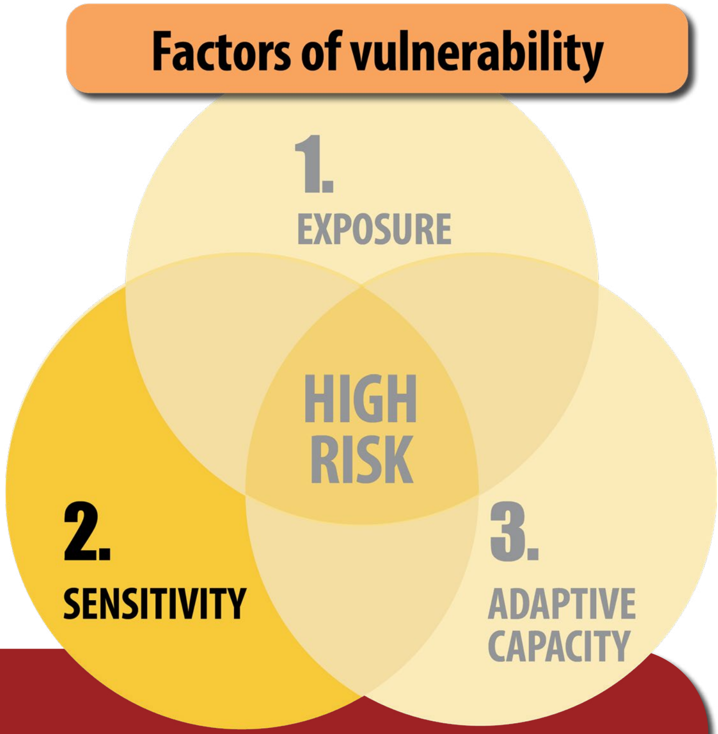
Figure 5.1.8 | Indoor temperature limits

Data Source: Used with permission by Glen P. Kenny, Human and Environmental Physiology Research Unit, University of Ottawa.

There is a lack of local data on indoor air temperature among heat-susceptible populations in Durham Region. However, there is evidence of key housing characteristics associated with a greater risk of exposure to high indoor temperatures (**Table 5.1**). These housing conditions could serve as indicators to identify and prioritize locations with a disproportionate risk of high indoor heat exposure. For example, lack of air conditioning is associated with living in a rented home. Durham's PNs have the highest proportion of renters among Health Neighbourhoods with the greatest proportion (67 per cent) living in Downtown Oshawa. [33]

Table 5.1 I Building characteristics associated with high indoor temperatures

Building characteristics associated with high indoor temperatures	
	• Face south (with south facing windows that increase solar heat gain) [32]
	• Lack mechanical cooling: a lack of mechanical cooling is associated with: ᴏ Living alone [41] ᴏ Living in a low-income or materially deprived neighbourhoods [40] ᴏ Living in a rented home [41]
	• Located in an urban heat island [34, 35, 36, 23]
	• Made with heat retaining materials including poor insulation [23, 37, 38, 34, 39, 36]
	• Lack shade [23]
	• Lack surrounding green space [40] [41, 40]
	• Have two or more floors [42]



This is going to be the norm. This is what we will be encountering going forward. We need to know who it is that needs the help first.

- Report: Lived Experience of Extreme Heat in BC: Final report to the Climate Action Secretariat [44]

5.2 Heat sensitivity in Durham Region

A commitment to health equity means prioritizing the needs and barriers of those who are at greater risk of poor health outcomes from extreme heat.

Some people are more sensitive to heat than others and there is strong evidence of a social gradient of heat-related health impacts. This section provides an overview of 8 broad heat-sensitive populations in Durham Region. Heat-related health risks are not evenly distributed across sensitive populations but are often more prevalent among those experiencing multiple health inequities. For example, a combined deprivation index was most strongly associated with increased odds of death during the 2021 BC heat dome. In contrast, socially and materially privileged neighbourhoods did not experience an increased risk of mortality during the same event. [40]

Considerations of intersectionality and compounding risk factors are essential to assessing vulnerability and prioritizing interventions. Understanding the interaction of heat sensitivity with other vulnerability factors is important for identifying and prioritizing those with the greatest risk of harm from heat. For example, an older adult may be more sensitive to heat, but because they have air-conditioning and family support at home, their risk of heat-related illness is lower than a similar older adult without air conditioning who lives alone.

5.2.1. Heat-sensitive populations in Durham Region

5.2.1.1 Older adults, 60 years of age and older [43]

Table 5.2 | Factors of heat vulnerability and potential health outcomes among adults 60 years of age and older

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Age-related sensitivity includes decreased ability to sense heat or thirst, decreased body temperature regulation and circulation, reduced fitness level, reduced sweating ability, and increased susceptibility to chronic dehydration. [9] **Interactions with other vulnerability factors:** **Exposure** • Greater potential exposure to high indoor temperatures if living alone and/or living in a rented home, and/or in a high-density urban setting with lack of green space. [41, 40] **Adaptive capacity** • Reduced ability to control environment due to visual, cognitive, hearing, and mobility challenges. [9] • Older adults living alone have significantly lower air conditioning rates compared with the Ontario average. [41] • Older adults living alone are less likely to seek help (from friends, family, or health care) or leave their home to access relief (e.g., an air-conditioned space). [41] • Caregiver dependency (e.g., living in an institution or being confined to a bed) is associated with increased risk of heat-related health impacts. [19] • Lack of transportation increases risk of HRI. [23] For example, during the 2021 BC heat dome event walking in extreme heat to access transportation was a barrier that kept many at home. [44]	• Individuals over the age of 60 have the highest rates of heat-related morbidity and mortality due to age-related physiological changes and reliance on others; 82 to 92 per cent of heat-related mortality occurs in this age group. [21, 23, 43] • Inability to care for oneself or dependence on a caregiver is associated with five times increase in the relative risk of developing heat stroke and six times heat-related mortality rate than those who do not need assistance. [23]

Durham Region has a rapidly growing older adult population.

By the year 2036, the age category of 65 years and older is projected to represent 24 per cent of the Region's population. [33, 30] This was the only group with noticeable growth from 2011 to 2021– approximately four times more than the Region's general population (**Figure 5.3**). [33] In general, the growth of the older adult population is greatest in the urban municipalities and although immigration is a substantial contributor to the Region's population growth, it does not have a major impact on the recent growth seen in this older adult population. [33]

Prioritizing healthy indoor temperatures for older adults who live alone, have a low income and/or are dependent on a caregiver can help prevent heat-related illness and mortality.

More than 8 per cent of Durham Region older adults live with a low income. Oshawa and Brock have the highest proportion of older adults with low incomes as well as the highest proportion that live alone. [33] Oshawa is also home to five of the Region's PNs where there is an overall higher prevalence of chronic diseases and low incomes than other Durham Region neighbourhoods. These neighbourhoods are also at greater risk of extreme heat exposure than other parts of Durham Region due to the urban heat island effect. As a result the potential heat-related health burden among older adults may be higher in these neighbourhoods.

Older adults, 65+

POPULATION GROWTH 2016 TO 2021

Durham average	65 years and older
7.9%	25.9%

POPULATION GROWTH 2011 TO 2021

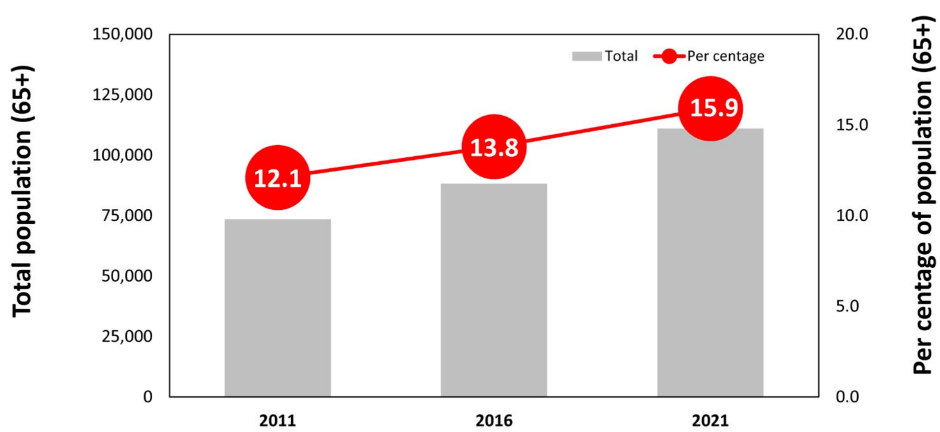


Figure 5.3 | Total and per cent population aged 65 years and older (2011 to 2021) and population growth (2016 to 2021) in Durham Region

Data source: Statistics Canada, 2021, 2016 & 2011 Census of Population.

A more fulsome demographic profile of Durham Region's older adult population can be found in Chapter five of the DRHD background primer: Climate Change and Health in Durham Region, available at www.durham.ca/ClimateAndHealth.

5.2.1.2 Infants and young children [9]

Table 5.3 | Factors of heat vulnerability and potential health outcomes among infants and young children

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Increased body heat production during physical activity, faster heat gain on hot days, reduced sweating, and an inability to increase cardiac output. [9] • Greater risk among children with breathing difficulties (asthma), heart or kidney conditions, developmental or physical challenges, diarrhea, and taking certain medications. [9] • More likely to over-exert while playing outdoors. [45] **Interactions with other vulnerability factors:** **Exposure** • More time outdoors and in settings that may not have air conditioning (e.g., schools and daycares). • Greater potential exposure to high indoor temperatures if living in a rented home, and/or in a high-density urban setting with lack of green space. [41, 40] **Adaptive capacity** • Limited ability to recognize or protect against heat exposure and dependence on caregivers for protection. [23]	• Children (under 18) and older adults (65 and older) are the age groups most frequently hospitalized due to heat-related illnesses. [46, 47]

Some children in Durham Region face a disproportionate risk of poor health outcomes from heat due to health and socioeconomic disparities such as asthma and low-income.

Childhood asthma prevalence rates[8] in Durham Region's municipalities are significantly higher than the Ontario average, ranging from 11.5 to 17.9 per cent. The highest rates are found in the southern municipalities of Whitby, Ajax, Clarington and Oshawa. [48] Health conditions such as asthma combined with socioeconomic risk factors including low-income and low-housing quality can increase the risk of poor health outcomes for children in general, including heat-related illness. For example, children and youth who experience hunger are more likely to suffer from chronic conditions including asthma. [49] In 2021, almost 9 per cent of Durham Region's children ages 5 and under were living with low income with the highest proportion living in Oshawa (almost 15 per cent). [33]

8 This indicator reflects the number of children aged 0 to 14 years diagnosed with asthma, per 100 children. The prevalence was standardized by age and sex using the 1991 Canadian Census population. Insurance Plan (OHIP) claims with an asthma diagnostic code or a hospital admission for asthma.

The concentration of dark red in **Figure 5.4.** shows the Health Neighbourhoods with the highest observed asthma rates. It is important to note that priority neighbourhood A2 (downtown Ajax) is dark red. The potential health burden from extreme heat may be disproportionately high among children in this neighbourhood due to higher temperatures from its urban heat island combined with some of highest rates of childhood asthma and lowest income levels in Durham Region.

Health promotion and heat-adaptation strategies, with an emphasis on equity-deserving children, may help prevent heat-related health burdens among children.

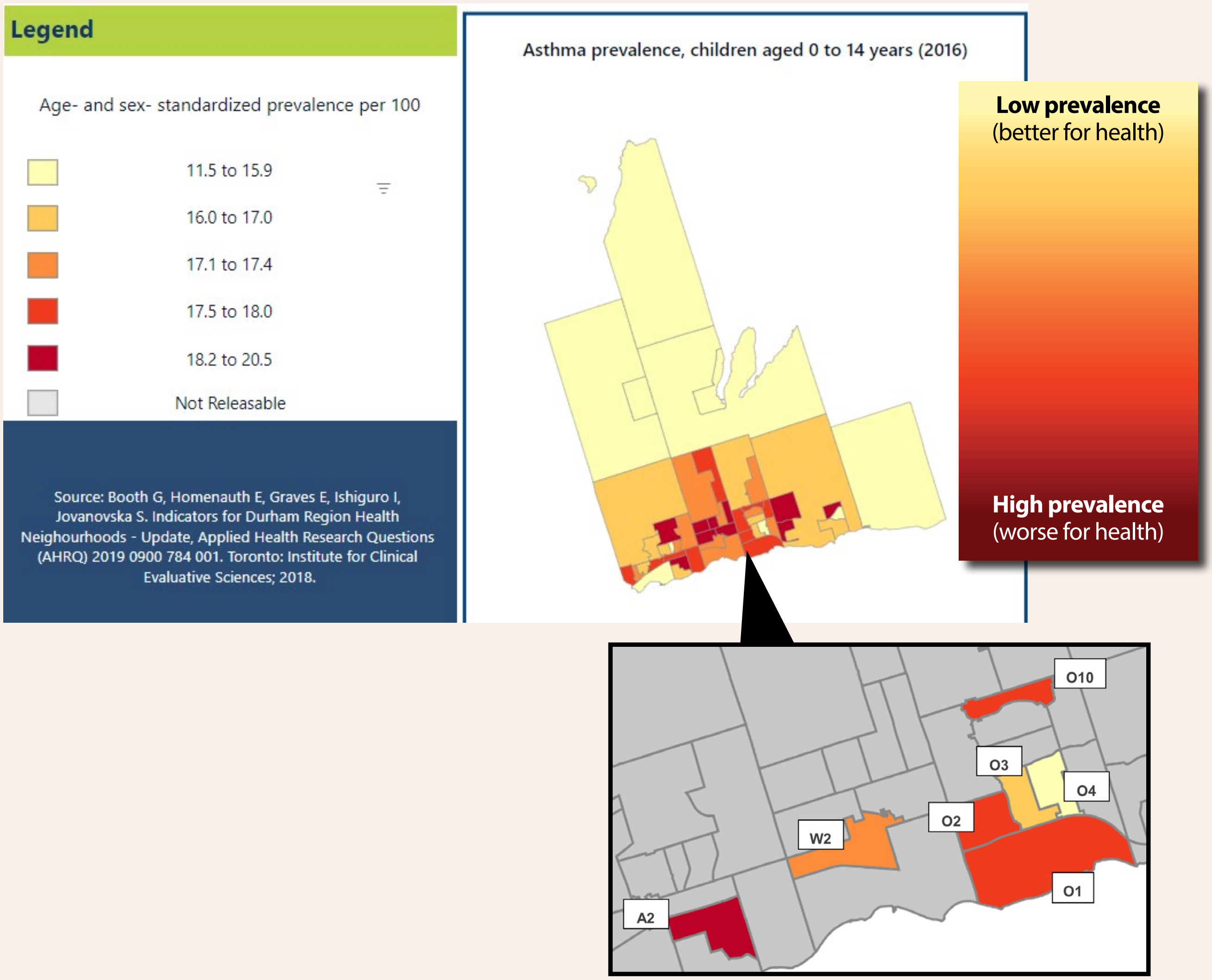


Figure 5.4 | Age and sex standardized asthma prevalence, children aged 0 to 14 years (2016) across Durham Region's 50 Health Neighbourhoods

Red indicates health neighbourhoods with the highest asthma prevalence rates. Higher prevalence's and increases are worse for health.

Figure adapted from the Health Neighbourhoods in Durham Indicator Summaries Dashboards, General Health Indicators, Asthma prevalence in children 2016., Available at: durham.ca/neighbourhoods.

5.2.1.3 Pregnant individuals [50, 51]

Table 5.4 | Factors of heat vulnerability and potential health outcomes among pregnant individuals

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Increased risk of HRIs due to the stress pregnancy can place on the body including decreased temperature regulation. [51, 50] **Interactions with other vulnerability factors:** **Exposure** • Greater potential exposure to high indoor temperatures if living alone and/or living in a rented home, and/or in a high-density urban setting with lack of green space. [41, 40] **Adaptive capacity** Capacity to protect against heat exposure may be reduced by mental, financial, social, and/or housing challenges. [51, 50]	• Extreme heat exposure in first trimester is associated with increased rates of miscarriage [52] [53] and congenital complications. [54] [55] • Exposure during third trimester is associated with preterm birth. [53]

In Durham Region, pregnant individuals experiencing mental, financial, social or housing stress are at greater risk of heat-related pregnancy complications than those without these challenges.

Although most Durham Region Health Neighbourhoods report similar preterm birth rates and birth weights, the Region's seven PNs have a higher proportion of pregnant youth and lower breastfeeding rates than the regional average[9] . [56] These neighbourhoods also generally experience lower incomes and a larger chronic disease burden. Many of these neighbourhoods also experience hotter temperatures than regional averages due to urban heat islands. These indicators suggest that there may be greater heat exposure and reduced adaptive capacity for pregnant individuals in Durham Region's PNs.

Targeted prenatal health promotion and adaptation strategies to reduce heat exposure may help reduce the risk of heat-related pregnancy complications, particularly among equity-deserving groups.

A better understanding of local heat risks for pregnant individuals is needed. In general, including heat health information in prenatal health promotion for those experiencing health inequities may help to reduce the risk of pregnancy complications associated with extreme heat. [53]

9 The Priority Neighbourhoods are: 1) Downtown Ajax – Ajax, 2) Downtown Whitby – Whitby, 3) Lakeview – Oshawa, 4) Gibb West – Oshawa, 5) Downtown Oshawa – Oshawa, 6) Central Park – Oshawa, 7) Beatrice North – Oshawa. Although the priority neighbourhoods have the lowest income levels of the 50 Health Neighbourhoods in Durham Region, they also have many positive attributes, community assets, resources and strengths See: Durham.ca/neighbourhoods.

5.2.1.4 Indigenous populations[10]

Table 5.5 | Factors of heat vulnerability and potential health outcomes among Indigenous Populations

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Processes of colonization have had a significant role in the increased sensitivity to heat related health risks among Indigenous Peoples. • Extreme heat and climate change also impact Indigenous peoples' Aboriginal and Treaty rights, including fishing and hunting. These rights are integral to the overall health and well-being of Indigenous communities, encompassing emotional, spiritual, physical, and mental health. **Interactions with other vulnerability factors:** **Exposure** • In general, many Indigenous Peoples are engaged in land-based activities that require substantial time outdoors (e.g., hunting, fishing, trapping), leading to disproportionate risks of exposure to extreme heat. **Adaptive capacity** • Processes associated with colonization has had a significant role in limiting the adaptive capacity of Indigenous Peoples, including the Mississaugas. Examples include deforestation, the filling of wetlands, and the conversion of grasslands, prairies, and savannahs into agricultural land for crops and grazing. These activities have contributed to a significant release of warming greenhouse gases into the atmosphere and decreased resilience to extreme heat. • The forced removal of Indigenous peoples from their lands and territories, and the genocidal practices of residential schools and the 60's Scoop has resulted in the intentional removal of traditional Anishnaabeg land management practices across much of Southern Ontario. • Adaptive capacity is related to processes of reconciliation such as local responsibility to restore ecosystems that re-capture carbon and increase extreme heat resilience.	**Increased food insecurity:** • Extreme heat events may reduce the number of days or hours available for fishing or hunting. • Reduction in ice cover on lakes, may limit winter fishing. • Failed seed production of native species of trees, shrubs, and herbaceous plants due to heat threatens Indigenous traditional foods and medicines. • Mass die off events of freshwater fish and other aquatic organisms from heat threatens traditional food of Indigenous Peoples. **Increased morbidity:** • Research on Indigenous populations and extreme heat is limited, but there is evidence that urban Indigenous populations in Ontario may be at greater risk of climate related illness than rural Indigenous populations due to inequities associated with health status, poverty, housing, political marginalization and access to health services. **Mental health impacts:** • Extreme heat contributes to water insecurity which is linked to mental and psychosocial distress among Indigenous Peoples.

10 The factors outlined in this table are not exhaustive and are based on knowledge shared by the Mississaugas of Scugog Island First Nation. Please see: Climate Change and Indigenous Peoples' Health In Canada for a further information on the impacts of extreme heat and Indigenous health. Available at https://www.nccih.ca/Publications/Lists/Publications/Attachments/10367/Climate_Change_and_Indigenous_Peoples_Health_EN_Web_2022-03-22.pdf

5.2.1.5 People with chronic health challenges including: chronic illnesses, disabilities, obesity, cognitive and mental health challenges, and substance use [57, 43]

Table 5.6 | Factors of heat vulnerability and potential health outcomes among people with chronic health challenges

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Disabilities and some chronic conditions especially diabetes, respiratory and cardiovascular related diseases, alcoholism, neurological diseases, kidney diseases, and mental health challenges can increase individual risk for developing HRI due to physical and physiological factors. [58] [23] [9] • Some medications affect heat sensitivity by interfering with the body's temperature regulation or water/salt retention (e.g., antihypertensives, antidepressants, antipsychotics, anti-Parkinsonian). [23, 9] • Health impairments may reduce ability to sense heat or thirst. [9] • Alcohol consumption or withdrawal can raise core body temperature on hot days. [23] • Exacerbation of asthma and other respiratory conditions due to poor air quality associated with extreme heat. [30] • Obesity may reduce thermal sensitivity and capacity to dissipate heat. [6] **Interactions with other vulnerability factors:** **Exposure** • Greater potential exposure to high indoor temperatures if living alone and/or living in a rented home, and/or in a high-density urban setting with lack of green space. [41, 40] **Adaptive capacity** • Reduced ability to control environment due health challenges. • Lack of transportation increases risk of HRI. [23] • Dependence on caregivers for heat protections. [23] • Individuals experiencing cognitive or mental health challenges may neglect protective behaviours and dismiss advice to protect their health during EHEs. [23] • Stigma and social isolation may prevent seeking help. [44]	• Hospital admission rates have been found to be 30 per cent higher for individuals with diabetes compared to the general population during EHEs. [23] • Hospitalized patients suffering from mental health challenges been shown twice as likely to have a fatal HRI during an EHE compared to non-hospitalized people with psychiatric illness, and four times as likely as the general public. [23] • Schizophrenia was most strongly associated with higher risk of death during the 2021 BC heat event. [59] • Inability to care for oneself or dependence on a caregiver for personal care has been found to be associated with a five time increase in the relative risk of developing heat stroke and six times heat-related mortality rate than those who do not need assistance. [23]

The prevalence of some chronic health conditions and associated heat vulnerability is higher in Durham Region than the Ontario average. Targeted heat health strategies may help to reduce heat risks and poor health outcomes, particularly among those with a chronic health condition and who live alone, are experiencing low income or are dependent on a caregiver.

A detailed regional profile of chronic health conditions is beyond the scope of this assessment, but some important trends related to heat vulnerability are highlighted in **Table 5.7** and summarized below.[11] [60, 48]

- The prevalence of hypertension in Durham Region is significantly higher than the Ontario average. The municipalities of Pickering and Ajax have the highest prevalence of hypertension (23.3 and 24.4 cases per 100 people, respectively).
- Durham Region has significantly higher rates of chronic obstructive pulmonary disease (COPD) in adults ages 35 years and older than Ontario's average, and rates in Oshawa, Clarington and Brock are significantly higher than Durham Region as a whole.
- Of Durham Region's municipalities, Whitby has a significantly higher prevalence of asthma than Durham Region overall, and all the southern municipalities have a significantly higher prevalence than the Ontario average.
- The prevalence of diabetes in Durham Region residents aged 20 and older is significantly higher than the Ontario average and the municipalities of Pickering, Ajax, and Oshawa, have significantly higher diabetes prevalence than the regional average.
- The percentage of obese adults in the Region is increasing.
- Mental health and addiction emergency visits are higher in some municipalities than others.
- The prevalence and experience of disability in Durham Region is not well understood and data is needed.

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11 For more detailed sociodemographic data, please see Appendix 5.1: Sociodemographic and Health Data for Durham Region's Local Municipalities in the DRHD background primer: Climate Change and Health in Durham Region, available at www.durham.ca/ClimateAndHealth

Table 5.7 | A summary of age and sex standardized health indicators by municipality with comparisons to Durham Region and Ontario

Geography	Asthma prevalence in children (2016)	Cardiovascular disease hospitalization rate (2015-2017)	Diabetes prevalence (2016)	High blood pressure prevalence (2016) COPD prevalence (2016)	COPD prevalence (2016)	Mental health and addiction emergency visits in children and youth (2016)
Pickering	16.9%	8.1 per 1,000	11.6%	23.3%	7.8%	14.0 per 1,000
Ajax	17.5%	8.3 per 1,000	13.2%	24.4%	7.8%	12.9 per 1,000
Whitby	17.9%	7.1 per 1,000	10.2%	21.9%	8.9%	14.5 per 1,000
Oshawa	17.2%	11.5 per 1,000	11.3%	22.9%	12.7%	31.2 per 1,000
Clarington	17.4%	8.3 per 1,000	9.9%	22.3%	11.4%	21.2 per 1,000
Scugog	14.2%	9.0 per 1,000	8.2%	20.5%	9.9%	17.2 per 1,000
Uxbridge	12.6%	7.2 per 1,000	7.5%	19.4%	6.9%	13.9 per 1,000
Brock	11.5%	13.0 per 1,000	9.4%	21.3%	12.4%	15.1 per 1,000
Durham Region	17.1%	8.9 per 1,000	11.0%	22.7%	9.9%	18.9 per 1,000
Ontario	14.2%	9.9 per 1,000	10.3%	21.0%	9.4%	19.0 per 1,000

Data sources: Asthma, diabetes, hypertension, COPD prevalence and MHA emergency department and doctor visits: Booth G, Homenauth E, Graves E, Ishiguro I, Jovanovska S. Indicators for Durham Region Health Neighbourhoods – Update, Applied Health Research Questions (AHRQ) 2019 0900 784 001. Toronto: Institute for Clinical Evaluative Sciences; 2018. Cardiovascular disease hospitalization rate: Hospital In-Patient Discharges, 2015-2017, Ministry of Health and Ministry of Long-Term Care, intelliHEALTH & 2016 Census, Statistics Canada.

5.2.1.6 Socially and materially disadvantaged individuals and communities including those living with low income, living alone, or experiencing homelessness [9]

Table 5.8 | Factors of heat vulnerability and potential health outcomes among people experiencing social and material deprivation

Factors of heat vulnerability	Examples of health outcomes
Sensitivity • Dehydration and malnourishment can increase risk of HRI. [23] **Interactions with other vulnerability factors:** **Exposure** • Greater risk of exposure to high indoor temperatures if living alone or in rented home. [41] • Increased environmental exposure though urban-heat-islands, limited trees and green space, poor quality housing and homelessness. [61, 23, 58] **Adaptive capacity** • Limited resources for heat protection. [23] • Decreased access to health care, social services and supports. [23] • Those living alone or renting home significantly less likely to have air conditioning. [41] • Lack of transportation increases risk of HRI. [23] • Stigma and social isolation may prevent seeking help. [44]	During the 2021 BC heat dome heat-related mortality was associated with deprivation, lower neighbourhood greenness, older age, and sex [40, 4]: • Higher risk observed among females because they are more likely to live alone in older age. [58] • A combined index of material and social deprivation was most predictive of heat dome risk. • No increased mortality risk found in socially and materially privileged neighbourhoods. • Socially and materially deprived neighbourhoods were associated with a 188 per cent increase in mortality risk.

Upstream interventions that address individual and neighbourhood level deprivation are important to preventing heat-related illness and death in Durham Region.

Durham Region residents experiencing multiple forms of social and material deprivation are expected to be impacted first and worst by extreme heat events. Key vulnerabilities are highlighted in the next section. A more detailed demographic and health profile of Durham Region communities can be found at durham.ca/neighbourhoods.

Some Durham Region residents experience financial hardship, inadequate housing, food insecurity and a lack of family or friends to count on. These factors increase their risk of harm during extreme heat events.

- There are currently 45,000 Durham Region residents living with low income. [33]
- **Table 5.9** presents the 2020 percentage of people by age category living with low income in Durham Region's municipalities. [33] Children and older adults are most impacted by low-income; these groups are also more sensitive to extreme heat than other age groups.
- Seventeen per cent of older adults (65 and older) in Durham Region live alone. [33] It is difficult to assess social isolation or experiences of loneliness due to a lack of local data; however, regional community engagement found consensus among participants that rates of social isolation have increased since the COVID-19 pandemic across all demographic and age groups. [62]
- It is difficult to characterize the rate of homelessness in Durham Region, but data suggest a significant increase since 2019, with 573 people experiencing homelessness on October 20 to 21, 2021, of which 20 per cent were homeless with children. [63] Of these people, 40 per cent lived in unsheltered public spaces. For more in-depth data on homelessness in the region see section 5.1.4.3 of the primer report: Climate Change and Health in Durham Region, available at: www.durham.ca/ClimateAndHealth
- Almost 16 per cent of Durham Region households are food insecure and the people at the greatest risk of experiencing food insecurity are [64]:
  - People living on social assistance or fixed incomes (e.g. pensions).
  - Workers relying on low-wage or precarious employment.
  - College and university students.
  - Single parents with children under 25 years old.
- Based on urban heat island mapping, there is a lack of cooling green spaces in the urban cores of the municipalities of Pickering, Ajax, Whitby, and Oshawa however neighbourhood-level analysis would help to understand which locations and neighbourhoods would most benefit from greening interventions. [30]

Table 5.9 | Percentage of children, older adults, and the total population in households with low income, based on the low-income measure, after tax (LIM-AT)[12], by municipality

Municipality	Age Group		
	Children 5 Years and Under	Older Adults 65 Years and Older	Total Population All Ages
	2021		
Pickering	7.2%	6.4%	5.3%
Ajax	8.0%	8.4%	5.5%
Whitby	7.3%	7.8%	5.4%
Oshawa	14.9%	10.0%	10.2%
Clarington	5.1%	6.4%	4.8%
Scugog	3.9%	7.5%	6.5%
Uxbridge	4.0%	9.3%	5.9%
Brock	4.2%	14.8%	8.7%
Durham Region	8.8%	8.3%	6.6%

Data source: Statistics Canada, 2016 & 2021 Census of Population

12 The LIM-AT is based on the median adjusted after tax income of all households in Canada. A household is considered to be living with low income if their income after tax is lower than the Canadian median income after tax for a household of the same size.

5.2.1.7 Newcomers to Canada and transient populations such as tourists [9]

Table 5.10 | Factors of heat vulnerability and potential health outcomes among newcomers and some transient populations

Factors of Heat Vulnerability	Examples of Health Outcomes
Sensitivity • Limited time to acclimate to heat can increase risk of HRI. [65] **Interactions with other vulnerability factors:** **Exposure** • Greater risk of exposure to high indoor temperatures if living alone or in rented home. [41] • Increased environmental exposure though urban-heat-islands, limited trees and green space, poor quality housing and homelessness. [61, 23, 58] **Adaptive capacity** • Language and literacy barriers. [9] • Cultural differences, such as food consumption habits, clothing choices, pre-existing social or cultural beliefs. [9] • Limited knowledge of local alert systems and health services. [9]	• Increased risk of heat related illness ranging from mild (heat edema and rash) to severe (heat stroke). [9]

As a general category, newcomers are not uniquely sensitive to extreme heat but may face barriers to protections. A better understanding of needs and barriers among this rapidly growing population is essential for reducing local heat-related health burdens.

Newcomers[13] represent almost 30 per cent of Durham Region's population and account for nearly two-thirds of its population growth in the past five years. [66] Approximately 97 per cent of Durham's total immigrant population lives in the southern municipalities, particularly Ajax, Oshawa and Whitby. [62][14]

13 Statistics Canada refers to newcomer populations as immigrants

14 For more detailed newcomer sociodemographic data please see Chapter 5 in the DRHD background primer: Climate Change and Health in Durham Region, available at www.durham.ca/ClimateAndHealth

There is a lack of local knowledge about specific barriers or facilitators to extreme heat protections among newcomers. A recent study of the service needs of racialized newcomers in Durham Region reported that many feel unsure about what services are available to them. They also report a lack of culturally appropriate and relevant services to assist with key challenges including employment, housing, the development of social networks, and in some cases, affordability. The study pointed to a need for more tailored services coordinated through trusted organizations with existing community relationships, such as faith-based organizations. [67]

Upstream factors like employment, housing and social networks influence heat vulnerability. There is a need to better understand the extreme heat adaptive capacity among newcomers.

"...Without a network what connections can you make it? The biggest challenge at that time you basically just don't know where to go - where to find a doctor, you know find a service, service for fixing a home or something like that. You just have no local knowledge."

– Report: Support and Inclusion for Success: Identifying the service needs of racialized immigrants in Durham Region. [67]

5.2.1.8 People who work or are physically active outdoors [9]

Table 5.11 | Factors of heat vulnerability and potential health outcomes among people who work or are physically active outdoors

Factors of Heat Vulnerability	Examples of Health Outcomes
Sensitivity • Muscular activity required to complete physical activities increases strain on the body, creating a surplus in intra-body heat in extreme heat conditions that add to the thermal load. [68] **Interactions with other vulnerability factors:** **Exposure** • Increased exposure among outdoor workers (e.g., farmers, construction workers, miners, tree planters, and landscapers). [68, 21] • Potential greater exposures among those who are active outdoors (e.g., athletes, people who walk or bike for transportation or recreation). [9] • Irregular heat exposure/lack of acclimatization for new workers. [21] **Adaptive capacity** • Little control over workplace temperature, health and safety regulations or standards. [9]. • Self-assessment as healthy may reduce perception of heat risk or vulnerabilities. [9] • International agricultural workers may also experience similar risks as newcomers related to language and literacy barriers and limited knowledge of local alert systems and health service programs. [9]	• Heat-related illnesses, injuries and reduced productivity, performance, and cognitive function. [69, 70] • From 2004 to 2010 there were 785 work related emergency department visits in Ontario for HRI, mainly among male seasonal outdoor workers. A 75 per cent increase in emergency visits occurred for each degree beyond 22 °C in ambient maximum temperature. [71]

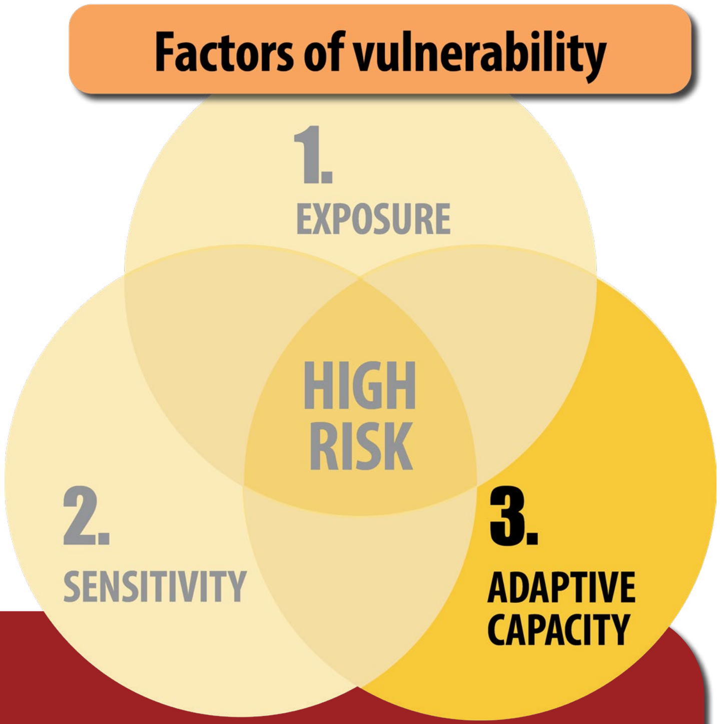
With the growing frequency, intensity and duration of extreme heat, outdoor protections are essential for Durham Region residents who must work outdoors.

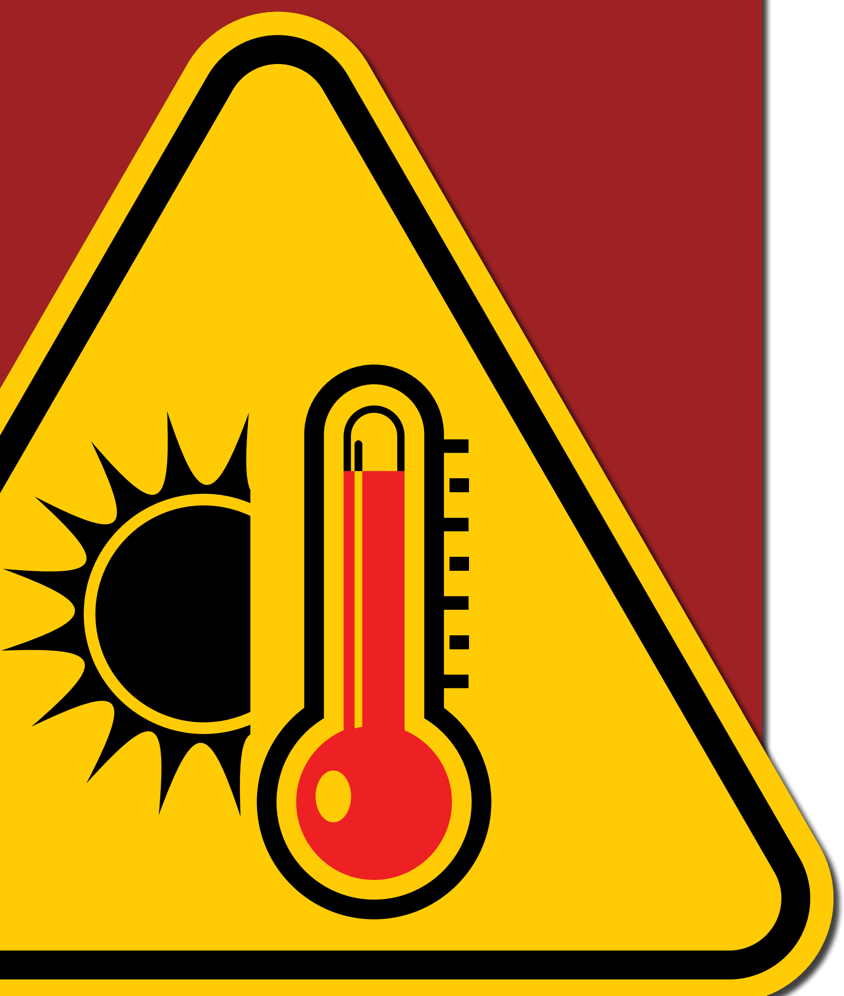
Based on 2016 data, almost 9 per cent of Durham Region residents work outdoors in the industries of agriculture, forestry, fishing and hunting, or construction (**Table 5.11**). During EHDs, these workers are at increased risk of injury, illness, lost productivity, hospitalization, or death. These data do not include potential heat exposure among individuals who must travel to work on extreme heat days and rely on public or active transportation.

Table 5.12 I Percentage of Durham Region residents who are outdoor workers (2016)

Industry classification	Totals	Per cent (%)
Agriculture, forestry, fishing, and hunting	3,005	0.9%
Construction	27,260	7.7%
Total	30,265	8.6

Data source: Statistics Canada. 2017. Durham Region Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.





5.3 Adaptive capacity to extreme heat in Durham Region

It is important that Durham Region residents have equal ability to avoid extreme temperatures.

Heat-related illness and death can be prevented by reducing heat exposure and ensuring people can maintain a normal body temperature of approximately 37˚C. [9] Unfortunately, not everyone has the capacity to adequately protect themselves as heat exposure is influenced by many factors such as neighbourhood conditions, income, mobility, housing quality and occupation. [72, 28] Tailored supports are needed to ensure equitable access to extreme heat protection. This may include integrated surveillance and public warning systems, equity-focused health promotion, and sustainable cooling programs at the neighbourhood, building, and individual levels. [11]

There is a growing call for extreme heat protections from all levels of government.

- Canada's 2023 National Adaptation Strategy has set targets for 80 per cent of health regions to have implemented evidence-based adaptation measures to protect people from extreme heat by 2026 and to eliminate deaths due to extreme heatwaves by 2040. [2] The strategy emphasizes access to reliable at-home cooling systems as central to meeting this goal. It also proposes two initial heat health indicators: 1) percentage of households with cooling systems; and 2) percentage of households with park or green space close to home. [2]
- In July 2023, the Ontario Public Health Emergencies Science Advisory Committee released interim recommendations to reduce health harms in heat emergencies including targeted communications strategies and strengthening heat emergency plans with an emphasis on those most likely to experience harm from heat. [3]
- Some Ontario municipalities are exploring maximum temperature by-laws for tenant communities. For example, in 2023 the City of Hamilton voted in favour of a motion to develop a maximum heat by-law to go into effect in 2024. [73]

5.3.1 Improving adaptive capacity to extreme heat in Durham Region

The following section identifies some local needs in support of adaptive capacity to heat. More comprehensive community engagement is required to understand the full range of needs and opportunities, particularly among priority populations and the organizations that serve them.

A better understanding of heat-related health burdens in Durham Region.

Surveillance systems are important for monitoring the health burden of extreme heat including impacts to chronic conditions, mental health, maternal, children and youth health, and aging populations. [74] The use of multiple equity stratifiers such as income, gender, disability status and housing status would also help to identify priority populations, support intersectionality in population health assessments, and develop appropriate needs-based interventions.

There are several challenges to capturing local heat-related deaths and illness. For example, in Ontario, the Coroner's Office does not release formal reports on the extent of heat-related deaths and only tracks sudden deaths where heat is the direct cause. [75] The office is not notified of "natural" deaths from chronic diseases exacerbated by heat. [75] In general, heat-related illness is under-recognized and under-reported because illness is attributed to pre-existing health conditions without identifying heat as a factor. [23] These challenges highlight the need for systematic approaches to measuring the burden of HRI in Ontario. [24]

Improved local knowledge of households without cooling systems and their heat-coping barriers and needs.

At-home mechanical cooling is shown to be one of the most effective ways to reduce heat exposure and prevent illness and death during extreme heat events. [76, 9, 23, 74, 41] Canada's National Adaptation Strategy emphasizes access to home cooling systems, particularly among at-risk groups with low air conditioning prevalence, as the core method for reducing the health burden of heat events. [40, 77]

Based on 2019 estimates, 88 per cent of households in Durham Region have a working air conditioner, which is higher than the provincial average of 85 per cent. [41, 78] However, there is a lack of data and knowledge about which Durham Region residents live without air conditioning and their barriers to access. According to national data, people living alone and people who did not own a home were significantly less likely to have air conditioning in Canada. In particular, older adults living alone had significantly lower air conditioning rates compared with the national and Ontario averages. [41] Engagement with resident groups such as tenant and seniors' communities is needed to better understand barriers and facilitators to accessing at-home cooling.

Increased community awareness about who is at risk and what actions to take.

Although heat exposures and HRI are preventable, individuals may not adapt their behaviours during extreme heat events if they are unaware of the risk to themselves or those in their care. [23, 21] Findings from BC community consultations suggest that there was a lack of general knowledge about extreme heat during the 2021 heat dome event. As one community member stated: "There was a lack of awareness about how to recognize the signs of heat injury, lack of awareness about cooling shelter locations, lack of awareness to check on your isolated elderly neighbour, lack of awareness about when to seek out help." [44]

Based on 2015 Rapid Risk Factor Surveillance System (RRFSS) survey estimates, the majority (79%) of Durham Region adults were aware that heat-related illnesses could be prevented. In general, most were aware of increased risks for people with chronic illnesses (85%) and infants and children (78%) (**Figure 5.5**). Fewer were aware of the increased risk to individuals with low incomes (65%) and people who take medications for certain mental health conditions (52%) (**Figure 5.5**).

Awareness of at-risk groups

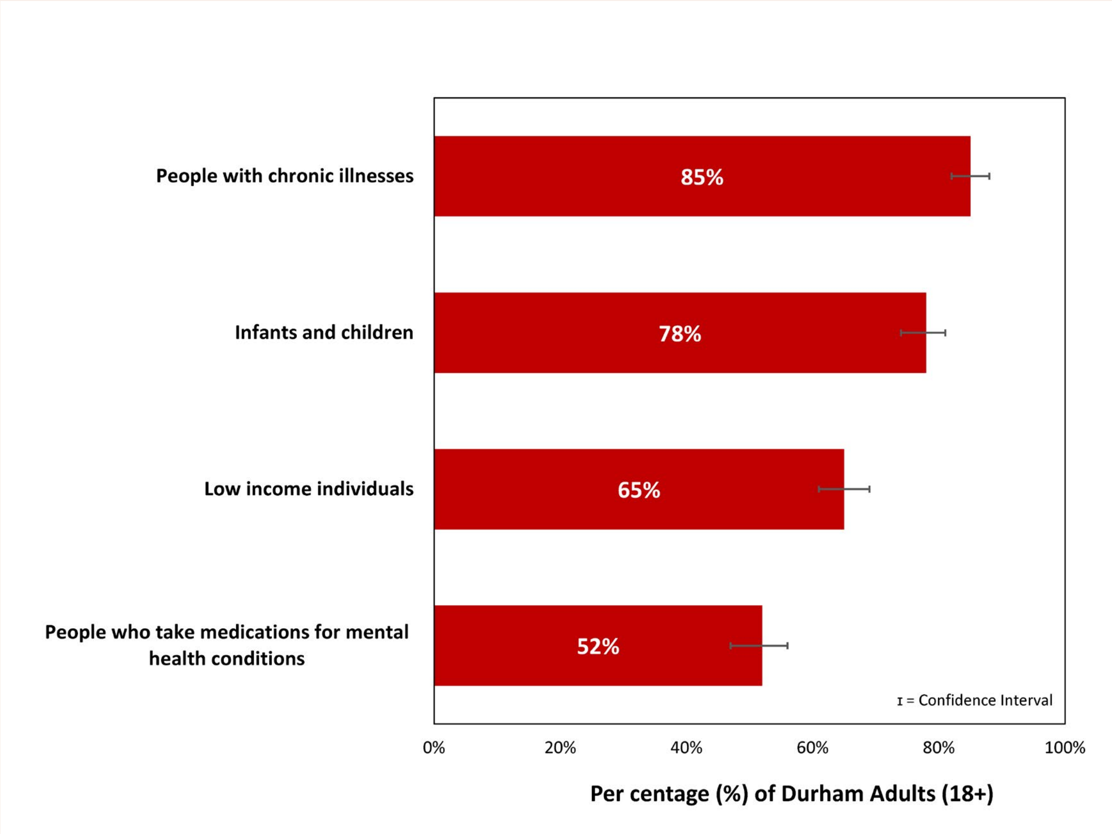


Figure 5.5 | Percentage of Durham Region adults (18+) aware of groups at-risk for heat related illnesses

I = 95% Confidence Interval

Data Source: RRFSS 2015 (May-Aug), DRHD, collected by ISR at York University.

Methods for identifying and reaching isolated individuals during extreme heat events.

Social isolation is a major barrier to an individual's capacity to protect themselves against extreme heat. Checking on older or ill neighbours and family members is important because these groups have a higher risk of developing heat-related illnesses, are more likely to lack air conditioning, and are less likely to seek help. [41, 44]

Regular check-ins on isolated residents during heat events can help prevent illnesses and deaths. Unfortunately, only 31 per cent of Durham Region adults reported visiting older and sick neighbours, friends, or family members during hot days. [78] It is suspected that social isolation has increased since the COVID-19 pandemic. To improve local adaptive capacity to extreme heat, there is a need for trust-based methods for reaching and responding to isolated community members. [62]

> ***"There needs to be a pathway to get people out of harm's way before the ambulance. Once they reach the ambulance, that means they have not reached any of the other safety nets, or worse, nobody found them, and we find a fatality."***
>
> *-Lived Experience of Extreme Heat in BC: Final report to the Climate Action Secretariat [44]*

> ***"People with disabilities are far more likely to experience poverty, unstable housing, and a multitude of social, economic and environmental barriers."***
>
> *- Dr. Ben Mortenson, Professor, University of British Columbia [117]*

Improved local data and understanding of residents living with disabilities.

The prevalence and distribution of people living with disabilities in Durham Region is not well understood. Residents who rely on Ontario Disability Support Program (ODSP) may face barriers to accessing affordable housing with adequate temperature controls. [8] Other residents who may not qualify for ODSP may also face physical, mental and social barriers to protecting themselves from extreme heat. Although people living with disabilities face significant health risks from climate hazards such as extreme heat, evidence reviews show that they are underrepresented and even excluded in the climate change and health literature. [79, 80] Outreach to understand the prevalence and unique needs of people living with disabilities in Durham Region is needed.

Improved understanding of the distribution, accessibility, and use of cooling centres.

There is some evidence that priority populations who lack household cooling systems are also least likely or able to visit a cooling centre. [81] There is also evidence that brief air conditioning exposure can help reduce the physiological burden of extreme heat, but the benefits are often short-lived if the individual is returning to a hot indoor home temperature over night. [82] Evidence from other Canadian jurisdictions suggest that cooling centres may not be used due to mobility and transportation challenges, lack of welcoming and safe spaces, feelings of discrimination, and inability to bring pets and belongings. [44] A more robust analysis of Durham Region cooling centre accessibility and use among high-risk residents would help to inform adaptation planning.

Identification of community areas with a high need for shade, green space and/or water features.

Equitable distribution of shade, tree cover, public green spaces and water features is essential to community heat health and adaptive capacity. Durham Region UHI mapping provides some indication of hotter and cooler areas, however there is a need for more localized assessments of high-need areas. Collaboration among conservation authorities, municipalities, foresters, planners, and the Health Department would help to identify and prioritize solutions for heat vulnerable locations. For example, the provision of tree shade in unavoidable, high-risk areas such as transit stops, active transportation routes, or places where residents must wait in line (e.g., shelters).

> ***"For our clients, many of whom are unhoused, and experienced mental illness and substance use issues, the spaces listed above (community centres, libraries, playground water parks) are not accessible as they are stigmatized by staff and patrons of those places. Further, everyone was incredibly emotionally heightened during the heat, leading to far more conflict in those public spaces."***
>
> *-Lived Experience of Extreme Heat in BC: Final report to the Climate Action Secretariat [44]*

5.3.2 Local strengths and opportunities for increasing adaptive capacity to heat

Heat-related illnesses and deaths can be prevented through community heat action plans that prioritize heat-vulnerable people and settings. The following strengths in Durham Region can help protect and promote heat health. Climate change will increase the frequency, intensity and duration of extreme heat events. There is a need to expand on and improve programs as well as address specific challenges that prevent at-risk residents from taking protective measures.

Existing forested ecosystems, wetlands and grasslands.

As residents experience increasing exposure to extreme heat, so will the natural environment. This connection is crucial and there is a need to protect and enhance existing natural heritage features. A major defense against extreme heat is our environment and diverse ecosystems. Durham Region is in the Lake Simcoe-Rideau Ecoregion which extends from Lake Huron in the west to the Ottawa River in the east and includes most of the Lake Ontario shoreline. Over 80 per cent of Durham Region lies within the provincially designated Greenbelt, which also contains the ecologically significant Oak Ridges Moraine. Water generally flows south from the Oak Ridges Moraine or Lake Iroquois Shoreline to Lake Ontario, or flows north from the Oak Ridges Moraine to Lake Scugog or Lake Simcoe, providing significant wetlands and other bodies of water in the region. These ecosystems are crucial to extreme heat mitigation and resilience in the region.[15]

Durham Region Heat Warning and Information System (HWIS).

As part of Ontario's harmonized Heat Warning and Information System (HWIS) implemented in 2016, the Health Protection Division (HPD) collaborates with Environment and Climate Change Canada to provide advance notice of extreme heat conditions to municipalities, community partners and the public. The HWIS allows community service agencies and municipalities to activate their heat-response plans in advance of the extreme heat. The HPD uses social media and news releases to provide information on reducing heat illness, updates Durham Region's extreme heat webpage includes information on recognizing heat-illness, promotes wellness checks and suggests low-cost ways to stay cool in a hot indoor setting. Annual HWIS meetings with local partners focus on heat response planning and include the needs of at-risk populations.

A 2022 time-series analysis found that implementation of the Ontario HWIS system was associated with a decline in emergency department visits for heat-related illness, adjusted for maximum daily temperature, in some subpopulations. [1] In the summer of 2023, subscriptions to the Region's HWIS more than doubled.

The Region-wide Durham Greener Homes Program.

Launched in April 2022, this program is managed by Durham Region staff in the Office of the CAO and supports residents to undertake energy efficient renovations. Building better insulated homes that have efficient cooling systems can improve resilience to extreme heat. The program has recently been augmented to include an income-qualified incentive for air source heat pumps, which can provide cooling to low-income households.

Durham Region Local Housing Corporation (DRLHC) Seniors Building Portfolio Retrofit Strategy.

The Region continues to advance an energy efficiency and resilience strategy for the DRLHC multi-unit seniors building portfolio that includes a focus on providing in suite cooling.

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15 To learn more about the significant ecosystems of Durham Region, see Chapter 4 of report Climate Change and Health in Durham Region | Understanding the local health impacts of climate change, available at: www.durham.ca/ClimateAndHealth

Tree planting and naturalization programs.

Trees and vegetation are most useful as a heat-mitigation strategy when planted in strategic locations around buildings or to shade pavement in parking lots and on streets. For example, the Region continues to coordinate a collaborative effort with local area municipalities to provide funding and communications support for the delivery of the LEAF backyard tree planting program which provides subsidized tree planting to residents in Pickering, Ajax, Whitby, Oshawa, Clarington, Brock, and Scugog. From June 2020 to December 2022, approximately 770 trees have been planted through the LEAF program. [83]

Local Municipal Shade Policies.

Some Durham Region municipalities have shade policies. For example, Ajax was identified as having some of the strongest municipal shade policies in the province.[16]

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16 Ontario Health Prevention System Quality Index 2023

5.3.3 Recent or expected provincial policies that support local heat health

Mandatory air conditioning in all Ontario long-term care homes.

In 2021 the Government of Ontario passed legislation requiring all long-term care homes to have air conditioning in residents' rooms. By summer 2023, more than 99 per cent of 625 homes in Ontario have met this requirement. [84, 85]

New proposed heat stress regulation under the Occupational Health and Safety Act.

The Ministry of Labour, Immigration, Training and Skills Development of Ontario (MLITSD) is proposing a stand-alone heat stress regulation under the Occupational Health and Safety Act (OHSA) with specific requirements that would apply to all workplaces to which the OHSA applies. [86] These proposed amendments have been developed in recognition that extreme heat events are a growing health risk to workers in Ontario and that heat stress is a significant cause of occupational illness and even death.

6. Next steps and priorities

This extreme heat vulnerability assessment characterized heat exposure, priority populations, and adaptive capacity in Durham Region. Due to climate change, residents will experience increasing exposure to extreme heat. Health promotion interventions are needed to increase all residents' ability to protect themselves and others. Due to unequal burdens of extreme heat, tailored strategies are also needed to meet the unique needs of priority populations.

Durham Region can improve adaptive capacity to extreme heat through data and knowledge gathering, health promotion strategies and local services and policies.

1. **Local knowledge and data** such as monitoring and reporting extreme heat events and associated local health impacts on people and health systems.
2. **Health promotion and education** to help Durham Region residents assess the risk to themselves and those they care for and take appropriate action. [28, 9]
3. **Heat health policies, programs, and services** to help residents avoid or escape from extreme heat. [9, 23] Plans may include tenant protections, cool building policies, green infrastructure, public transportation, health services, public health programming, services and outreach, community outreach programs and accessible cooling spaces. [23]

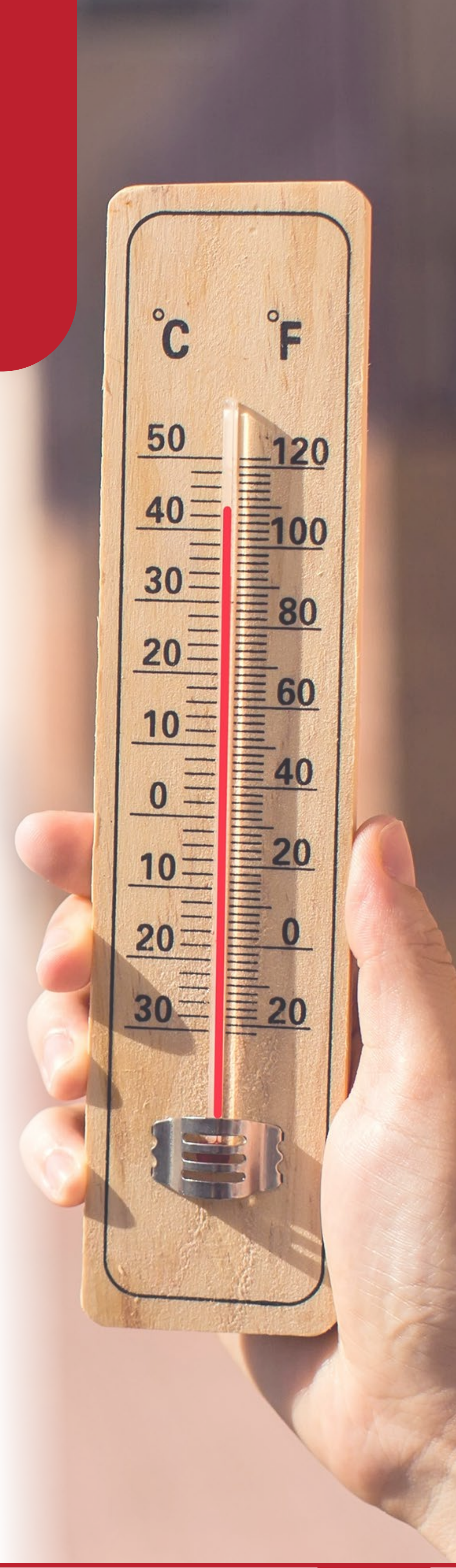
Table 6.1 provides examples of adaptation initiatives for each category. These are illustrative examples only and have yet to be assessed for feasibility or priority.

Table 6.1 I Examples of heat health adaptation initiatives

Examples of heat health adaptation initiatives	
Local Knowledge and Data	• Extreme heat forecasting and early warning system • RRFSS modules to capture access and barriers to at-home air-conditioning • Assessment of at-home air conditioning access • Development of key indicators to quantify health impacts of extreme heat • Monitoring and surveillance of heat-related illness, injury, or death • Assessment of health and social services capacity during extreme heat • Mapping of heat vulnerable communities • Shade mapping to identify high-need locations • Cooling centre mapping to identify underserved neighbourhoods • Survey of at-risk community members to understand coping strategies and needs during extreme heat events • Survey of community partners who serve at-risk residents on key barriers to staying cool during heat events • Inventory of municipal or community heat-adaptation activities
Health Promotion and Education	• Public maps of neighbourhood locations to escape the heat • Targeted messaging on recognizing and responding to heat-illness • Messaging on how to prepare for extreme heat emergencies • Targeted information for service providers to learn how to recognize and respond to signs of heat-related illness among the populations they serve • Promotion of the benefits of trees and vegetation to improve thermal comfort • Social campaign to promote outreach to isolated community members ("phone tree" systems) • Communications campaign to subscribe to heat alert program • Guides for service providers on developing extreme heat response plan tailored to the communities they serve • Multiple forms of communication on heat events such as physical signs of heat illness and what to do particularly for at-risk groups and organizations that serve them • Presentations to decision-makers and community leaders on local heat vulnerabilities to ensure at-risk groups are prioritized in decision making • Knowledge exchange through DRHD staff participation in climate change and health forums

Examples of heat health adaptation initiatives	
Programs, Policies or Services	• Community-led "buddy system" programs to check on neighbours during/after extreme heat events • Heat wellness checks training programs • Targeted heat health check training and response (e.g. for those serving at-risk groups including older adults who live alone, children, people living with chronic health conditions mental health conditions, addiction, homelessness, people who work and exercise outdoors • Expansion of community cooling centres, with focus on accessibility and inclusivity for residents experiencing stigma or marginalization • Urban heat island mitigation plans in Durham Region priority neighbourhoods • Heat impact assessments as a mandatory component of Environmental Impact Assessments • Tree conservation and clear-cutting by-laws to reduce the loss of carbon sinks • Transportation to cooling centres for at-risk individuals • Mobile cooling stations or outdoor water stations in high-risk neighbourhoods • Expanded air-conditioned recreational programs during summer months • Access to drinking water for housing insecure people on extreme heat days (i.e., distribution of water bottles, access to drinking fountains) • Assistance for eligible residents to access items to mitigate heat (e.g., fans) • Maximum temperature thresholds for rental units • Addressing by-laws and regulations that limit installation of cooling devices in multi-unit residential buildings • Mandatory air-conditioned common rooms in rental units • Employment policies to protect outdoor workers during extreme heat events • Increased green infrastructure (e.g., shade trees) in high-need areas. For example, tree shade in unavoidable and high-risk areas such as transit stops or places where at-risk groups must wait in line (e.g., shelters) • Vulnerable persons registry to support extreme heat wellness checks • Leverage residential retrofit programs to communicate awareness and protective measures for heat related illness to PNs

7. Assessment methods and limitations



Durham Region Health Department's CCHVA approach is adapted from the Ontario Ministry of Health and Long-Term Care's (MOHLTC) Guidelines for Ontario [87, 29, 88] and Health Canada's adaptation workbook [89]. Assessment of heat risk is examined through the three factors of vulnerability: exposure, sensitivity and adaptive capacity and draws on empirical studies, social theory and local data on health, socioeconomic disparities, the built environment, and climate trends. [58] For a complete description of the assessment process, scope, and limitations, please see Appendix 3.1 of the primer report: ***Climate Change and Health in Durham Region*** (durham.ca/ClimateAndHealth).

Additional limitations of this assessment include:

- Inherent uncertainties in climate modelling which can provide long-term heat projections but cannot predict the timing or duration of heat events or emergencies.
- Limited evidence of health impacts from compounded climate hazards such as heat, poor air quality and extreme storms.
- As explored in the report, there is a lack of individual and community-level data on exposure to urban heat islands, green spaces and heat-vulnerable housing.
- There is a relative lack of data for rural areas, and research suggests that urban and rural communities have different priorities and needs for addressing extreme heat.
- The urban heat island maps only provide a point in time snapshot of land surface temperatures (LST) and may not accurately reflect local experiences of heat exposure. For example, LST can help determine some degree of terrestrial radiation from the ground but does not necessarily predict human thermal comfort. [58]

References

[1] Public Health Ontario, Environmental Scan: Heat Alert and Response Systems (HARS), King's Printer for Ontario, 2023.

[2] Environment and Climate Change Canada, "Canada's National Adaptation Strategy," Government Of Canada, Ottawa, 2023.

[3] Ontario Public Health Emergencies Science Advisory Committee, "Seasonal Bulletin: Interim Recommendations," King's Printer for Ontario, Toronto, 2023.

[4] S. Henderson, F. Lamothe, J. Yao, C. Plante, S. Donaldson, R. Stranberg, D. Kaiser and T. Kosatsky, "Improving attribution of extreme heat deaths through interagency cooperation," Canadian Journal of Public Health, no. 113, pp. 698-702, 2022.

[5] H. Chen, J. Wang, Q. Li, A. Yagouti, E. Lavigne, R. Foty, R. Burnett, J. Villeneuve, S. Cakmak and R. Copes, "Assessment of the effect of cold and hot temperatures on mortality in Ontario: a population based study," CMAJ Open, vol. 4, no. 1, 2016.

[6] K. Bassil, D. Cole, R. Moineddin, W. Lou, A. Craig, B. Schwartz and E. Rea, "The relationship between temperature and ambulance response calls for heat-related illness in Toronto, Ontario, 2005," J Epidemiol Community Health, vol. 65, no. 9, 2011.

[7] C. Hebbern, P. Gosselin, K. Chen, H. Chen, S. Cakmak, M. MacDonald, J. Chagnon, P. Dion, L. Martel and E. Lavigne, "Future temperature-related excess mortality under climate change and population aging scenarios in Canada," Canadian Journal of Public Health, 2023.

[8] Climate Risk Institute, "Ontario Provincial Climate Change Impact Assessment Report," Ontario Ministry of the Environment, 2023.

[9] Health Canada, "Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials," Health Canada, Ottawa, 2011.

[10] J. Liu, B. Varghese, A. Hansen, Y. Zhang, T. Driscoll, G. Morgan, K. Dear, M. Gourley, A. Capon and P. Bi, "Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis," The Lancet Planetary Health, vol. 6, no. 6, pp. E484-E495, 2022.

[11] Government of Canada, "Climate Change is Increasing Risks to Canadians from Extreme Heat: Science Assessment 2022," 2022.

[12] B. Doyon, D. Belanger and P. Gosselin, "The potential impact of climate change on annual and seasonal mortality for three cities in Quebec, Canada," International Journal of Health Geographics, vol. 7, pp. 23-35, 2008.

[13] B. Doyon, D. Belanger and P. Gosselin, "Effects du Climat sur la Mortalite au Quebec Meridional de 1981 a 1999 et Simulations pour des Scenarios Climatiques Futurs," Institut National de Sante Publique de Quebec, Quebec, 2006.

[14] A. Swirski and T. Zupancic, "Climate Change and Health in Durham Region: Understanding the local health impacts of climate change," Durham Region Health Department, 2023.

[15] J. Eyquem and B. Feltmate, "Irreversible Extreme Heat: Protecting Canadians and Communities from an Extreme Future," University of Waterloo: Intact Centre on Climate Adaptation, 2022.

[16] BC Coroners Service, "Extreme Heat and Human Mortality:," BC Coroners Service, 2022.

[17] Government of Canada, "Government of Canada adaptation action plan," Environment and Climate Change Canada, Gatineau, 2023.

[18] M. Marmor, "Heat wave mortality in New York City, 1949 to 1970," Archives of Environmental Health, vol. 30, pp. 130-136, 1975.

[19] S. Hajat and T. Kosatsky, "Heat-related mortality: A review and exploration of heterogeneity," Journal of Epidemiology and Community Health, vol. 64, pp. 753-760, 2010.

[20] D. Mitchell, L. Senay, C. H. Wyndham, A. J. van Rensburg, G. G. Rogers and N. B. Strydom, "Acclimatization in a hot, humid environment: energy exchange, body temperature, and sweating," Journal of Applied Physiology, vol. 40, no. 5, pp. 768-778, 1976.

[21] E. Esplin, J. Marlon, A. Leiserowitz and P. Howe, ""Can you take the heat?" Heat-induced health symptoms are associated with protective behaviours," Weather, Climate, and Society, vol. 11, no. 2, pp. 401-417, 2019.

[22] Government of Canada, "Surviving the heat: The impacts of the 2021 western heat dome in Canada," 26 June 2022. [Online]. Available: https://science.gc.ca/site/science/en/blogs/science-health/surviving-heat-impacts-2021-western-heat-dome-canada. [Accessed September 2023].

[23] Health Canada, "Extreme Heat Event Guidelines: Technical Guide for Health Care Workers," Health Canada, Ottawa, 2011.

[24] K. Bassil, D. C. Cole and R. Moineddin, "Development of a Surveillance Case Definition for Heat-Related Illness using 911 Medical Dispatch Data.," Canadian Journal of Public Health, pp. 339-343, 2008.

[25] P. Berry and R. Schnitter, "Health of Canadians in a changing climate: Advancing our knowledge for action," Government of Canada, Ottawa, 2022.

[26] D. Beugin, D. Clark, S. Miller, R. Ness, R. Pelai and J. Wale, "The Case for Adapting to Extreme Heat: Costs of the 2021 BC Heat Wave," Canadian Climate Institute, 2023.

[27] F. Delaney, P. Ng, K. Dokoska, G. Milner, K. Potter and M. Notaro, "Guide to Conducting a Climate Change Analysis at the Local Scale: Lessons Learned from Durham Region," Ontario Climate Consortium, Toronto, 2020.

[28] Health Canada, "Heat alert and response systems to protect health: Best practices guidebook," Health Canada, Ottawa, 2012.

[29] W. Gough, V. Anderson and K. Herod, "Ontario Climate Change and Health Modelling Study," Queen's Printer for Ontario, Toronto, 2016.

[30] Regional Municipality of Durham, "Keeping Our Cool: Managing Urban Heat Islands in Durham Region," The Regional Municipality of Durham, Whitby, 2018.

[31] Public Health Agency of Canada, "Chief public health officer of Canada's report on the state of public health in Canada 2022: Mobilizing public health action on climate change in Canada," Public Health Agency of Canada, Ottawa, ON, 2022.

[32] G. Kenny, A. Flouris, A. Yagouti and S. Notley, "Towards establishing evidence-based guidelines on maximum indoor temperatures during hot weather in temperate continental climates," Temperature, vol. 6, no. 1, pp. 11-36, 2019.

[33] Statistics Canada, "Census Profile. 2021 Census of population. Statistics Canada Catalogue no. 98-316-X2021001.," Statistics Canada, Ottawa, 2023.

[34] F. Aram, E. H. Garcia, E. Solgi and S. Mansourina, "Urban green space cooling effect in cities," Heliyon, vol. 5, no. e01339, 2019.

[35] J. Voogt, "Urban Heat Island," in Encyclopedia of Global Environmental Change, vol. 3, T. Munn, Ed., Chichester, John Wiley and Sons, 2002, p. 460.

[36] C. O'Malley, P. Piroozfar, E. R. P. Farr and F. Pomponi, "Urban heat island (UHI) mitigating strategies: A case-based comparative analysis," Sustainable Cities and Society, vol. 19, pp. 222-235, 2015.

[37] R. A. Memon, D. Y. Leung and L. Chunho, "A review on the generation, determination and mitigation of urban heat island," Journal of Environmental Science, vol. 20, pp. 120-128, 2008.

[38] L. Kalkstein and S. Sheridan, The Impacts of Heat Island Reduction Strategies on Health-Debilitating Opressive Air Masses in Urban Areas, United States Environmental Protection Agency (US EPA), 2003.

[39] F. Pacheco-Torgal, "Introduction to eco-efficient materials to mitigate building cooling needs," in Eco-Efficient Materials for Mitigating Building Cooling Needs: Design, Properties and Applications, Elsevier Ltd., 2015, pp. 1-9.

[40] S. Henderson, K. McLean, M. Lee and T. Kosatsky, "Analysis of community deaths during the catastrophic 2021 heat dome," Environmental Epidemiology, vol. 6, no. 1, 2022.

[41] M. Quick and M. Tjepkema, "The prevalence of household air conditioning in Canada," Statistics Canada, 2023.

[42] S. Larrieu, L. Carcaillon, A. Lefranc, C. Helmer, J.-F. Dartigues, B. Tavernier, M. Ledrans and L. Filleul, "Factors associated with morbidity during the 2003 heat wave in two population-based cohorts of elderly subjects: PAQUID and Three City," European Journal of Epidemiology, vol. 23, no. 4, pp. 295-302, 2008.

[43] G. P. Kenny, J. Yardley and C. Brown, "Heat Stress in Older Individuals and Patients with Common Chronic Diseases.," Can. Med. Assoc. J., vol. 8, 2009.

[44] L. Yumagulova, T. Okamoto, E. Crawford and K. Klein, "Lived Experience of Extreme heat in BC: Final report to the Climate Action Secretariat," BC Climate Action Secretariat, 2022.

[45] S. Mahant, "The evaluation and management of heat injuries in an intensive care unit," Indian J Crit Care Med, vol. 19, no. 8, pp. 479-83, 2015.

[46] C. Lefevre, W. Bruine de Bruin, A. Taylor, S. Dessai, S. Kovats and B. Fischhoff, "Heat protection behaviours and positive affect about heat during the 2013 heat wave in the United Kingdom," Social Science and Medicine, vol. 128, pp. 282-289, 2015.

[47] V. Limaye, J. Vargo, T. Holloway and J. Patz, "Climate change and heat-related excess mortality in the eastern USA," EcoHealth, vol. 15, no. 3, pp. 485-496, 2018.

[48] G. Booth, E. Homenauth, E. Graves, I. Ishiguro and J. S., "Indicators for Durham Region Health Neighourhoods - Update, Applied Health Research Questions (AHRQ)," Institute for Clinical Evaluative Sciences, Toronto, 2019.

[49] K. Clemens, B. Le, A. Ouedraogo, C. Mackenzie, M. Vinegar and S. Shariff, "Childhood food insecurity and incident asthma: A population-based cohort study of children in Ontario, Canada," PLoS One , vol. 16, no. 6, 2021.

[50] L. Konkel, "Taking the heat: Potential fetal health effects of hot temperatures," Environmental Health Perspectives, vol. 127, no. 10, 2019.

[51] L. Kuehn and S. McCormick, "Heat exposure and maternal health in the face of climate change," International Journal of Environmental Research and Public Health, vol. 14, no. 8, 2017.

[52] N. Auger, W. D. Fraser, A. Smargiassi, M. Bilodeau-Bertrand and T. Kosatsky, "Elevated outdoor temperatures and risk of stillbirth," Epidemiology, vol. 46, no. 1, pp. 200-2008, 2017c.

[53] N. Auger, A. I. Naimi, A. Smrgiassi, E. Lo and T. Kosatsky, "Extreme heat and risk of early delivery among preterm and term pregancies," Epidemiology, vol. 25, no. 3, 2014.

[54] N. Auger, W. D. Fraser, L. Arbour, M. Bilodeau-Bertrand and T. Kosatsky, "Elevated ambient temperatures and risk of neural tube defects," Occupational and Environmental Medicine, vol. 74, no. 5, pp. 315-320, 2017a.

[55] N. Auger, W. D. Fraser, R. Sauvé, M. Bilodeau-Bertrand and T. Kosatsky, "Risk of congenital heart defects after ambient heat exposure early in pregnancy," Environmental Health Perspectives, vol. 125, no. 1, pp. 8-14, 2017b.

[56] Durham Region Health Department, "Building on Health in Priority Neighbourhoods," Regional Municipality of Durham, Whitby, 2015.

[57] A. Bouchama, M. Dehbi and G. Mohamed, "Prognostic Factors in Heat Wave Related Deaths: A Meta-Analysis," Arch. Intern. Med., vol. 167, pp. 2170-2176, 2007.

[58] C. Wenwen, D. Li, Z. Liu and R. Brown, "Approaches for identifying heat-vulnerable populations and locations: A systematic review," Science of the Total Environment, vol. 799, p. 149417., 2021.

[59] M. Lee, K. McLean, M. Kuo, G. Richardson and S. Henderson, "Chronic Diseases Associated With Mortality in British Columbia, Canada During the 2021 Western North America Extreme Heat Event," GeoHealth, vol. 7, no. 3, 2023.

[60] B. G, E. Homenauth, E. Graves, I. Ishiguro and J. S., "Indicators for Durham Region Health Neighourhoods - Update, Applied Health Research Questions (AHRQ) 2019 0900 784 001.," Institute for Clinical Evaluative Sciences., Toronto, 2018.

[61] A. Smargiassi, M. Fournier and C. Griot, "Prediction of the Indoor Temperatures of an Urban Area with an in-Time Regression Mapping Approach.," J. Expo. Sci. Environ. Epidemiol.,, vol. 18, pp. 282-288, 2008.

[62] The Regional Municipality of Durham, "Community safety and well-being plan," The Regional Municipality of Durham, Whitby, 2021.

[63] S. Arman, "Durham Region point-in-time count report 2021 - Measuring the scope and nature of homelessness in Durham," Community Development Council Durham, The Regional Municipality of Durham, Whitby, 2021.

[64] Durham Region Health Department, "The price of eating well in Durham Region 2022," Durham Region Health Department, Whitby, 2022.

[65] K. Bassil and D. Cole, "Effectiveness of Public Health Interventions in Reducing Morbidity and Mortality during Heat Episodes: a Structured Review," Int. J. Environ. Res. Public Health, vol. 7, no. 3, pp. 991-1001, 2010.

[66] The Regional Municipality of Durham, "2021 Census of population - Citizenship and immigration, ethnocultural and religious composition, mobility and migration (Release 6), File: D01-03. Report #2022-INFO-102," Commissioner of Planning and Economic Development, Whitby, 2002.

[67] D. P. Taylor, "Support and Inclusion for Success: Identifying the service needs of racialized immigrants in Durham Region," Durham Local Immigration Partnership, Trent University and Community Health, 2023.

[68] S. Singh, E. Hanna and T. Kjellstrom, "Working in Australia's heat: health promotion concerns for health and productivity," Health Promotion International, vol. 30, no. 2, pp. 239-250, 2015.

[69] J. Vanos, L. Kalkstein and T. Sanford, "24. Vanos, J,Detecting synoptic warming trends across the US Midwest and implications to human health and heat-related mortality.," I J Climatol, pp. 85-96, 2015.

[70] A. Adam-Poupart, N. Nicolakakis, E. Anassour Laouan Sidi, P. Berry, C. Campagna, D. Chaumont, L. F. Hamel D and M.P. Sassine, "Climate change and heat vulnerabilities of Canadian workers: Focus on the Central and Western provinces of Canada," Institut national de santé publique du Québec, 2021.

[71] M. Fortune, C. Mustard and P. Brown, "The use of bayesian inference to inform the surveillance of temperature-related occupational morbidity in Ontario, Canada, 2004–2010.," Environ. Res., vol. 132, p. 449–456., 2014.

[72] E. Bush and D. S. Lemmen, Eds., Canada's Changing Climate Report, Ottawa, Ontario: Government of Canada, 2019

[73] Public Health Committee, Motion: Implementation of an Adequate Temperature By-law, Hamilton: City of Hamilton, 2023.

[74] Public Health Agency of Canada, "Chief Public Health Officer of Canada's Report on the State of Public Health in Canada 2022: Mobilizing public health action on climate change in Canada," Public Health Agency of Canada, Ottawa, ON, 2022.

[75] Ministry of the Solicitor General, "Office of the Chief Coroner and Ontario Forensic Pathology Servive," 2021.

[76] A. Bouchama, M. Dehbi, G. Mohamed, F. Matthies, M. Shoukri and B. Menne, "Prognostic Factors in Heat Wave Related Deaths: A Meta-Analysis," Archives of Internal Medicine, vol. 167, pp. 2170-2176, 2007.

[77] Government of Canada, "Canada's National Adaptation Strategy," 2023.

[78] Durham Region Health Department and Institute for Social Research (ISR), Rapid Risk Factor Surveillance System (RRFSS), York University, 2019.

[79] R. Schnitter, E. Moores, P. Berry, M. Verret, C. Buse, C. Macdonald, M. Perri and D. Jubas-Malz, "Climate change and health equity," in Health of Canadians in a changing climate: Advancing our knowledge for action, P. Berry and R. Schnitter, Eds., Ottawa, ON, Government of Canada, 2022.

[80] S. Jodoin, A. Bowie-Edwards, N. Ananthamoorth and R. Paquet, "Disability Rights in Canadian Claimate Policies: a systematic analysis," McGill Centre for Human Rights & Legal Pluralism, Montreal, 2022.

[81] A. Alberini, W. Gans and M. Alhassan, " Individual and public-program adaptation: coping with heat waves in five cities in Canada.," Alberini A, Gans W, Alhassan M. Individual and public-program adaptation: coping w International journal of environmental research and public health. 2011 Dec;8(12):4679-701., vol. 12, no. 4, pp. 679-701., 2011.

[82] G. Kenny, "Extreme heat events and overheating in the home," in Presentation of the Huma and Environmental Physiology Research Unit, Ottawa.

[83] LEAF Backyard Tree Planting Program - Final Report, Toronto, 2023.

[84] L. Casey, "99% of Ontario nursing homes now have air conditioning in residents' rooms: minister," The Canadian Press, 2023.

[85] Government of Ontario, ONTARIO REGULATION 66/23: FIXING LONG-TERM CARE ACT, 2021, King's Printer for Ontario, 2023 April.

[86] Ontario's Regulatory Registry, New Heat Stress Regulation Under the Occupational Health and Safety Act, Toronto: Government of Ontario, 2023.

[87] J. Paterson, A. Yusa, V. Anderson and P. Berry, "Ontario climate change and health vulnerability and adaptation assessment guidelines - Workbook," Queen's Printer for Ontario, Ontario, 2016.

[88] K. Ebi, V. Anderson, P. Berry, J. Paterson and A. Yusa, "Ontario climate change and health vulnerability and adaptation assessment guidelines - Technical Document," Queen's Printer for Ontario, Toronto, 2016.

[89] P. Enright, P. Berry, J. Paterson, K. Hayes, R. Schnitter and M. Verret, "Climate change and health vulnerability and adaptation assessment: Workbook for the Canadian health sector," Health Canada, Ottawa, ON, 2022.

[90] N. R. Mascioli, A. M. Fiore, M. Previdi and G. Correa, "Temperature and precipitation extremes in the United States: quantifying the response to anthropogenic aerosols and greenhouse gases.," Journal of Climate, vol. 29, no. 7, pp. 2689-2701, 2016.

[91] Intergovernmental Panel on Climate Change (IPCC), "Annex II: Glossary," in Climate change 2022: Impacts, adaptation and vulnerability, H. Pörtner, D. Roberts, M. Tinor, E. Poloczanska, K. Mitenbeck, A. Alegría and e. al., Eds., Cambridge, UK, Cambridge University Press, pp. 2897-2930, 2022.

[92] National Collaborating Centre for Determinants of Health, "Glossary of essential health equity terms," National Collaborating Centre for Determinants of Health, St. Francis Xavier University, Antigonish, 2022.

[93] U.S. Global Change Research Program, "The impacts of climate change on human health in the United States: A scientific assessment," U.S. Global Change Research Program, Washington, DC, 2016.

[94] L. Vescovi, M. Rebetez and F. Rong, "Assessing public health risk due to extremely high temperature events: climate and social parameters," Climate Research, vol. 30, pp. 71-78, 2005.

[95] L. D. Pengelly, M. E. Campbell, C. C. Cheng, C. Fu, S. E. Gingrich and R. Macfarlane, "Anatomy of Heat Waves and Mortality in Toronto: Lessons for Public Health Protection," Canadian Journal of Public Health, vol. 98, no. 5, pp. 364-368, 2007.

[96] H. Akbari and D. Kolokotsa, "Three decades of urban heat islands and mitigation technologies research," Energy and Buildings, vol. 133, pp. 834-842, 2016.

[97] J. A. Derecki, "Hydrometeorology: Climate and Hydrology of the Great Lakes," in Hydrometeorology, , , 1976, pp. 71-104.

[98] Environmental Law & Policy Center (ELPC), "An Assessment of the Impacts of Climate Change on the Great Lakes," ELPC, Boston, 2019.

[99] R. W. Scott and F. A. Huff, "Impact of the Great Lakes on regional climate conditions," Journal of Great Lakes Research, vol. 22, pp. 845-863, 1996.

[100] A. Dimoudi, A. Kantzioura, S. Zoras, C. Pallas and P. Kosmopoulos, "Investigation of urban microclimate parameters in an urban center.," Energy and Buildings, vol. 64, pp. 1-9, 2013.

[101] Environmental Protection Agency (EPA), Reducing Urban Heat Islands: Compendium of Strategies, E. Wong, K. Hogan, J. Rosenburg and A. Denny, Eds., US EPA, 2009.

[102] R. Giridharan and R. Emmanuel, "The impact of urban compactness, comfort strategies and energy consumption on tropical urban heat island intensity: a review," Sustainable Cities and Society, vol. 40, pp. 677-687, 2018.

[103] B. Dousset, F. Gourmelon and E. Mauri, "Application of satelite remote sensing for urban risk analysis: a case study of the 2003 extreme heat wave in Paris," in 2007 Urban Remote Sensing Joint Event, , 2007.

[104] D. E. Bowler, L. Buyung-Ali, T. M. Knight and A. S. Pullin, "Urban greening to cool towns and cities: A systematic review of the empirical evidence," Landscape and Urban Planning, vol. 97, no. 3, pp. 147-155, 2010.

[105] Y. Hu, Z. Dai and J.M. Guldmann, "Greenspace configuration impact on the urban heat island in the Olympic Area of Beijing," Environmental Science and Pollution Research, vol. 28, pp. 33096-33107, 2021.

[106] J. A. Boulant, "Hypothalamic mechanisms in thermoregulation," Federation Procedings , vol. 40, no. 14, pp. 2843-2850, 1981.

[107] L. Sherwood, Human Physiology: From Cells to Systems, Belmont, CA: Wadsworth Publishing Company, 1997, p. 880.

[108] C. B. Wegner, "Human Adaptation to Hot Environments," in Medical Aspects of Harsh Environments, K. B. Pandolf and R. E. Burr, Eds., Washington, DC: Borden Institute, 2001, p. 31.

[109] A. Gasparrini, Y. Guo, M. Hashizume, E. Lavigne, A. Zanobetti, J. Schwartz, A. Tobias, S. Tong, J. Rocklöv, B. Forsberg, M. Leone, M. De Sario, M. L. Bell, Y.-L. L. Guo, C. Wu, H. Kan, S.-M. Yi, M. de Sousa Zanotti Stagliorio Coelho et. al., "Mortality risk attributable to high and low ambient temperature: A multicountry observational study," The Lancet, vol. 386, no. 9991, pp. 369-375, 2015.

[110] Z. Xu, G. FitzGerad, Y. Guo, B. Jalaludin and S. Tong, "Impact of heatwave on mortality under different heatwave definitions: A systematic review and metaanalysis," Environment International, vol. 89, pp. 193-203, 2016.

[111] Z. Sun, C. Chen, D. Zu and T. Li, "Effects of ambient temperature on myocardial infarction: A systematic review and meta-analysis," Environmental Pollution, vol. 241, pp. 1106-1114, 2018.

[112] M. T. Moghadamnia, A. Ardalan, A. Mesdaghinia, A. Keshtkar, K. Naddafi, and S.Yekaninejad, "Ambient temperature and cardiovascular mortality: A systematic review and meta-analysis," Peerj, vol. 5, p. e3574, 2017.

[113] E. Lavigne, A. Gasparrini, X. Wang, H. Chen, A. Yagouti, M. D. Fleury and S. Cakmak, "Extreme ambient temperatures and cardiorespiratory emergency room visits: Assessing risk by comorbid health conditions in a time series study," Environmental Health, vol. 13, no. 1, 2014.

[114] R. Basu, D. Pearson, B. Malig, R. Broadwin and R Green, "The effect of high ambient temperature on emergency room visits," Epidemiology, vol. 23, no. 6, 2012.

[115] X. Wang, E. Lavigne, H. Ouellette-Kuntz and B. E. Chen, "Acute impacts of extreme temperature exposure on emergency room admissions related to mental and behavioural disorders in Toronto, Canada," Journal of Affective Disorders, vol. 155, pp. 154-161, 2014.

[116] S. Vida, M. Durocher, T. B. M. J. Ouarda and P. Gosselin, "Relationship between ambient temperaure and humidity and visits to mental health emergency departments in Québec," Psychiatric Services, vol. 63, no. 11, pp. 1150-1153, 2012.

[117] Pathways, "Putting accessibility at the centre of climate action," University of British Columbia, Faculty of Medicine, 2023. [Online].

[118] Regional Municipality of Durham, "Envision Durham: Draft Official Plan," 2023.

Appendix A: Acronyms, terms and definitions

AC	Air conditioner
ACES	Acute Care Enhanced Surveillance System
BC	British Columbia
CCHVA	Climate change and health vulnerability assessment
CI	Confidence interval
CO2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CSWB	Community safety and well-being
˚C	Degree(s) Celsius
DRHD	Durham Region Health Department
DRLHC	Durham Regional Local Housing Corporation
ECCC	Environment and Climate Change Canada
EHD	Extreme heat day
EHE	Extreme heat event
HPD	Health Protection Division
HRI	Heat-related illness
HN	Health Neighbourhood
HWIS	Heat warning and information system
LIM-AT	Low-income measure after tax
LST	Land surface temperature
MLITSD	Ministry of Labour, Immigration, Training and Skills Development
NA-CORDEX	North American Coordinated Regional Climate Downscaling Experiment
ODSP	Ontario Disability Support Program
OHSA	Occupational Health and Safety Act
PN	Priority neighbourhood
RCP	Representative concentration pathway
RRFSS	Rapid Risk Factor Surveillance System
UGS	Urban green space
UHI	Urban heat island

Terms & Definitions

A more complete list of terms and definitions related to climate change and health can be found in our primer report: Climate Change and Health in Durham Region: Understanding the local health impacts of climate change, available at: www.durham.ca/ClimateAndHealth

ACCLIMATIZATION

The gradual exposure to increasing temperatures which results in changes in the body that can improve a person's ability to tolerate the heat. The process can take up to several weeks to occur. [1]

AMBIENT AIR TEMPERATURE

How hot or cold it is outdoors as measured by a thermometer in degrees Celsius.

CLIMATE VULNERABILITY

The predisposition for health to be adversely affected by climate change. Climate vulnerability is determined by differential exposure, sensitivity, and capacity to adapt to climate hazards. In public health, the concept of vulnerability can be highly stigmatizing, so it is important to emphasize that vulnerability is not a label for communities or populations. [2, 3, 4]

EQUITY-DESERVING GROUPS

Equity-deserving groups are populations or communities that experience significant collective barriers to participating in society often due to historical and structural disadvantages, inequities, and underrepresentation.

EVAPORATIVE COOLING

Reduction in temperature resulting from the evaporation of a liquid. This is the physical basis of how sweating, which cools your body as you sweat, absorbs heat from the body as it evaporates.

EXPOSURE

The degree to which an individual or community encounters climate hazards. It is influenced by underlying social and economic conditions that result in some individuals or communities experiencing more exposure to climate hazards than others.

EXTREME HEAT EVENT (EHE)

Defined based on regional guidelines and in Durham Region, refers to times when temperatures are 31˚C or higher and/or the Humidex value is 40 or higher for two or more consecutive days and overnight temperatures above 20°C or greater. Also known as a "heat wave".

HEALTH EQUITY

Health equity means that everyone has a fair opportunity to enjoy their full health potential and are not disadvantaged by unfair social, economic, and environmental conditions. Many factors outside the health care system influence health. Health equity is achieved when health between groups due to unfair social and structural factors are eliminated. [5, 6]

HEALTH INEQUITY

Differences in health outcomes that are unfair, unjust, and avoidable. Health differences result from social, economic, demographic, geographic, or environmental disadvantages.

HEALTH NEIGHBOURHOODS

Durham Region has 50 Health Neighbourhoods and tracks 96 indicators to better understand the demographics and health of Durham Region communities.

HEAT

The combination of ambient temperature, heat load, humidity, and wind speed.

HEAT STRESS

The combined heat burden on the body from the combination of body heat, clothing, and exposure to environmental heat.

HUMIDITY

The amount of water vapour in the air.

HUMIDEX

An indicator of how hot it feels outside. Values take into consideration the effect of both relative humidity and temperature on the human body.

IMPACTS

This term is used to refer to the effect of climate events and changes on natural and human-made environments. These impacts often refer to effects on lives, livelihoods, health, ecosystems, societies, economies, service delivery and infrastructure. Impacts are also sometimes called consequences or outcomes.

RADIANT HEAT

Refers to the transfer of heat from a heated surface. The most common form is the transfer of heat from the Sun to the Earth. In general, dark-coloured surfaces like parking lots absorb more radiant heat from the Sun than light-coloured surfaces which tend to reflect energy from the Sun instead of absorbing it.

SENSITIVITY

How much individuals or a population are affected by the health impacts of climate change. It is influenced by biologic and social factors within the population such as age, sex, chronic illness, or socioeconomic status.

SOCIAL ISOLATION

This refers to people who are living alone without support and/or who are too far away from services and supports. Social isolation is the state of having a smaller number of social contacts, which may contribute to loneliness.

SOLAR RADIATION

Energy radiated from the Sun in the form of electromagnetic waves, including visible and ultraviolet light and infrared radiation. Usually referred to as sunlight.

THERMOREGULATION

A person's ability to regulate their body temperature.

TROPICAL NIGHTS

The annual number of days when the daily minimum temperature is greater than 20˚C. This means that nighttime temperatures remain 20˚C or warmer.

URBAN HEAT ISLAND (UHI) EFFECT

This is the effect where communities in urban areas experience higher ambient temperatures than the less urban areas surrounding them because of the absorption of energy from the Sun by surfaces like asphalt.

URBANIZATION

The increase in the proportion of a population living in urban areas; the process by which many people become permanently clustered in relatively small areas, forming cities.

WIND SPEED

The speed air moves, also referred to as air velocity.

References

[1] N. R. Mascioli, A. M. Fiore, M. Previdi and G. Correa, "Temperature and precipitation extremes in the United States: quantifying the response to anthropogenic aerosols and greenhouse gases.," Journal of Climate, vol. 29, no. 7, pp. 2689-2701, 2016.

[2] Intergovernmental Panel on Climate Change (IPCC), "Annex II: Glossary," in Climate change 2022: Impacts, adaptation and vulnerability, H. Pörtner, D. Roberts, M. Tinor, E. Poloczanska, K. Mitenbeck, A. Alegría and e. al., Eds., Cambridge, UK, Cambridge University Press, 2022, pp. 2897-2930.

[3] U.S. Global Change Research Program, "The impacts of climate change on human health in the United States: A scientific assessment," U.S. Global Change Research Program, Washington, DC, 2016.

[4] P. Berry and R. Schnitter, "Health of Canadians in a changing climate: Advancing our knowledge for action," Government of Canada, Ottawa, 2022.

[5] R. Schnitter, E. Moores, P. Berry, M. Verret, C. Buse, C. Macdonald, M. Perri and D. Jubas-Malz, "Climate change and health equity," in Health of Canadians in a changing climate: Advancing our knowledge for action, P. Berry and R. Schnitter, Eds., Ottawa, ON, Government of Canada, 2022.

[6] National Collaborating Centre for Determinants of Health, "Glossary of essential health equity terms," National Collaborating Centre for Determinants of Health, St. Francis Xavier University, Antigonish, 2022.

Appendix B: Understanding thermoregulation

Heat-related illnesses mainly result from the body's lack of being able to cope with the heat. To understand the health risks of exposure to heat, it is important to first be familiar with the body's ability to thermoregulate and deal with excess heat.

Thermoregulation: the process in which the body regulates or maintains a stable core body temperature of approximately 37˚C.

Thermoregulation consists of three ways that are important for maintaining a stable body temperature:

- **Afferent sensing: receptors throughout the body help to determine if the body core temperature is too hot or too cold and send signals to the hypothalamus.**
- **Central control: the hypothalamus region in the brain controls thermoregulation. [1]**
  If the hypothalamus senses internal body temperatures that are too hot or too cold, it automatically sends signals to other parts of the body to start efferent responses.
- **Efferent responses: behavioural and automatic responses by the body to protect itself from extreme changes in temperature.**
  This can include behavioural responses to heat like removing an article of clothing or moving to a shaded spot. Automatic responses by the body include things like sweating and shivering. [1]

Excess heat release: Excess heat produced in the body can be released into the environment through the skin.

The body produces heat internally through processing food and physical exertion. If more heat is generated within the body than is required to maintain core body temperature the excess heat needs to be released from the body. This is achieved by first transferring the heat to the skin where it can then be released through four possible mechanisms:

- **Conduction: two-way transfer of heat between two touching surfaces with different temperatures.**
  This includes external conduction which occurs when the skin is in contact with cool surfaces or objects.
- **Convection: two-way transfer of heat when air or water molecules touch the skin.**
  Skin temperature is around 35˚C on average. [2] When air temperatures are lower than the skin temperature, the transfer of heat from the body to the air can help carry heat away from the body through convection. However, when air temperatures are higher than the skin temperature, heat will be gained by the body. [3]
- **Radiation: two-way transfer of infrared rays released from one object and absorbed by another.**
  A person can radiate heat to cooler objects and absorb heat from warmer objects. Radiant heat can be generated by several sources in a person's environment including direct sunlight, ovens, hot asphalt, and buildings made of absorptive or dark materials. The body can also radiate heat to help with cooling itself.
- **Evaporation: one-way transfer of heat from the body into the environment through evaporation of water from the skin through sweat or from the respiratory system through breathing.**
  Evaporation of sweat is the most important thermoregulatory mechanism in hot temperatures. When the air temperature is higher than the skin temperature, evaporation through sweating is the only possible way for the body to get rid of excess heat and is responsible for approximately 90 per cent of heat loss. [4] Air movement can help improve evaporative cooling, but high humidity can reduce efficiency and in some cases stop it altogether. It is important to note that the act of sweating itself does not release heat from the body it is the evaporation of the sweat that provides cooling. [3]

During periods of high heat and humidity, an increase in the body's heat strain may occur which leads to increased body temperature and susceptibility to developing heat related illness. The direct health effect of this exposure on an individual is impacted by many physiological factors including health conditions that reduce an individual's ability to thermoregulate. Risk factors that affect a person's exposure to the heat itself can make their health sensitivities worse and increase the likelihood of developing a heat related illness.

References

[1] J. A. Boulant, "Hypothalamic mechanisms in thermoregulation," Federation Procedings , vol. 40, no. 14, pp. 2843-2850, 1981.

[2] L. Sherwood, Human Physiology: From Cells to Systems, Belmont, CA: Wadsworth Publishing Company, 1997, p. 880.

[3] Health Canada, "Extreme Heat Event Guidelines: Technical Guide for Health Care Workers," Health Canada, Ottawa, 2011.

[4] C. B. Wegner, "Human Adaptation to Hot Environments," in Medical Aspects of Harsh Environments, K. B. Pandolf and R. E. Burr, Eds., Washington, DC: Borden Institute, 2001, p. 31.

Appendix C: Which environmental factors impact heat?

The level of heat experienced within a community is influenced by several environmental factors including, climate, season, and community design. [1, 2, 3, 4, 5, 6, 7]

When evaluating the potential impact of exposure to heat on health it is important to note that air temperature and heat do not mean the same thing, even though they are often used interchangeably. Heat refers to how temperature "feels" to us; this is also referred to as thermal comfort. The heat experienced by a person is the result of the interaction of four environmental components (**Figure C.1**):

1. Ambient air temperature: How hot or cold it is outdoors, measured by a thermometer in degrees Celsius (˚C).
2. Radiant heat: Heat radiated or transferred from a heated surface to a cooler surrounding surface.
3. Humidity: The amount of water vapour in the air.
4. Wind speed: The speed at which air moves, also referred to as air velocity.

Although ambient air temperature is the most important determinant of heat, as it has the greatest affect on the rate of heat loss or cooling that the body can do; the combination of these four factors reflect the most accurate picture of a person's level of heat stress. [2]

The level of heat an individual is exposed to is a combination of the level of actual heat within the environment and several community and individual factors. These factors influence heat exposure based on an individual's awareness of heat risks, and the ability to assess their own risk of exposure and adopt protective behaviours to prevent or decrease heat exposure. [5, 1]

As Durham Region's climate changes, exposures to heat may vary as seasonal temperatures and the frequency of EHEs and tropical nights increase in the future. [8]

Environmental components of heat

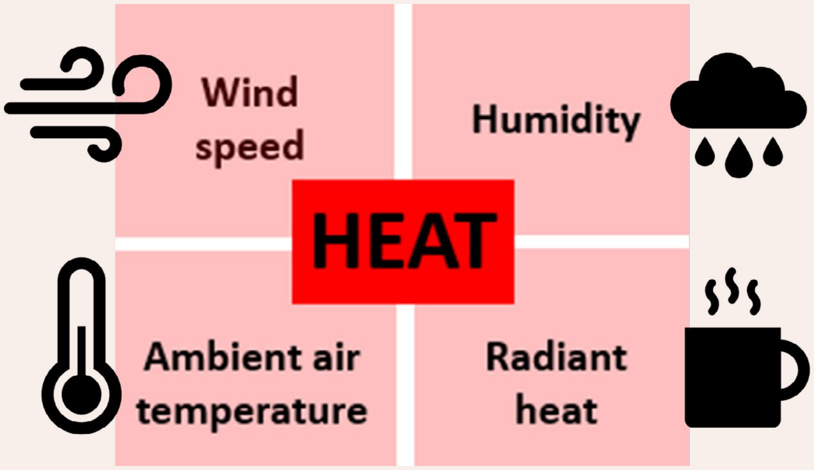


Figure C.1 | The four environmental components which interact to produce the heat felt by a person

These four environmental components of heat (**Figure C.1**) are influenced by several factors in the local environment including: [1, 2, 3, 4, 5, 6, 7]

- Local climate
- Season
- Community design

The interaction of these environmental components results in a noticeable variation in the level of heat experienced by Durham Region's communities.

References

[1] Health Canada, "Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials," Health Canada, Ottawa, 2011.

[2] Health Canada, "Extreme Heat Event Guidelines: Technical Guide for Health Care Workers," Health Canada, Ottawa, 2011.

[3] F. Aram, E. H. Garcia, E. Solgi and S. Mansourina, "Urban green space cooling effect in cities," Heliyon, vol. 5, no. e01339, 2019.

[4] L. Kalkstein and S. Sheridan, The Impacts of Heat Island Reduction Strategies on Health-Debilitating Opressive Air Masses in Urban Areas, United States Environmental Protection Agency (US EPA), 2003.

[5] L. Vescovi, M. Rebetez and F. Rong, "Assessing public health risk due to extremely high temperature events: climate and social parameters," Climate Research, vol. 30, pp. 71-78, 2005.

[6] L. D. Pengelly, M. E. Campbell, C. C. Cheng, C. Fu, S. E. Gingrich and R. Macfarlane, "Anatomy of Heat Waves and Mortality in Toronto: Lessons for Public Health Protection," Canadian Journal of Public Health, vol. 98, no. 5, pp. 364-368, 2007.

[7] C. O'Malley, P. Piroozfar, E. R. P. Farr and F. Pomponi, "Urban heat island (UHI) mitigating strategies: A case-based comparative analysis," Sustainable Cities and Society, vol. 19, pp. 222-235, 2015.

[8] F. Delaney, P. Ng, K. Dokoska, G. Milner, K. Potter and M. Notaro, "Guide to Conducting a Climate Change Analysis at the Local Scale: Lessons Learned from Durham Region," Ontario Climate Consortium, Toronto, 2020.

Appendix D: The influence of local climate, season, and the built environment on extreme heat

LOCAL CLIMATE

Local climate plays a key role in the level of heat experienced within a community due to local variations in temperature, humidity, and wind patterns. [1, 2, 3]

Durham Region has a humid continental climate and experiences a wide range of temperatures throughout the year with hot summers and cold winters. The local climate can vary noticeably across municipalities due to the region's vast size and differences in local geography. [4]

Although there are many environmental factors that can affect the climate in a particular location, latitude and proximity to large water bodies are the primary drivers of local climate variation in Durham Region. Climate change has also begun to impact climate at the local level and these impacts are anticipated to increase in the future. [4]

LATITUDE

Latitude refers to how far away a location or community is from the equator.

As latitude increases, the sun reaches the earth at more of an angle and provides less warming energy. As a result, the farther away a location is from the equator, the cooler and more variable the temperatures experienced in that location are.

Durham Region is located within a temperature latitude zone which experiences moderate temperatures, although they vary widely throughout the year. The latitude varies from 43.8˚ in the most southern part of the region and 44.5˚ in the most northern part. This small change in latitude can influence regional temperatures with southern municipalities like Ajax, Pickering and Whitby experiencing warmer temperatures, on average, compared to northern municipalities like Uxbridge, Scugog, and Brock.

LAKE EFFECTS

The lakes surrounding Durham Region play a key role in moderating temperatures throughout the year through lake effects. [5, 6, 7]

The lakes surrounding Durham Region are large and deep enough to influence local climate and weather patterns across the region through lake effects. [5, 6, 7] Lake effects play an important role in cooling temperatures in the spring and summer months (**Figure D.1**). [5, 6, 7] They also release large quantities of moisture into the air through evaporation, which increases humidity levels over and around the lake and feeds cloud cover in the surrounding areas. [7]

Lakes surrounding Durham Region

Figure D.1 | Location of the large lakes surrounding Durham Region

Lake Simcoe (north) and Lake Ontario (south) are large enough to impact climate and weather across the region through lake effects.

SEASON

Season primarily impacts heat due to increases in solar radiation during the summer months, although longer days can also play a role in increased temperatures within a community.

Increased temperatures, resulting from seasonal impacts, can affect other environmental factors, like evaporation rates and lake levels, which can impact the other environmental components of heat such as humidity and wind patterns.

In general, Durham Region experiences four distinct seasons with large annual fluctuations in temperature (**Figure D.2**). The warmest temperatures occur in the summer, from June to September, with the hottest temperatures experienced in July, on average.

Average monthly temperatures

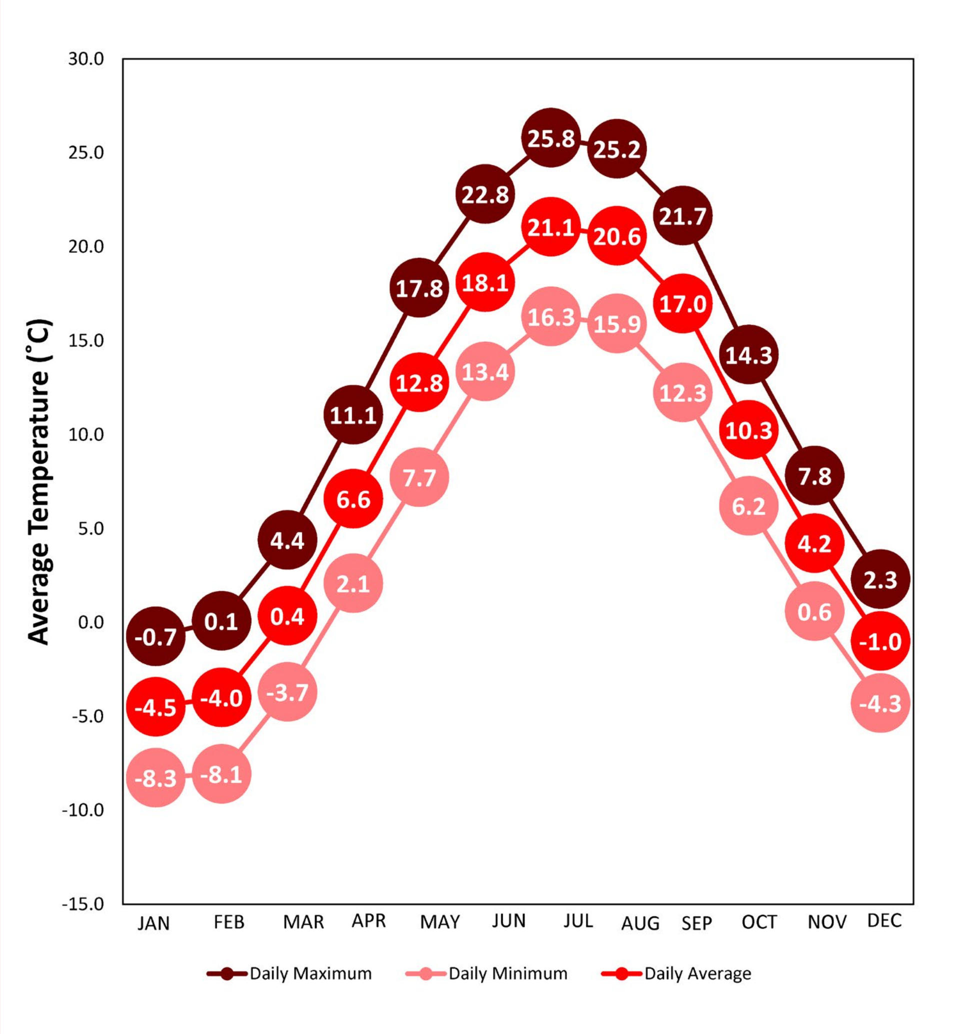


Figure D.2 | Historical average monthly temperature range (˚C) in Durham Region, 1981 to 2010

Statistics were calculated using data measured at the Oshawa Water Pollution Control Plant. Data Source: Environment Canada, Canadian Climate Normals 1981-2010 Station Data, Oshawa WPCP. 2021.

BUILT ENVIRONMENT

Cities often experience temperatures 1˚C to 6˚C warmer than surrounding non-urban areas due to the urban heat island (UHI) effect. [8, 9, 3, 1]

Canadian cities have been designed and built to withstand cold and retain heat. Large differences in temperatures can be experienced between urban and rural areas due to the built environment, or city design, and increased radiant temperatures due to the UHI effect. [3, 10] Depending on the local city design, suburban areas can also experience a UHI effect and warmer temperatures. [1, 3, 10, 11]

URBAN HEAT ISLAND EFFECT

The combined effect of solar heat absorption by dark building surfaces and limited green spaces in urban areas, can lead to higher temperatures in cities compared to surrounding rural areas; this occurrence is known as the UHI effect. [3, 10, 8, 1] Research suggests the UHI effect can create localized microclimates and result in several degrees difference from 1˚C to 6˚C above average.

The UHI effect results form the combined impact of three key factors within the built environment:

1. Physical properties of building materials and surfaces
2. Urban compactness
3. Deficient urban greenspace. [8, 1, 12, 3, 11]

PHYSICAL PROPERTIES OF BUILDING MATERIALS AND SURFACES

The ability of a material to absorb and retain heat and then radiate back out into the environment (i.e., emissivity) is a key component of the UHI effect. [13, 3, 14, 1, 15]

Generally, dark-coloured surfaces and building materials, like the asphalt used on parking lots and building roofs, absorb more radiant heat form the sun compared to light-coloured or reflective surfaces which tend to reflect solar radiation. [3] Materials that easily absorb the sun's solar radiation can trap heat during the day, and if they have a high level of emissivity they can then radiate this heat back out into the environment when air temperatures drop, including during the night. [3, 13] This results in increased ambient air temperatures within the communities affected by the UHI effect.

The use of building materials with high albedo ratings (i.e., reflectivity) for pavement, ground surfaces, and roofs have been shown to reduce the UHI effect. [1, 14, 15] Covering a roof with a layer of plants, referred to as "green roofs" or "living roofs" can also help decrease temperatures by decreasing heat absorption. [16] Use of green roofs instead of traditional roofing has been shown to substantially reduce heat-related mortality during heatwaves in large cities within the United States. [16]

URBAN COMPACTNESS AND DESIGN

Urban compactness includes the density of buildings and structures, land use, and travel proximity. [12, 1, 8, 15, 17]

Cities with high building density can make temperatures higher. [1, 12, 17, 8] Building density and city design can also impact the amount of air flow and shade from structures within a city, which can also impact the level of heat experienced. [1, 12, 17, 15] Travel proximity, or how far people need to travel for work or to access essential stores and services, can also increase temperatures as the number of cars and the distance they are travelling increases within the community. [1, 12]

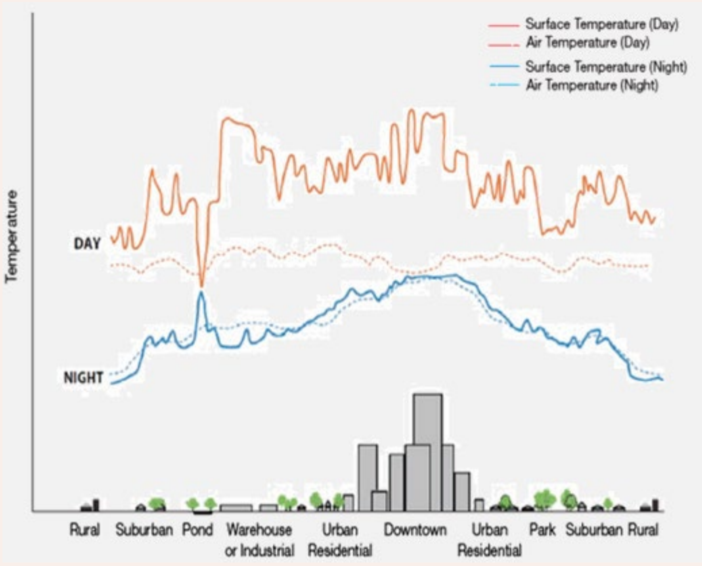
URBAN GREENSPACES

Urban greenspaces (UGS) include parks, forests, gardens, street tree plantings, green roofs, and facades.

The presence of UGS in a community can play a large role in the land surface temperatures (LST) experienced within a community. [1, 18] Extensive evidence exists showing the effectiveness of UGS in reducing the UHI effect through cooling effects and providing thermal comfort to residents. [2, 1, 18, 11, 19, 15, 3] Consequently, loss of these green spaces contributes to significant increases in LST. [18]

The relationship between urban, suburban, and rural areas and observed day and nighttime ambient air and surface temperatures is illustrated below in **Figure D.3**.

The temperature difference between urban and rural areas is the largest in the evening, which demonstrates the relationship between warmer nighttime temperatures and density of the built environment. [17] This difference is of particular concern when considering the impacts of climate change on exposure to heat; nighttime temperatures are projected to have the greatest increase as a result of climate change and warm nighttime temperatures do not allow individuals reprieve from warm temperatures. [3] Increased temperatures due to the UHI effect can lead to increase exposure to extreme heat conditions for communities living in these areas.



Built Environment and Temperature

Figure D.3 | Relationship between temperature and the built environment

Urban areas with limited green space experience increased daytime and nighttime temperatures, resulting in the UHI effect. [10, 11]

Figure Source: Adapted from the Extreme Heat Technical Guide [3]

References

[1] F. Aram, E. H. Garcia, E. Solgi and S. Mansourina, "Urban green space cooling effect in cities," Heliyon, vol. 5, no. e01339, 2019.

[2] H. Akbari and D. Kolokotsa, "Three decades of urban heat islands and mitigation technologies research," Energy and Buildings, vol. 133, pp. 834-842, 2016.

[3] Health Canada, "Extreme Heat Event Guidelines: Technical Guide for Health Care Workers," Health Canada, Ottawa, 2011.

[4] F. Delaney, P. Ng, K. Dokoska, G. Milner, K. Potter and M. Notaro, "Guide to Conducting a Climate Change Analysis at the Local Scale: Lessons Learned from Durham Region," Ontario Climate Consortium, Toronto, 2020.

[5] J. A. Derecki, "Hydrometeorology: Climate and Hydrology of the Great Lakes," in Hydrometeorology, , , 1976, pp. 71-104.

[6] Environmental Law & Policy Center (ELPC), "An Assessment of the Impacts of Climate Change on the Great Lakes," ELPC, Boston, 2019.

[7] R. W. Scott and F. A. Huff, "Impact of the Great Lakes on regional climate conditions," Journal of Great Lakes Research, vol. 22, pp. 845-863, 1996.

[8] A. Dimoudi, A. Kantzioura, S. Zoras, C. Pallas and P. Kosmopoulos, "Investigation of urban microclimate parameters in an urban center.," Energy and Buildings, vol. 64, pp. 1-9, 2013.

[9] Health Canada, "Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials," Health Canada, Ottawa, 2011.

[10] J. Voogt, "Urban Heat Island," in Encyclopedia of Global Environmental Change, vol. 3, T. Munn, Ed., Chichester, John Wiley and Sons, 2002, p. 460.

[11] Environmental Protection Agency (EPA), Reducing Urban Heat Islands: Compendium of Strategies, E. Wong, K. Hogan, J. Rosenburg and A. Denny, Eds., US EPA, 2009.

[12] R. Giridharan and R. Emmanuel, "The impact of urban compactness, comfort strategies and energy consumption on tropical urban heat island intensity: a review," Sustainable Cities and Society, vol. 40, pp. 677-687, 2018.

[13] R. A. Memon, D. Y. Leung and L. Chunho, "A review on the generation, determination and mitigation of urban heat island," Journal of Environmental Science, vol. 20, pp. 120-128, 2008.

[14] F. Pacheco-Torgal, "Introduction to eco-efficient materials to mitigate building cooling needs," in Eco-Efficient Materials for Mitigating Building Cooling Needs: Design, Properties and Applications, Elsevier Ltd., 2015, pp. 1-9.

[15] C. O'Malley, P. Piroozfar, E. R. P. Farr and F. Pomponi, "Urban heat island (UHI) mitigating strategies: A case-based comparative analysis," Sustainable Cities and Society, vol. 19, pp. 222-235, 2015.

[16] L. Kalkstein and S. Sheridan, The Impacts of Heat Island Reduction Strategies on Health-Debilitating Opressive Air Masses in Urban Areas, United States Environmental Protection Agency (US EPA), 2003.

[17] B. Dousset, F. Gourmelon and E. Mauri, "Application of satelite remote sensing for urban risk analysis: a case study of the 2003 extreme heat wave in Paris," in 2007 Urban Remote Sensing Joint Event, , 2007.

[18] D. E. Bowler, L. Buyung-Ali, T. M. Knight and A. S. Pullin, "Urban greening to cool towns and cities: A systematic review of the empirical evidence," Landscape and Urban Planning, vol. 97, no. 3, pp. 147-155, 2010.

[19] Y. Hu, Z. Dai and J.-M. Guldmann, "Greenspace configuration impact on the urban heat island in the Olympic Area of Beijing," Environmental Science and Pollution Research, vol. 28, pp. 33096-33107, 2021.

Appendix E: Heat trends in Durham Region

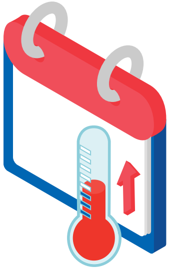
As a result of climate change, Durham Region is projected to experience warmer temperatures and more frequent EHDs and tropical nights by the end of the century, with the greatest increases anticipated in the northern municipalities. [1]

Climate change and warming temperatures have already made noticeable and measurable impacts on air temperatures across Durham Region, including increased EHEs, average annual temperatures and warm nighttime temperatures. [1] These changes are expected to have a substantial impact on heat exposures in Durham Region as we move into the future.

To better understand how climate change may impact Durham Region residents through changes in local climate and weather, **short term** (2011 to 2040), **medium term** (2041 to 2070), and **long term** (2071 to 2100) climate projections were created by the Ontario Climate Consortium as part of the 2019 Durham Climate Modeling Project. [1] A full description of data sources, methods and results of the 2019 Durham Climate Modeling Project can be found in Delaney et al. 2020. [1]

A summary of historical and projected heat trends based on the **RCP 8.5 climate scenario** from the 2019 Durham Climate Modeling Project are described below. Projections are described for Durham Region as a whole and by municipality, where appropriate.

Average annual temperatures



Durham Region experiences a wide range of temperatures annually. By 2100, the average annual temperature in Durham Region is anticipated to be 5˚C warmer than the historical average because of climate change. [1]

Mean annual temperatures: The average annual mean temperature in Durham Region is anticipated to increase until the end of the century up to a maximum of 12.1˚C. [1]

Over the baseline period of 1971 to 2000, the average annual mean temperature in Durham Region was 7.1˚C (**Figure E.1**). [1]

Average annual temperatures

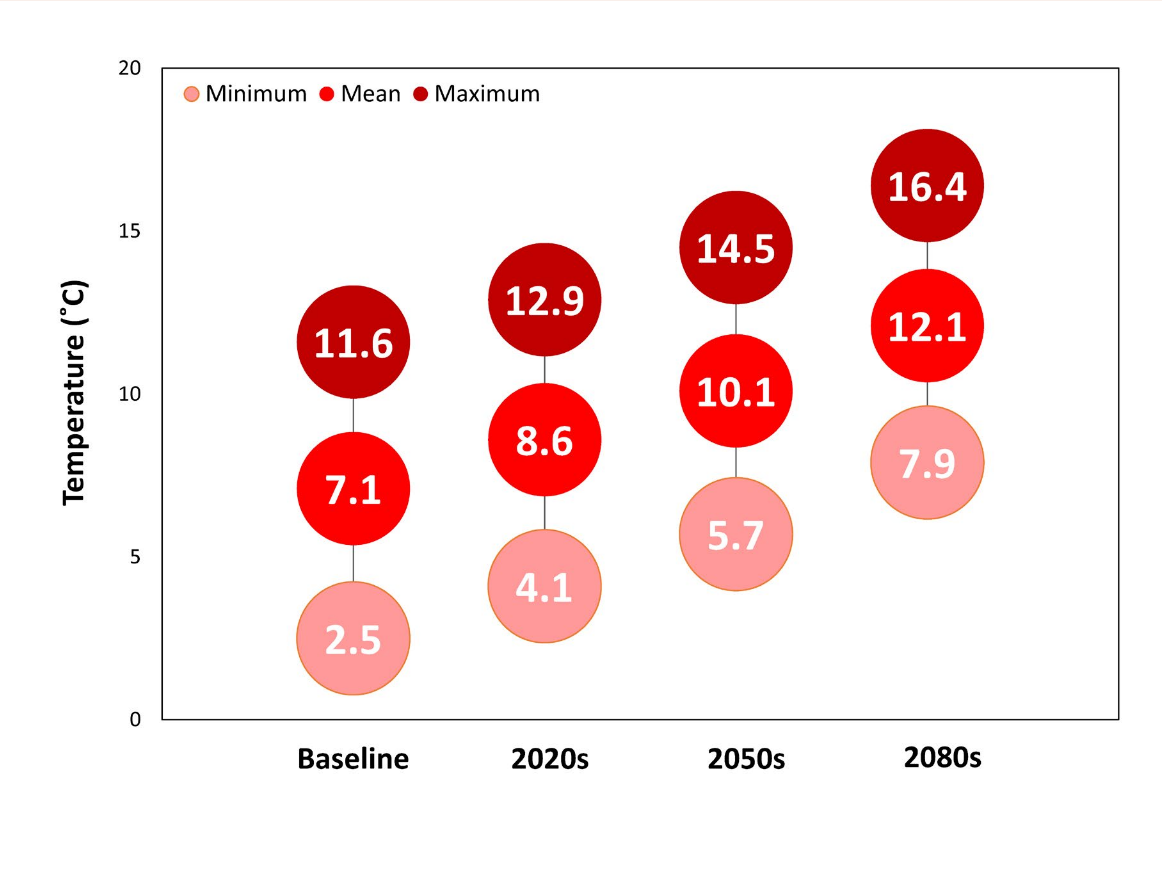


Figure E.1 | Projected annual average temperature range (˚C) for Durham Region based on the RCP 8.5 climate scenario

Temperature projections were calculated using the downscaled NA-CORDEX Climate Model Ensemble.

Data Source: 2019 Durham Climate Modeling Project. [1]

Future projections: Based on current projections, average annual mean daily temperatures are anticipated to increase until the end of the century (**Figure E.2**). By 2100, the average annual mean temperature in Durham Region is expected to be between 12˚C to 14˚C. Warmer temperatures, up to 16˚C, are anticipated to occur in the southernmost part of the region along the shores of Lake Ontario (**Figure E.2**).

Average temperatures across Durham Region

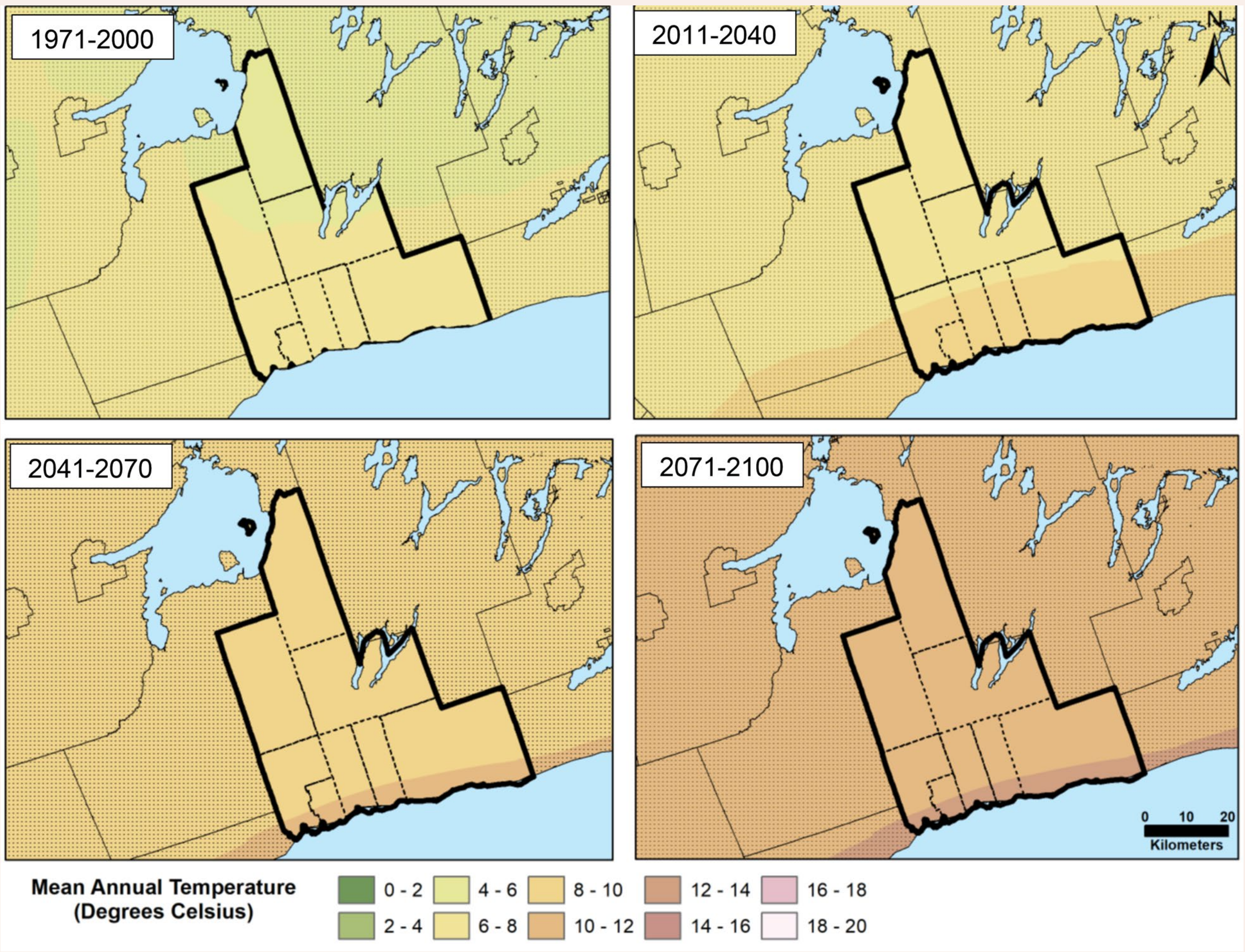


Figure E.2 | Projected mean annual temperature (˚C) for Durham Region based on the RCP 8.5 climate scenario

Temperature projections were calculated using the downscaled NA-CORDEX Climate Model Ensemble.

Figure source: Adapted from Delaney et al. 2020. [1]

Regional temperature variation: Although warming is expected to occur across the region until the end of the century, the rate of warming is expected to vary by municipality. The fastest rate of warming is projected for the northern municipalities of Brock and Uxbridge and the eastern municipalities of Clarington and Oshawa. **Figure E.3** shows the projected rates of warming by 2100 for each municipality, in order of increasing rate.

Temperature increases by municipality

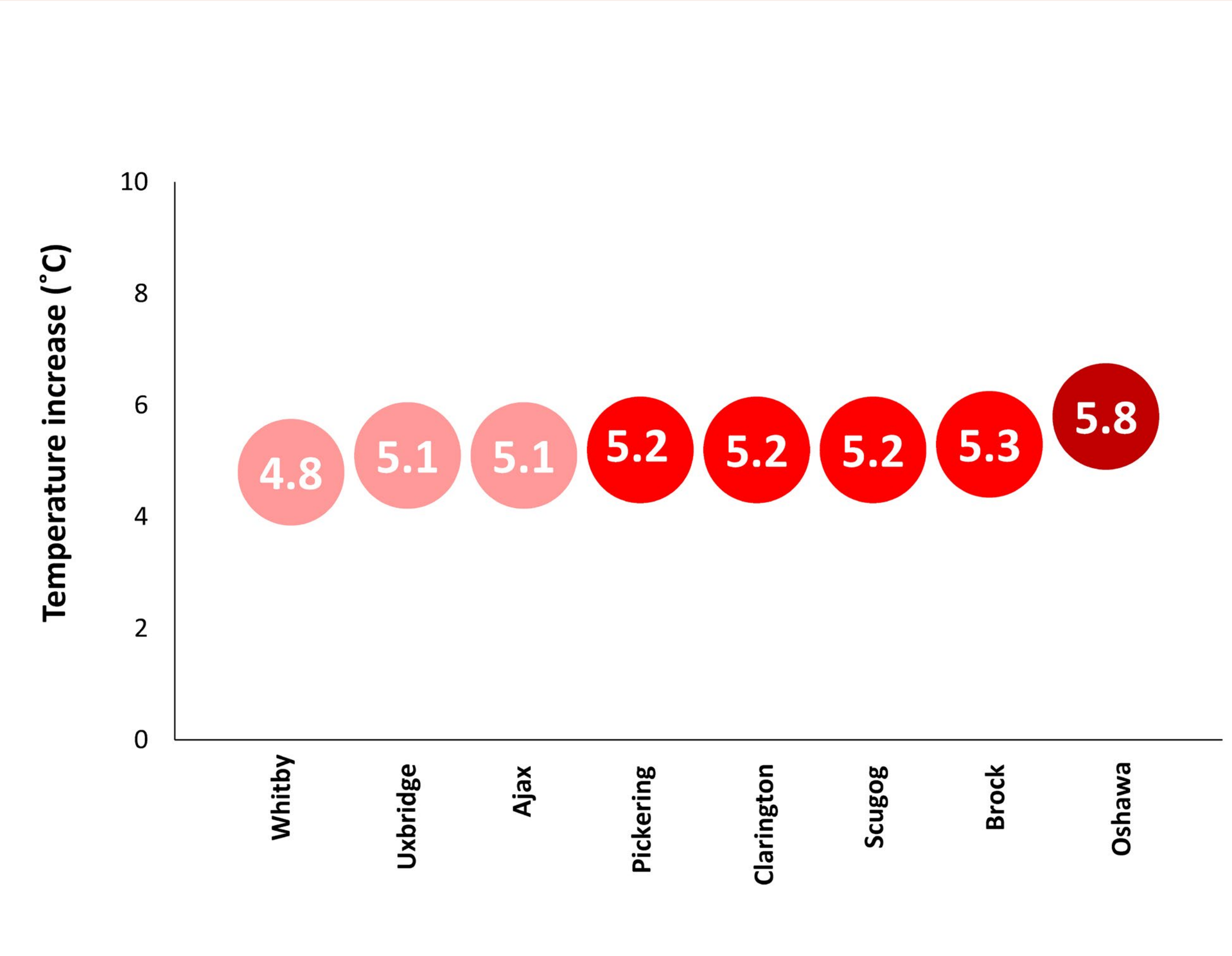


Figure E.3 | Projected increases in mean annual temperatures (°C) by 2100 for Durham Region municipalities based on the RCP 8.5 climate scenario

Data Source: 2019 Durham Climate Modeling Project. [1]

Average maximum daily temperatures: The average annual mean temperature in Durham Region is anticipated to increase until the end of the century up to a maximum of 16.4˚C. [1]

Over the baseline period of 1971 to 2000, the average annual daily maximum temperature in Durham Region was 11.6˚C (**Figure E.2**). [1]

Future projections: Based on current projections, the average annual maximum daily temperature in Durham Region is expected to increase until the end of the century. [1] These increases are anticipated to vary by municipality and climate period as illustrated in **Figure E.4** below.

In the short term, average annual daily maximum temperatures are expected to reach temperatures between 12˚C to 14˚C, with slightly cooler temperatures of 10˚C to 12˚C anticipated in the northernmost part of the region. In the long term, maximum average annual temperatures between 14˚C to 16˚C are expected for most of the region, except for a small part in the west which will see warmer temperatures between 16˚C to 18˚C.

Average maximum temperatures across Durham Region

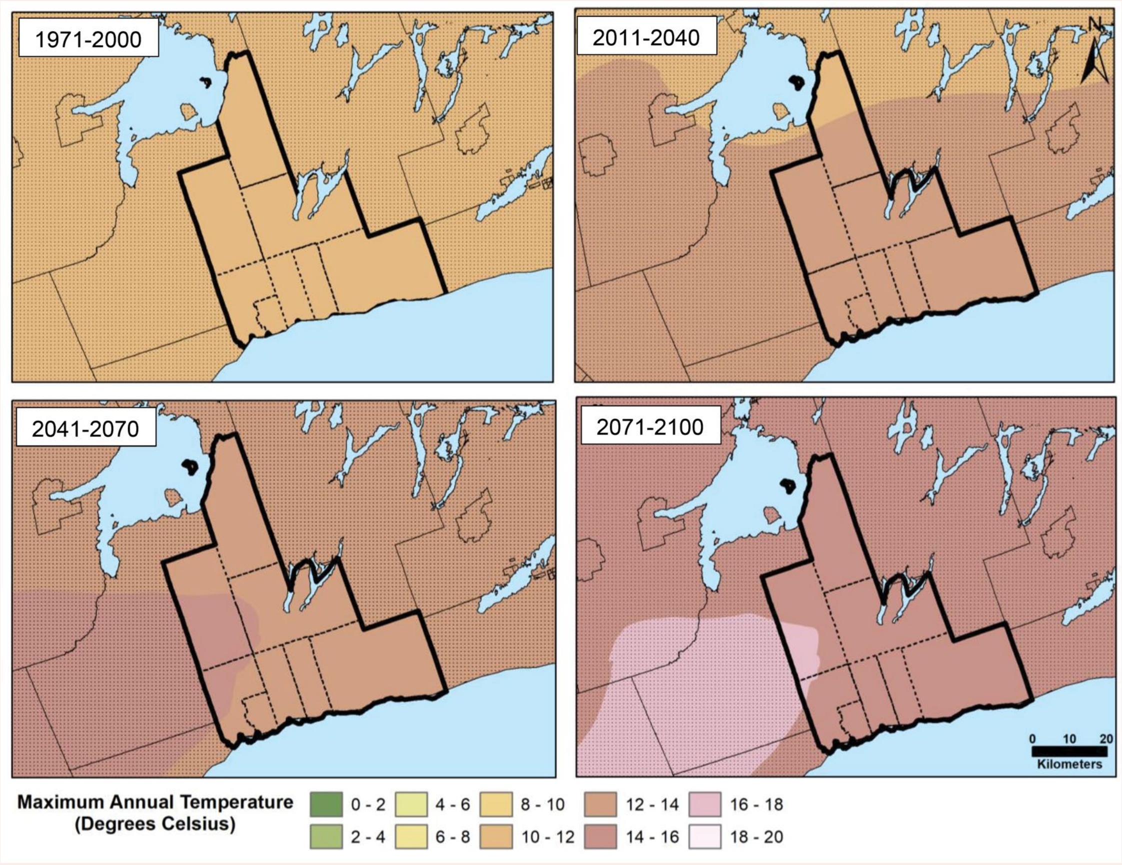


Figure E.4 | Projected mean annual minimum daily temperatures (˚C) for Durham Region based on the RCP 8.5 climate scenario

Temperature projections were calculated using the downscaled NA-CORDEX Climate Model Ensemble.

Figure source: Adapted from Delaney et al. 2020. [1]

Seasonal temperatures

Durham Region experiences warm summers which are expected to become warmer and up to two months longer as Durham's climate continues to change. [1]

Durham Region's climate varies substantially by season and experiences cold winters, moderate spring and fall seasons, and warm summers. On average, July is the warmest month and January is the coldest month.

Summer temperatures: Average mean summertime temperatures in Durham Region are projected to reach an average of 22.3˚C by the end of the century. [1]

Based on historical data (1971 to 2000) the average mean summertime temperature in Durham Region was 17.1˚C (**Figure E.5**). [1]

Future projections: Summertime temperatures in Durham Region are projected to increase by an average of 5˚C compared to the historical average by the end of the century (**Figure E.5**). [1] By 2100, summer temperatures are expected to be particularly warm with minimum and maximum average air temperatures of 18˚C and 26.6˚C, respectively.

Summer temperatures

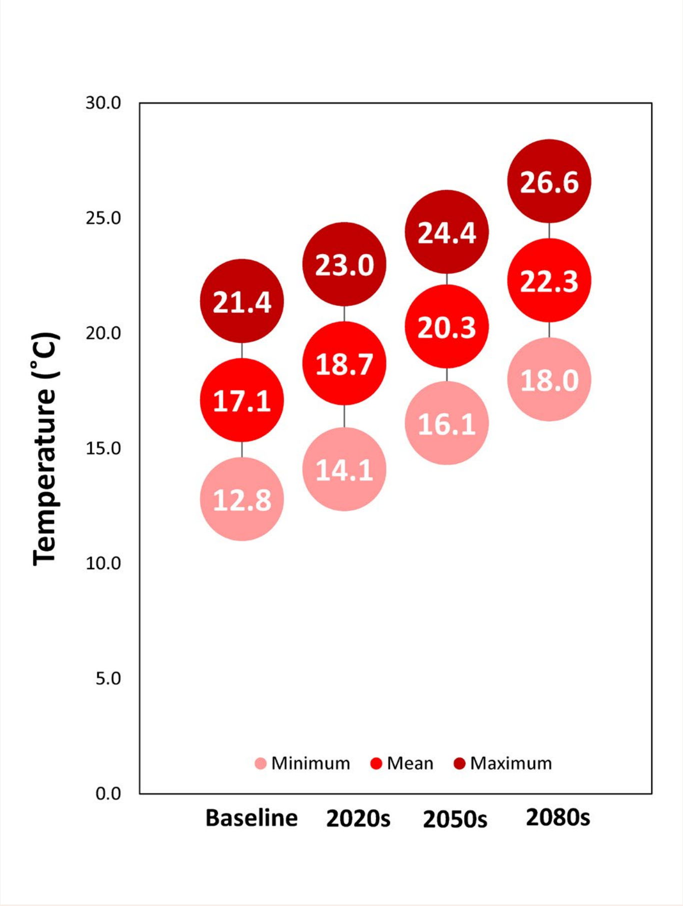


Figure E.5 | Projected average summertime temperature range (˚C) for Durham Region based on the RCP 8.5 climate scenario

Summer (Jun-Aug). Temperature projections were calculated using the downscaled NA-CORDEX Climate Model Ensemble.

Data Source: 2019 Durham Climate Modeling Project. [1]

Summer days: Durham Region can expect longer summers in upcoming years, with northern municipalities experiencing the largest increases in duration. [1]

Based on historical data (1971 to 2000), Durham Region typically experiences an average of 42.1 summer days, or days where the maximum temperature reaches 25˚C or higher each year. [1]

Future projections: Durham Region is projected to experience longer summers in the upcoming years, as shown in **Figure E.6** below. [1] By the end of the century, summers are anticipated to be 58 days or almost two months longer that the historical average, lasting up to 100 days on average.

Summer days

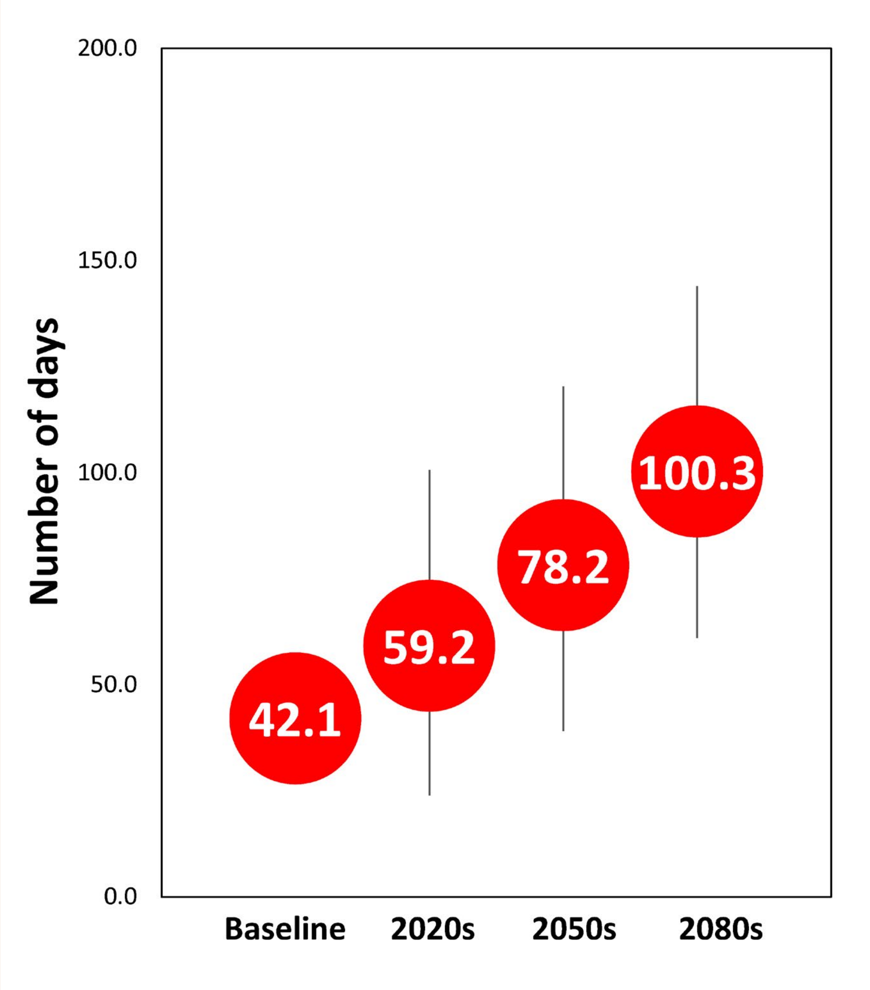


Figure E.6 | Projected number of summer days in Durham Region based on the RCP 8.5 climate scenario

Summer days refer to the total number of days each year when the daily maximum air temperature is greater than 25˚C.

The line on each estimate represents the 10th and 90th percentile.

Data Source: Delaney et al 2020. [1]

Regional variation: There is strong evidence to suggest that changes in the annual number of summer days experienced in Durham Region will vary substantially across the various municipalities. Based on current climate projections, the northern municipalities of Scugog, Brock, and Uxbridge will likely experience a longer summer each year compared to southern municipalities (**Figure E.7**). The number of summer days experienced annually in these communities may rise by approximately 63 days or two months, compared to baseline (1971 to 2000) by the 2080s. The contrast between the northern and southern municipalities may need to be considered in the future as policies and programs to reduce extreme heat exposures are developed and implemented at both municipal and regional levels.

Increased summer length

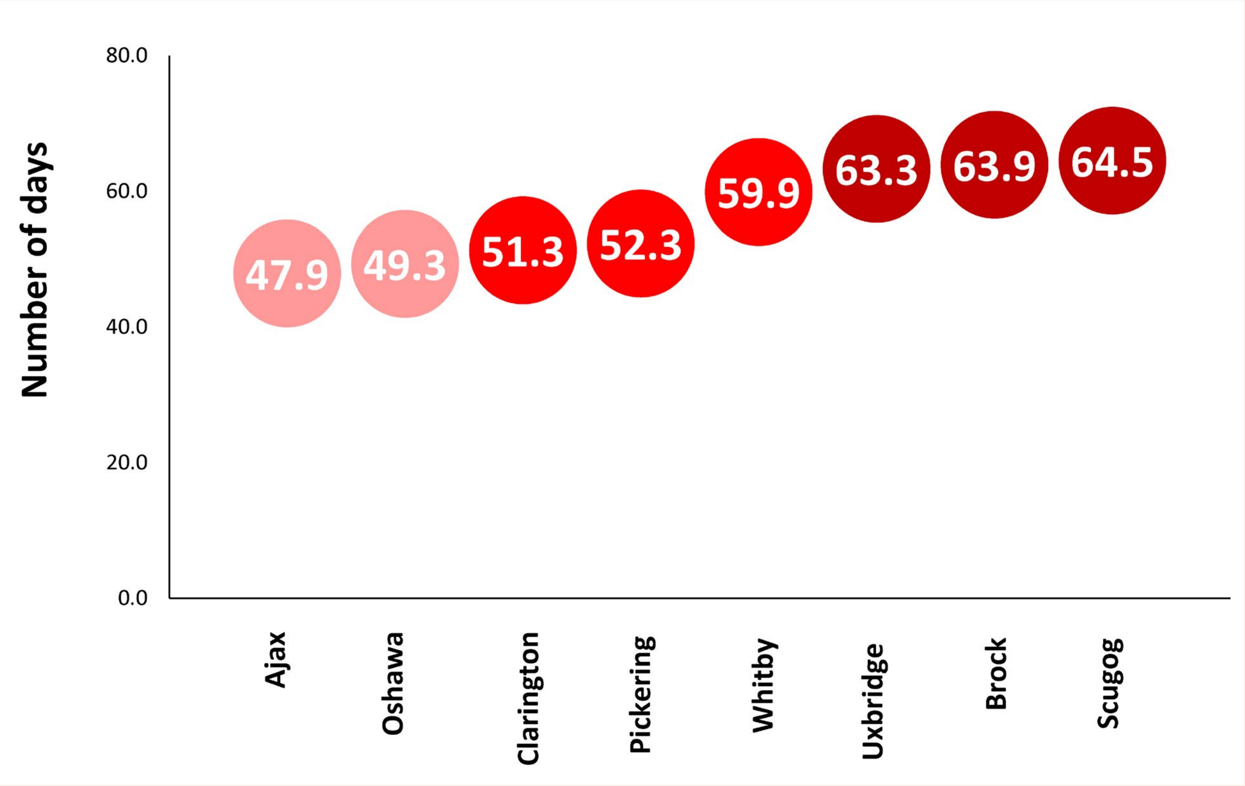


Figure E.7 | Projected increases in average annual number of summer days by 2100 for Durham Region municipalities based on the RCP 8.5 climate scenario

Municipalities are ranked in order to increased days compared to the historical # of summer days of 42.1.

Data Source: Delaney et al 2020. [1]

References

[1] F. Delaney, P. Ng, K. Dokoska, G. Milner, K. Potter and M. Notaro, "Guide to Conducting a Climate Change Analysis at the Local Scale: Lessons Learned from Durham Region," Ontario Climate Consortium, Toronto, 2020.

DURHAM REGION

HEALTH DEPARTMENT

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July 2024