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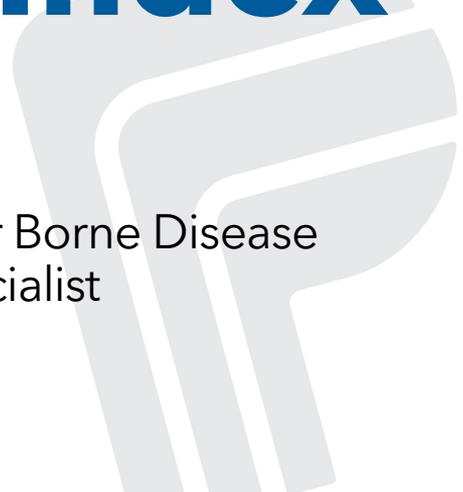
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Peel Public Health's Heat Vulnerability Index

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Land Acknowledgement

We would like to begin by acknowledging the land on which we gather, and which the Region of Peel operates, is part of the Treaty Lands and Territory of the Mississaugas of the Credit. For thousands of years, Indigenous peoples inhabited and cared for this land and continue to do so today. In particular, we acknowledge the territory of the Anishinabek, Huron-Wendat, Haudenosaunee and Ojibway/Chippewa peoples; the land that is home to the Metis; and most recently, the territory of the Mississaugas of the Credit First Nation who are direct descendants of the Mississaugas of the Credit.

We are grateful to have the opportunity to work on this land, and by doing so, give our respect to its first inhabitants.

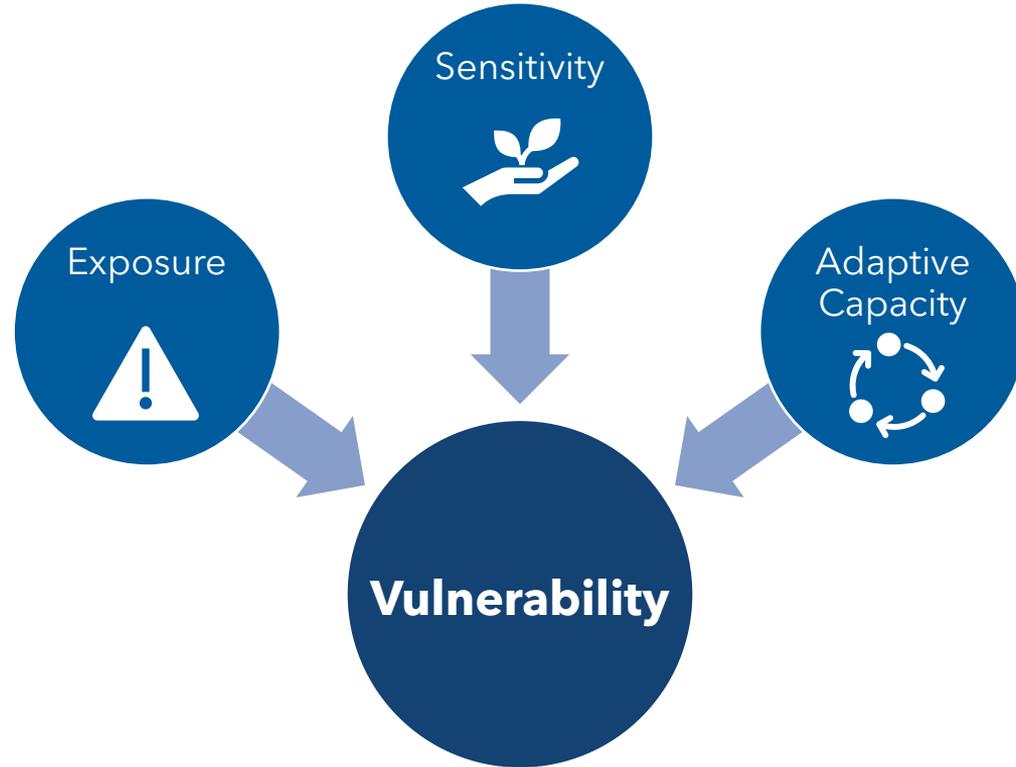
Learning Objectives

- Explain the relevance of the components of heat vulnerability (i.e., adaptive capacity, sensitivity, and exposure), in assessing heat-related health risks.
- Describe the methodology used to develop and map the Heat Vulnerability Index (HVI), including application of Principle Component Analysis (PCA).
- Identify the practical applications of the HVI in guiding targeted interventions and resource allocation to reduce inequitable health outcomes.

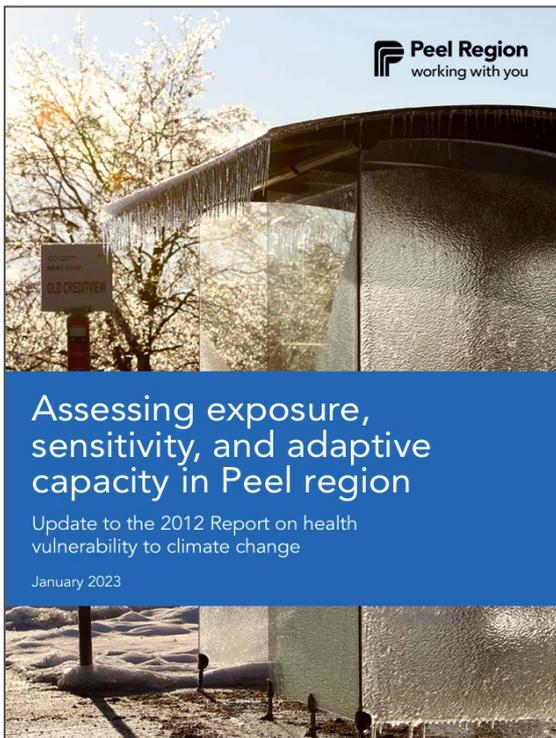
Agenda



Climate Change & Health Vulnerability Assessment



Context



- Heat is one of the top five climate-related health hazards.
- Recommendations included mapping at-risk communities.
- Temperatures projected to continue rising, increasing heat-related illness risk.

Integration of VA results into PPH's Strategic Priorities.



Health Impacts of Heat in Peel



Temperatures in Peel have been increasing, with annual mean temperatures rising from 8.1°C in 1938 to 9.3°C in 2017.



Projections show an increase in expected days above 35°C, increasing the risk of heat-related illness and death.



For every 5°C increase in daily mean temperature, there is a 2.5% increase in non-accidental deaths.



Heat-related illnesses include heat stroke, heat exhaustion, fainting, edema, heat rash and cramps.

Project Objectives

1

Identify, assess, and map communities in Peel at-risk of heat-related illness.

2

Begin discussions and strengthen understanding of how these communities are impacted by heat.

3

Ensure effective and equitable programs and policies are explored to mitigate the risk of heat on health.

Principle Component Analysis (PCA) Methodology



Methodology overview

Part 1: Principal component analysis (PCA)

Research questions

- Which indicators associated with vulnerability to heat-related harms **best explain the variance in the whole dataset?**
- Can **an index summarizing these data** be created to describe each Census Tract in Peel?

Part 2: Geospatial analyses

- **Which areas have the most risk** for heat events within Peel?
- Do these areas exhibit **spatial clustering?**
- What can we learn about these communities regarding the social determinants of health, the built environment, and health outcomes?

Methods

1. Select indicators based on vulnerability assessment
2. Reduce variables and test assumptions for PCA
3. Select components
4. Compute component scores and Heat Vulnerability Index score per Census Tract

1. Assess large-scale variation: spatial autocorrelation
2. Assess small-scale variation: cluster and outlier analysis
3. Explore health equity stratifiers by index quintiles

Indicator selection

Characteristics of indicators selected for inclusion in PCA:

- ✓ **Data represents the concept accurately**
- ✓ **Data are accessible** by Peel Public Health and are releasable as per data sharing agreements
- ✓ **Data are available and reliable at the census tract (CT) level**

Examples of included and excluded data sources/indicators:

- ✓ Census data
- ✓ Environmental exposure data from Canadian Urban Environmental Health Research Consortium (CANUE)
- ✓ IC/ES data request for chronic disease prevalence by CT
- ✗ Canadian Community Health Survey (CCHS) data were not validated for small-area analysis
- ✗ Healthcare utilization data → high proportion of CTs with 0-4 events
- ✗ Availability of air conditioning in homes → Census variable % dwellings built before 1960 not a good proxy
- ✗ Availability of heat response plans by municipality → no variation

Principal component analysis (PCA)

Factors associated with heat vulnerability



Variable reduction & test assumptions

Variables dropped during iterative process

Run PCA

Final components

1. Adaptive capacity



Low income



Living alone



Renters

2. Sensitivity



Cancer



Respiratory disease



Heart disease

3. Exposure



Maximum temperature



Tree canopy



Normalized Difference Vegetation Index

Compute scores for each Census Tract

- For each of the 3 components (Adaptive Capacity, Sensitivity, Exposure)
- Combined: Heat Vulnerability Index (HVI)

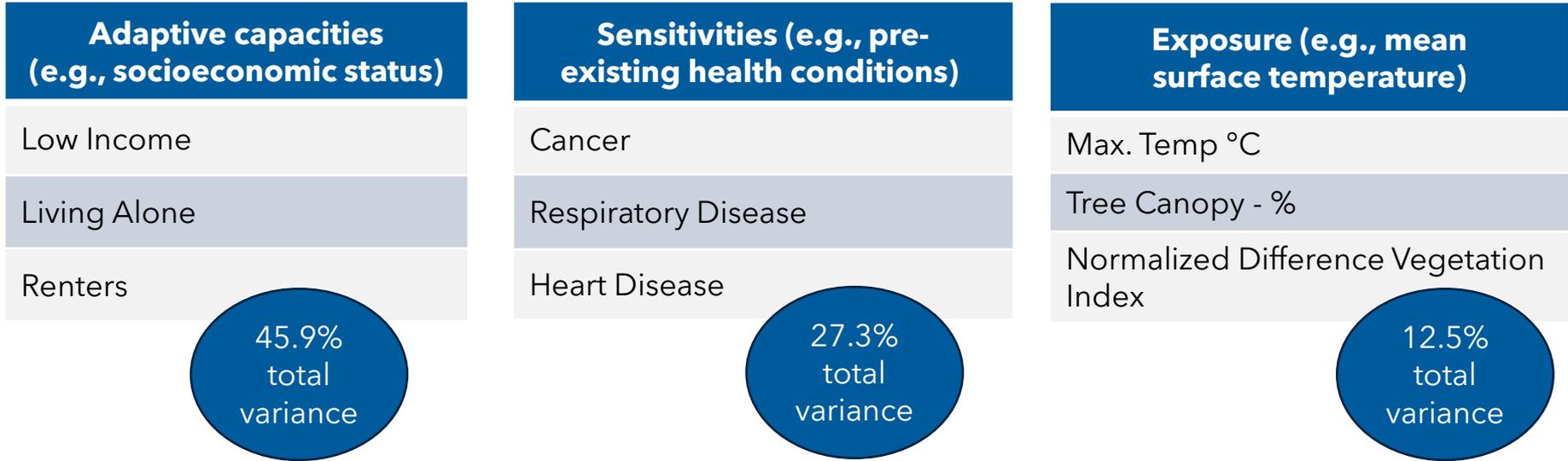
Final components & indicators

| Component | Area-level indicator (at Census Tract geography) | Data source |
|------------------------------|---|-------------------------------|
| 1 - Adaptive Capacity | Percent of private households by household size: one person | Census (2021) [1] |
| | Percent of private households by tenure: renter | Census (2021) [1] |
| | Percent of population in the low income measure, after tax | Census (2021) [1] |
| 2 - Sensitivity | Prevalence of heart disease (congestive heart failure, ischemic heart disease, or atrial fibrillation) | IC/ES data request (2023) [2] |
| | Prevalence of cancer | IC/ES data request (2023) [2] |
| | Prevalence of respiratory diseases (asthma or chronic obstructive pulmonary disease) | IC/ES data request (2023) [2] |
| 3 - Exposure | Annual maximum mean warm-season land surface temperature | CANUE (2021) [3] |
| | Percent tree canopy cover | Peel Data Centre (2021) [4] |
| | Normalized Difference Vegetation Index : mean greenest pixel | USGS (2021) [5] |

CANUE: Canadian Urban Environmental Health Research Consortium; **CT**: census tract; **IC/ES**: Institute for Clinical Evaluative Sciences; **USGS**: United States Geological Survey.
Please see reference slide for data references.

Results

Three components were selected during PCA:

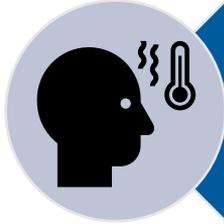


These three components together explain 85.7% of the total variance

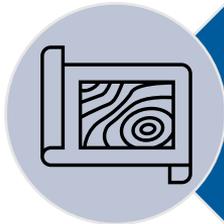
Spatial Analysis & Mapping



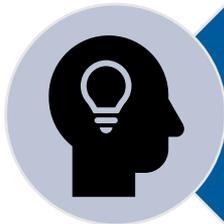
Spatial Mapping Objectives



Which areas have the most risk for heat events within Peel?

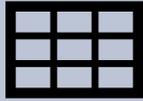


Do these areas exhibit spatial clustering within Peel?



What can we learn about these communities regarding the social determinants of health, the built environment, and health outcomes?

Mapping the results



Join the tabular data to the cartographic boundary file for Peel.

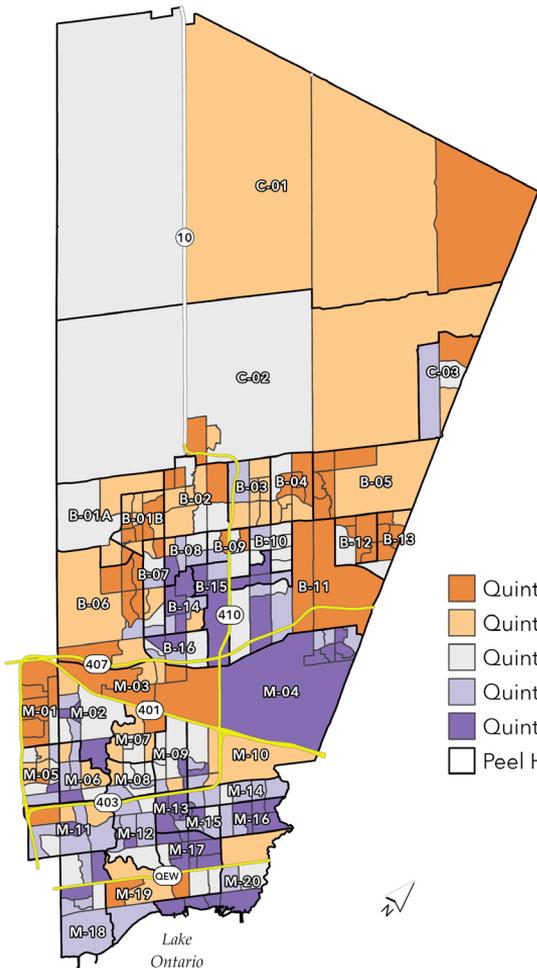


Map the results for each component and the HVI using a choropleth map and quintile classification.



Test for spatial association (similarity) and map significant results.

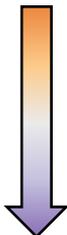
Adaptive Capacity



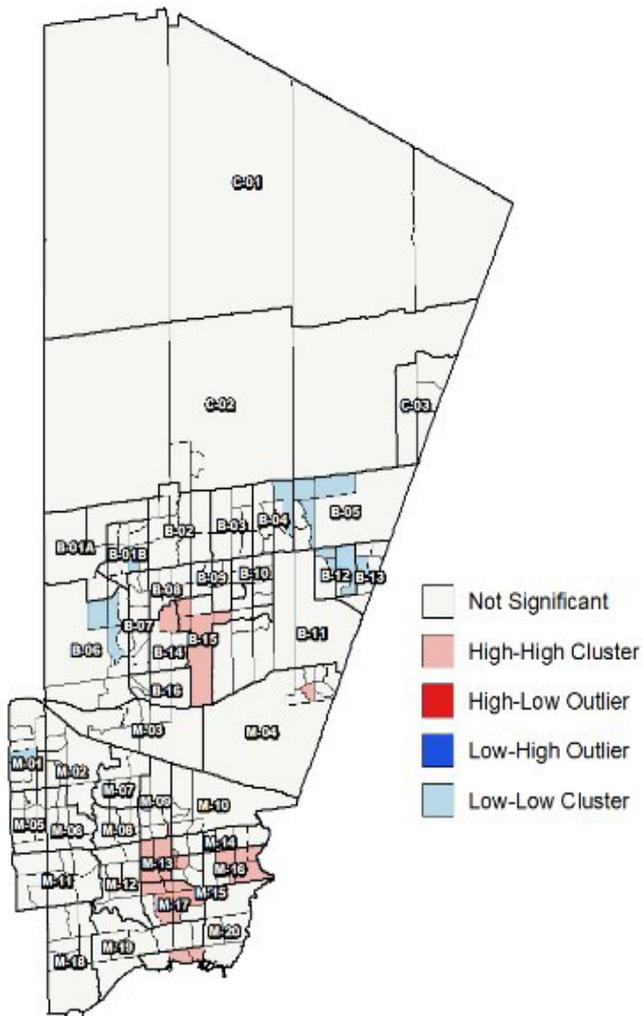
- Quintile 1 - Least Vulnerable
- Quintile 2
- Quintile 3
- Quintile 4
- Quintile 5 - Most Vulnerable
- Peel Health Data Zones



Protective

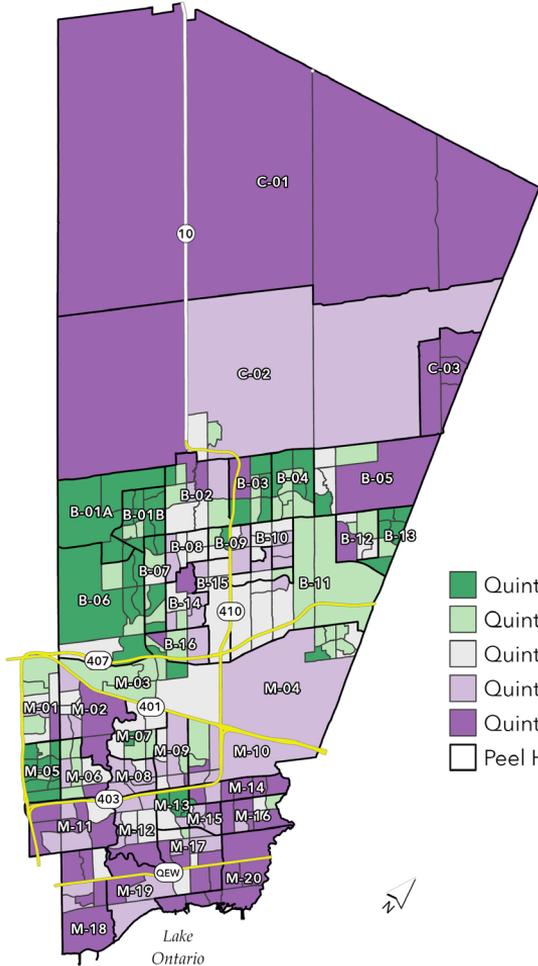


Risk



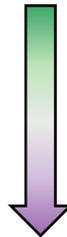
- Not Significant
- High-High Cluster
- High-Low Outlier
- Low-High Outlier
- Low-Low Cluster

Sensitivity

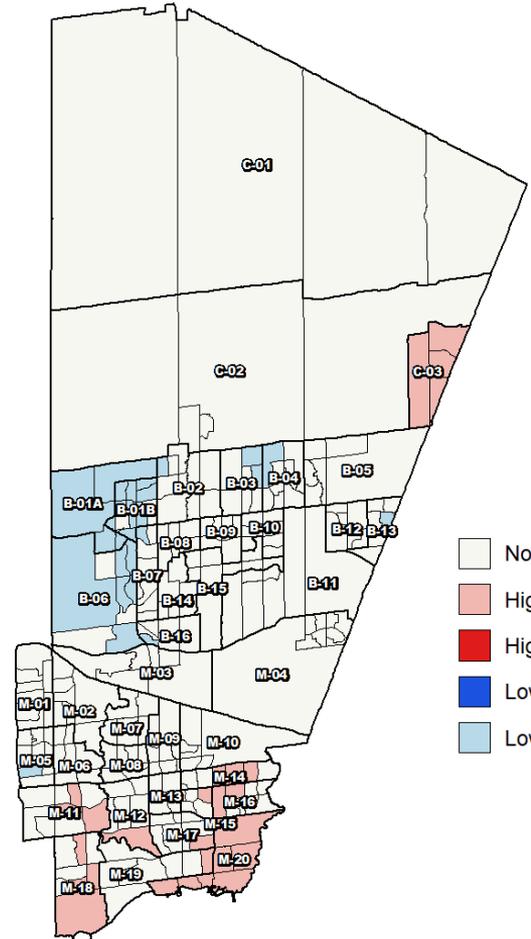


- Quintile 1 - Least Vulnerable
- Quintile 2
- Quintile 3
- Quintile 4
- Quintile 5 - Most Vulnerable
- Peel Health Data Zones

Protective

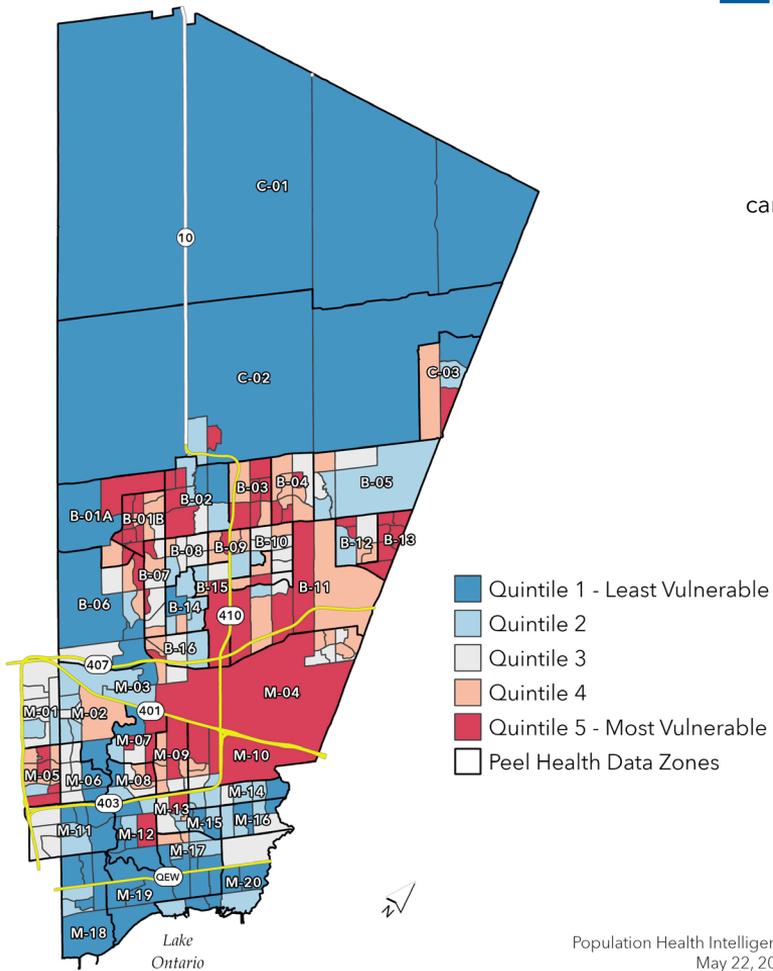
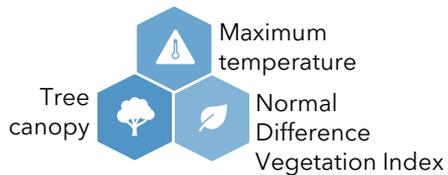


Risk

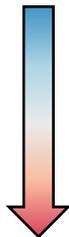


- Not Significant
- High-High Cluster
- High-Low Outlier
- Low-High Outlier
- Low-Low Cluster

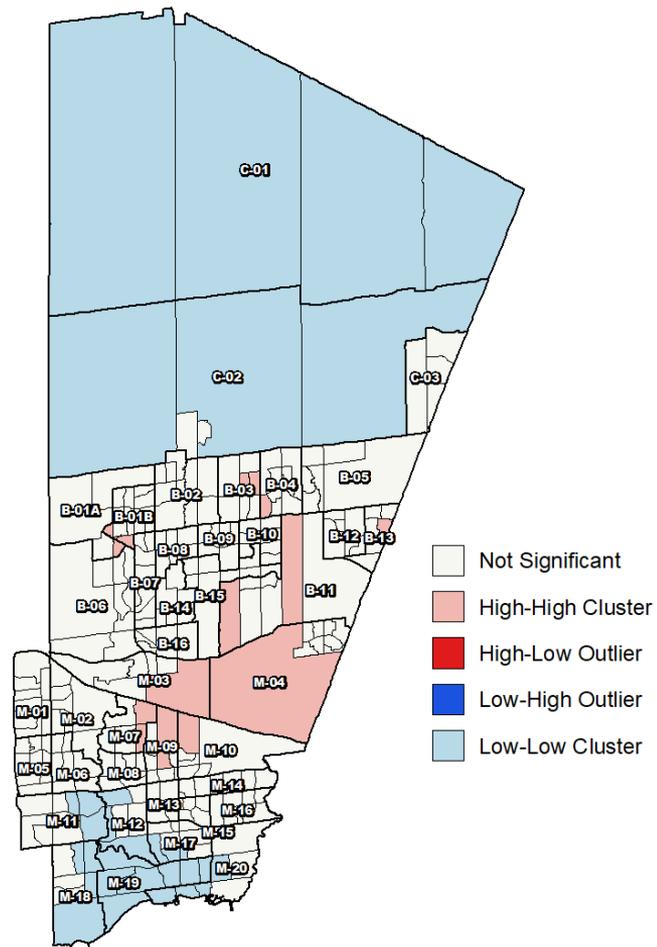
Exposure



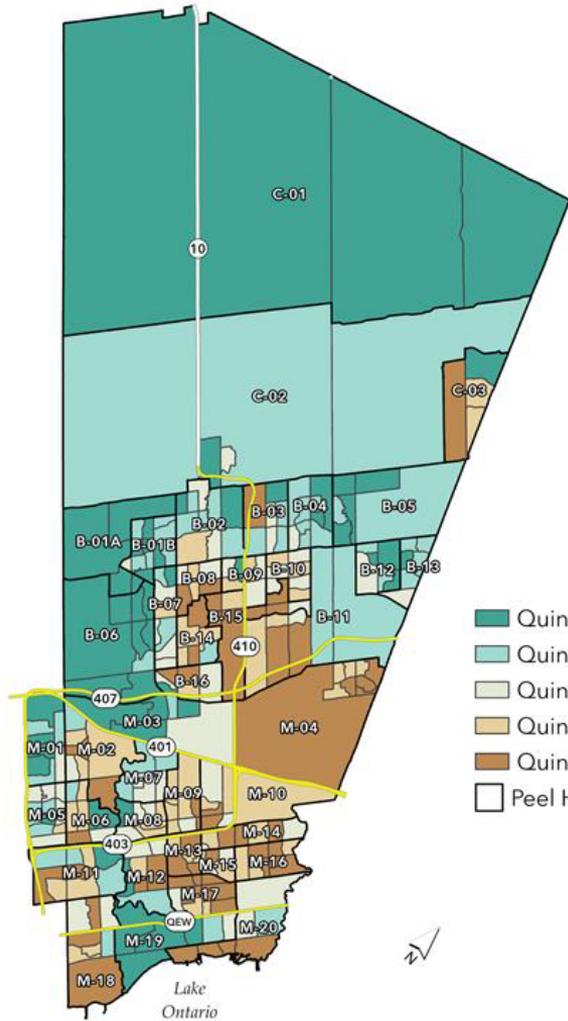
Protective



Risk

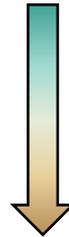


Heat Vulnerability in Peel Region

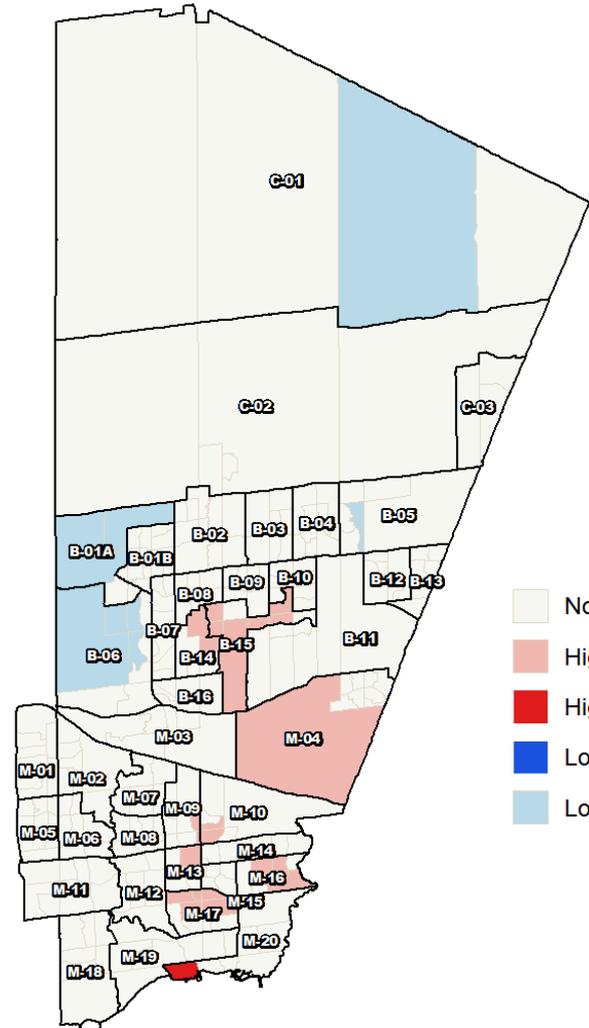


- Quintile 1 - Least Vulnerable
- Quintile 2
- Quintile 3
- Quintile 4
- Quintile 5 - Most Vulnerable
- Peel Health Data Zones

Lower
Vulnerability



Greater
Vulnerability



- Not Significant
- High-High Cluster
- High-Low Outlier
- Low-High Outlier
- Low-Low Cluster

HVI Dashboard

Heat Vulnerability Index

Municipality
Select a municipality

Peel Health Data Zones
Select a data zone(s)

Census Tracts
Select a census tract(s)

Heat Vulnerability Index

Heat Vulnerability Index (HVI)

The climate in Canada is changing. Variable weather patterns, extreme heat, and increased precipitation are all impacting Canadians. The extent of the impacts will vary depending on geographic and demographic characteristics of the population, for example the degree of exposure to climate hazards, sensitivities contributing to increased risk, and the ability to adapt to a changing climate.

The region of Peel, one of the largest municipalities in Ontario, is home to over 1.5 million people. Peel is comprised of a culturally and socio-economically diverse population, with five percent growth between 2016 and 2021. The senior's population, those over 65 years of age, are the largest and fastest growing age group in Peel, introducing unique risks associated with the health impacts of climate change.

Temperatures throughout Peel have been slowly increasing, with annual mean temperatures rising from 8.1°C in 1938 to 9.3°C by 2017. The most significant increases occurring in the summer and winter.

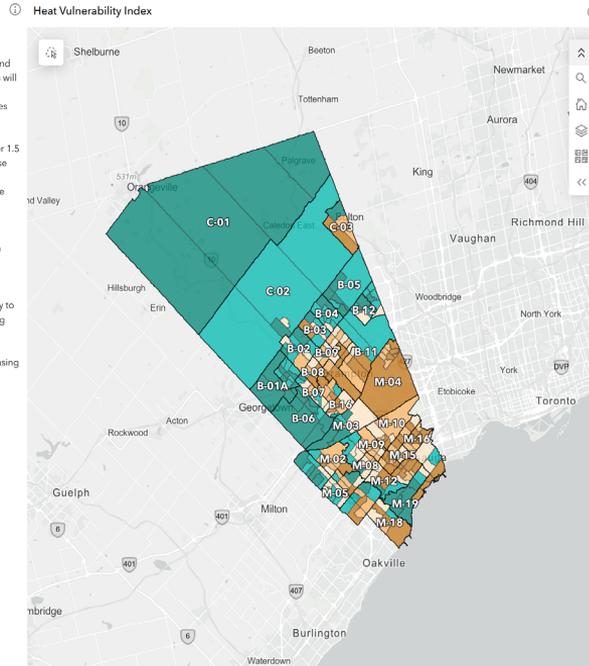
The purpose of the HVI is to identify and visualize areas of greater vulnerability to heat in Peel, with the goal of reducing risk, morbidity, mortality, and supporting emergency responses.

The HVI is a composite index displayed using quintiles. Quintiles reflect increasing risk to the population as values increase from one to five.

Heat Vulnerability Index

Heat Vulnerability Index - Quintile

- Quintile 5 (Increased Risk)
- Quintile 4
- Quintile 3
- Quintile 2
- Quintile 1 (Decreased Risk)



Census Tract Insights

5350500.01 | M-20

The **Heat Vulnerability Index (HVI)** was developed to identify area-level characteristics related to adaptive capacity to mitigate heat risk, heat exposure, and sensitivity to heat, using available sociodemographic, exposure, and health status data. Higher quintile values indicate greater vulnerability due to heat, and heat related events.

Quintile - 5 (Very High)

Adaptive capacity refers to the ability of individuals, communities, or systems to adjust to, mitigate, and cope with the consequences of heat related events. It plays a crucial role in determining how vulnerable a population is to heat-related risks. Key aspects include community and individual supports, adequate housing and economic stability.

Quintile - 5 (Very High)

Exposure refers to the degree to which individuals or communities are exposed to extreme heat conditions. Key aspects include the surface temperature, the density and health of vegetation, and the presence of tree canopy cover. Trees and vegetation provide shade, which reduces the amount of solar radiation reaching the ground and buildings, lowering ambient temperatures

Quintile - 1 (Very Low)

Sensitivity refers to the degree to which individuals, communities, or systems are affected by exposure to heat related events. Key aspects include demographics (older and younger populations are more impacted) and pre-existing health conditions that can worsen during heat events. Health conditions included in this index are cancer, heart disease, and respiratory disease

Quintile - 5 (Very High)

Heat Vulnerability Index

3.0
Average

Adaptive Capacity

3.0
Average

Exposure

3.0
Average

Sensitivity

3.0
Average

Find the HVI maps here <https://peelregion.ca/health/health-status-data/peel-health-data-zone-information-tool> under the "Heat Vulnerability Index" tab.

Additional Analyses

- Compare social determinants with heat vulnerability.
- Identify disproportionate representation.
- Support targeted planning and interventions to reduce inequities.

Limitations and reflections

Limitations of area-based indices

- Ecological fallacy
- Modified area unit problem

Reflections on the maps and analysis

- What are the intended uses of these maps and analysis?

Public Health Applicability



Public Health Applicability

| Adaptive capacities (e.g., socioeconomic status) |
|---|
| Low Income |
| Living Alone |
| Renters |

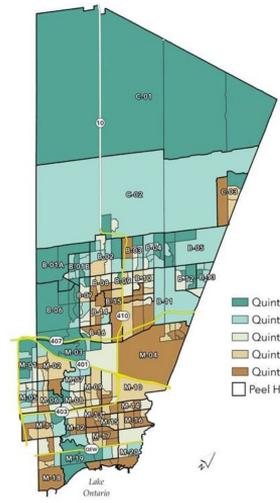
45.9%
total
variance

| Sensitivities (e.g., pre-existing health conditions) |
|--|
| Cancer |
| Respiratory Disease |
| Heart Disease |

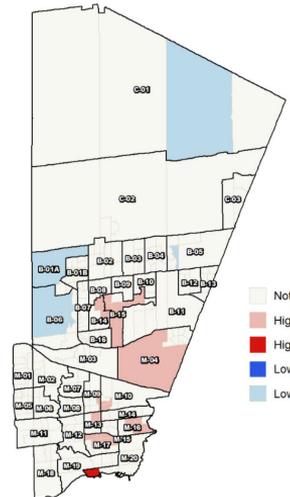
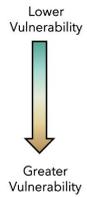
27.3%
total
variance

| Exposure (e.g., mean surface temperature) |
|---|
| Max. Temp °C |
| Tree Canopy - % |
| Normalized Difference Vegetation Index |

12.5%
total
variance



Heat Vulnerability in Peel Region



Applicability

Support planning
and program/policy
development.

Applicability

Support planning
and program/policy
development.

Increase
understanding of
neighbourhood
specific needs.

Applicability

Support planning
and program/policy
development.

Increase
understanding of
neighbourhood
specific needs.

Development of an
all-hazards climate
change emergency
plan.

Applicability

Support planning and program/policy development.

Increase understanding of neighbourhood specific needs.

Development of an all-hazards climate change emergency plan.

Collaboration across public health, broader organization and community partners.

Find the HVI maps here <https://peelregion.ca/health/health-status-data/peel-health-data-zone-information-tool> under the "Heat Vulnerability Index" tab.

Applicability

Support planning
and program/policy
development.

Increase
understanding of
neighbourhood
specific needs.

Development of an
all-hazards climate
change emergency
plan.

Collaboration across
public health,
broader
organization and
community partners.

Application support.

Heat Vulnerability Index and Peel Living Buildings

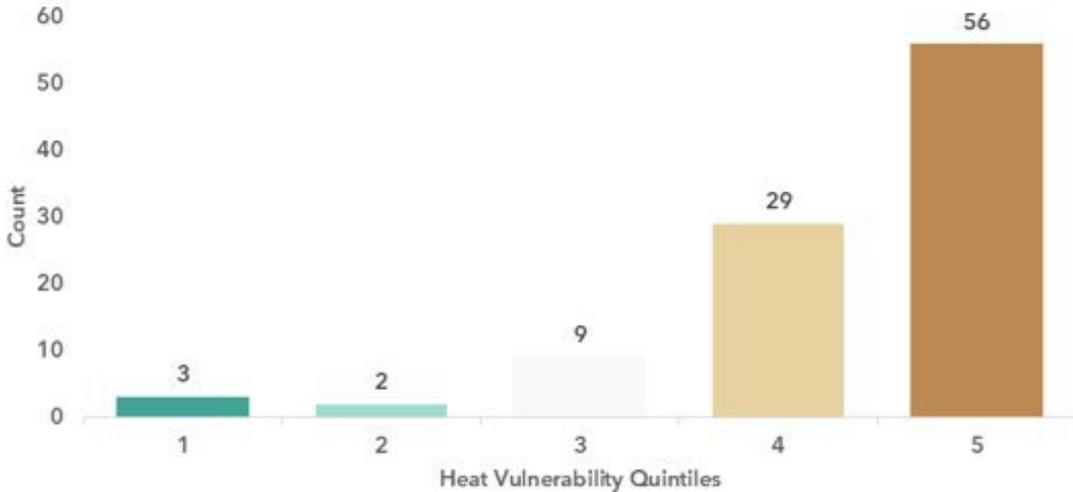
Census Tracts



- Heat Vulnerability Index - Quintiles
- Quintile 1 (Least Vulnerable)
 - Quintile 2
 - Quintile 3
 - Quintile 4
 - Quintile 5 (Most Vulnerable)
 - Peel Living Buildings

Prioritization of Climate Retrofits in Peel Buildings

Peel Living Buildings by Heat Vulnerability Index Quintile



Lower risk Greater risk

Acknowledgements

- David Guillette, GIS Specialist
- Elena Galatsis, Health Analyst
- Franca Ursitti, Program Manager
- Greg Kujbida, Program Manager
- Jessica Mammone, Analyst
- Louise Aubin, Director
- Lydia Cheng, Epidemiologist
- Maureen Horn, Program Manager
- Meagan Temporale, Advisor
- Monali Varia, Director
- Nicholas Brandon, AMOH

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2. Wilton D, Diong C, Paterson M. Climate Change Vulnerability Assessment through Principal Component Analysis and Data Mapping by Census Tracts in Peel Region, Applied Health Research Question (AHRQ) #2024 0950 156 000. Toronto: Institute for Clinical Evaluative Sciences; 2023.
3. Metrics of land surface temperature, indexed to DMTI Spatial Inc. postal codes were provided by CANUE (Canadian Urban Environmental Health Research Consortium). References: [1] Setton, E; Redivo A. (2022). Three-year warm-season maximum land surface temperature from LandSat 8. Developed for the Canadian Urban Environmental Health Research Consortium. [2] Osei, Edwin (2022). Google Earth Engine code for calculating LST using LandSat 8. Computer code, posted on Stack Exchange April 22, 2022. [3] CanMap Postal Code Suite [compute file] DMTI Spatial Inc,. various years.
4. Peel Data Centre
5. NDVI values for Peel were determined using the NDVI Function (ArcGIS Pro 2.9.9) and the red band (Band 4) and near-infrared (NIR) band (Band 5) from Landsat imagery (USGS, July 13, 2021). The mean NDVI value for each census tract in Peel was extracted using the Zonal Statistics function (ArcGIS Pro 2.9.9)

Data Sources

Institute for Clinical Evaluative Sciences (IC/ES)

- Wilton D, Diong C, Paterson M. Climate Change Vulnerability Assessment through Principal Component Analysis and Data Mapping by Census Tracts in Peel Region, Applied Health Research Question (AHRQ) #2024 0950 156 000. Toronto: Institute for Clinical Evaluative Sciences; 2023.

The Canadian Urban Environmental Health Research Consortium (CANUE)

- Setton, E; Redivo A. (2022). Three-year warm-season maximum land surface temperature from LandSat 8. Developed for the Canadian Urban Environmental Health Research Consortium.
- Osei, Edwin (2022). Google Earth Engine code for calculating LST using LandSat 8. Computer code, posted on Stack Exchange April 22, 2022.
- CanMap Postal Code Suite [compute file] DMTI Spatial Inc., various years

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- Statistics Canada. (2021). Household Characteristics: Renter
- Statistics Canada. (2021). Low income and income inequality in 2020: Prevalence of low income based on the Low-income measure, after tax (LIM-AT)(%)

Thank you.

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