## Novo Nordisk Network for Healthy Populations

# Current State of Type 2 Diabetes in the Peel Region

2022

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**Editors**

Lorraine L. Lipscombe, MDCM, MSc
Fatema M. Ali, MSc
Krista Lamb, BAA
Laura C. Rosella, PhD, MHSc
Baiju R. Shah, MD, PhD
Ian S. Zenlea, MD, MPH

**Reviewers**

Dianna J. Magliano, PhD, MPH, GAICD
Sarah Wild, PhD, MSc

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## AUTHOR AFFILIATIONS

**Shadia Adekunte, BMSc**
MD Candidate, University of Toronto Temerty School of Medicine

**Fatema M. Ali, MSc**
Network Coordinator, Novo Nordisk Network for Healthy Populations, University of Toronto

**Yu Qing Bai, MSc, MASc**
Senior Research Associate, Institute of Health Policy, Management & Evaluation, University of Toronto

Appointed Analyst, ICES University of Toronto

**Gillian L. Booth, MD, MSc**
Scientist, MAP Centre for Urban Health Solutions, Li Ka Shing Knowledge Institute, St. Michael's Hospital

Endocrinologist, Division of Endocrinology, St. Michael's Hospital

Professor, Department of Medicine and Institute for Health Policy, Management and Evaluation, University of Toronto

Adjunct Scientist, ICES

**Jeffrey R. Brook, PhD, MSc**
Associate Professor, Occupational & Environmental Health Division, Dalla Lana School of Public Health, University of Toronto

Associate Professor, Department of Civil and Mineral Engineering, University of Toronto

Principal Investigator and Scientific Director, The Canadian Urban Environmental Health Research Consortium (CANUE)

**Ghazal S. Fazli, PhD, MPH**
Training and Education Lead, Novo Nordisk Network for Healthy Populations, University of Toronto

Assistant Professor, Department of Geography, Geomatics, and the Environment, University of Toronto Mississauga

Adjunct Scientist, ICES

**David Guillette**
Data and GIS Specialist, Peel Public Health, Peel Region

**Calvin Ke, MD, PhD**
Assistant Professor, Department of Medicine, University of Toronto

Clinician Scientist, Toronto General Hospital Research Institute

Staff Endocrinologist, Toronto General Hospital, University Health Network

Adjunct Scientist, ICES

**Chris Kenaszchuk, MSc**
Research Analyst, Novo Nordisk Network for Healthy Populations, University of Toronto

**Lorraine L. Lipscombe, MDCM, MSc**
Executive Director, Novo Nordisk Network for Healthy Populations, University of Toronto

Professor, Department of Medicine, Temerty Faculty of Medicine and Dalla Lana School of Public Health

Staff Physician and Senior Scientist, Research and Innovation Institute, Women's College Hospital

Senior Adjunct Scientist, ICES

**Sarah M. Mah, PhD**
Post-Doctoral Fellow, Population Health Analytics Laboratory Dalla Lana School of Public Health, University of Toronto

**Laura C. Rosella, PhD, MHSc**
Data Collection, Analysis and Evaluation Lead, Novo Nordisk Network for Healthy Populations, University of Toronto

Stephen Family Chair in Community Health, Institute for Better Health, Trillium Health Partners

Professor, Dalla Lana School of Public Health, University of Toronto

Professor, Laboratory Medicine and Pathobiology, Temerty Faculty of Medicine, University of Toronto

Adjunct Scientist, ICES

Education Lead, Temerty Centre for Artificial Intelligence Research and Education in Medicine (T-CAIREM), University of Toronto

Associate Director Education & Training, Data Sciences Management & Evaluation, University of Toronto

**Baiju R. Shah, MD, PhD**
Novo Nordisk Research Chair in Equitable Care of Diabetes and Related Conditions, University of Toronto

Professor, Department of Medicine and Institute for Health Policy, Management and Evaluation, University of Toronto

Head, Division of Endocrinology, Sunnybrook Health Sciences Centre

Senior Scientist, ICES

**Karen Tu, MD, MSc**
Professor, Department of Family and Community Medicine, Temerty Faculty of Medicine | University of Toronto

Chair in Family and Community Medicine Research in Primary Care, University Health Network

Family Physician, University Health Network, Toronto Western Family Health Team

Research Scientist, North York General Hospital

Associate Director, UTOPIAN Data Safe Haven

**Michael J. Widener, PhD**
Associate Professor and Chair, Department of Geography and Planning, University of Toronto

Associate Professor, Division of Epidemiology, Dalla Lana School of Public Health, University of Toronto

**Walter Wodchis, PhD, MA, MAE**
Research Chair in Implementation and Evaluation Science, Institute for Better Health, Trillium Health Partners

Professor, Institute of Health Policy, Management and Evaluation, University of Toronto

Senior Adjunct Scientist, ICES

**Ian S. Zenlea, MD, MPH**
Family and Community Health & Engagement Lead, Novo Nordisk
Network for Healthy Populations, University of Toronto

Division Head & Medical Director, Children's Health, Paediatric Endocrinology, Trillium Health Partners

Clinician Scientist & Lead, Family and Child Health Initiative, Institute for Better Health, Trillium Health Partners

Part-time Assistant Professor, Temerty Faculty of Medicine, University of Toronto

Assistant Professor, Status Only, Institute for Health Policy, Management & Evaluation, University of Toronto

## EXPERT REVIEWERS

**Dianna J. Magliano, PhD, MPH, GAICD**
Head, Diabetes and Population Health, Baker Heart and Diabetes Institute

Professor, School of Public Health and Preventive Medicine, Monash University

National Health and Medical Research Council Investigator Grant Fellowship L2, Australia

Co-ordinator of Master of Public Health, Monash University

**Sarah Wild, PhD, MSc**
Professor of Epidemiology, Usher Institute, University of Edinburgh

Honorary consultant in public health, NHS Lothian and Public Health Scotland

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Sandra Fitzpatrick
Philip Cavicchia
Greg Kujbida

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Robert Trewartha

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Rick Glazier
Anne-Marie Tynan
Peter Gozdyra
Gary Moloney
Mohammed Agha

**ICES**

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# LIST OF EXHIBITS

## CHAPTER 3: BUILT ENVIRONMENT AND DIABETES

**CHAPTER 5: HEALTH SERVICES AND QUALITY OF CARE**

# EXECUTIVE SUMMARY

## CONTEXT AND OVERVIEW

This report is a comprehensive overview of four key issues in the Region of Peel that relate specifically to type 2 diabetes risk. Working together with academics, policymakers, community organizations, researchers, governments, patient partners and other experts, the Novo Nordisk Network for Healthy Populations at the University of Toronto has developed this evaluation of the current situation. The findings in this report are a first step in identifying and informing future research and policy priorities and actions necessary for reducing the burden of diabetes in the region.

Ontario's Peel presents an excellent test case for population-based interventions, given it has an extremely diverse population and landscape. Comprised of three municipalities: Brampton, Mississauga, and Caledon, with a population of 1.4 million, Peel's population is expected to grow from 1.5 to 2.2 million people by 2051 and is also undergoing demographic shifts with both an ageing population and the arrival of newcomers to Canada.

From the very urban centres of Mississauga and Brampton to the rural expanses of Caledon, this area is diverse in many ways, including incomes, ethnicities, and age groups. In 2007, it was estimated that 1 in 10 people in Peel lived with type 2 diabetes. In 2025, that number is estimated to reach 1 in 6. This condition, which can lead to serious health complications like kidney disease, heart disease and vision loss, is traumatic for the patient and costly to the healthcare system.

Looking at four specific areas: current diabetes burden, the built environment, behavioural demographics to predict future risk, and health services and quality of care, the Network can effectively determine what the problems are as we set out to solve them.

## GOALS AND AIM

The overall goal of this report is to provide a baseline understanding of the current situation in Peel Region as it relates to chronic disease and, specifically, type 2 diabetes. The research streams of this report each focus on a specific level of diabetes and chronic disease burden – from the health care system to communities to living environments. Efforts within each stream overlap and interconnect to address the overall goal of reducing the risk and burden of diabetes and related conditions for healthier populations in Peel Region and beyond.

The aim of this report was to understand and outline the current state of diabetes in the region and the next phase of research will look at potential solutions that are tailored to the community's diverse needs.

# KEY FINDINGS

Below are the key findings in each of our four target areas.

## CURRENT TYPE 2 DIABETES BURDEN IN THE PEEL REGION

In **2020**, there were **175,000 people living with diabetes in Peel Region**, compared to 161,000 people in 2015. Factoring in age, the rate of type 2 diabetes in adults over 20 in Peel was higher than the provincial and national average. **Rates of diabetes prevalence differ substantially across the Region** and are especially **high** (upwards of 26.5 per 100) in adults aged 45-64 living in Brampton. Among adults aged 65 and above, diabetes prevalence rates remained elevated in all Areas of Peel, with the highest rates being reported in Brampton.

The number of **low-income households** in the region is **higher in central** and the **north- east of Mississauga** and **across the south-east region of Brampton**, **encompassing central and south-west Brampton**. Also, north-east Mississauga and regions across south-east and south-west Brampton specifically have a **higher prevalence of diabetes** than their surrounding areas.

Peel region is home to a **greater proportion of newcomers** relative to the rest of the country and has among the largest concentrations of ethnic minority groups (62.3% of Peel's population) in Canada.

In 2021, there was a **higher concentration of recent immigrants** living in certain neighbourhoods of the Region, including the city centres of Mississauga and Brampton, as well as the northwest regions of Brampton, and in these **same areas, diabetes prevalence rates are also very elevated.**

## THE BUILT ENVIRONMENT AND TYPE 2 DIABETES

**Walkability** is **generally low** in most areas in **Peel**; however, there is **relatively good access to public parks** and **greenspace** throughout the region. In addition, access to frequent transit is present only in certain regions (i.e. along the lakeshore and in central areas of Mississauga and Brampton) and completely absent in Caledon – creating a further barrier to active transportation as an alternative to car use.

Other neighbourhood characteristics that influence the risk of type 2 diabetes, such as **fast-food access** and **housing need**, are highly variable across the region, while **poor air quality** is highly concentrated in communities surrounding the airport and major transit routes.

**Neighbourhoods with high rates of type 2 diabetes** have one or more characteristics that make it **challenging to adopt a healthy lifestyle**. Policies to create healthier environments need to address the diverse needs of each community. Due to the overlap between environmental factors and diabetes rates, it is important to consider the collective impact of social and environmental factors.

## DEMOGRAPHIC, BEHAVIOURAL, AND SOCIAL DETERMINANTS AND FUTURE RISK OF TYPE 2 DIABETES

**Type 2 diabetes prevalence** in Peel Region is **increasing** because of factors such as **age, socioeconomic status, race/ethnicity and immigrant status**. This prevalence is also impacted by factors including mental health, housing and food insecurity, racism, trauma and oppression.

The **future risk** of **developing diabetes** among residents in Peel is disproportionately elevated among visible minority and immigrant groups. We must consider the many factors that increase type 2 diabetes risk when looking for ways to reduce this risk. In the coming years, **diabetes incidence in Peel Region is projected to rapidly increase**, particularly among those experiencing a greater degree of socioeconomic disadvantages and health inequities.

**Over half of the population** in Peel Region is represented by those who identify as a **visible minority** (58.7% among adults with diabetes and 57.3% among those without diabetes). A higher proportion of immigrants are living with diabetes (73.3%) compared to immigrants without diabetes (56.6%). Among adults living with diabetes, 40.7% reported being physically inactive as compared to 27.3% of adults living without diabetes.

A significant proportion of residents reported being **overweight** (37.7% with diabetes and 33.2% without diabetes). Over half of the residents with **hypertension** reported having diabetes (60.8%), which was comparable to those living without diabetes (57.4%).

Although **food insecurity** is an important determinant of type 2 diabetes risk and an indicator of poverty, only a small number of residents reported experiencing severe food insecurity (3.1% among those living with diabetes and 2.0% living without diabetes). A small fraction of residents reported an **income of less than $20,000** (6.5% among those with diabetes and 5.7% of those living without diabetes).

The 10-year risk of developing new diabetes for residents of Peel Region overall is 11.5%, with an additional 102,000 adults aged >20 years living with diabetes by 2028.

## HEALTHY SERVICES AND QUALITY OF CARE

Peel Region is served by multiple Ontario Health Teams (OHTs), including the Central West, Mississauga, and Hills of Headwaters Collaborative OHTs. The Mississauga OHT serves a population of 859,392 individuals who receive most of their health services in Mississauga.

The below key findings focus on the health services and the quality of care for people living with diabetes in the **Mississauga OHT.**

- The **quality of diabetes services** in the Mississauga OHT is **broadly similar** to those in the **rest of Ontario**.
- Diabetes Canada's recommended ideal standard for **regular blood glucose monitoring** (HbA1c testing) was not met in more than 50% of people with diabetes in the Mississauga OHT.
- Nearly 40% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's ideal recommended **target HbA1c level**.
- Diabetes Canada's recommended ideal standard for **regular blood cholesterol monitoring** (LDL cholesterol testing) was not met in around 30% of people with diabetes in the Mississauga OHT
- 43% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's recommended ideal **target cholesterol level**.
- Diabetes Canada's recommended ideal standard for regular **retinopathy (eye) screening** was not met in around 45% of people with diabetes in the Mississauga OHT.
- The proportion of those attending retinopathy screening was slightly lower in the Mississauga OHT than in the rest of Ontario.
- In the Mississauga OHT, 65% and 74% of people with diabetes aged 65 years or older **received kidney- and heart-protective medications**; these figures fell short of the recommended ideal standard benchmark of 80% despite these medications being subsidized by the provincial drug benefit plan.

## OVERALL IMPLICATIONS

This report presents the current risk and burden of type 2 diabetes in the Peel Region with a goal of understanding the impact of macro elements, such as the built environment, meso elements, like health behaviours, and micro indicators, like quality of care. All of these elements contribute to the rising rates of type 2 diabetes in Peel.

The findings indicate the potential focus and priorities of interventions that could reduce type 2 diabetes risk or improve care for those living with the condition. In our next phase, the Network will identify causes and factors contributing to the problems we have outlined and map the areas of greatest need. From there, research projects that support interventions or which will build on or leverage resources can be developed and implemented.

Whether it be through increasing access to public transit, improving air quality, supporting healthcare providers to reach guideline-informed targets, or reducing barriers to healthcare access for newcomers to Canada, the end goal of all work must be to improve the overall health of those living in the region. Potential solutions must consider a diverse and far-reaching population and speak to their needs on both a collective and individual basis.

# CHAPTER 1:
# INTRODUCTION TO THE NETWORK FOR HEALTHY POPULATIONS


## AUTHORS

Fatema M. Ali

Ghazal S. Fazli

Ian S. Zenlea

Laura C. Rosella

Baiju R. Shah

Lorraine L. Lipscombe

## INTRODUCTION

This report serves as a comprehensive overview of the Novo Nordisk Network for Healthy Populations (NHP) efforts to comprehensively assess the diabetes landscape in Peel Region. The report provides information about the organization, insights on the prevalence of diabetes in the Peel Region, and the implications these findings hold for shaping our future initiatives. It stands as a testament to our commitment to addressing the challenges posed by diabetes in the Peel Region and underscores our dedication to fostering a healthier population through informed and targeted interventions.

## BACKGROUND OF THE NETWORK FOR HEALTHY POPULATIONS

Established in 2021, the NHP is a cross-disciplinary research network at the University of Toronto that aims to reduce the risk and burden of type 2 diabetes and related chronic conditions.

The University of Toronto (UofT) is home to world-renowned leaders in public health, diabetes research, urban geography, policy development and implementation, risk-reduction interventions, and healthy child development—fields that are key to addressing the concerning links between obesity, urban health, and diabetes and its related chronic conditions. The NHP brings together experts from the Dalla Lana School of Public Health, Temerty Faculty of Medicine, and the University of Toronto Mississauga—where the Network is based—to find new ways to support healthier urban living. In collaboration with community partners in Mississauga and Peel Region, these UofT researchers are creating locally relevant solutions that can help improve health outcomes for not just individuals but whole communities. This interdisciplinary collaborative effort fosters innovation, builds capacity in the region, and catalyzes connections across fields to integrate diverse mindsets and approaches in the fight against chronic conditions like diabetes.

This initiative between researchers and community partners intends to:

1. Target the root causes of type 2 diabetes and related chronic conditions,
2. Develop interventions to prevent its unsustainable rise,
3. Enable more early detection of the disease,
4. Ameliorate risk conditions and barriers to health resources and services,
5. Close the gap in health outcomes for equity-deserving communities, who currently bear a disproportionate impact of diabetes and its related conditions.

Ultimately, the NHP aims to ***discover, implement, and validate feasible, equitable, and sustainable solutions*** that can make cities around the world healthier places to live—for all of their residents. In doing so, NHP's scalable solutions will have an impact globally as more cities adopt and adapt these for their own unique contexts.

## OBJECTIVES AND MISSION OF THE NETWORK

The mission of the NHP is to reduce inequities in the risk and burden of diabetes and other chronic diseases through better care, lower risk factors and healthier living environments. Three areas of activities have been identified to address the NHP's mission, which includes the following:

### CAPACITY BUILDING:

Create **new relationships** and opportunities that bring together the community with students, healthcare providers, policymakers, and academics to **collectively address the burden of chronic disease**.

### EDUCATION AND KNOWLEDGE SHARING:

Create a network and a platform for researchers, students, providers, community members, and decision-makers to share and **advance knowledge**, promote innovation, explore new methods, and learn from one another.

### CATALYZE AND SUPPORT SCALABLE SOLUTIONS:

Foster and facilitate cross-disciplinary collaborative teams to co-design, launch, and evaluate community-based projects and **reciprocal partnerships** to **demonstrate impact** on the burden of diabetes and chronic disease.

## WHAT IS THE PROBLEM TO BE SOLVED?

Cities everywhere are struggling with rising rates of chronic conditions, and the global number of people aged 20-79 years with diabetes is estimated to have reached 537 million in 2021.[1] The vast majority of the rising prevalence of diabetes is due to type 2 diabetes, which accounts for over 90% of diabetes.[2] In 2007, Peel's estimates showed that 1 in 10 adults was diagnosed with diabetes, and this is projected to increase to 1 in 6 adults by 2025.[3] The prevalence of diabetes in this region has been consistently higher than that of Ontario as a whole since 1996, and it is expected to continue to grow in the coming years, if left unaddressed.[4] The increasing prevalence of diabetes has been linked to significant shifts in age-standardized population demographics, better survival of people with diabetes, and the concurrent epidemic of overweight and obesity, which accounts for an estimated 52% of the risk of diabetes.[2] The global rise in obesity has been largely attributed to massive changes in living environments and social policies that favour more sedentary behaviour, higher food intake, and unhealthy food options.

This shift in health behaviours and consequent rise in obesity and diabetes is due to a complex array of biological, social, cultural, and environmental determinants that interact with behavioural changes. There is also evidence that diabetes disproportionally affects more socially disadvantaged and ethnic minority populations, highlighting the central role of the social determinants of health in contributing to the overall burden and increasing disparities in diabetes.[5] While these underlying factors are often highly contextual, many adverse social conditions contribute to the health behaviours linked to obesity and diabetes (*see Exhibit 1.1*). Therefore, research and policy response efforts will require a multi-pronged approach that addresses the root causes of obesity and diabetes, concurrently targeting individual behaviours, physical environments, and underlying social determinants of health that are contributing to these inequities in diabetes and related chronic disease burden.

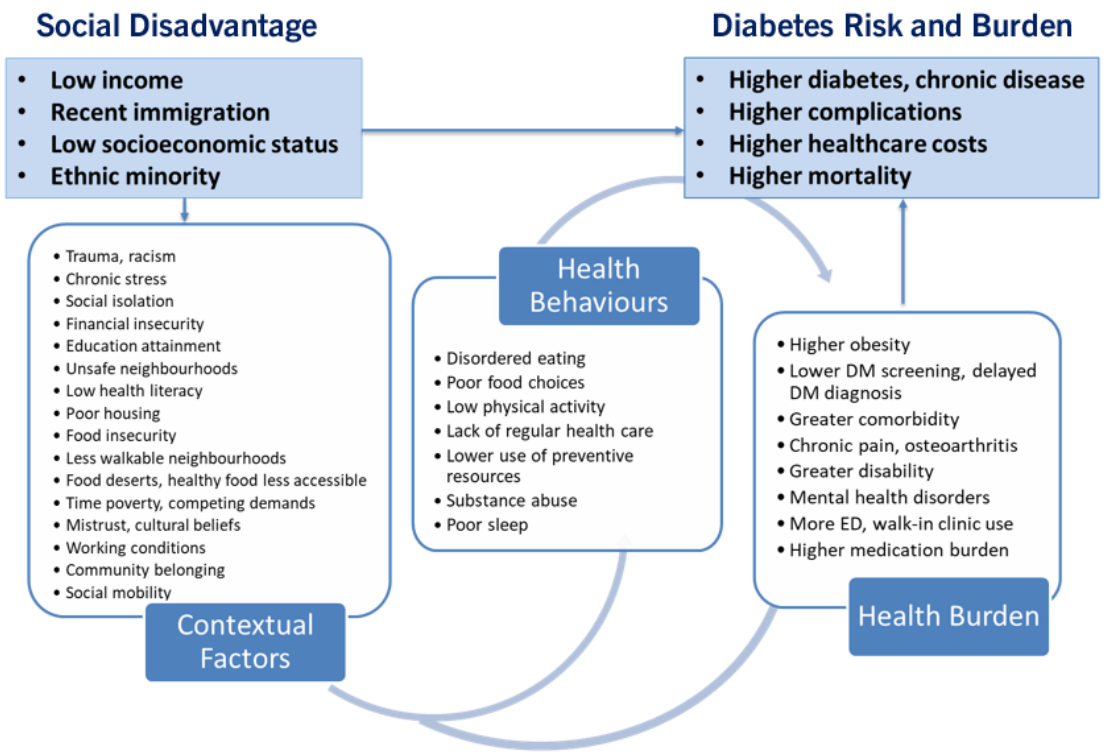


**Exhibit 1.1** The role of social determinants of health in diabetes burden.

## CONTEXT MATTERS: OVERVIEW OF PEEL REGION

The Peel Region is an ideal location for developing this kind of transformational research and developing innovative outreach initiatives that can make cities healthier places to live. Ontario's Peel Region comprises three municipalities (*Exhibit 1.2*): Brampton, Mississauga, and Caledon, with a population of 1.4 million.[6] Peel's population is expected to grow from 1.5 to 2.2 million people by 2051 and is also undergoing demographic shifts with both an ageing population and the arrival of newcomers to Canada.[7-9] The region is home to a greater proportion of newcomers relative to the rest of the country and has among the largest concentrations of ethnic minority groups (62.3% of Peel's population) in Canada, the largest groups of which are South Asian (50.8%) and Black (15.3%).[10] Throughout the country, shifting societal norms and an aging population have also resulted in changing household structures over time, such as a greater proportion of single-parent households and individuals living alone.

This growing region provides an opportunity for NHP to unite researchers with local organizations and decision-makers to understand the impact of social and built environments on behaviours, health outcomes, and access to services in a highly diverse setting. Thus, NHP is uniquely positioned to identify research priorities and solution- and equity-oriented interventions and train the next generation of health leaders to address the underlying determinants and reduce their impact to achieve the most significant and equitable results in diabetes prevention and management in the region.

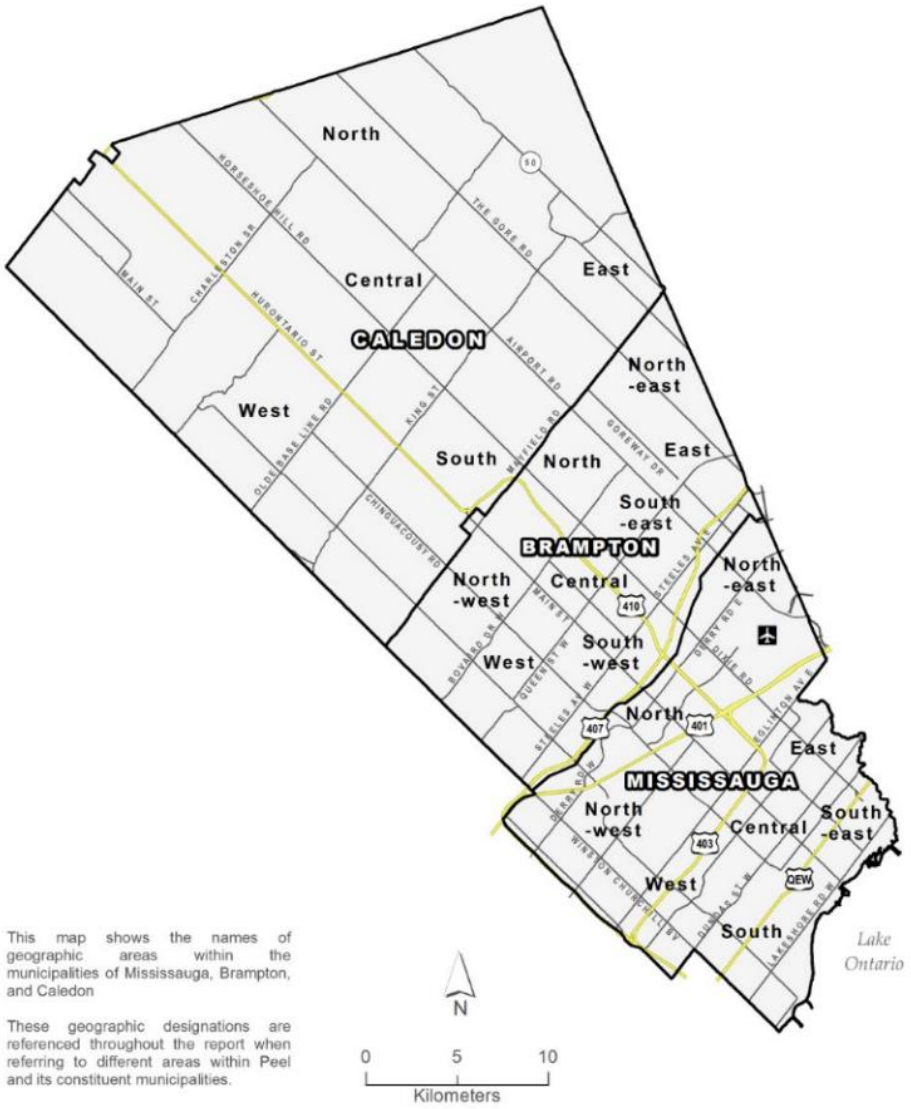


**Exhibit 1.2** Designation of geographic area with Mississauga, Brampton, and Caledon [2023].

## THE NETWORK'S ACTIONS TO ADDRESS THE RISK AND BURDEN OF DIABETES IN PEEL REGION

Since its inception and launch in the Fall of 2021, the Network has strived to understand the current opportunities and needs of Peel communities. This has been accomplished through a number of community engagement activities, including establishing and engaging with an advisory committee of diverse experts, community organizations, and decision-makers; hosting an academic think tank event; holding a data strategy validation webinar; and participating in one-on-one conversations with local organizations and decision-makers. These events and conversations have been invaluable in defining NHP's structure, priorities, and goals, as shown in Exhibit 1.3.

A vital result of the feedback received through these engagement opportunities was the need to understand existing patterns of diabetes and chronic disease risk and burden in the region. This led to the development of NHP's Baseline Data Strategy (BDS).

| Activity | Purpose |
|---|---|
| **Community Conversations** | Gain a comprehensive understanding of research capacity, resources, and healthcare in the region, as well as the community's specific needs related to diabetes and its prevention. These conversations support developing connections with key community members, and they are ongoing. |
| **Think Tank** | Identify foundational intentions and initial actions for the first year. |
| **Baseline Data Strategy (BDS) Webinar** | Gain feedback on needs and opportunities for baseline data evaluation in Peel and identify opportunities for partnership with the community and other researchers. |
| **NHP Advisory Committee:**<br>**Launch Meeting** | Connect with the community to discuss the role of the NHP. Identify the activities that would have the most significant impact and determine current local initiatives that address the burden of chronic disease in Peel. Identify opportunities for additional outreach and membership. |
| **Catalyst Grant Competition** | Launch a grant competition that ensures successful applicants will develop projects and interventions that are community-engaged. Create new relationships and encourage the implementation of community interventions. |

**Exhibit 1.3** Summary of NHP engagement activities* completed during 2021-2023.
* Researchers, community partners, policymakers, healthcare providers, and community members attended these sessions.

The BDS includes three streams of inquiry that align with NHP's mission: 1) the delivery of care and prevention for diabetes and chronic disease; 2) disparities in social and behavioural risk factors for diabetes and chronic disease; and 3) structural/built environment and policy factors associated with risk of diabetes and chronic disease (*Exhibit 1.4*).

Three BDS working groups were created to address these streams of inquiry. As a first step, each group was tasked with describing the risk and burden of diabetes and its risk factors across the region. While the first phase was focused on diabetes, future efforts will involve examining the risk factors of other diabetes-related chronic diseases in the region.

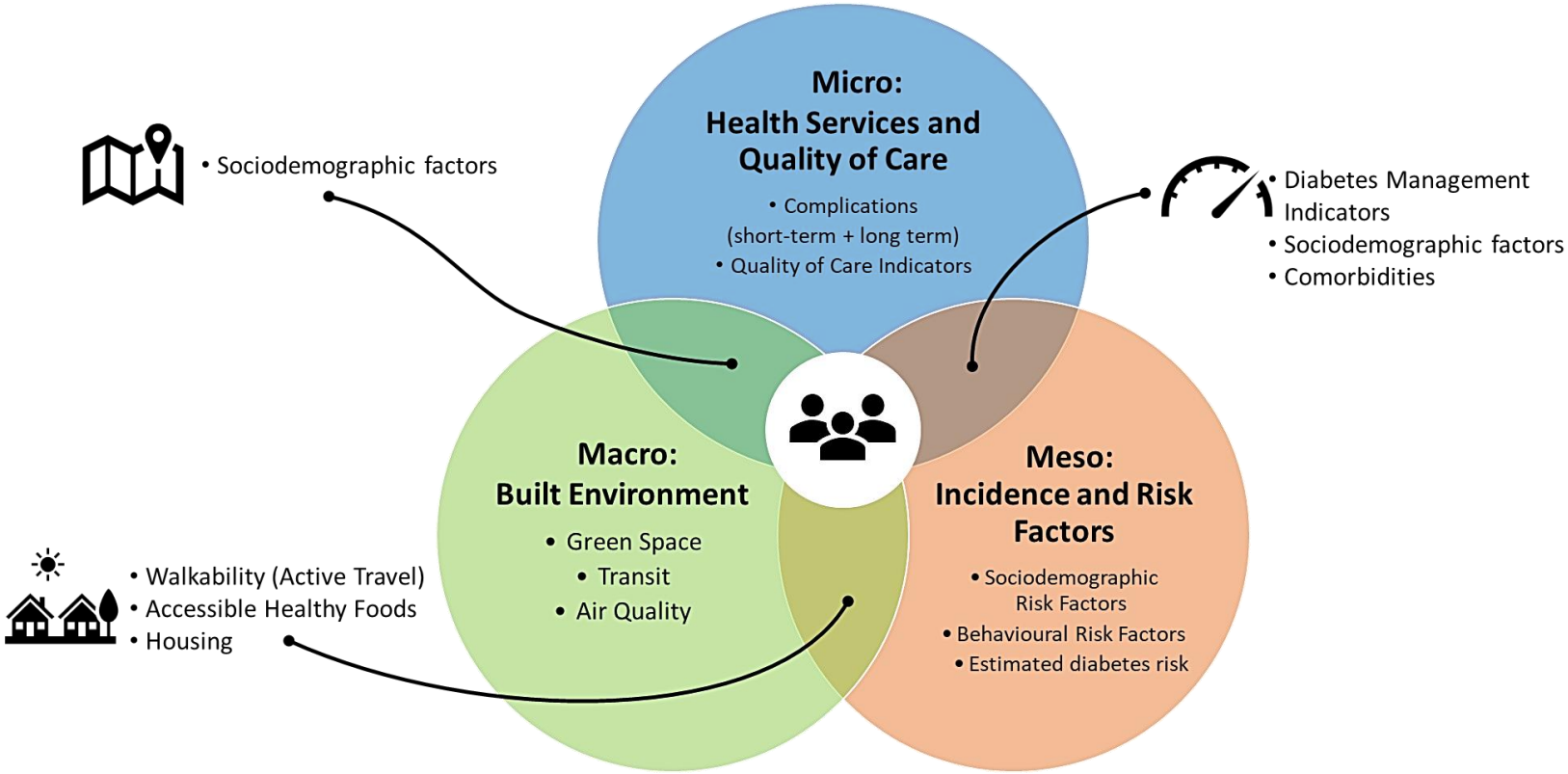


**Exhibit 1.4** Three research streams of the Baseline Data Strategy Group and the interconnectedness of the shared risk factors of diabetes and chronic disease.

## BUILDING ON THE 2013 PEEL DIABETES ATLAS

The *Diabetes Atlas for the Region of Peel,* published in 2013, informed NHP's initial research streams and provided critical foundational information.[3] This comprehensive and detailed report has mapped several indicators and variables connected to diabetes risk and burden throughout the Peel Region.

Key findings from the 2013 *Diabetes Atlas for the Region of Peel* included overall diabetes prevalence among immigrants, different ethnic groups, and neighbourhoods. Some of the highlights were:

- The age- and sex-standardized prevalence of diabetes among adults in Peel was higher (10.0%) than the overall prevalence in Ontario (8.8%). In 2007, one in ten adults in Peel had been diagnosed with diabetes, and this is expected to reach one in six by 2025. Prevalence varied across the Peel Region, with the highest prevalence in many of Brampton neighbourhoods as compared to Mississauga and Caledon.
- Although settlement patterns differed by ethnic group, areas with higher proportions of recent immigrants also had a higher prevalence of diabetes compared to the rest of Peel.
- Between 2003 and 2008, the prevalence of overweight and obesity in Peel was higher (47.0%) than in the Greater Toronto Area (GTA) (44.4%).
- About half (56.7%) of the region's residents were at least moderately physically active during their leisure time (equivalent to walking 30 to 60 minutes a day of more).
- In Peel, there was a fairly consistent inverse relationship between the prevalence of diabetes and socioeconomic status, with higher diabetes prevalence in equity-deserving areas.
- Most areas across Mississauga and Brampton are automobile-dependent with low walkability, which creates challenges for evaluating the relationship between built environment factors (such as green space, walkability, and modes of available transportation) and diabetes prevalence.
- With respect to access to parks and schools, the density of the park areas varied significantly across the region. In many areas in Mississauga and central Brampton, residents had relatively lower access to parks compared to other areas in the Peel Region.
- Access to family physicians was fairly evenly distributed across the Peel Region, with a higher concentration in central Mississauga versus other areas. However, longer travel distances in Caledon and northeast Brampton may have an impact on access to care for residents living in these areas.

One of the first steps of the BDS committee has been to build on the *Atlas* to further understand the current risk and burden of diabetes and chronic disease in the Peel Region. As a first step, we undertook an analysis of available data on indicators related to the quality of care, risk factors, and built environment and identified future research and policy priorities and actions to target these modifiable indicators of diabetes risk and burden.

**Therefore, the aims of this Baseline Report are explored in the subsequent chapters in the following order:**

**Chapter 2: Overview of the Diabetes Burden in Peel Region**

**Aim:** Describe the prevalence of diabetes and sociodemographic disparities in the Region of Peel and how these vary by neighbourhood.

**Chapter 3: Built Environment and Diabetes**

**Aim:** Characterize the built environment (neighbourhood design, parks and green spaces, access to transportation, food environment, housing, air quality) using neighbourhood-level data and novel measures and assess their correlation with diabetes across the Region of Peel

**Chapter 4: Demographic, Behavioural, and Social Determinants and Future Risk of Diabetes**

**Aim:** Describe the risk factors and indicators for diabetes in Peel Region and use modelling to predict the future risk of diabetes to inform targeting of potential interventions.

**Chapter 5: Health Services and Quality of Care**

**Aim:** Describe the adequacy of processes and targets of diabetes care, including laboratory tests for blood glucose (sugar) and low-density lipoprotein cholesterol, retinopathy screening, prescriptions for organ-protective medications, and hospitalizations for complications among adults with diabetes in the Mississauga OHT from 2019 to 2022.

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# CHAPTER 2: OVERVIEW OF THE DIABETES BURDEN IN THE PEEL REGION


## AUTHORS

Ghazal S. Fazli

Fatema M. Ali

Calvin Ke

Sarah M. Mah

Ian S. Zenlea

Laura C. Rosella

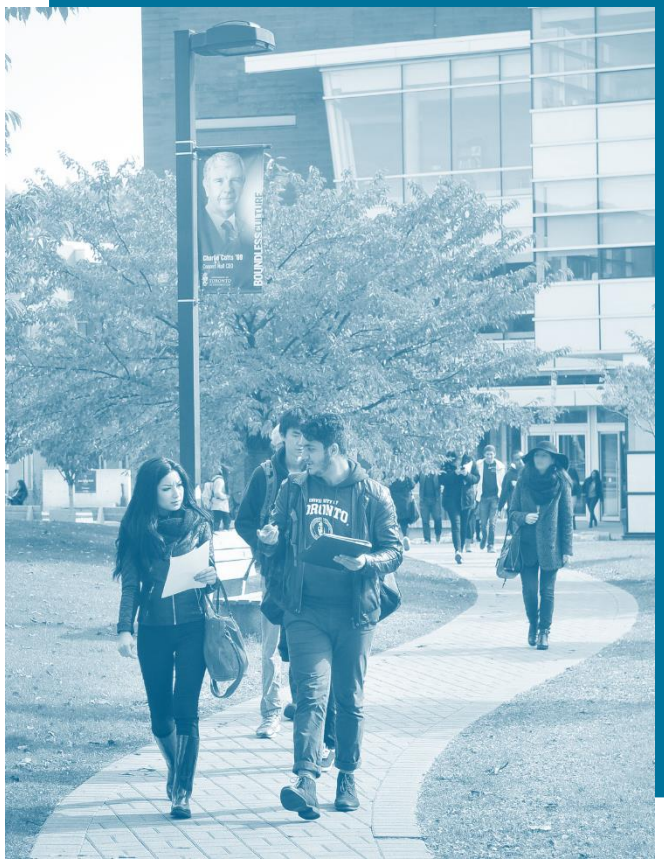
Baiju Shah

Lorraine L. Lipscombe

## KEY FINDINGS

### TYPE 2 DIABETES PREVALENCE VARIES ACROSS THE REGION OF PEEL

- In 2020, there were 175,000 people living with diabetes in Peel Region, compared to 161,000 people in 2015.
- Factoring in age, the rate of type 2 diabetes in adults over 20 in Peel was higher than the provincial and national average.
- Rates of diabetes prevalence differ substantially across the Region and are especially high (upwards of 26.5 per 100) in adults aged 45-64 living in Brampton.
- Among adults aged 65 and above, diabetes prevalence rates remained elevated in all areas of Peel, with the highest rates being reported in Brampton.



### SOCIO-DEMOGRAPHIC PROFILE OF PEEL AND TYPE 2 DIABETES

- The number of **low-income households** in the region is higher in central and the north-east of Mississauga and across the south-east region of Brampton, encompassing central and south-west Brampton. Also, north-east Mississauga and regions across south-east and south-west Brampton specifically have a higher prevalence of diabetes than their surrounding areas.
- Peel region is home to a **greater proportion of newcomers** relative to the rest of the country and has among the largest concentrations of ethnic minorities (62.3% of Peel's population) in Canada.
- Most of the equity-deserving population in the area identify as South Asian (50.8%) or Black (15.3%).
- In 2021, there was a higher concentration of **recent immigrants** living in certain neighbourhoods of the Region, including the city centres of Mississauga and Brampton, as well as the northwest regions of Brampton, and in these same areas, diabetes prevalence rates are also very elevated.

## THE RISING BURDEN OF DIABETES

With a global estimate of the number of 20–79-year-olds rapidly reaching 537 million in 2021, diabetes continues to pose one of the most significant public health challenges worldwide.[1] The current prevalence of diabetes continues to exceed projected estimates, creating significant challenges for health systems and economies. In 2022, four million Canadians (10% of the adult population) are living with diagnosed diabetes,[2] representing an increase from 3.1 million (8.6%) in 2013.[3]

Although there are three major forms of diabetes (type 1, type 2, and gestational diabetes), this report focuses on type 2 diabetes (herein referred to as diabetes), which represents over 90% of cases.[4] Diabetes is a chronic progressive condition characterized by impaired production or action of insulin, which regulates blood sugar or serum glucose.[5] The complications arising from uncontrolled diabetes and associated risk factors can be severe and include cardiovascular disease, chronic kidney disease, as well as microvascular nerve and vision damage.[2]Diabetes and related complications also disproportionately affect many equity-deserving groups such as racialized communities, ethnic minorities, and persons with low income, highlighting the intersection between social determinants of health and shifts in living environments that promote unhealthy behaviours and weight gain.[6] There is evidence that for some individuals, diabetes can be prevented /delayed by adopting and maintaining regular physical activity, a healthy diet, and a healthy weight and that complications of diabetes can be reduced with adequate treatment and diabetes care.[7-10] Yet the prevalence of diabetes is expected to increase in many low- and middle-income settings and socially disadvantaged groups, underscoring the urgent need for greater efforts to translate this evidence into action in an equitable way.[1] Thus, as an essential first step, we sought to understand the existing burden of diabetes and socio-demographic disparities across the region.

This chapter describes the prevalence of diabetes and socio-demographic risk factors in the Region of Peel and how these vary by neighbourhood. We used population-based data sources housed at ICES from 2020 to collect information on adults living with diabetes and their socio-demographic and place of residence characteristics. Diabetes cases were based on physician diagnoses and hospital records (see technical appendix for more details). Maps are displayed by Peel Health Data Zones, which are defined geographic areas within Peel and are smaller than municipality levels (See Technical appendix for further details on the maps provided in this chapter).

## DIABETES PREVALENCE VARIES ACROSS THE REGION OF PEEL

In 2020, there were 175,000 people with a diagnosis of diabetes in Peel Region, compared to 161,000 people in 2015.[11] The overall age-standardized prevalence of diabetes among adults over age 20 in 2020 was 15.5% for Peel, and this figure is higher than both the provincial (9.8%) and national (10.0%) age-standardized prevalence.[2] However, the age-standardized diabetes prevalence for 20+ year olds differs substantially across the Region, from as low as 9% in southern regions of Mississauga and swathes of Caledon to 20% for areas of Brampton (*Exhibit 2.1*). The burden of diabetes also varies by biological sex, whereby males have a higher age-standardized prevalence (16.1 %) than females (14.8 %) (*Exhibit 2.2*).

Further, diabetes prevalence appeared to be particularly high (upwards of 26.5%) among adults aged 45-64 years living in Brampton (*Exhibit 2.3*). In all areas of Peel, diabetes prevalence rates tend to vary by age group, with the highest rates being among adults aged 65 and above (*Exhibit 2.3*).

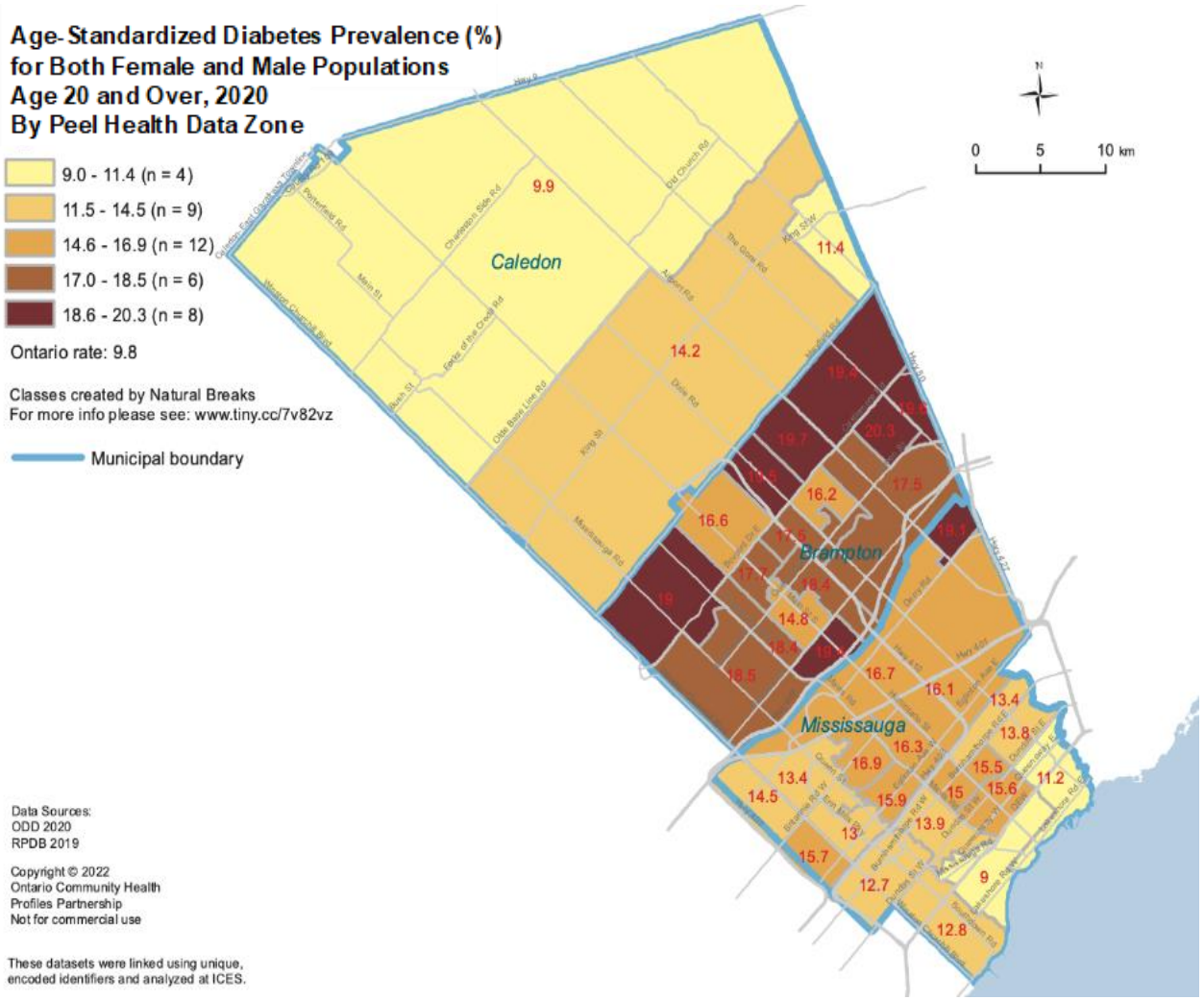



**Exhibit 2.1** Age-standardized diabetes prevalence (%), for people aged 20 years and over in 2020 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

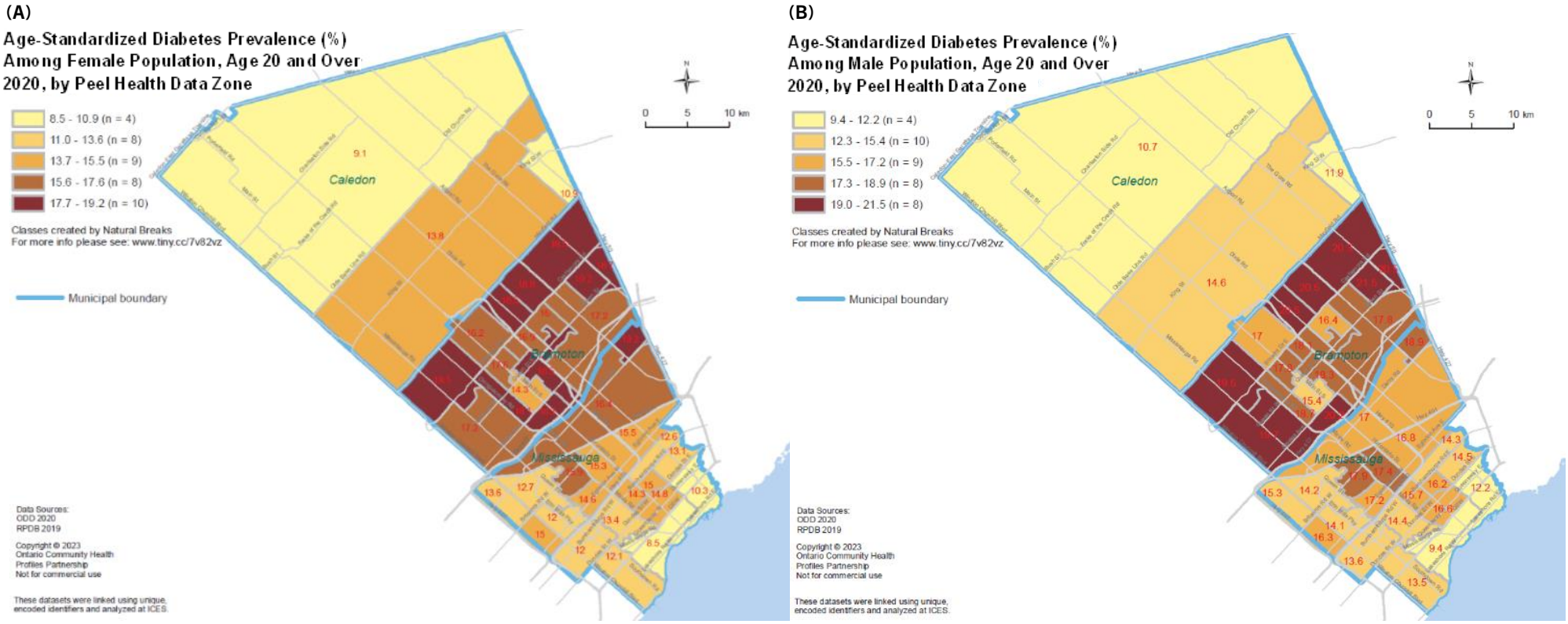



**Exhibit 2.2** Age-standardized diabetes prevalence (%), by sex among adults aged 20 years and over in 2020 by Peel Health Data Zone (A) Female (B) Male. Source: Ontario Community Health Profiles Partnership.

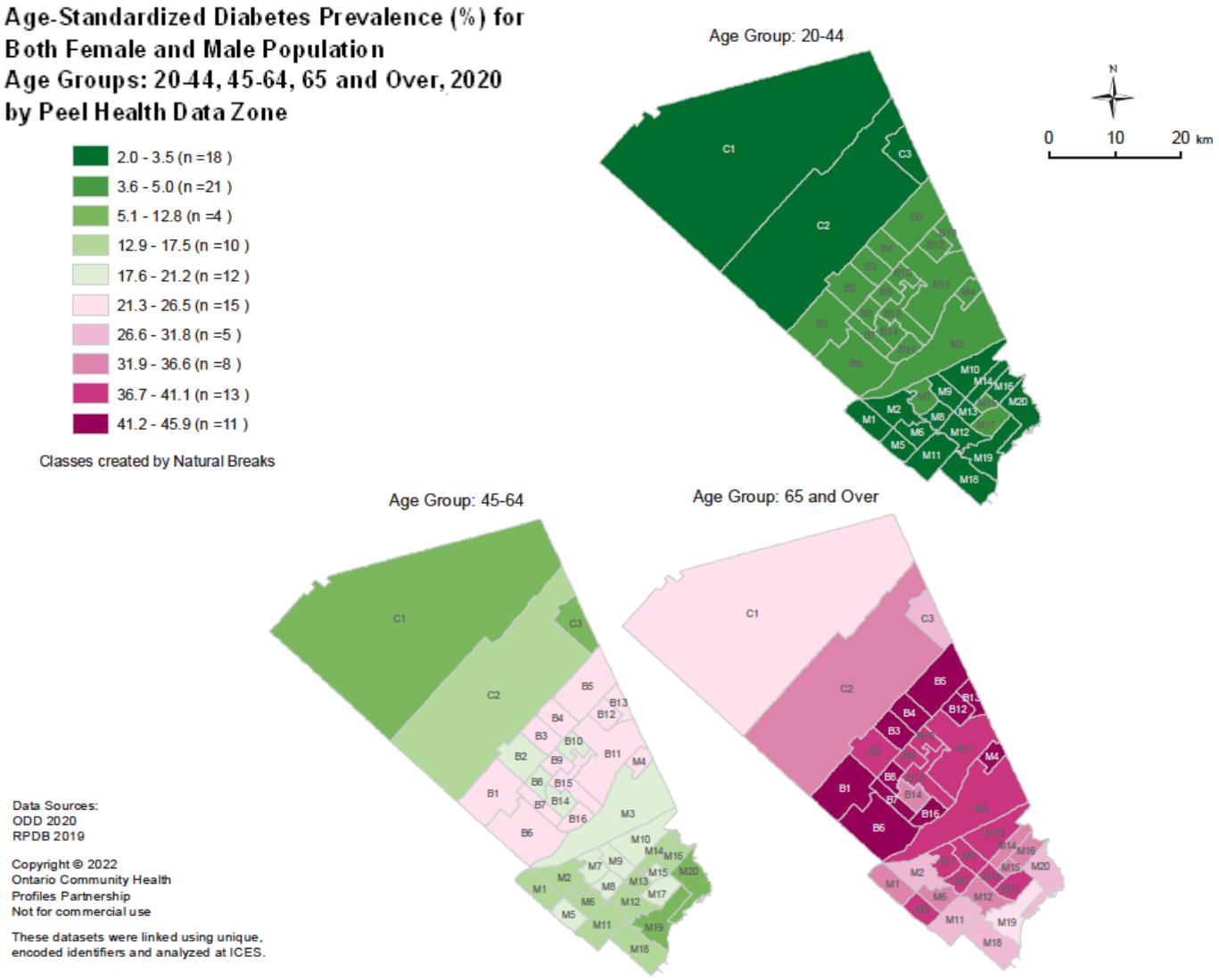



**Exhibit 2.3** Age-standardized age-specific prevalence diabetes, among adults of 20+ years of age in 2020 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

## SOCIAL DETERMINANTS OF HEALTH LINKED TO DIABETES VARY SPATIALLY ACROSS THE REGION

Diabetes burden differs across groups of people by social and demographic characteristics. There is considerable evidence demonstrating that an inverse gradient exists for diabetes prevalence across multiple measures of socioeconomic status, whereby diabetes prevalence is higher among those in the lowest income group.[6,12-13] As well, certain socially disadvantaged populations have been found to be at higher risk of diabetes and diabetes-related complications.[14]

Certain ethnic minority groups, such as persons of South Asian, Black, and Indigenous heritage, also have a higher risk of diabetes.[2] A previous study from Ontario has shown a higher incidence of prediabetes (a condition with elevated levels of blood glucose that has not yet reached the level of diabetes) for immigrants of non-European ethnic backgrounds.[15] These populations also experience a more rapid progression from prediabetes to diabetes than people of European ancestry or the population as a whole.[16] The excess risk of diabetes in socially disadvantaged and ethnic minority groups can at least partly be attributed to inequities in the social determinants of health, such as material deprivation, housing affordability and food insecurity, neighbourhood design, as well as racism and structural inequalities, along with other barriers that shape preventive health behaviours. These social conditions can have long-lasting and cumulative effects on health, from early life before birth to childhood and all the way to adulthood. In fact, the disproportionate risk of diabetes in ethnic groups from low- and middle-income countries has been partly explained by effects of early life exposures in the womb, such as prenatal undernutrition and maternal stress, that can program long-term, multi-generational epi-genetic metabolic changes.[17] These changes provide an early survival advantage in resource-poor environments but can increase the risk of disease later in life when nutritional conditions are modified. For many populations, these developmental factors add to ongoing socioeconomic inequalities and have a cumulative burden on the risk of obesity and diabetes. While diabetes risk tends to increase with age, this complex interplay between the genetic and epi-genetic risk factors of diabetes and the ongoing influence of social determinants of health contribute to an earlier onset of diabetes that is more marked among high-risk populations.

## SOCIO-DEMOGRAPHIC PROFILE OF PEEL REGION

Peel has been described as an example of 'hyper-diversity', referring to the region's intense diversity in socioeconomic status, racial and ethnic identities, gender, and age, in addition to there being differing lifestyles, attitudes, and activities among diverse immigrant populations.[18-19] Therefore, the socio-demographic profile of Peel Region tends to vary across several neighbourhood-level characteristics, including low income, recent immigrant status, and household structure (e.g., persons in one-parent families and persons living alone).

The proportion of households with low income in this region (5.4%) is comparable to the number of households living in low income in Ontario (5.3%).[20] In Peel, the proportion of low-income households appears to be more concentrated in central and the north-east of Mississauga and across the southeast region of Brampton, encompassing central and south-west Brampton (*Exhibit 2.4*). However, north-east Mississauga and regions across southeast and southwest Brampton specifically have a higher age-standardized prevalence of diabetes than their surrounding areas (*Exhibit 2.1*).

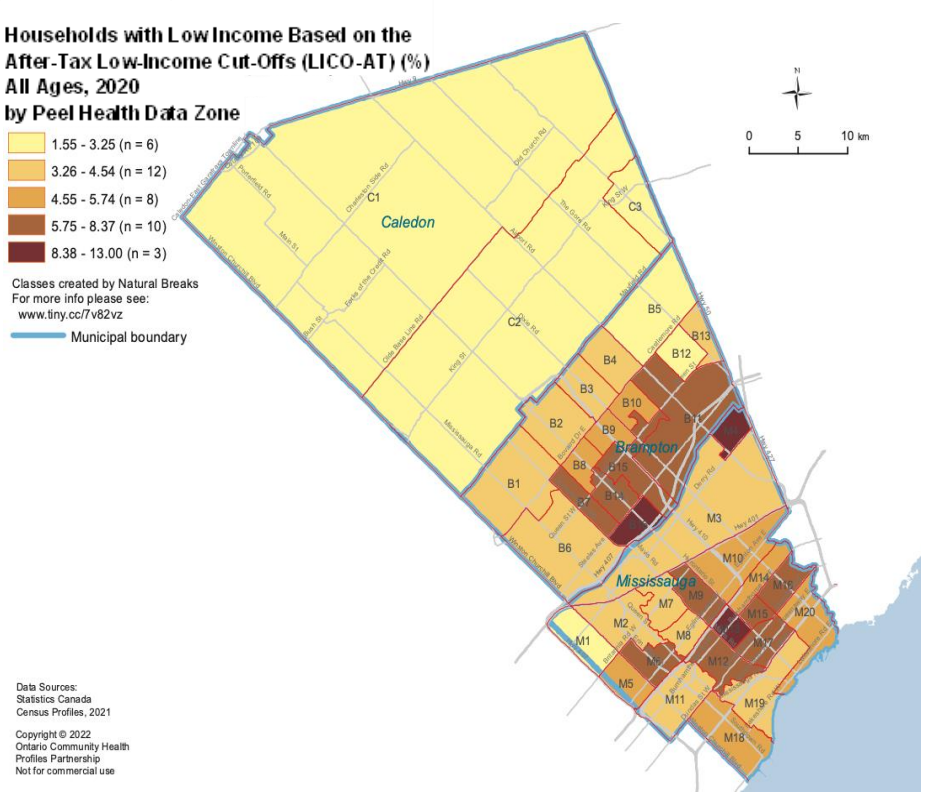



**Exhibit 2.4** Proportions of households with low income, based on Low-Income Cut-Offs After Tax (LICO-AT), females and males aged 20 and over in 2020 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

In terms of the immigrant population, this region is home to a greater proportion of newcomers relative to the rest of the country and has among the largest concentrations of racialized people (62.3% of Peel's population) in Canada, the largest groups of which are South Asian (50.8%) and Black (15.3%).[21] Specifically, in 2021, there is a higher concentration of recent immigrants living in certain neighbourhoods of the Region, including the city centres of Mississauga and Brampton, as well as the northwest regions of Brampton (*Exhibit 2.5*), and in these same areas, the prevalence of diabetes is particularly high (as shown in *Exhibit 2.1*).

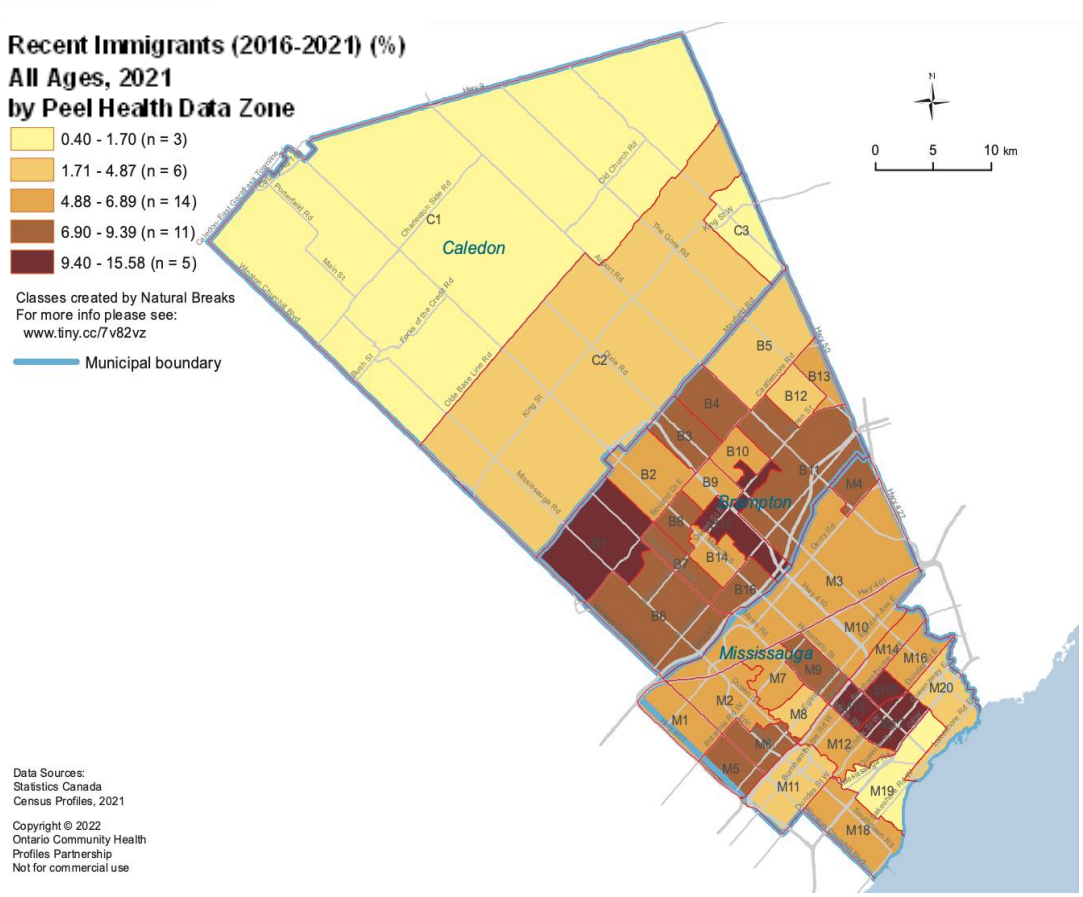



**Exhibit 2.5** Recent immigrants (%), all ages, in 2021 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

Additionally, prior research has shown that loneliness has been associated with a 2-fold higher risk of diabetes.[22-23] While loneliness and social isolation were not captured in this report, we evaluated the proportion of single-adult households in Peel Region as a signal for potential social isolation. These figures show the proportion of one-parent households in Peel Region, defined as households with one adult and one or more children, and households of persons living alone, defined as those with one single person aged 15 years or older. While Central Brampton is home to the greatest proportion of single-parent households as well as higher diabetes prevalence rates (*Exhibit 2.6*), there are more residents living alone in Mississauga's city centre and the southeast region of Mississauga (*Exhibit 2.7*), where diabetes prevalence rates are lower relative to the surrounding neighbourhoods. This paradoxical relationship at the neighbourhood level will need to be explored further to determine what factors drive the potential relationships between these neighbourhood characteristics and the diabetes burden in Peel Region.

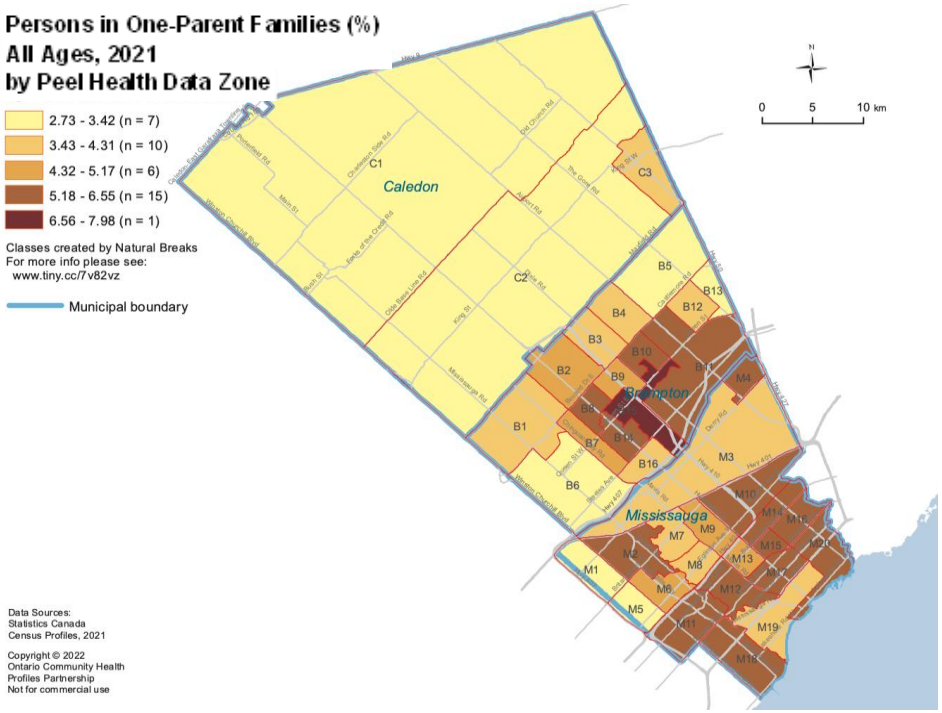



**Exhibit 2.6** Percentage of single-parent households, all ages, in 2021 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

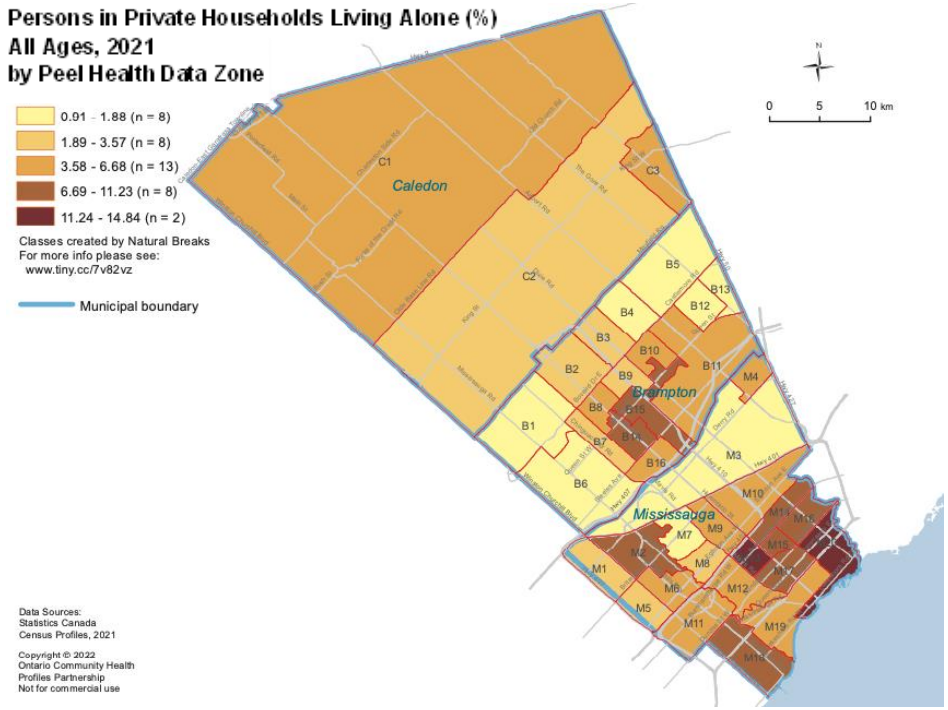



**Exhibit 2.7** Percentage of persons living alone, all ages, in 2021 by Peel Health Data Zone. Source: Ontario Community Health Profiles Partnership.

## UNDERSTANDING THE DETERMINANTS OF DIABETES

The Public Health Agency of Canada's new *National Framework for Diabetes in Canada* calls for more holistic and comprehensive approaches to understanding and, ultimately, preventing and managing diabetes by targeting the upstream factors and improving health and health equity.[24] For example, previous research has shown that socioeconomic indicators and other factors influence health-related behaviours and diabetes risk and management in Peel Region, especially among ethnic minority populations.[25-27] The impacts of these factors have been further exacerbated due to the COVID-19 pandemic, as Peel Region was one of the hardest-hit regions in Canada.[28-29]

To understand factors that affect the risk of diabetes and related chronic diseases and identify potential challenges and opportunities for prevention and improving care, this report and the overarching work of the Network is adopting a comprehensive, multi-sectoral baseline data strategy framework (*Exhibit 2.8*) that includes factors at several levels:

**Level 1- Macro**: This level targets factors that affect the entire population and examines the role of environmental determinants of chronic disease related to how we design and build our neighbourhoods. Interventions targeting the macro level may include municipal and regional policies and urban planning to optimize the built environment and improve access to nutritious foods, physical activity, and housing to ultimately **create healthy environments**.

**Level 2- Meso**: This level focuses on groups that are disproportionally affected by diabetes and address how to promote healthy living and behaviours through socioculturally-specific co-designed interventions. Interventions may involve strengthening and enhancing community action and mobilization by designing and implementing prevention programs across various settings and contexts to raise awareness and promote **healthy living and behaviours**.

**Level 3- Micro:** This level addresses individuals with or at risk of diabetes and chronic disease within the healthcare system and examines how access and quality of chronic disease healthcare can influence potential health outcomes and quality of life. Interventions may focus on patients and families, healthcare providers and administrators to **improve chronic disease care** by making health services more coordinated, effective, accessible, and equitable.

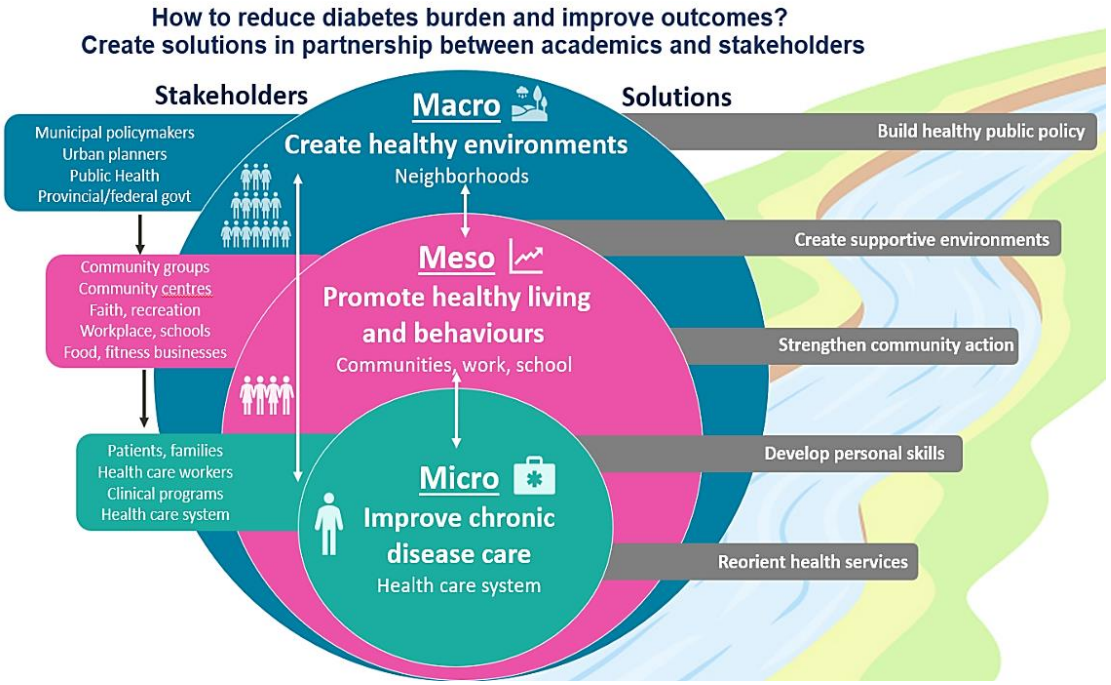



**Exhibit 2.8** Interventions for reducing the burden of diabetes must target micro, meso, and macro-level risk factors and involve multi-sectoral partnerships and collaboration across academic disciplines, policy, and community organizations.

***This report has been divided into three chapters, each addressing key indicators within the three levels of engagement and intervention depicted in Figure 2.8.***

### *Chapter 3: Macro Level*

Neighbourhood environments are the *macro-level* factors which comprise the conditions that enable or prevent the adoption of active lifestyles and healthy behaviours such as physical activity and nutrition (*Exhibit 2.8*). How we design our neighbourhoods and policies significantly influences health behaviours and quality of life across all ages, which can be understood as upstream determinants of health and community wellbeing. By 2051, Peel's population is expected to grow from 1.5 to 2.2 million alongside a massive demographic shift with both an ageing population and the arrival of newcomers to Canada.[30-32] In response to the growing need for housing and infrastructure support, the Region has recently been undergoing rapid development, resulting in neighbourhoods dominated by low-density, sprawling areas and largely car-dependent for transportation. The Region's landscape includes five 400-series highways, including the busiest highway 401, which has undergone further expansion in recent years (*Exhibit 2.9*). These highways serve as major transport routes to the Toronto Pearson International Airport and support car use for travelling from and to the Region from all other surrounding cities. In addition, sprawling, low-population-density residential neighbourhoods, if poorly designed, limit opportunities for physical activity.[33] This type of infrastructure prevents pedestrian foot traffic, exacerbates car dependency and serves as a major source of extremely high air pollution exposure. Other environmental characteristics also enable or limit the adoption of healthy behaviours such as physical activity and healthy diets, including lack of access to transit, safe, adequate, and affordable housing, and healthy food options (also called the food environment). Chapter 3 provides an overview of key built environment and neighbourhood features and their spatial relationship with diabetes prevalence in the Peel Region to prompt future research and policy actions in these areas.

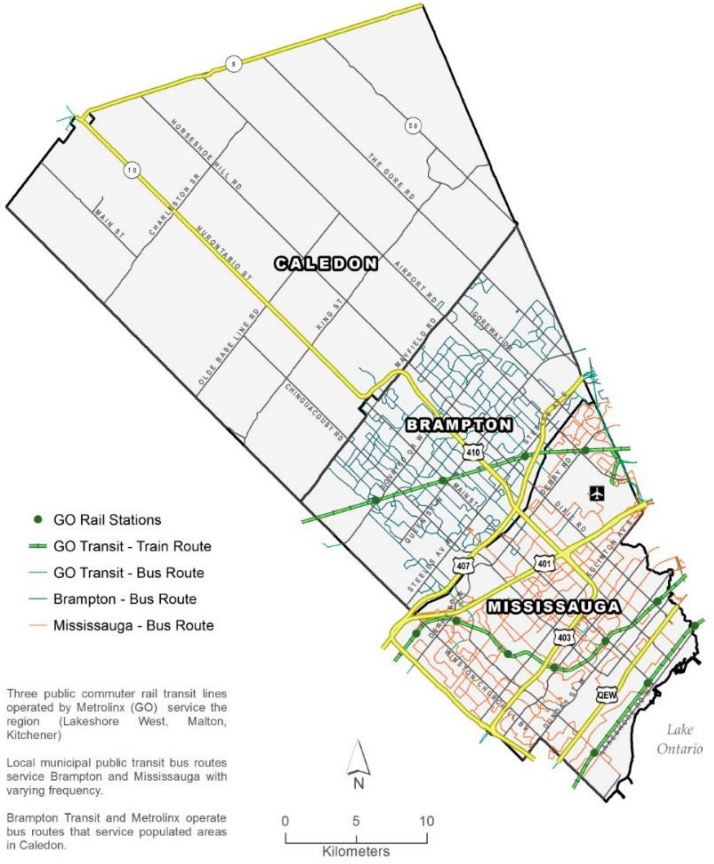



**Exhibit 2.9** Highways, roads, municipal and regional public transit systems, in Peel Region.

### *Chapter 4: Meso Level*

Several individual and community-level determinants of health also influence the risk and burden of diabetes through effects on healthy living, which we term *Meso-level* factors in this report. Specifically, the rising prevalence of diabetes in Peel Region can be attributed to the interaction between sociodemographic factors such as age, socioeconomic status, race/ethnicity and immigrant status, and the unequal distribution of deeply rooted determinants that include, but are not limited to, psychosocial (perceived health and mental health, self-efficacy), community-level (housing, food insecurity, sense of belonging, and material deprivation), and more upstream health mediators such as racism, trauma, and oppression, which together influence health behaviours that contribute to diabetes that increase incidence (new cases) of diabetes, alongside improvements in survival of people with diabetes.[34-35] In Chapter 4, we have mapped these risk factors to the Socio-ecological Model of Health to understand the extent to which they may be associated with the future risk of diabetes development in the Peel Region (*Chapter 4*). This will provide the opportunity to identify and guide the development and implementation of programmes and interventions targeting these factors (*Exhibit 2.8*) to reduce the risk of diabetes incidence in the Peel Region.

### *Chapter 5: Micro Level*

In Peel Region and across Ontario, people with diabetes and related chronic conditions receive health services from various sources, including primary care providers, nurses and dietitians employed at community- and hospital-based diabetes education programs, and specialist physicians, with support from community pharmacists.[36] This report focuses on the care of people with diabetes in the region as the most common and readily identifiable chronic disease. Around 80% of health services for people with diabetes are provided in the primary care setting.[37]

In 2014, the *Peel Diabetes Atlas* reported that family physicians were fairly evenly distributed across Peel Region, with a higher concentration in central Mississauga and longer travel distances for patients in Caledon and northeast Brampton, based on geospatial analysis of the distance between resource locations.[33] Eye specialists were evenly distributed, and endocrinologists were located only near major hospitals.[33] Diabetes education programs were located throughout Mississauga and Brampton, with only one location in Caledon.[33] To our knowledge, the quality of diabetes health services provided in the Peel Region has not yet been assessed and reported.

The health services and quality of care working group is focused on identifying and measuring the key quality of care processes and outcome indicators, which we refer to as *micro-level* indicators in this report (*Exhibit 2.8*). Diabetes-related health services are administered under regional bodies, which have recently been restructured as Ontario Health Teams (OHTs) to improve the integration of health services.[32] Peel Region is served by multiple OHTs, including the Central West, Mississauga, and Hills of Headwaters Collaborative OHTs. The Mississauga OHT (MOHT) serves a population of 859,392 individuals who receive most of their health services in Mississauga. [38] Most individuals in the MOHT reside in East and Northwest Mississauga, while others reside in Southwest Mississauga, Brampton, and other areas of Peel Region and Ontario (*Exhibit 2.10*).[38] In Chapter 5, we focus on health services and the quality of care for people living with diabetes in the MOHT.

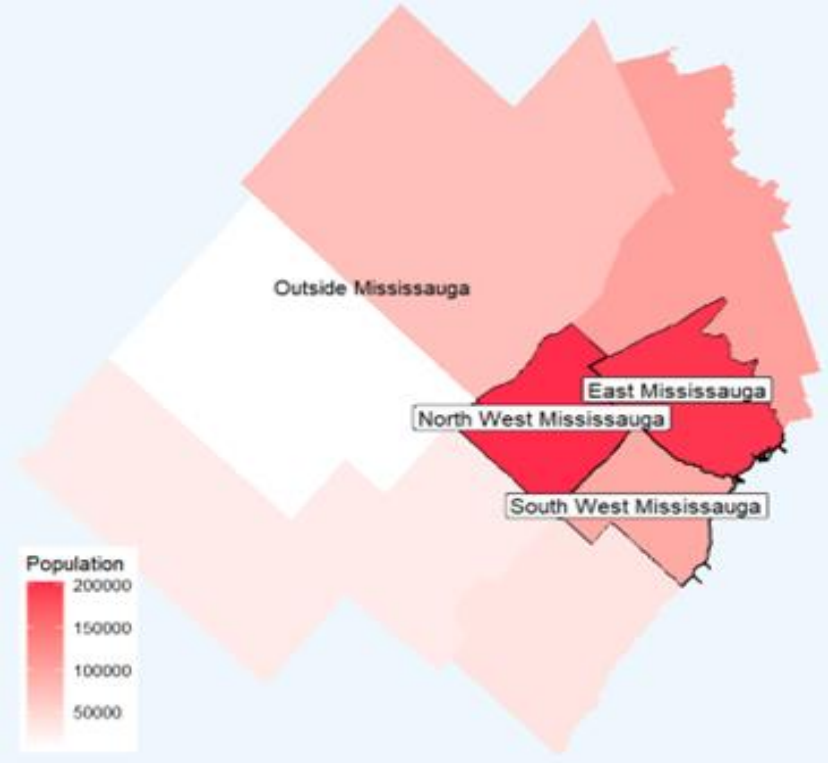



**Exhibit 2.10** Place of residence for individuals in the Mississauga Ontario Health Team.*
*Only neighbouring Mississauga sub-regions are shown; those living outside Mississauga extend beyond this map.
Source: Rosella et al., 2021[31]

## COMMUNITY ENGAGEMENT

Community partners and other key decision-makers provided essential guidance on the objectives of this report and its approach to understanding the risk and burden of diabetes in the Peel Region. The NHP engaged community members, researchers, public health officials, policymakers, and physicians in Peel Region at an online event held on June 6, 2022, to seek input on the potential indicators of the burden of diabetes and chronic disease in Peel related to healthcare, risk factors and living conditions. We also sought insight into the needs and opportunities for our baseline data evaluation plan in Peel to help shape this report and future research. We identified several opportunities for partnerships and future collaborations on the identified priorities and areas of action.

The overarching themes identified from this consultation highlighted the importance of recognizing health equity and social justice issues as well as the integration of services and intersectoral collaborations to address the risk and burden of diabetes and chronic disease in the Region. Webinar participants also provided input on the current gaps and suggested approaches to addressing them, including:

- Lack of access to services and primary care.
- Lack of system funding for health services.
- The impact of the COVID-19 pandemic.
- Need for intersectoral work and collaborations.
- Need to examine the impact of other environmental exposures beyond the built environment (such as climate) on diabetes-related health outcomes and wellbeing.

The gaps identified by our community partners and network members, as well as the proposed approaches to addressing them, are an integral component of NHP's efforts to collectively work towards addressing diabetes and chronic disease burden in the Peel Region. The information garnered by community consultation also provided the necessary context and direction informing the aims and preliminary reporting, in addition to informing the future efforts of the Baseline Data Strategy Team.

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# CHAPTER 3:
# BUILT ENVIRONMENT AND DIABETES


**AUTHORS**

Sarah M. Mah

David Guillette

Michael J. Widener

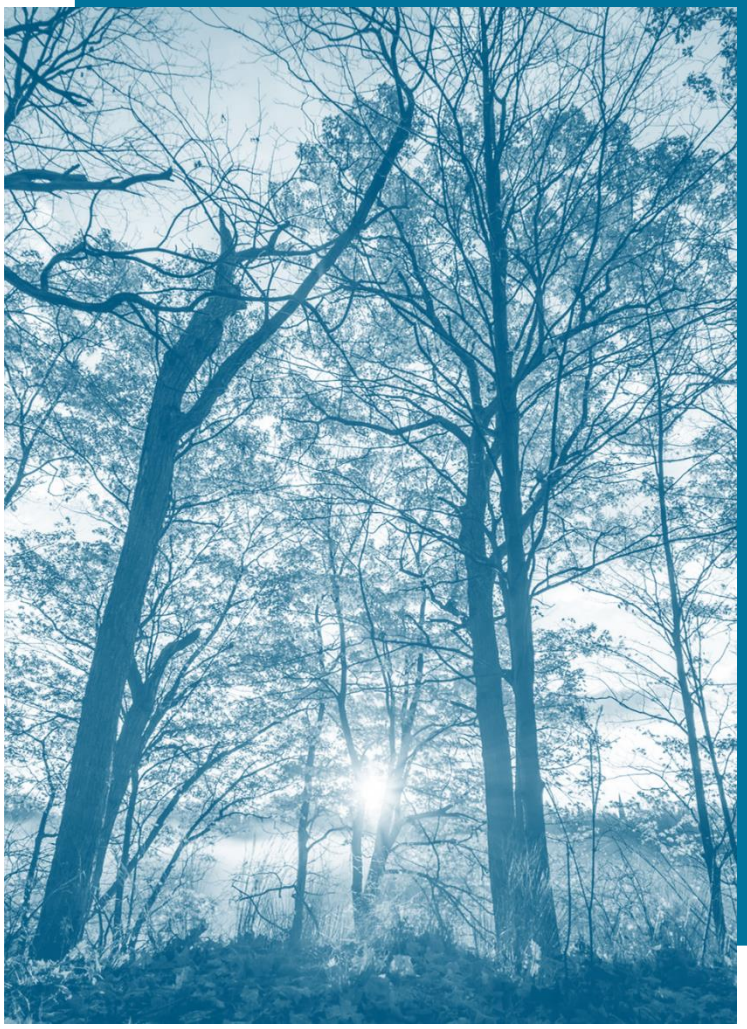
Jeffrey R. Brook

Lorraine L. Lipscombe

Gillian L. Booth

## KEY FINDINGS

- **Walkability** is generally low in most communities in Peel; however, there is relatively good access to public parks and greenspace throughout the region. In addition, access to frequent transit is present only in certain regions (i.e. along the lakeshore and in central areas of Mississauga and Brampton) and completely absent in Caledon – creating a further barrier to active transportation as an alternative to car use.
- Other neighbourhood characteristics that influence the risk of diabetes, such as **fast-food access and core housing need**, are highly variable across the region, while poor air quality is highly concentrated in communities surrounding the airport and major transit routes.
- High diabetes prevalence neighbourhoods have one or more characteristics that make it challenging to adopt a healthy lifestyle. Policies to create healthier environments need to be multifaceted to address the diverse needs of each community.
- Some neighbourhoods have favourable characteristics that may compensate for less favourable aspects - for instance, the presence of a **transit network** may allow one to circumvent living in a less walkable neighbourhood.
- The spatial overlap between key environmental indicators and diabetes rates underscores the importance of assessing a range of social and environmental characteristics and their collective impacts on diabetes.



## INTRODUCTION

In this chapter, we turn our attention toward the macro-level sector described in Chapter 2: understanding how neighbourhood features, including their infrastructure and amenities, can be targeted to prevent type 2 diabetes. By definition, the 'built' environment encompasses structures within communities that were made or modified by humans (e.g. buildings, roads, parks and transportation systems), and thus, it represents the physical environment in which we live, work, and play. The built environment impacts diabetes risk indirectly by creating opportunities for (or barriers to) healthy, active living. This includes whether neighbourhoods are conducive to walking and cycling; the presence of parks, natural environments, and recreational spaces; and access to frequent transit, healthy food, and safe, affordable housing. However, it may also affect diabetes risk directly through exposures such as air pollution or social stresses.

Research linking neighbourhood environments to health has grown substantially in recent decades.[1] Populations that use 'active' forms of transportation more often (i.e. walking, cycling, or public transit use) are more physically active, spend less time engaged in sedentary behaviour, and have better health outcomes than those who travel primarily by car .[2-4] Neighbourhoods that make it easier for residents to engage in active transportation are associated with higher rates of physical activity and lower rates of obesity, hypertension, type 2 diabetes incidence, and mortality, compared to car-oriented areas.[5-12] Highly walkable communities are more densely populated, compact, and oriented toward pedestrians than low walkability areas and have an abundance of service and shopping destinations within walking distance of people's homes, making it possible for people to carry out daily activities on foot or by cycling .[13] In contrast, sprawling, low-density neighbourhoods typically have few walkable destinations and infrequent transit, resulting in a greater dependency on car travel. Many other factors, such as housing prices and car ownership, can play a role by limiting one's options for where to live and the ability to live in a suitable, high-quality dwelling, underscoring the importance of how these relationships vary by socioeconomic status.

Built environment characteristics may have additive or synergistic effects. In an international study, residents living in communities that scored highly on multiple features (walkability, greenspace, and transit access) were far more likely to meet the target level of physical activity established by national guidelines than those living in areas where all three features were lacking.[14] Neighbourhood greenspace has been linked to a range of health benefits, including increased physical activity, social connectedness, mood and well-being, and reduced levels of obesity-related diseases.[1,15] Greenspace offers a central location for residents to engage in social and physical activities[16,17] and has the added benefit of reducing air pollution levels and urban heat and mitigating their downstream health impacts.[18,19] High concentrations of traffic-air pollution from idling cars may reduce the benefits of living in a highly walkable neighbourhood.[9] The retail food environment is another factor that can influence diabetes risk by altering one's ability to make healthy food choices.[20] Although research in this area is still growing, a Canadian systematic review showed an association between the food environment and body mass index,[20] while

a recent international study showed an association between access to unhealthy food outlets and both prevalence and incidence of type 2 diabetes.[21] While the relationship is complex, the proportion of nearby restaurants that serve fast food appears to be most consistently related to the risk of obesity and diabetes, particularly in neighbourhoods that have a high restaurant volume.[22-23]

To address the growing burden of type 2 diabetes, the Region of Peel has acknowledged the role of neighbourhoods in enabling healthy lifestyles in their ongoing initiatives . This includes innovative Region of Peel Official Plan (OP) Health and the Built Environment policies. These policies support the creation of healthy built environments by requiring a Health Assessment on all applicable development applications. The assessment involves reviewing and providing comments on the design details of the applications from a public health perspective to foster the development of healthy, complete, and compact communities that support active transportation.

As part of this program, a key innovation included the implementation of the Healthy Development Framework,[24] a collection of tools and indicators tailored to planners and developers in the Region of Peel for assessing the health-promoting potential of neighbourhoods and new policies to better meet the needs of a diverse population. Further, these Official Plan policies also require Peel's local municipalities to integrate the core elements of the Healthy Development Framework (HDF) into their land use development policies, including the requirement for a Health Assessment. Consequently, these Region of Peel policies support the creation of more walkable, healthier built environments throughout Peel to meet the needs of a diverse population.

The objective of this chapter is to build upon previous initiatives from the Region of Peel and its partners, such as the Healthy Development Mapping and Monitoring Project[25] and the Peel Diabetes Atlas[26], to characterize the built environment characteristics of the region and their spatial relationships to diabetes rates in Peel using recent data and novel measures.

## METHODOLOGICAL APPROACH

This report investigates the spatial distribution of key built environmental characteristics and their association with diabetes prevalence in Peel. For this chapter, we chose six environmental aspects as our focus, based on previous frameworks for understanding the relationship between the built environment and health[27,28] , expert knowledge from members of the Novo Nordisk Network for Health Population Built Environment Baseline Data Strategy Working Group, as well as preliminary public consultations conducted by the Network (*Chapter 2)*.

Key indicators that reflect these environmental aspects are summarized in Table 2.1. Where possible, indicators were selected based on their broader availability (to enable comparisons to other regions), validity (their ability to capture specific features), and relevancy (completeness and degree to which data sources are current). We took a spatial descriptive approach[26] by mapping these indicators alongside diabetes prevalence rates at three different geographies (from smallest to largest): the dissemination area (DA), the census tract (CT), and the Peel Health Data Zone (PHDZ). A full description of the measures and methods used for this chapter is available in the Technical Appendix.

**Table 2.1 Summary of Indicators**

| Environmental characteristic | Indicator | Data | Source | Year | Original geography |
|---|---|---|---|---|---|
| Neighbourhood Design | Clustered Active Living Environment class;<br>Canadian Active Living Environments Database (Can-ALE) | Canadian Census<br>OpenStreetMap | Canadian Urban Environmental Health Research Consortium<br>(CANUE) | 2016 | DA |
| Natural environments/ Parks | Proximity to Parks and Green Space | Municipal parks/conservation area data | Region of Peel | 2018 | DA |
| Transportation | Proximity to Frequent Transit | General Transit Feed Specification (GTFS) Data | Region of Peel | 2016 | DA |
| Food Environment | Fast-food restaurant mix ($R_{mix}$);<br>Canadian Food Environments Database (Can-FED) | Statistics Canada Business Register | Statistics Canada | 2018 | DA |
| Housing | Core Housing Need | Canadian Census<br>Canadian Income Survey<br>Canadian Housing Survey | Canadian Mortgage and Housing Corporation (CMHC) | 2021 | DA |
| Air Quality | Nitrogen dioxide (NO2) | National NO2 (ppb) land use regression model | CANUE | 2016 | Postal code |

## FINDINGS

***Neighbourhood design*** plays an essential role in promoting an active lifestyle. Here, neighbourhood design is described using the Active Living Environment (ALE) class measure, which reflects whether or not neighbourhoods are conducive to active living (e.g. walking, cycling or public transit use). ALE is based on the following factors: residential density, street connectivity, and the number of walkable destinations[29] in each neighbourhood. This measure is similar in its construction to other walkability indices[5,13]. Neighbourhoods are assigned into five categories ranging from very unconducive (ALE class 1) to very conducive to active living (ALE class 5).

As depicted in *Exhibit 3.1,* most areas of Peel are classified as having low levels of conduciveness to active living. M ississauga's City Centre and its surrounding areas are the most active living-friendly areas in Peel, while most other urban areas within the region, including downtown Brampton, are far less favourable for active-living (*Exhibit 3.1, Appendix 3.1*). In addition, most areas within Caledon are categorized as being in the least favourable active living class regardless of which geographic unit was used (*Exhibit 3.1*), in keeping with the largely rural nature of this community. When the spatial relationship between ALE and diabetes is visualized at the level of PHDZs, it can be noted that several areas in Brampton have both unfavourable active living scores and high rates of diabetes. In contrast, central and eastern areas of Mississauga that are favourable for active living have low rates of diabetes *(Exhibit 3.2)*.

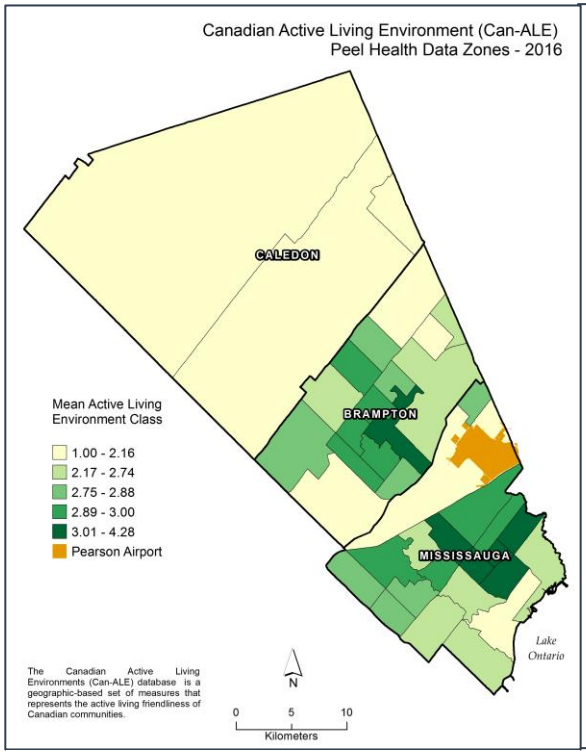



**Exhibit 3.1** Active living environments [2016] as the mean Can-ALE class (class 1 to 5) grouped by quintile, by Peel Health Data Zone [2021].

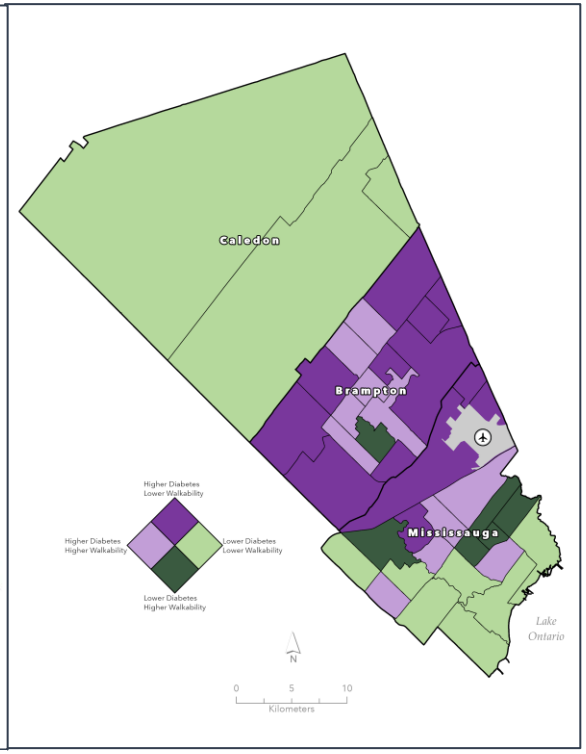



**Exhibit 3.2** Spatial relationship between active living environments [2016] and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The top two quintiles were considered areas of *higher walkability,* and the bottom three quintiles areas of *lower walkability.*

***Proximity to parks and green space*** describes the percentage of residents that live within a 5-minute walk (400-meters) to a park or conservation area that contains an active recreation feature (e.g. playground, baseball diamond, or tennis or basketball court) or pedestrian infrastructure such as walking paths or trails[25]. According to this proximity measure, over three-quarters of residents live within walking distance of a park or conservation area in Peel overall, and much of Mississauga and Brampton have areas with very good access to these amenities. Most of Caledon and the western areas of Brampton are measured as having lower access to public parks and green space (*Exhibit 3.3)*, although it is important to note that this does not include green areas that could be used recreationally but are not considered municipal public areas. The southern regions of Mississauga contain more parks and green space than surrounding areas. This was more pronounced when assessed at the DA- and CT-level than at the PDHZ-level (*Appendix 3.2)*. As noted for ALE, the northeast and southwest regions of Brampton have both lower access to parks and green space and higher rates of diabetes, while the western areas of Mississauga that have higher access to parks and green space have lower rates of diabetes *(Exhibit 3.4)*.

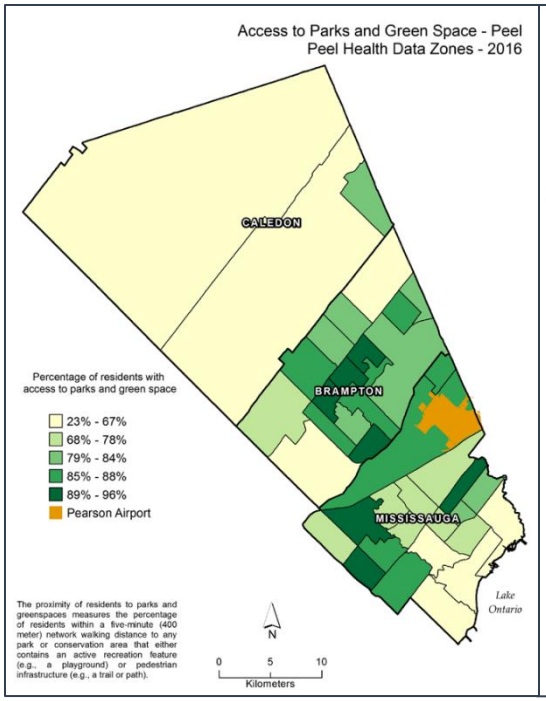



**Exhibit 3.5** Access to parks and green space [2016] as the percentage of residents grouped by quintile, by Peel Health Data Zone [2021].


**Exhibit 3.4** Spatial relationship between access to parks and green space [2016] as the percentage of residents grouped by quintile and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The top two quintiles were considered areas of *higher access to green space,* and the bottom three quintiles areas of *lower access.*

***Proximity to frequent transit*** describes the percentage of the population that lives within a five-minute walking distance (400 meters) of a municipal transit stop and/or a 10-minute walking distance (800 meters) of a GO bus or rail stop with frequent service (see Technical Appendix for definition). Public transit systems are recognized as a key aspect of supporting active transportation and achieving physical activity guidelines.[30] Based on this measure, most Peel residents (59%) have no or low levels of access to frequent transit.[25] The highest percentage of residents with frequent transit access are found in areas of Central Mississauga, the Lakeshore, and central Brampton (*Exhibit 3.5*). No areas of Caledon were identified as having frequent transit access, owing to the absence of a transit network for the town. Areas in southeast and eastern Brampton had both a high prevalence of diabetes and low access to frequent transit (*Exhibit 3.6*).

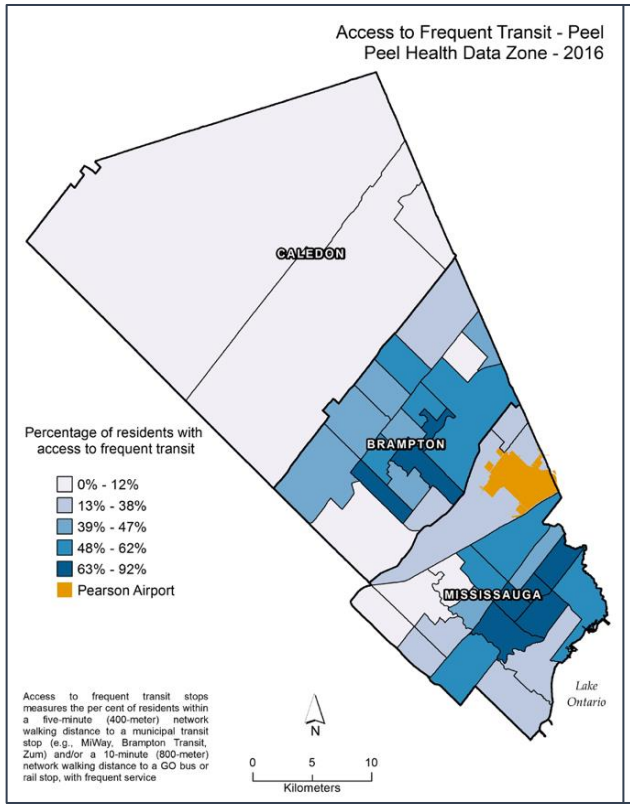



**Exhibit 3.6** Access to frequent transit [2016] as the percentage of residents grouped by quintile, by Peel Health Data Zone [2021].


**Exhibit 3.7** Spatial relationship between access to frequent transit [2016] as the percentage of residents grouped by quintile and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The top two quintiles were considered areas of *higher access to frequent transit,* and the bottom three quintiles areas of *lower access.*

***The food environment*** generally refers how locally accessible different types of food sources, including restaurants and food stores, are in a given area. The Canadian Food Environment Database (Can-FED)[31,32] contains a measure of the proportion of all restaurants that serve fast-food. The measure clusters neighbourhoods into four categories, ranging from those with the lowest density of fast-food places (Can-FED class 1) to those with the highest (Can-FED class 4). Neighbourhoods that have no fast-food outlets or no food outlets of any kind are assigned a class of 0.

In Peel, about one-third of neighbourhoods are classified as having a very high proportion of fast-food outlets, while only 4% are classified as having a very low proportion of fast-food outlets. Many neighbourhoods (27%) do not have fast-food outlets or any food outlets at all. Looking at larger geographies (at PDHZs), regions with higher proportions of fast-food outlets overlap with areas with high diabetes prevalence, while those with low proportions of fast-food outlets have lower diabetes prevalence. However, mapping food environments in smaller areas (such as the CT or DA) within these larger regions reveals a more heterogeneous pattern to the food environment than mapping at larger regions seems to suggest (Appendix 3.4). As an example, many neighbourhoods in Brampton do not contain any fast-food or food establishments. However, when we evaluate these same areas at the larger PHDZ regional level, some are characterized as having a very high proportion of fast-food outlets – a discrepancy that likely arises from a few specific zones within the PHDZs that have high concentrations of fast-food establishments.

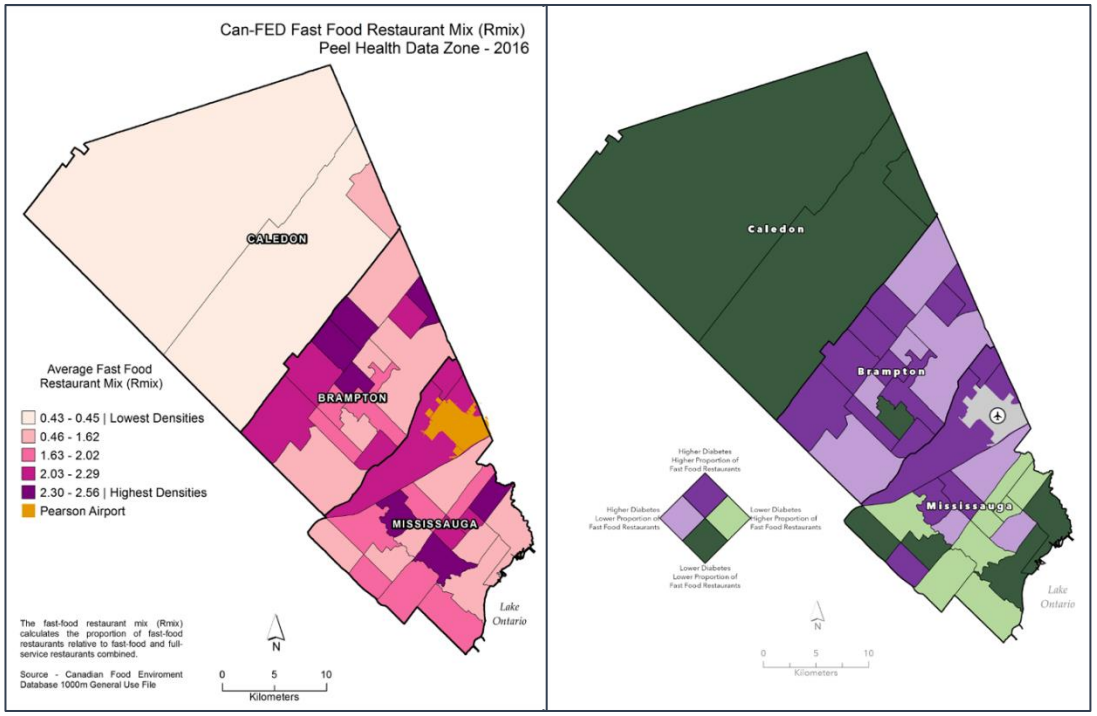



**Exhibit 3.9** Food environments [2016] as the mean fast food restaurant mix $R_{mix}$ (scores ranging from class 0 to 4) grouped by quintile, by Peel Health Data Zone [2021].

**Exhibit 3.8** Spatial relationship between food environments [2016] and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The bottom two quintiles were considered areas with *lower proportions of fast food,* and the top three quintiles areas of *higher proportions.*

***Core Housing Need*** is a key indicator for housing that is inversely related to socioeconomic status and also captures aspects of one's sustained, material living conditions. This measure is defined as the proportion of households living in an unsuitable, inadequate, or unaffordable dwelling and not able to afford alternative housing in their community. Prior reports suggest that rates of core housing need have fallen across Canada by ~20% in recent years.[33] Similar findings were noted for Peel and Ontario as a whole; however, the rate of core housing need remains consistently higher in Peel than Ontario (16.9% versus 15.3% in 2016 and 13.7% versus 12.1% in 2021, respectively). As shown in *Exhibit 3.9* and *Appendix 3.5,* rates of high core housing need are dispersed across Mississauga and Brampton based on DA-level maps, which is less apparent in maps at the levels of census tract and Peel Health Data Zones (PHDZ). No DAs in Caledon fall into the highest core housing need category. The bivariate map in *Exhibit 3.10*, which displays 2 variables, reveals overlap between high core housing need and high diabetes prevalence in four Peel Health Data Zones (PHDZs in Mississauga and several PHDZs in Brampton. Overall, Caledon PHDZs exhibit low rates of core housing need and low diabetes prevalence.

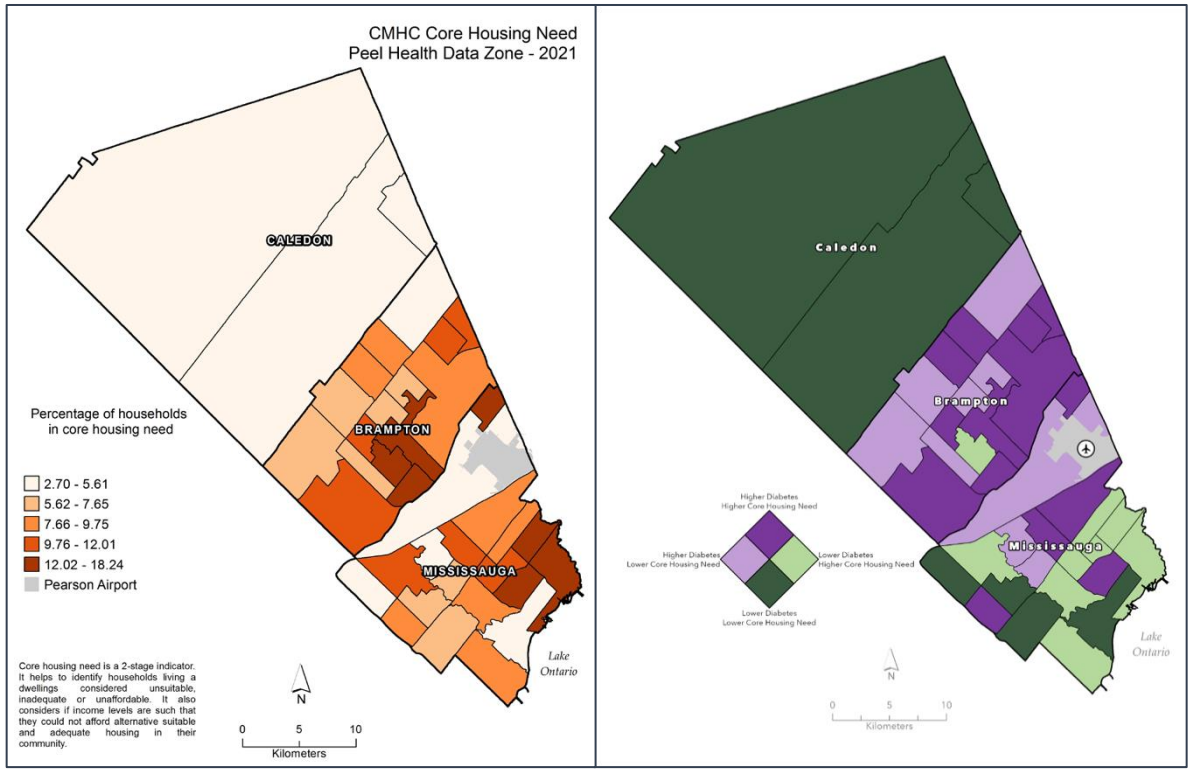



**Exhibit 3.10** Core housing need [2021] as the mean percentage of households in core housing need grouped by quintile, by Peel Health Data Zone [2021].

**Exhibit 3.11** Spatial relationship between core housing need [2021] and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The bottom two quintiles were considered areas of *lower core housing need,* and the top three quintiles areas of *higher need.*

***Poor air quality*** has been identified as a major public health concern, owing to its ubiquity and growing prevalence as an urban environmental exposure. Air pollution has been associated with higher odds of developing diabetes and related outcomes,[34] through what is thought to be direct effects on insulin resistance.[35]

Nitrogen dioxide ($NO_2$) is one of the most common outdoor air pollutants, a major source of which is motor vehicle emissions. Although somewhat paradoxical, some highly walkable areas can have increased concentrations of $NO_2$ due to traffic congestion and idling cars, which can offset the benefits of living in a highly walkable neighbourhood.[36] In Peel Region, areas with the highest measured concentrations of $NO_2$ are in the eastern regions of Brampton and Mississauga, which overlap with the airport and major highways (*Exhibit 3.11, Appendix 3.6*). Such regions appear to have intermediate diabetes prevalence but do not otherwise correspond with areas of high diabetes prevalence, as seen in the northern regions of Brampton (*Exhibit 3.12*).

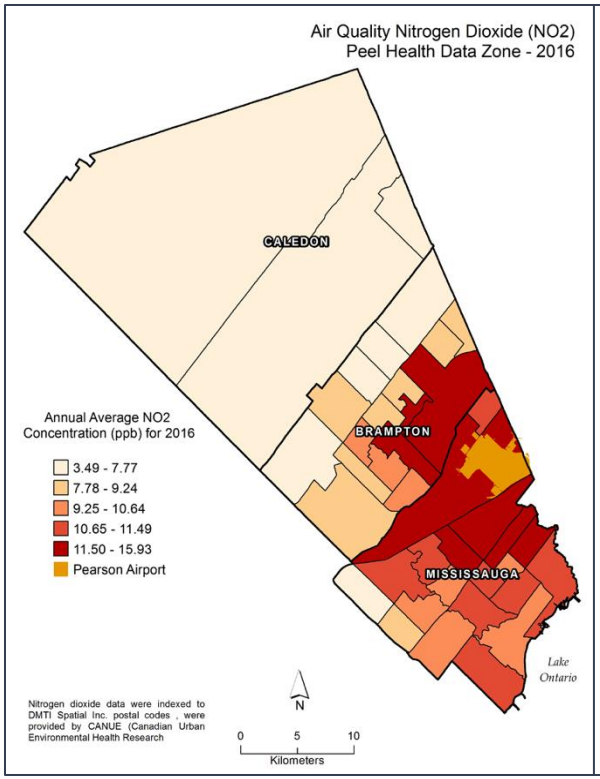



**Exhibit 3.12** Air quality [2016] as the mean annual average concentration (parts per billion, ppb) of nitrogen dioxide ($NO_2$) grouped by quintile, by Peel Health Data Zone [2021].

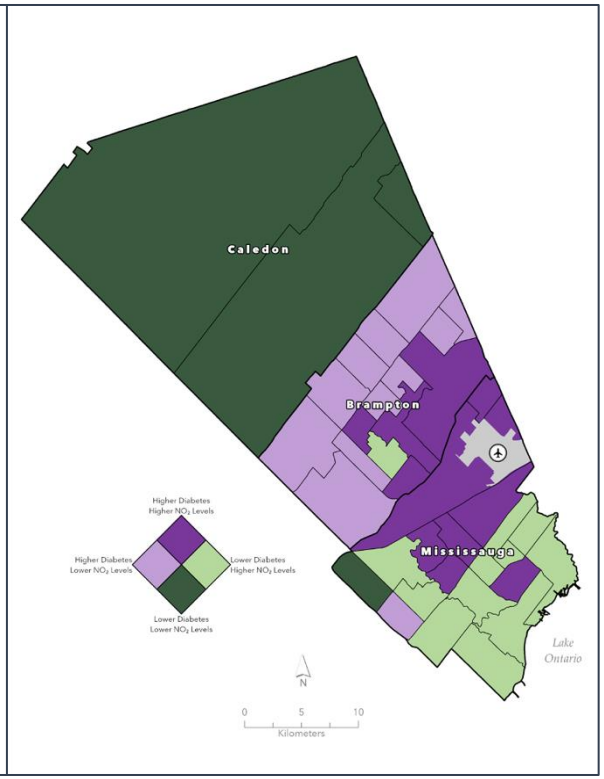



**Exhibit 3.13** Spatial relationship between air quality [2016] and age-standardized prevalence rate ratios of diabetes [2020], by Peel Health Data Zone [2021]. The bottom two quintiles were considered areas of *higher air quality* (lower $NO_2$ levels), and the top three quintiles areas of *lower air quality* (higher $NO_2$ levels).

## INTERPRETATION

***Summary of Findings:***

Our findings demonstrate considerable variation in neighbourhood characteristics across Peel. Overall, the Region of Peel has an abundance of unfavourable active living environments. In contrast, green space is broadly accessible in most communities but appeared more heavily concentrated toward the western areas of Mississauga and central Brampton. Access to frequent transit is present throughout much of Mississauga and Brampton, but many neighbourhoods lack frequent transit altogether, including all areas in Caledon. Access to fast-food outlets is quite variable throughout Mississauga and in central Brampton when assessed at the level of dissemination areas, as is the core housing need for all three municipalities. This highlights how heterogeneous neighbourhoods in the region are with respect to some aspects of the built environment. For example, many residents in Peel live near retail areas that have a high concentration of fast food outlets, with few non-fast food alternatives, while others do not. Poor air quality affects neighbourhoods close to the airport and major transit routes in Mississauga and Brampton.

Numerous adverse built environment indicators appear to correlate with high diabetes prevalence across Peel, particularly in areas of Brampton. While causal relationships between these indicators and risk of diabetes cannot be established, these findings underscore the need to prioritize the living conditions of areas that are most affected by diabetes. Disentangling the mechanisms that lead to these outcomes is also increasingly important. For example, there is an abundance of low-density neighbourhoods in regions with few walkable destinations, and while these areas may lead to fewer opportunities for walking, cycling and other forms of active transit, the presence of a transit network may allow one to circumvent low walkability.

***Strengths and Limitations***

These findings provide a glimpse into the built environment features of Peel Region and their spatial relationships with diabetes prevalence. Our report focuses on six factors covering six different aspects of the built environment that are strongly linked to diabetes-related health behaviours.[27,28] We used comprehensive, validated data sources and summary metrics. However, our findings have limitations that warrant consideration. First, Peel Health Data Zones (PHDZs) were the only units available for the spatial assessment of environmental characteristics and diabetes prevalence, and they are relatively large geographic units. PDHZs have a mean population size of 37,000 and range from approximately 23,000 to 103,000. Caledon is composed of only three PHDZs. Such large areas mask important variations across smaller areas for both environmental features (as apparent in *Appendices 3.1-3.6*) and diabetes prevalence (*Exhibit 2.1*).

Second, the results presented here are descriptive in nature, and caution should be taken when interpreting these findings. Although the literature that connects the built environment to health is extensive, we did not test whether residential areas that have unfavourable features are a direct risk factor for the development of diabetes. There are several known confounders in the relationship between the built environment and diabetes other than age that we did not explore or account for in this analysis, such as car ownership, socioeconomic status, the race/ethnic of residents, and other socio-cultural characteristics. It is possible that these factors contributed to the associations we observed.

Third, we chose six key indicators to study in this report. There are other potentially

important measures of the built environment that can influence health and health behaviours. For example, access to frequent transit does not capture travel behaviours nor travel purpose (i.e. transit for commuting to work or school versus transit to other locations). In addition, each measure we used has its strengths and limitations. As an example, we measured proximity to parks and green space based on walking distance to municipal parks that have recreational or pedestrian infrastructure. Much of Caledon appeared inaccessible to parks and green space with these features despite appearing relatively "green" based on other measures, such as the normalized difference vegetation index (NDVI). Given the abundance of green space in rural settings like Caledon, these populations may be less reliant on municipal parks for recreational physical activity. Lastly, our report did not assess for potential interplay between built environment indicators (e.g., walkability and access to fast food or traffic-related air pollution) or between the built environment and socioeconomic variables (e.g., access to green space and income). Such an analysis was beyond the reach and scope of this descriptive report.

### *Implications and Future Directions*

Examining the spatial overlap between key environmental indicators and diabetes rates is a first step toward identifying the most important environmental characteristics to inform and tailor neighbourhood-level interventions to reduce the burden of diabetes in Peel. We found that neighbourhoods with high diabetes prevalence have one or more of the six environmental characteristics that make it challenging to adopt healthy lifestyles. Our findings reinforce the need for policies and interventions to be multifaceted in their approach in order to address the diverse needs of each community in Peel.[26]

This report also offers insight into the potential for favourable neighbourhood characteristics to compensate for less favourable aspects. For instance, the presence of a transit network may allow one to engage in active transportation, thereby circumventing the level of car dependency that is common in less walkable neighbourhoods. There remains a need for studies that examine the impact of a broader range of social and environmental characteristics on diabetes risk beyond those explored in this brief study, as well as a need for data available at smaller geographic scales.

Diabetes is a complex disease that is profoundly affected by our behaviours. Understanding the needs of local residents and their perceptions of their neighbourhood environment is essential for identifying interventions that will meaningfully promote physical activity and healthy eating. A full picture of how neighbourhood environments shape our behaviours and, in turn, our diabetes risk will be integral to the success of diabetes prevention strategies at the level of populations, communities and individuals.[26]

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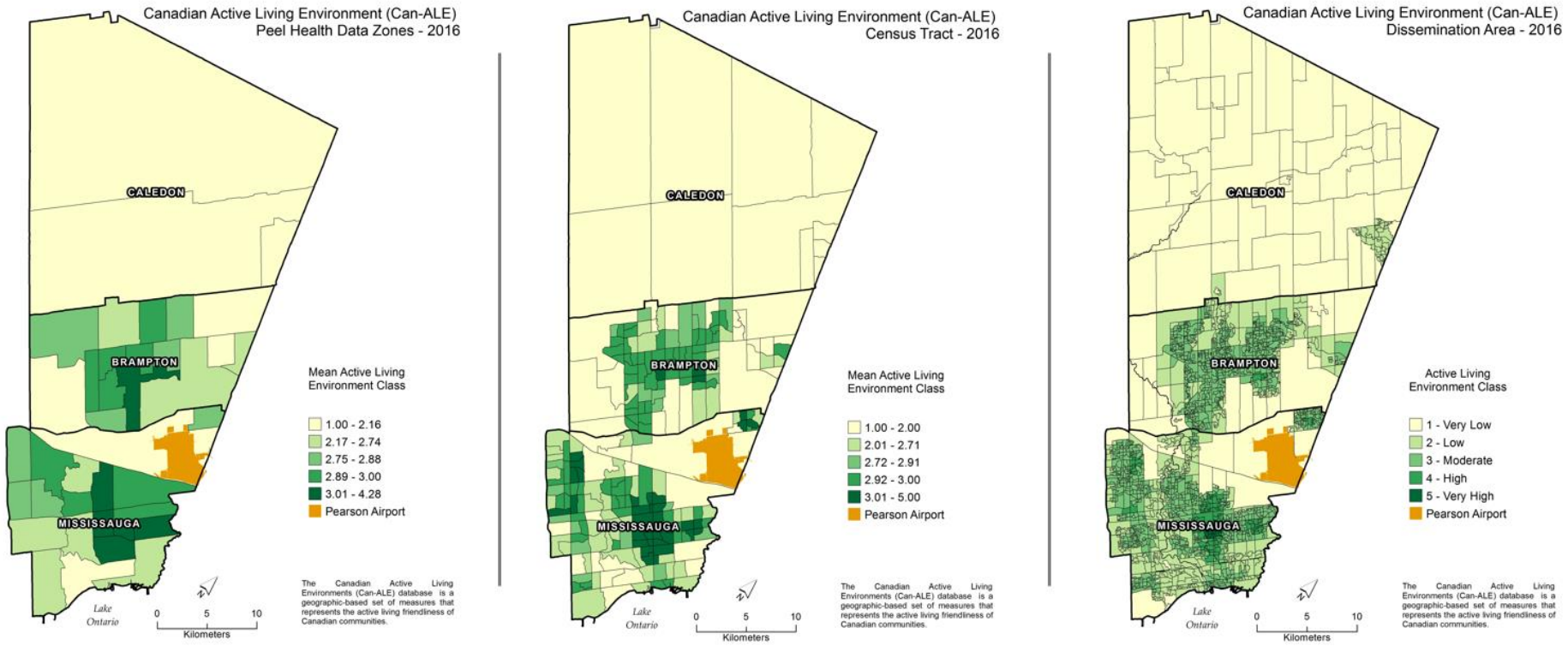
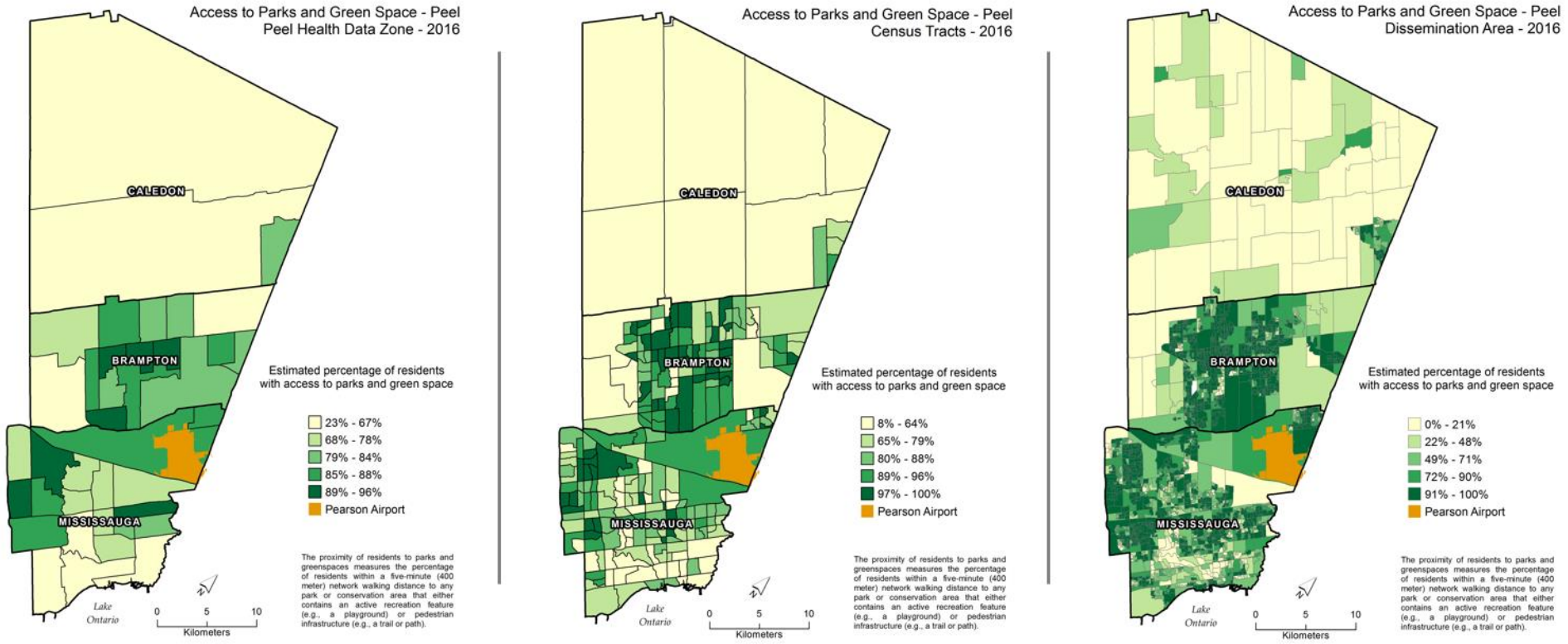
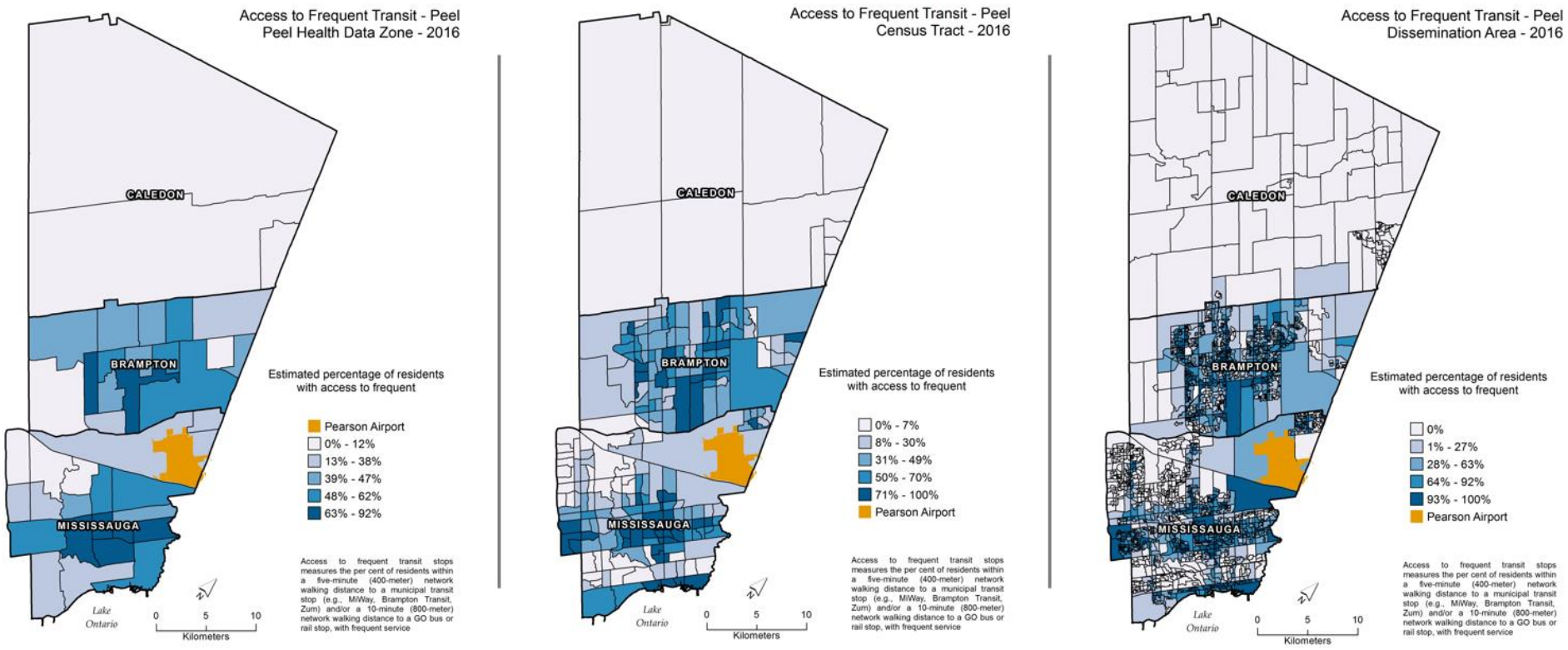
## APPENDIX



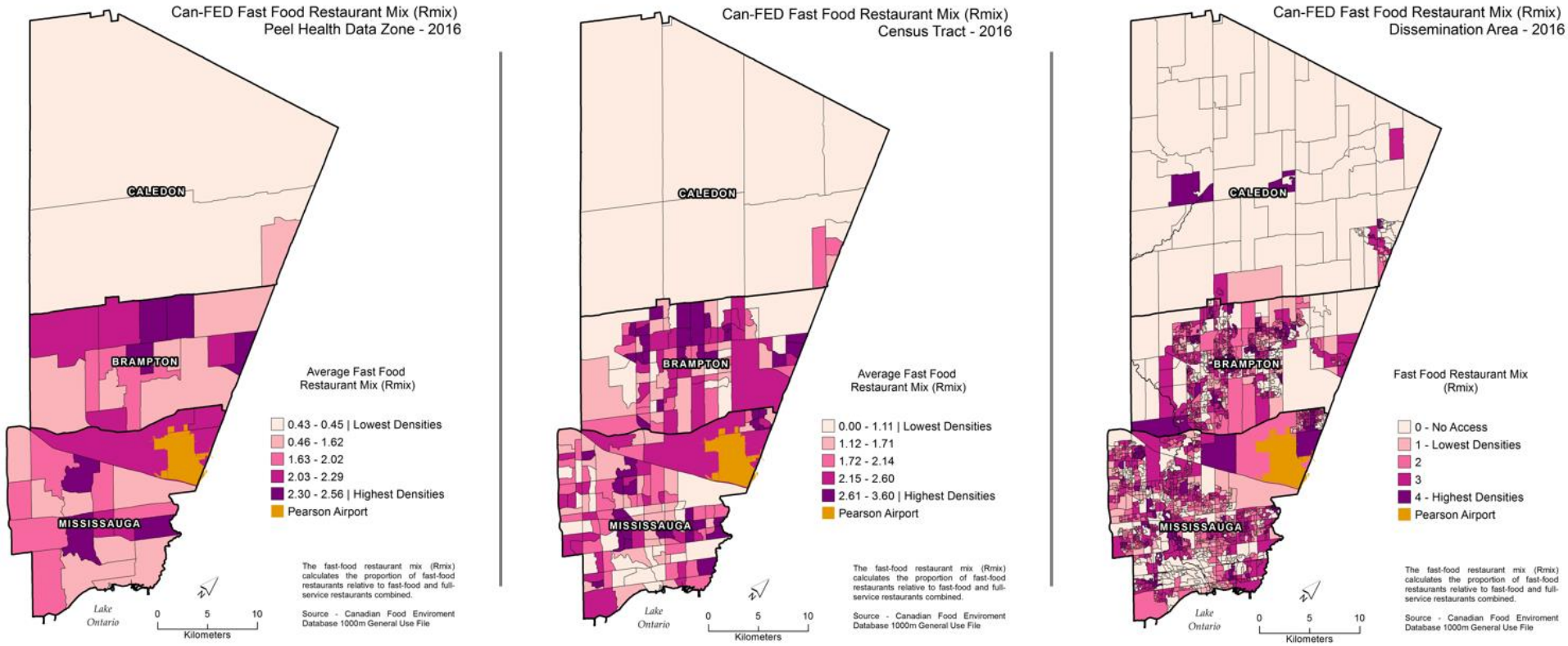

**Appendix 3.1** Active living environments [2016] as the mean Can-ALE class (class 1 to 5) grouped by quintile for Peel Health Data Zones [2021] and census tracts [2021], and by Can-ALE class for dissemination areas [2021].



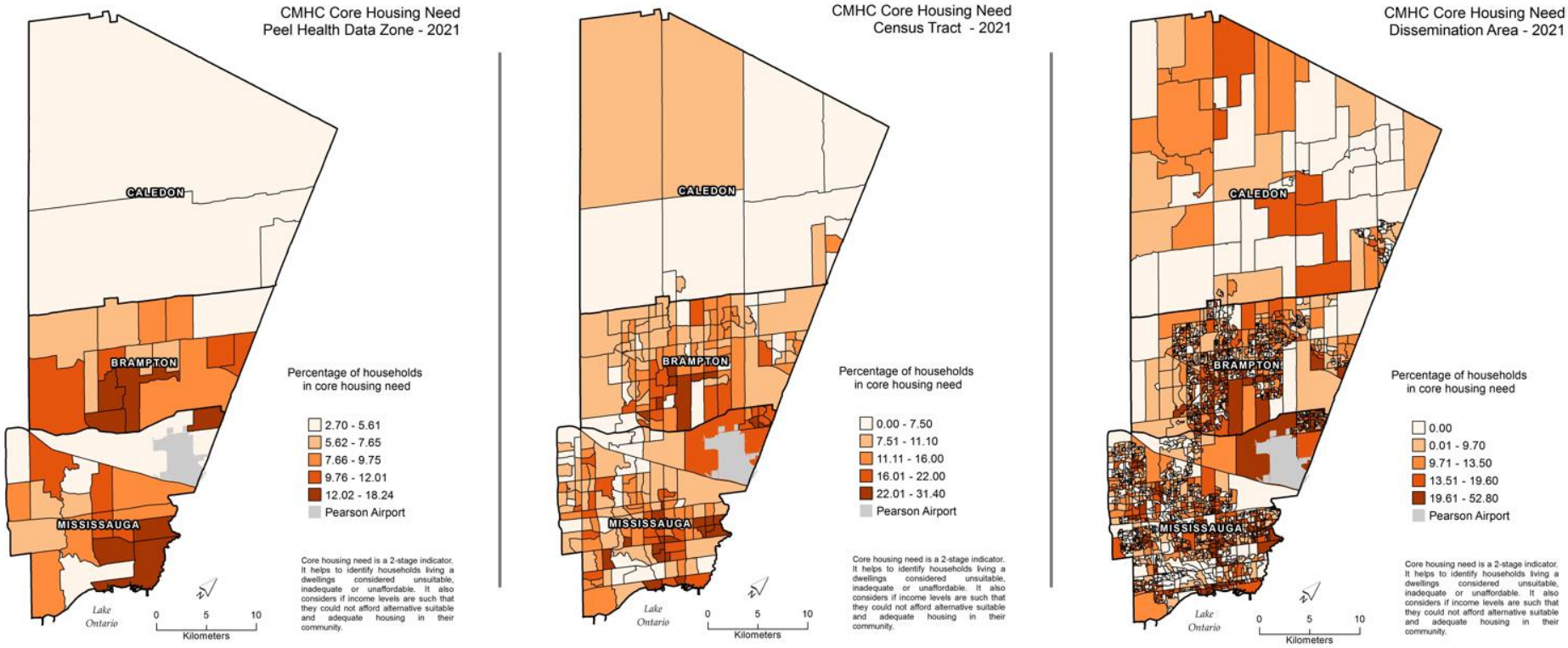

**Appendix 3.2** Access to parks and green space [2016] as the percentage of residents grouped by quintile, by Peel Health Data Zone [2021], census tracts [2021], and dissemination areas [2021].



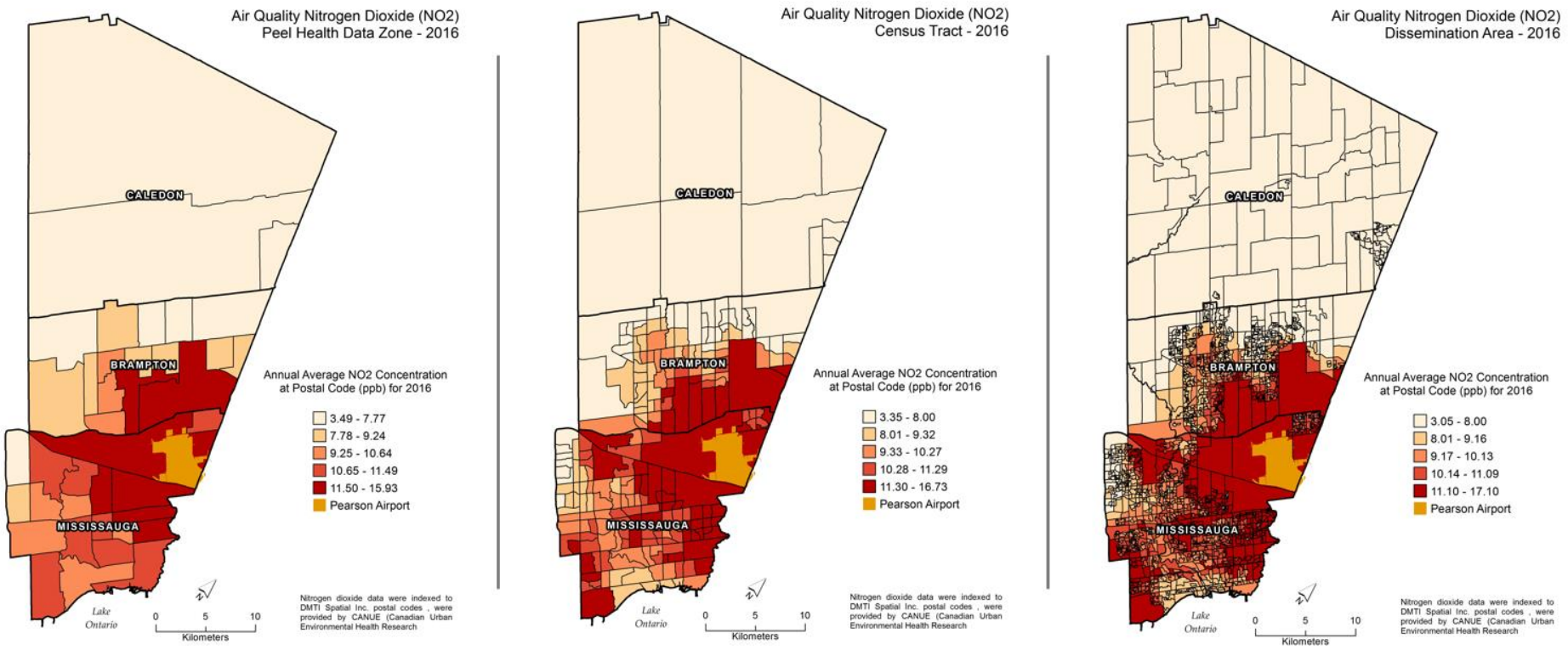

**Appendix 3.3** Access to frequent transit [2016] as the percentage of residents grouped by quintile, by Peel Health Data Zone [2021], census tracts [2021], and dissemination areas [2021].




**Appendix 3.4** Food environments [2016] as the mean fast food restaurant mix $R_{mix}$ (scores ranging from class 0 to 4) grouped by quintile for Peel Health Data Zone [2021] and census tracts [2021], and by $R_{mix}$ for dissemination areas [2021].




**Appendix 3.5** Core housing need [2021] as the mean percentage of households in core housing need grouped by quintile for Peel Health Data Zone [2021], census tracts [2021] and dissemination areas [2021].




**Appendix 3.6** Air quality [2016] as the mean annual average concentration (parts per billion, ppb) of nitrogen dioxide ($NO_2$) grouped by quintile for Peel Health Data Zone [2021], census tracts [2021] and dissemination areas [2021].

# CHAPTER 4: DEMOGRAPHIC, BEHAVIOURAL, AND SOCIAL DETERMINANTS AND FUTURE RISK OF TYPE 2 DIABETES


## AUTHORS

Ghazal S. Fazli

Lorraine L. Lipscombe

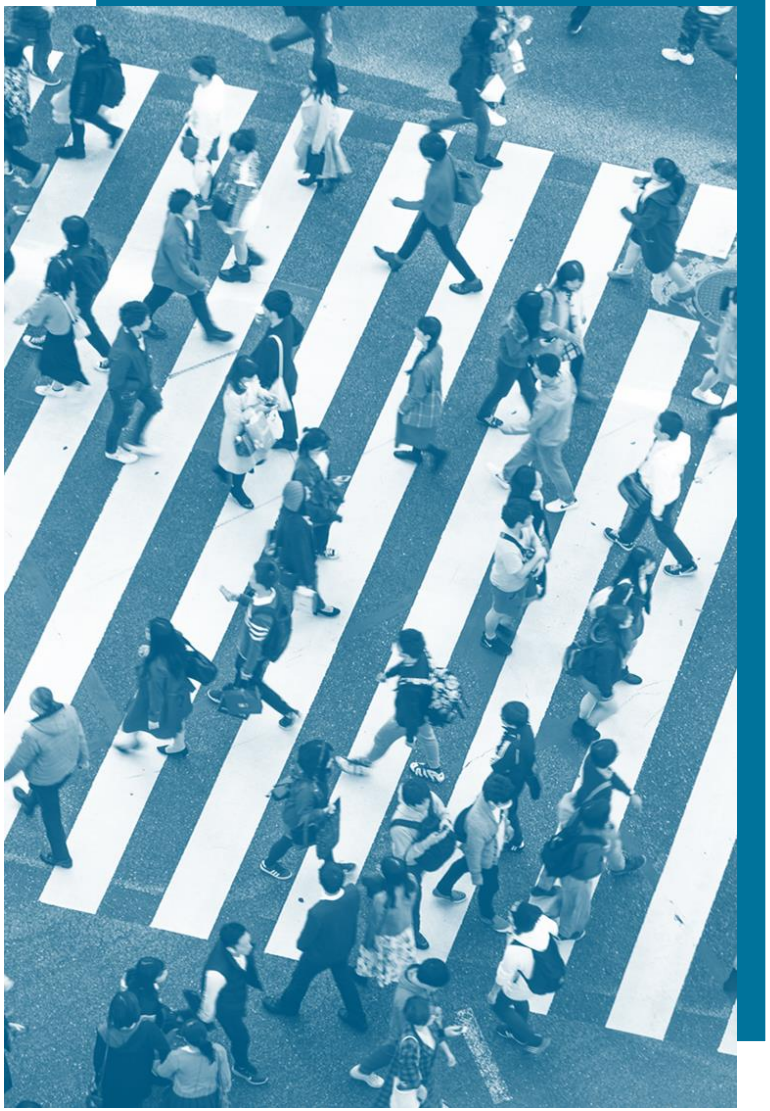
Fatema M. Ali

Chris Kenaszchuk

Laura C. Rosella

## KEY FINDINGS

- The **future risk of developing diabetes** among residents in Peel is **disproportionately** elevated among **visible minority and immigrant groups**.
- We must consider the many factors that increase type 2 diabetes risk when looking for ways to reduce this risk.
- In the coming years, **diabetes incidence** in Peel Region is **projected to rapidly increase,** particularly among those experiencing a **greater degree of socioeconomic disadvantages** and **health inequities**.
- Over half of the population in Peel Region is represented by those who identify as a **visible minority** (58.7% among adults with diabetes and 57.3% among those without diabetes).
- A **higher proportion of immigrants are living with diabetes** (73.3%) compared to immigrants without diabetes (56.6%).
- Among adults living with diabetes, 40.7% reported being **physically inactive** as compared to 27.3% of adults living without diabetes.
- A significant proportion of **residents reported being overweight** (37.7% with diabetes and 33.2% without diabetes).
- Over half of the residents with **hypertension** reported having diabetes (60.8%), which was comparable to those living without diabetes (57.4%).
- Although **food insecurity** is an important determinant of type 2 diabetes risk and an indicator of poverty, only a small number of residents reported experiencing severe food insecurity (3.1% among those living with diabetes and 2.0% living without diabetes)
- A small fraction of residents reported an **income** of less than $20,000 (6.5% among those with diabetes and 5.7% of those living without diabetes).
- The **10-year risk of developing new diabetes for residents of Peel Region overall is 11.5%,** with an additional 102,000 adults aged >20 years living with diabetes by 2028.



## INTRODUCTION

Several individual and community-level factors influence the development of type 2 diabetes (diabetes). Some of these risk factors include non-modifiable sociodemographic factors (e.g., age, sex, ethnicity, immigrant status); or modifiable health behaviours such as unhealthy diets, physical inactivity, sedentary living, and smoking; and their subsequent health states (e.g., obesity, hypertension) that predispose or correlate with diabetes.[1-2] There are also underlying social determinants of health or contextual factors, such as food insecurity, housing affordability, sense of belonging, perceived health and socioeconomic status, that combine with these indicators to further contribute to the risk of developing diabetes. [3-4]

Previous research has demonstrated that the onset of diabetes can be delayed or prevented with tailored health promotion interventions targeting the modifiable risk factors and determinants of diabetes in clinical and community settings.[5-8] Such efforts have the potential to reduce the risk and burden of diabetes by identifying optimal diabetes prevention strategies that are tailored, effective, and solution-oriented. Identifying those groups at the highest risk of future diabetes and their key risk factors is an essential first step in developing such interventions. In this chapter, we have mapped these risk factors to the Socio-ecological Model of Health (*Exhibit 4.1*) to understand the extent to which they are associated with the future risk of diabetes development in the Peel Region.

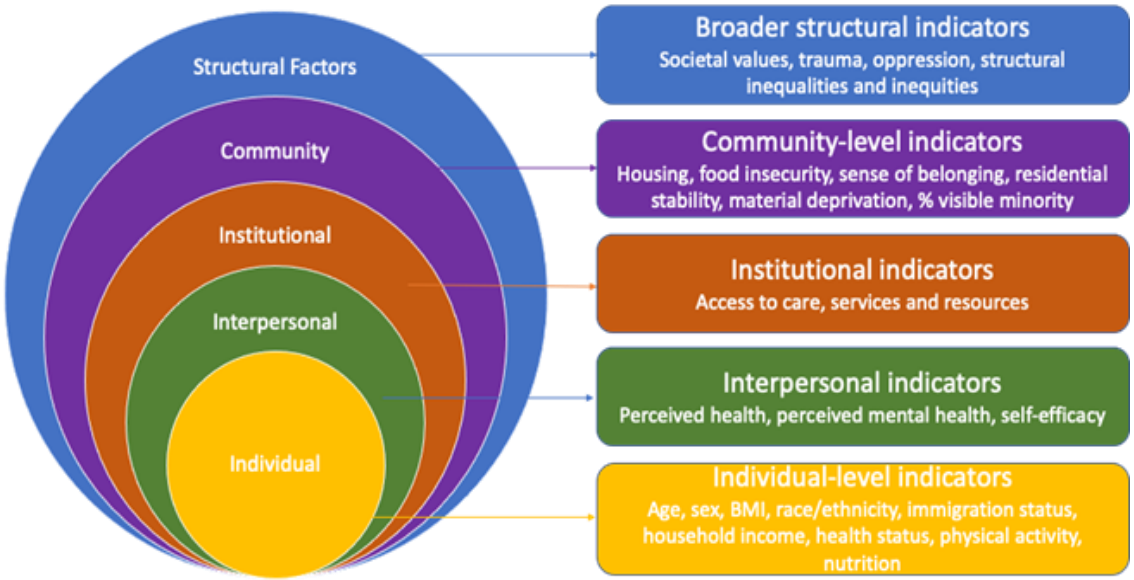



**Exhibit 4.1** Mapping the risk factors of type 2 diabetes to the Socio-ecological Model of Health.

This chapter uses the data from the Canadian Community Health Survey (CCHS), a national population-based survey, to 1) describe the distribution of the sociodemographic and behavioural risk factors in persons with and without self-reported diagnosis of diabetes and 2) estimate the 10-year risk of diabetes based on the risk factors among residents living in Peel Region, in Ontario, Canada.

## METHODS

The CCHS is a national cross-sectional survey questionnaire developed by Statistics Canada and administered every 1-2 years to collect health-related information from a sample of the Canadian population aged 12 years and above.[11] The CCHS is designed to allow for accurate population estimates at the level of a health region, in our case, Peel Region. We used the public use version of the 2017/2018 CCHS survey data, accessed through the University of Toronto and Statistic's Canada Data Liberation Initiative (DLI).

***1. Distribution of risk factors in persons with and without diabetes***

We used descriptive statistics to calculate the distribution of the risk factors among persons with and without diabetes (as defined by self-report of diagnosed diabetes). The total number of respondents in this sample was 1,462 (167 without diabetes and 1,295 with diabetes) for Peel Region. Due to the small sample size, we were not able to calculate diabetes prevalence by risk factor status.

***2. The influence of risk factors on 10-year risk of diabetes***

The Diabetes Population Risk Tool (DPoRT) used CCHS survey data to estimate risk of diabetes for different groups. DPoRT provides a unique opportunity to estimate the future risk of developing diabetes based on key risk factors of diabetes and to inform future population-wide diabetes prevention strategies.[9-10]

DPoRT is a population-based risk prediction algorithm that aims to estimate the future risk of type 2 diabetes based on self-reported data on key risk factors, including age, sex, ethnicity, immigration status, body mass index, hypertension, income, food insecurity, social capital, perceived physical health, and access to care among others.[9-10] The tool has been previously validated in various populations across different ethnic compositions and settings (local, provincial governments and health agencies) and has been an integral component of conceptualizing and developing population-based interventions by local public health agencies and governments to reduce the future risk of diabetes. [12-14] Additional details on the creation and validation of the DPoRT tool have been described elsewhere.[9-10]

Risk estimates were calculated among adults in Peel Region who were aged 20 and above and did not self-report previous diabetes or pregnancy at the time the survey was completed. We computed DPoRT risk equations based on risk factor information from the CCHS to predict future diabetes risk and the number of new cases in the 10 years after the most recent CCHS survey in 2017/2018. Survey weights based on Peel Region's population were applied to the estimates to ensure population generalizability. All analyses were completed using SAS Studio 9.4 version. See the Technical Appendix for more details.

## RESULTS

### *1) Distribution of Risk Factors in Persons With & Without Diabetes*

The prevalence of key risk factors among those living with and without diabetes is shown in *Exhibits 4.2* and *4.3.* Among residents living in Peel Region, physical inactivity, smoking, overweight/obesity, and hypertension were highly prevalent among those living with diabetes, as shown in *Exhibit 4.2* and described below.

*Key Findings:*

- Over half of the population in Peel Region are represented by those who identify as a visible minority (58.7% among adults with diabetes and 57.3% among those without diabetes)
- A higher proportion of immigrants are living with diabetes (73.3%) compared to immigrants without diabetes (56.6%)
- Among adults living with diabetes, 40.7% reported being physically inactive, as compared to 27.3% of adults living without diabetes
- A substantial proportion of residents reported being overweight (37.7% with diabetes and 33.2% without diabetes)
- Over half of the residents with hypertension reported having diabetes (60.8%), which was comparable to those living without diabetes (57.4%)
- Generally, food insecurity is an important determinant of diabetes risk and an indicator of poverty; however, in Peel Region, a small proportion of residents reported experiencing severe food insecurity (3.1% among those living with diabetes and 2.0% living without diabetes)
- A small fraction of residents reported an income of <$20,000 (6.5% among those with diabetes and 5.7% of those living without diabetes).

Table 3.1. List of risk factors categories and indicators from the 2017-2018 Canadian Community Health Survey

| Risk Factor Category | Indicator* |
|---|---|
| ***Sociodemographic*** | Age<br>Sex<br>Visible Minority<br>Immigration Status |
| ***Health Behaviour*** | Smoking<br>Physical activity |
| ***Health Status*** | BMI<br>Obesity<br>Hypertension |
| ***Social Determinants of Health*** | Household income<br>Sense of belonging<br>Food insecurity<br>Perceived health<br>Perceived mental health |

*Definitions of the indicators are listed in the Technical Appendix

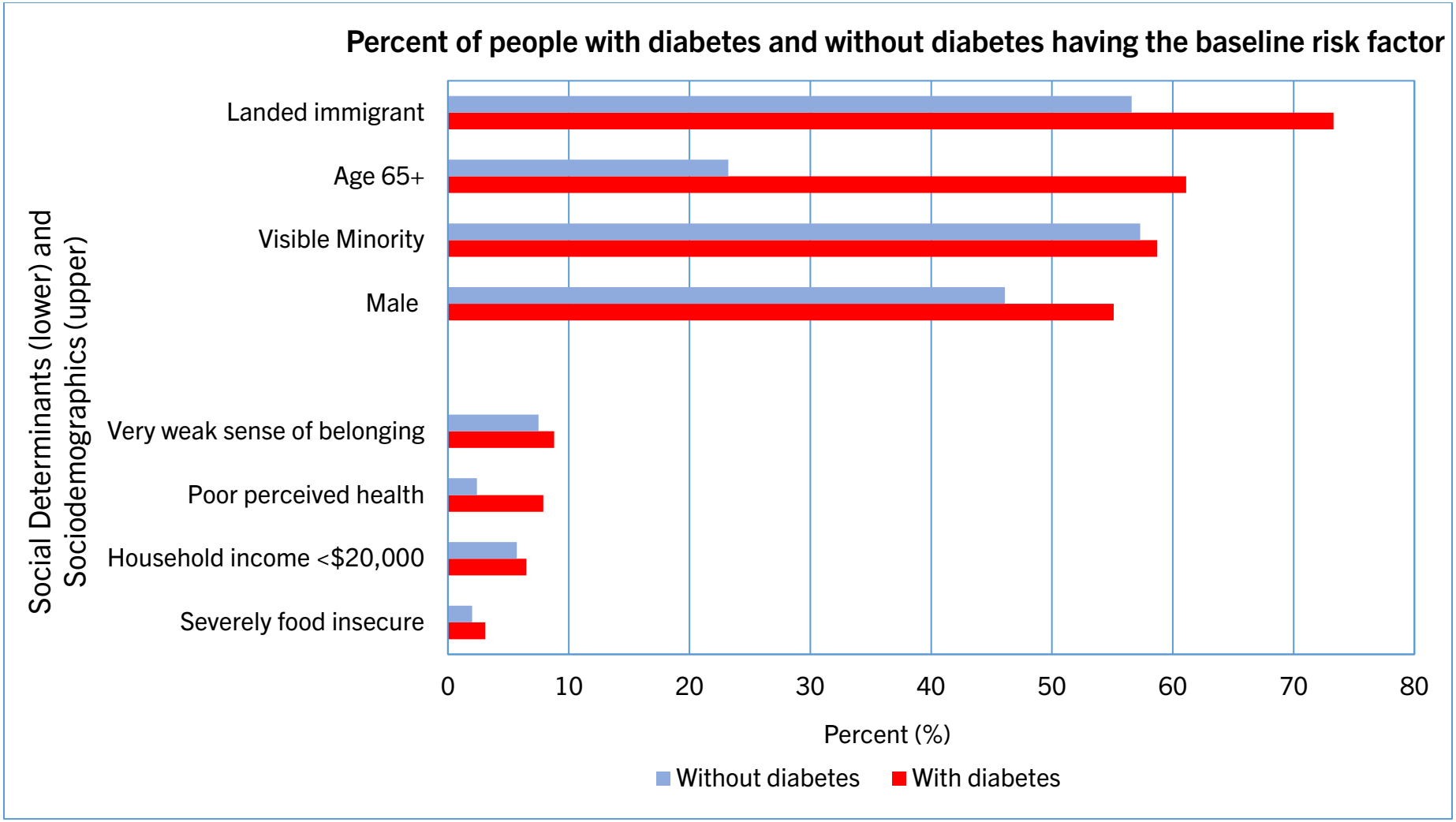



**Exhibit 4.2** Proportion (%) of adults aged 20+ living in Peel Region, with (red bar) and without diabetes (blue bar), with unfavorable risk factors: sociodemographic factors and social determinants of health.

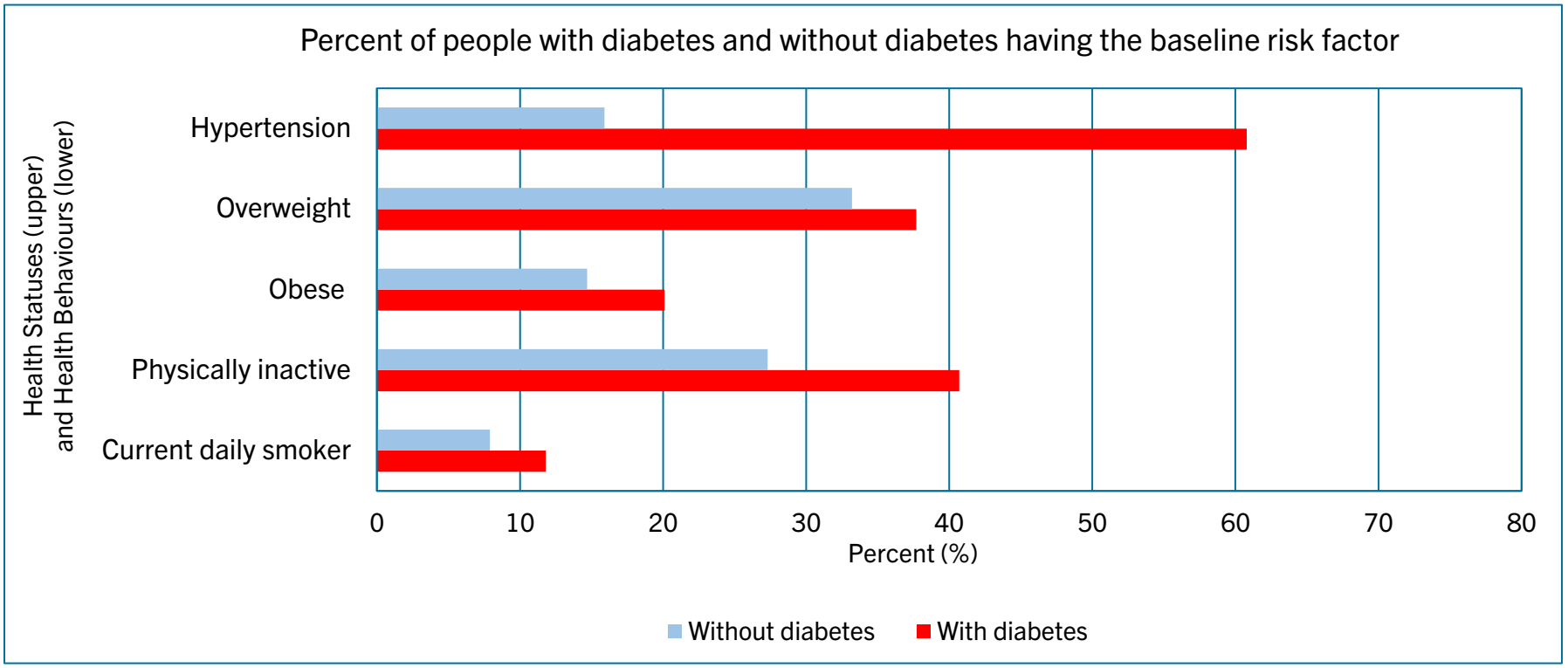



**Exhibit 4.3** Proportion (%) of adults aged 20+ living in Peel Region, with (red bar) and without diabetes (blue bar), with unfavorable risk factors: health status and health behaviours.

### *2) Estimated Future Type 2 Diabetes Cases*

In Peel Region, it is predicted that in the subsequent 10 years, according to the most recent CCHS survey in 2017/2018, an additional 102,000 adults aged older than 20 years will be newly diagnosed with type 2 diabetes. Similarly, the 10-year risk of developing new diabetes for residents of Peel Region overall is 11.5% (*Exhibit 4.4*), which corresponds to what has been previously predicted for the region.[14] This projected increase in diabetes risk in Peel will pose significant challenges to the sustainability of the healthcare system due to the increased number of people living with diabetes and needing care.[15]

### *Predicted Diabetes Cases by Sociodemographic Factors*

The future risk of diabetes is similar in males and females but increases with age (*Exhibit 4.4*). Between 2017/2018 and 2027/2028, older adults above the age of 65 years are estimated to have the greatest 10-year risk of developing type 2 diabetes, with 1 in 5 seniors being diagnosed over that time period (Exhibit 4.3). However, the highest number of new cases of diabetes is expected to be among those aged 45-64 years (42,590 cases) compared to adults older than 65 years (24,968 cases) and younger adults aged 20-44 years (28,730).

The large number of predicted new cases of diabetes among younger adults may be related to the rising incidence of prediabetes,[16] early progression from prediabetes to type 2 diabetes,[17] and young-onset diabetes,[18] which may be amplified with exposure to socioeconomic disadvantages. Moreover, while females currently have a lower burden of diabetes, as shown in Chapter 2, their predicted increase in new cases over the next 10 years is similar to males. Overall, these trends also suggest that the rising diabetes rates in working-age populations contribute to indirect costs to health systems and the economy due to loss of productivity, disability, and absenteeism.

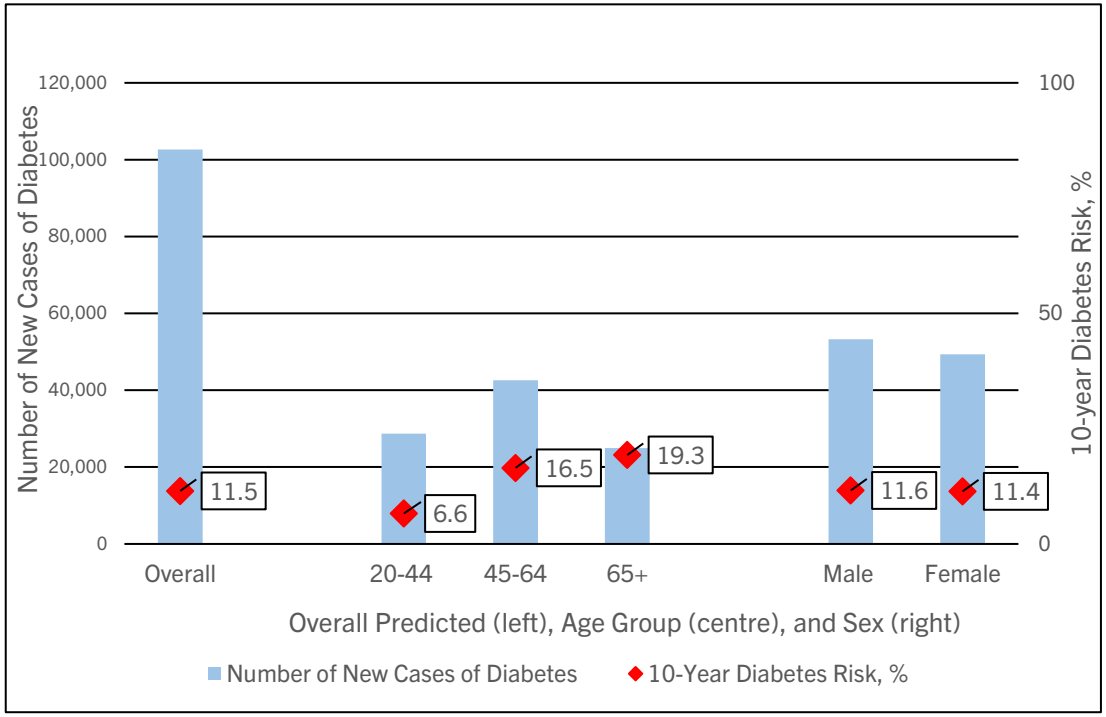



**Exhibit 4.4** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, overall, and by age group and sex, between 2017-18 and 2027-28.

Visible minority* populations have a 32% greater risk of developing diabetes and twice as many predicted new cases (71,417 cases) compared to non-visible minority counterparts (*Exhibit 4.5*). Similarly, immigrants in Peel Region have a 54% higher risk of developing diabetes, and over one-third more cases are estimated to be diagnosed in immigrants compared to non-immigrant groups. These estimates indicate the future burden of diabetes in Peel will continue to be significant and pose a large burden for individuals, communities, and the health system. Moreover, diabetes health services and prevention strategies will need to prioritize the unique needs and circumstances of visible minority and immigrant populations, who are not only overrepresented in the region but also carry the greatest burden of diabetes.

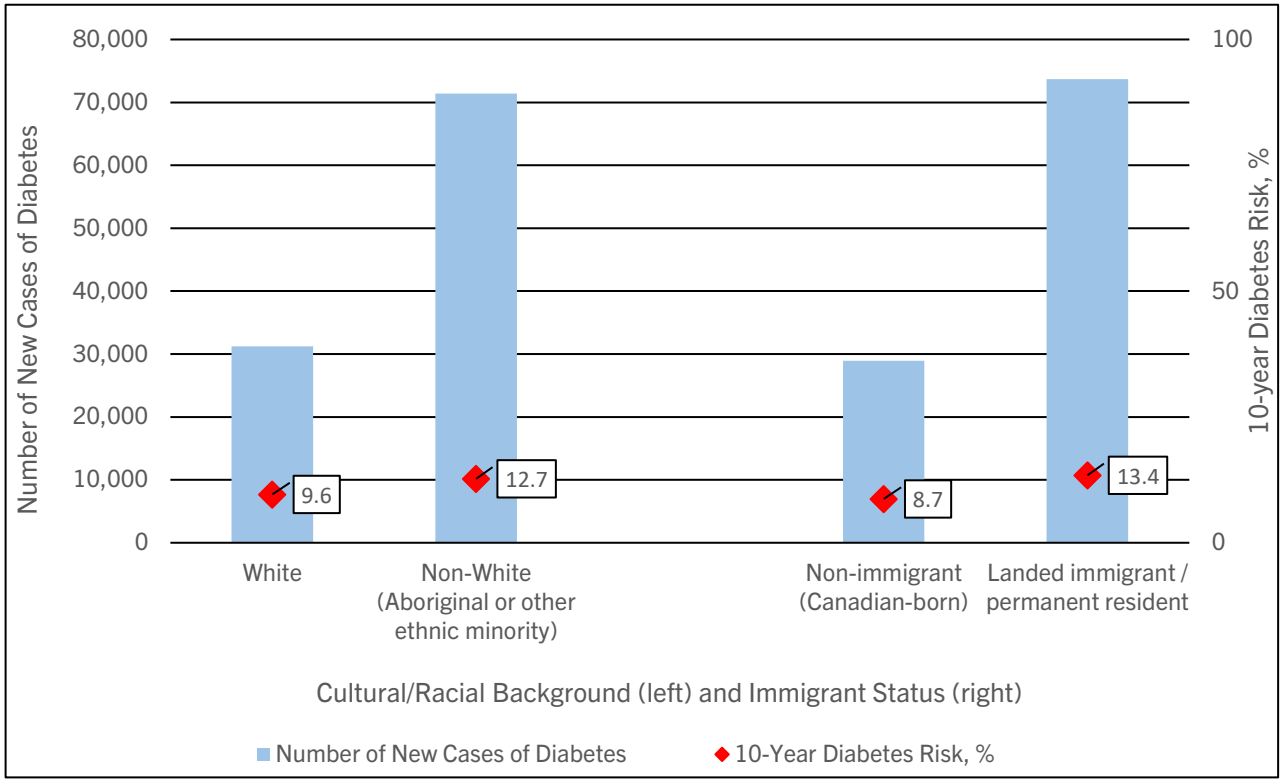



**Exhibit 4.5** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by visible minority* and immigrant status, between 2017-18 and 2027-28.

**Visible minority:* is a CCHS variable that refers to "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour", please refer to the technical appendix for a more detailed definition.[19]

### *Diabetes Cases by Health Behaviours and Health Status*

Between 2017/2018 and 2027/2028, the risk of developing diabetes and the number of new cases among residents living in Peel Region varied across levels of smoking and physical activity (*Exhibit 4.6*). For example, nearly 50% of new cases of diabetes (42,026 cases) are projected to be among those who are physically inactive and have an estimated 40% greater risk of diabetes than their active counterparts (*Exhibit 4.6*). Furthermore, while the 10-year risk of developing diabetes was highest among occasional smokers, the number of new cases of diabetes is projected to be highest among non-smokers (63,667 cases), reflecting the patterns of smoking in the population (*Exhibit 4.6*). There is evidence that suggests that smoking is associated with an increased risk of developing diabetes.[20] Future research and policy solutions will need to explore this finding more deeply to determine how best to intervene and reduce future risk of diabetes in this group.

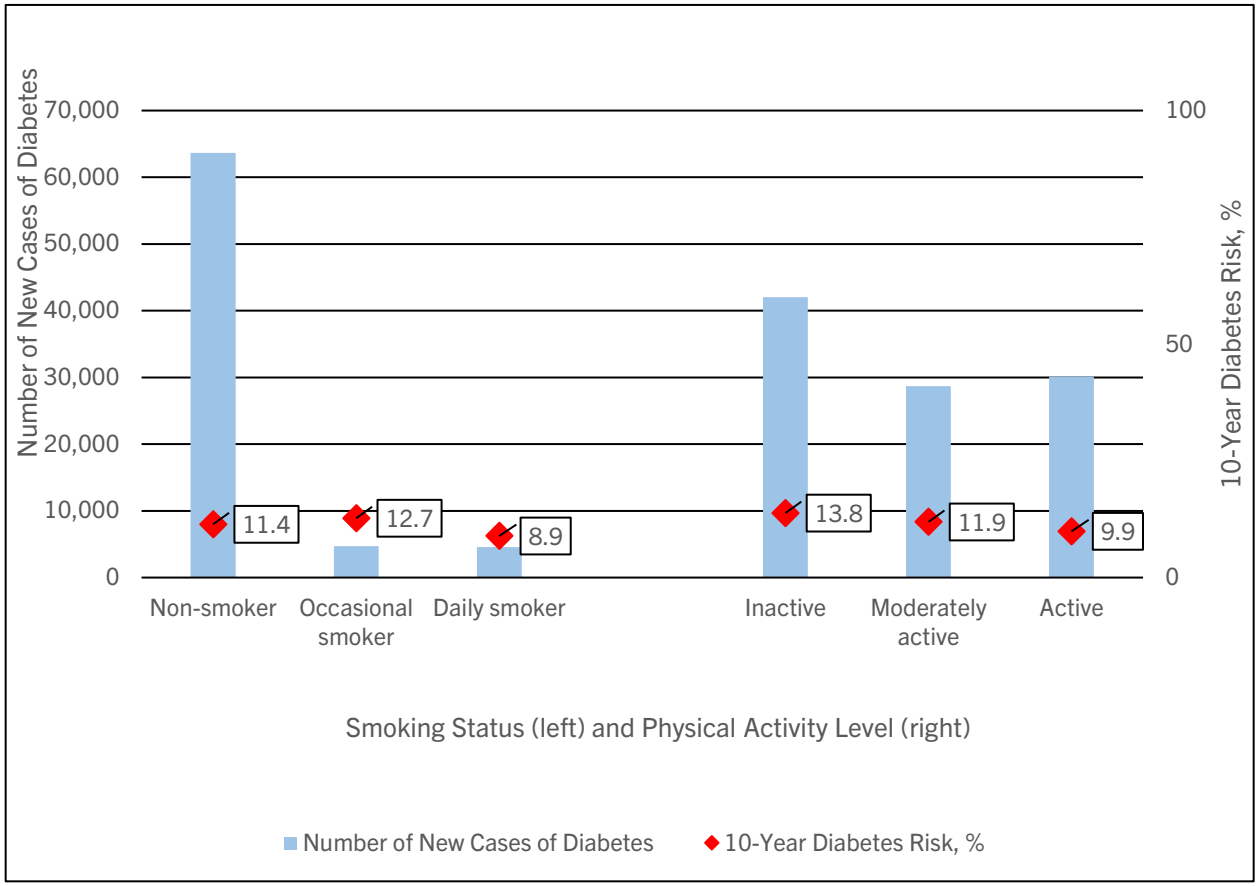



**Exhibit 4.6** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by smoking status and physical activity level, between 2017-18 and 2027-28.

Not surprisingly, the future risk of developing diabetes increased substantially with increasing weight categories. Compared to a 10-year risk of 7.7% among those with normal weight, the risk of diabetes was 50% higher, close to 3-fold higher, and over 4-fold higher for those who were classified as overweight, obese, and severely obese, respectively (*Exhibit 4.7*). However, of the total number of new cases of diabetes projected over 10 years, over one-third (41.3%) are among those who were overweight (39,002 cases) compared to those who were classified as obese (18,974 cases) and severely obese (11,450 cases). This reflects the fact that the largest proportion (over 30%) of Peel residents without diabetes are overweight rather than being in other body mass index (BMI) categories (*Exhibit 4.3).* This finding further emphasizes the importance of considering population-wide strategies for diabetes prevention along with targeted high-risk approaches tailored to different populations.

Similarly, hypertension is another important risk factor for diabetes incidence, whereby the 10-year risk of developing diabetes among those with hypertension was over 2-fold higher than those with normal blood pressure. The largest number of new cases of diabetes is projected to be among those with normal blood pressure (68,066 cases) compared to those with elevated blood pressure (34,549 cases) (*Exhibit 4.7*). This again emphasizes that those with risk factors are at high risk, but the distribution of risk in the population must also be considered such that population-wide interventions that reach all segments of the population to promote healthy behaviours and ensure that the overall burden of diabetes is reduced.

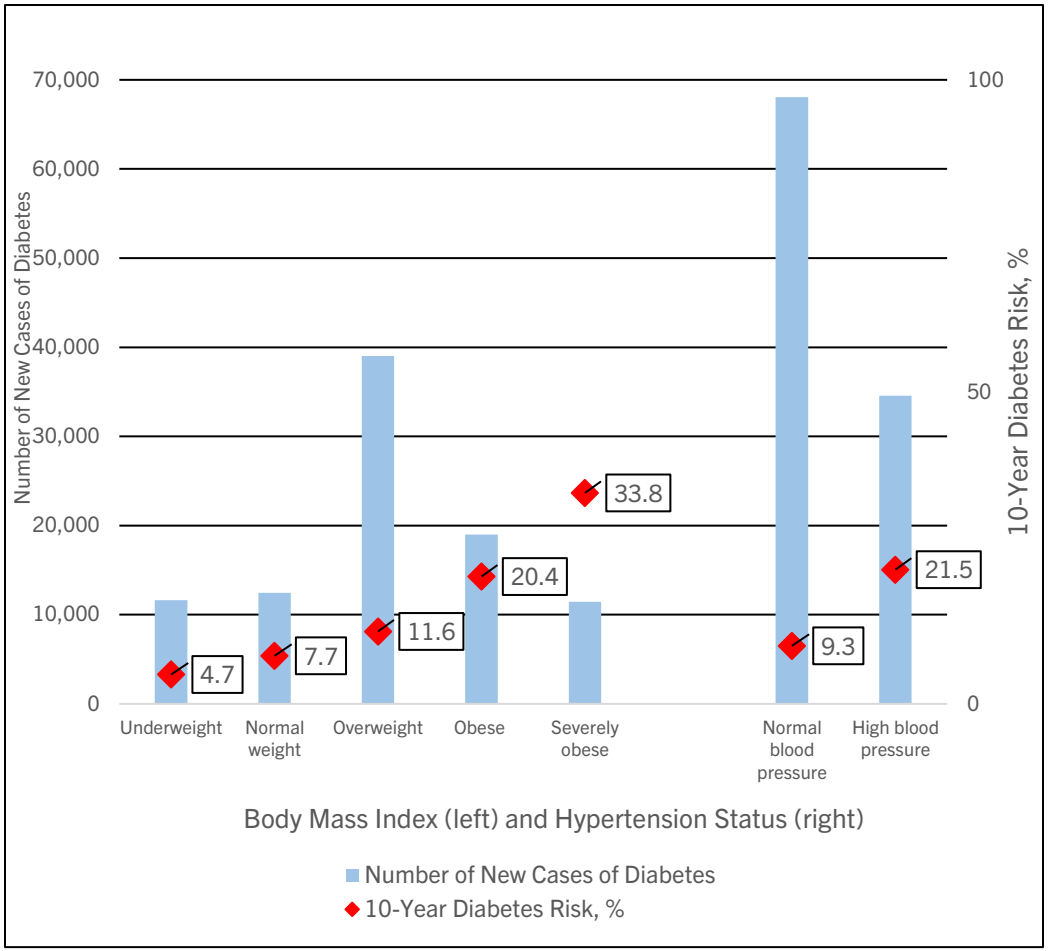



**Exhibit 4.7** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by Body Mass Index (BMI) and hypertension status, between 2017-18 and 2027-28.

***Diabetes cases by social determinants of health***

In Peel Region, the predicted risk of diabetes is highest in populations with the lowest household income. Between 2017/2018 and 2027/2028, the 10-year risk of developing diabetes is approximately 40% higher among those in the lowest income bracket (<$20,000) than all other income groups. Furthermore, the highest number of 28,187 new cases will be diagnosed in those with the lowest household income (*Exhibit 4.8*). This indicates that the greatest burden of diabetes will be felt in marginalized populations and will require combined efforts between the healthcare and social systems to adequately reduce risk and manage the condition in the years to come.

While the number of new diabetes cases was most pronounced among food-secure households and accounted for 91.6% of new cases of diabetes (94,189 cases), 10-year risk of developing diabetes is disproportionately larger in Peel residents experiencing food insecurity (*Exhibit 4.9*). Food insecurity still remains one of the most potent determinants of health and poverty and particularly of future diabetes risk and burden.[21]

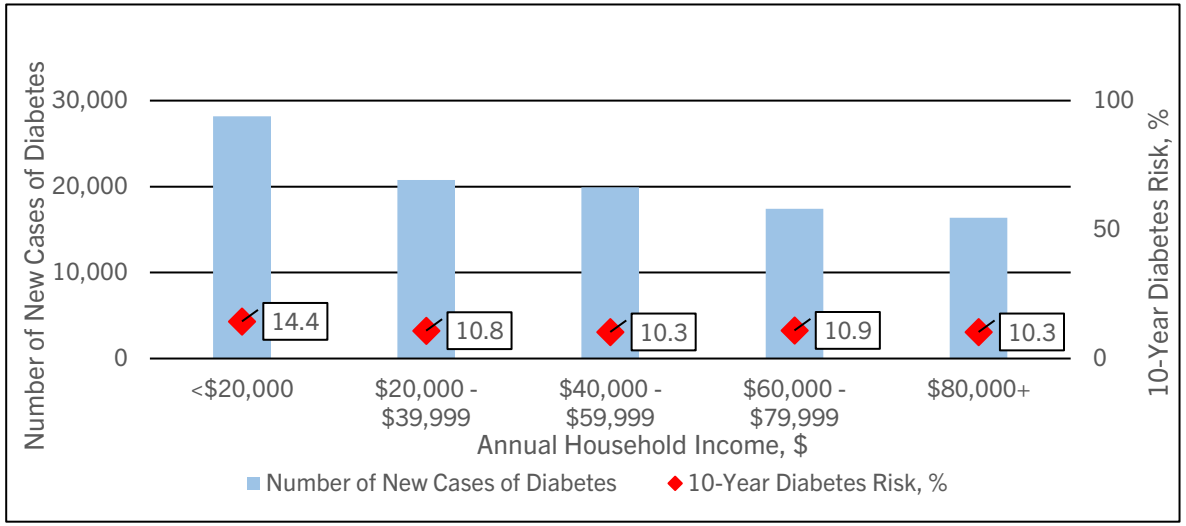



**Exhibit 4.8** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by annual household income, between 2017-18 and 2027-28.

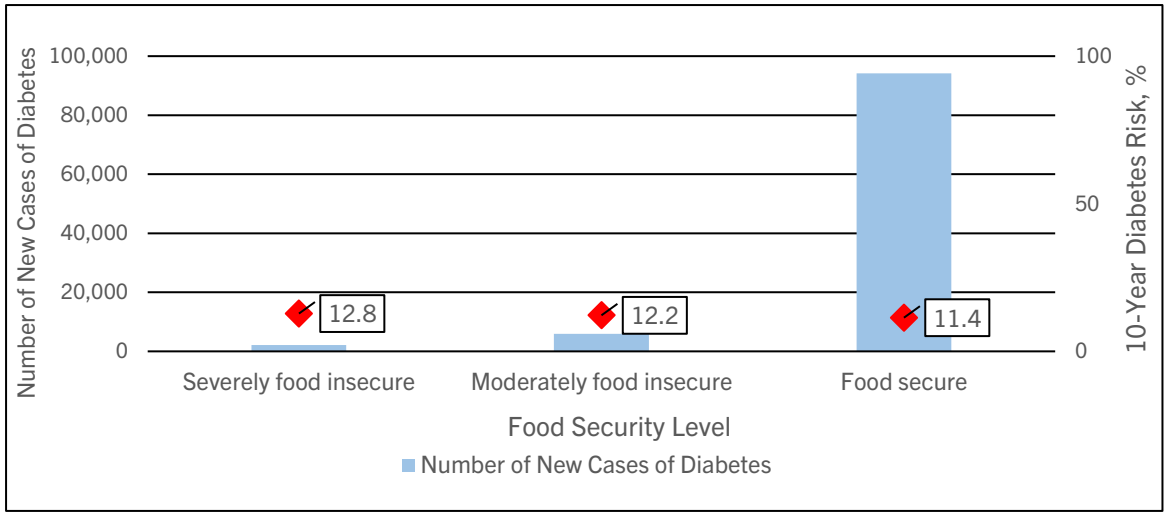



**Exhibit 4.9** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by food security level, between 2017-18 and 2027-28.

Over the next 10 years, the future estimated risk of developing diabetes was 1.5 to 2-fold higher for persons who reported fair or poor perceived health. On the other hand, the largest number of new cases are predicted to occur in those who perceive their health as good, indicating a need for broad population-based education regarding diabetes risk (*Exhibit 4.10)*. A sense of belonging in one's community is an important indicator of social capital. Self-reported sense of belonging did not appreciably influence the 10-year estimated risk of diabetes for Peel residents. Further research may be needed to explore more deeply how improving or targeting a sense of belonging in future community-based interventions may help to curb diabetes risk in the region.

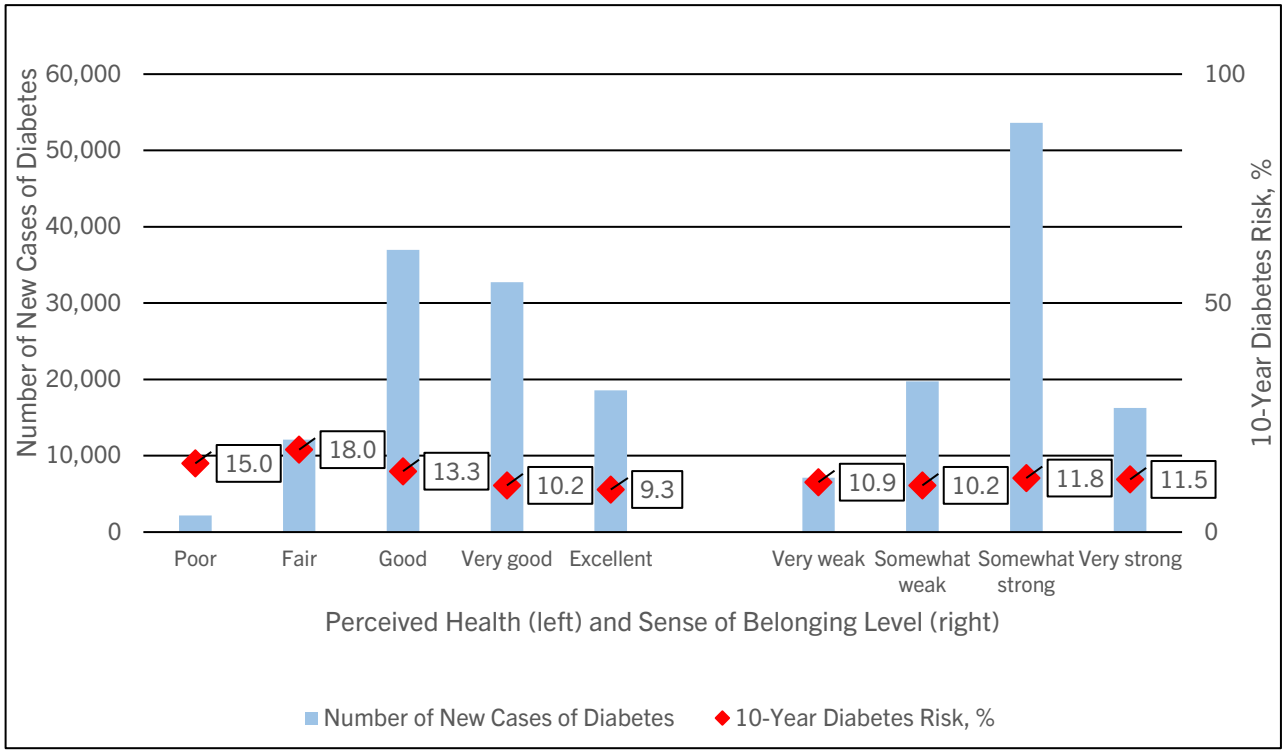



**Exhibit 4.10** Predicted number of new diabetes cases and 10-year incidence risk among adults aged 20+ living in Peel Region, by perceived health and sense of belonging, between 2017-18 and 2027-28.

## INTERPRETATION

***Summary of Findings***

In this chapter, we have shown the high future diabetes risk expected in Peel region and the key individual and community-level determinants of health that are associated with this future risk. Specifically, along with increasing age and being from a visible minority or immigrant population, social disadvantages due to low socioeconomic status and food insecurity, in combination with being overweight or obese and physically inactive, were highly prevalent risk factors for future diabetes burden among those living in Peel Region.

In particular, the highest predicted risk (%) of diabetes will occur among those with the following risk factor characteristics:

- Older age
- Visible minority
- Low household income (<20,000 per year)
- Food insecurity
- Physically inactive
- Overweight or obese
- Hypertension

Our findings reveal that in the coming years, diabetes incidence in Peel Region is projected to rapidly increase, particularly among those experiencing a greater degree of socioeconomic disadvantages and health inequities. Inequities in access to income, employment, housing, and food security are major drivers of chronic disease risk and burden.[22] Thus, these findings have important implications for addressing the future onset of diabetes and potential complications. Specifically, disparities in household income, food insecurity and modifiable risk factors such as physical inactivity, overweight and obesity, and hypertension will require multi-faceted and tailored policy interventions to curb the projected incidence of diabetes in the region and improve the quality of life.

The future risk of developing diabetes among residents in Peel was disproportionately elevated among visible minority and immigrant groups. This unequal distribution and projected risk of diabetes in these populations are important prompts for developing and implementing culturally tailored policy and programmatic interventions that consider the unique needs and circumstances of these groups. Strategies will need to target the macro-level determinants (i.e., living environments, social policies, and structural inequalities) as well as the meso-level determinants (i.e., health literacy and beliefs, food insecurity, housing affordability) of diabetes risk to optimize opportunities and empower individuals to adopt healthy behaviours (i.e., physical activity, healthy eating, etc.).

Health behaviours such as physical inactivity, sedentary lifestyles, unhealthy eating patterns, and consequent overweight and obesity are more common among those living in low socioeconomic status, thereby increasing the future risk of developing diabetes.[23-25] Previous research has shown that those living in lower socioeconomic status experience significant inequities and barriers to adopting healthy behaviours.[22-24] This is largely due to living in areas with limited -to no- access to healthy resources (i.e. healthy food options, parks and greenspace, public transit, and community resources) and lack of policies and interventions that target the social indicators of poverty and diabetes risk such

as food insecurity and housing affordability.[26-28] This is particularly important because our findings revealed that future risk of diabetes will disproportionately occur among those who have a lower household income and, are physically inactive, overweight, or obese, and are experiencing severe food insecurity.

### *Limitations*

There are a few limitations to consider in this chapter. First, the analysis was limited to one CCHS cycle, which limited the ability to explore diabetes prevalence across risk groups or regional variation in risk factors and estimated future risk due to a smaller sample size and representation. Second, the findings presented are based on self-reported data collected by the CCHS, and thus, there may be some degree of reporting bias, including recall of risk factor information, social desirability in reporting certain information and overreporting some health and health behaviour information. Thus, it is possible that the estimates generated from DPoRT may underestimate the true diabetes risk among those living in Peel Region. Future research should explore the risk and burden of diabetes using a combination of large population-based datasets as well as additional cycles of survey information to gain a deeper understanding of the future risk of diabetes in the population.

### *Implications & Future Directions*

This chapter presented new information on the future risk of diabetes among residents living in Peel Region. This was calculated using individual-level risk factor information, including sociodemographic, health behaviour and social determinants of health and a validated diabetes risk prediction algorithm. In particular, we found that low household income, physical inactivity, overweight and obesity, hypertension, and food insecurity are significant drivers of future diabetes risk. As well the projected risk of diabetes is also disproportionately high among racialized communities (visible minority and immigrant populations). In future efforts, this information is integral for gaining a deeper understanding of the inequities that drive diabetes risk in these communities and for identifying future research priorities and policy interventions to address them.

Future policy interventions will need to consider the interconnected nature of the many socioeconomic disadvantages that drive diabetes risk and identify prevention strategies that target the macro, meso, and micro-level determinants of diabetes through individual (high-risk) and population-level approaches. For instance, the distribution of the projected incidence of diabetes observed across various risk factors suggests that diabetes prevention strategies may need to include a combination of individual and population-wide approaches across different healthcare and public health programming and policies.

Examples of individual approaches may involve identifying high-risk populations across different settings (clinics, community, workplaces), incorporating diabetes prevention efforts into routine preventive health care services, and empowering individuals to identify and adopt healthy behaviours (i.e., physical activity and healthy eating).[29-31] Furthermore, action at the population level is required to support individuals such as interventions and policies targeting food insecurity, taxation of unhealthy foods, housing affordability, socioeconomic status, workplace wellness and improving the built environment through healthy

neighbourhood design may help to achieve a greater impact on diabetes risk reduction and prevention.[29-31]

In doing so, policymakers and health planners may need to consider the contexts and environments (i.e. social and physical environments) that may influence the future onset of diabetes in Peel. Given the wide distribution of risk in the population, interventions that consider reaching whole populations (e.g., policies and built environment) will have the greatest impact on reducing the overall diabetes burden. Thus, combined efforts between individual and population-level approaches are required to shift the distribution of diabetes risk and achieve substantial benefits for health systems and economies.

Because Peel's population is heterogeneous and ethnically and culturally very diverse, it offers a unique opportunity for future research and policy interventions to collaborate with community partners across different sectors and agencies and engage with patients and community members in all stages of the research and policymaking process. This step is vital to better understand the implications and meaning of these findings for the community and to co-create knowledge to determine 'research needs and scope', 'what intervention and prevention strategies are necessary', 'what works for whom' and 'under what local contexts' in order to meet the needs of the community and to achieve the greatest impact in reducing diabetes risk. Thus, moving forward, such engagements are integral for current and future diabetes research and policy efforts to collectively identify multi-faceted approaches to addressing the projected risk of diabetes in the Peel Region.

In summary, population-based risk prediction algorithms are promising avenues to inform diabetes prevention strategies and the development and implementation of potential local health-promoting interventions. DPoRT has been integral in guiding and supporting local health decision-making and planning initiatives across several settings and populations. The projected incidence of diabetes for Peel Region across several modifiable risk factors can help to prompt and direct where future policy interventions will need to target through individual and population-level approaches and community engagement efforts in order to reduce the future risk and burden of diabetes, promote healthier living and improve quality of life.

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# CHAPTER 5: HEALTH SERVICES AND QUALITY OF CARE


## AUTHORS

Calvin Ke

Lorraine L. Lipscombe

Walter P. Wodchis

Fatema M. Ali

Yu Qing Bai

Karen Tu

Shadia Adekunte

Baiju R. Shah

## KEY FINDINGS

- The **quality of diabetes services** in the Mississauga OHT is **broadly similar to those** in the rest of **Ontario**.
- Diabetes Canada's recommended ideal standard for **regular blood glucose monitoring (HbA$_{1c}$ testing)** was not met in more than 50% of people with diabetes in the Mississauga OHT.
- Nearly 40% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's **ideal recommended target HbA$_{1c}$ level.**
- Diabetes Canada's recommended ideal standard for **regular blood cholesterol monitoring (LDL cholesterol testing)** was not met in around 30% of people with diabetes in the Mississauga OHT.
- 43% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's recommended **ideal target cholesterol level.**
- Diabetes Canada's recommended **ideal standard for regular retinopathy** (eye) screening was not met in around 45% of people with diabetes in the Mississauga OHT.
- The proportion of those attending **retinopathy screening** was slightly lower in the Mississauga OHT than in the rest of Ontario.
- In the Mississauga OHT, 65% and 74% of people with diabetes aged 65 years or older received **kidney- and heart-protective medications**; these figures fell short of the recommended ideal standard benchmark of 80% despite these medications being subsidized by the provincial drug benefit plan.

## INTRODUCTION

Type 2 diabetes (90% of all diabetes) is a lifelong chronic disease that requires multi-faceted management, including nutrition and physical activity support, medications, and regular healthcare visits and testing. Intensive type 2 diabetes management supported by a professional team has been shown to prevent the health consequences of diabetes known as "complications" (e.g., heart attack, stroke).[1–3] Diabetes management includes lifestyle modifications and medications for blood sugar (glucose) control, regular monitoring of diabetes control and early signs of complications, and medications to prevent vascular consequences, such as heart attack and stroke.

Thus, Diabetes Canada's *Clinical Practice Guidelines for the Prevention and Management of Diabetes in Canada* recommend that health services for people with type 2 diabetes should include regular monitoring of blood glucose (glycated hemoglobin or $HbA_{1c}$), blood cholesterol (low-density lipoprotein or LDL)), the eyes (checking for retinopathy), and the feet.[1] Many people with diabetes are also recommended to take heart- and kidney-protective medications to help prevent complications (e.g., angiotensin-converting enzyme (ACE) inhibitors, angiotensin-receptor blockers (ARBs), and statins).[4–6] These tests and preventive treatments are collectively known as "processes of care." We defined five indicators to assess the quality of these processes of care within eligible age groups (*see Exhibit 5.1*).

Aside from processes of care, the quality of type 2 diabetes care can also be measured by examining various "outcomes of care." These outcomes include the levels of blood sugar and cholesterol and whether these levels meet Diabetes Canada's recommended targets. It has been shown that meeting these targets helps prevent complications.[4,7] People with type 2 diabetes may require admission to the hospital to treat the immediate short-term complications of abnormal blood sugars (e.g., diabetic ketoacidosis, hypoglycemia) and complications that occur because of long-term high blood sugars (e.g., heart attack, stroke).

In Ontario, health services are administered at the level of the Ontario Health Team (OHT).[8] Because the Mississauga OHT serves many individuals living in Mississauga and throughout Peel Region (see Chapter 2), our team chose Mississauga OHT as the focus for this chapter. Our objectives were to determine (1) whether Mississauga OHT meets the recommended ideal standards for type 2 diabetes care (*see Exhibit 5.1*); (2) how Mississauga OHT's performance compares to Ontario; and (3) how Mississauga OHT's performance has changed during the peak of the coronavirus disease 2019 (COVID-19) pandemic from 2019 to 2022.

| Type of Indicator | Indicator | Definition and/or recommended ideal standard of care | Age Group* |
|---|---|---|---|
| **Processes of Care** | Blood sugar ($HbA_{1c}$) monitoring | At least two $HbA_{1c}$ tests in the past 12 months | ≥40 years |
| | Blood cholesterol monitoring | At least one low density lipoprotein (LDL) cholesterol test in the past 12 months | ≥40 years |
| | Screening for eye disease (retinopathy) | Attended an eye exam in the past 24 months | ≥40 years |
| | Kidney-protective medication prescription | At least one prescription for ACE inhibitor or ARB filled within the past 12 months | ≥66 years |
| | Heart-protective medication prescription | At least one prescription for statin filled within the past 12 months | ≥66 years |
| **Outcomes of Care** | Blood sugar ($HbA_{1c}$) on target | Mean $HbA_{1c}$ level ≤7% among those with at least one test performed | ≥40 years |
| | Blood cholesterol on target | Mean LDL cholesterol level ≤2 mmol/L among those with at least one test performed | ≥40 years |
| | Short-term complications (hospitalizations only) | Rate of hospitalization (per 1,000 population) for a short-term complication: diabetic ketoacidosis, hyperglycemic hyperosmolar state, mixed ketoacidosis, hypoglycemic or insulin coma | ≥18 years |
| | Long-term complications (hospitalizations only) | Rate of hospitalization (per 1,000 population) for a long-term complication: ophthalmic, renal, neurologic, circulatory, or multiple complications of diabetes | ≥18 years |

**Exhibit 5.1** Classification of indicators for health services and quality of care. Unless otherwise indicated, all values are percentages of adults in the age group listed in the last column. The recommended ideal standard is no short- or long-term complications, and 100% achievement of the other indicators, except for prescriptions. The recommended ideal standard for the prescription indicators is at least 80% of the population, based on our previous work.[9]

*Age groups vary based on data availability

## METHODS

This was a retrospective descriptive study of adults with diabetes (both type 1 and type 2) using population-based healthcare administrative data housed at ICES (see Technical Appendix for details). We evaluated diabetes care process and outcome in adults assigned to the Mississauga Ontario Health Team (OHT) and the entire adult population of Ontario (inclusive of Mississauga OHT). Adults assigned to the Mississauga OHT include (1) those whose primary care physician was assigned to the Mississauga OHT; or (2) those without a primary care physician but resided in a neighbourhood where the majority of residents had a primary care physician assigned to the Mississauga OHT (see Technical Appendix for details). Processes and outcomes of care listed in Exhibit 5.1 were reported for each fiscal year between April 1, 2019 to March 31, 2022. Results were presented for the Mississauga OHT overall and stratified by area of residence (East Mississauga, Southwest Mississauga, Northwest Mississauga, outside Mississauga).

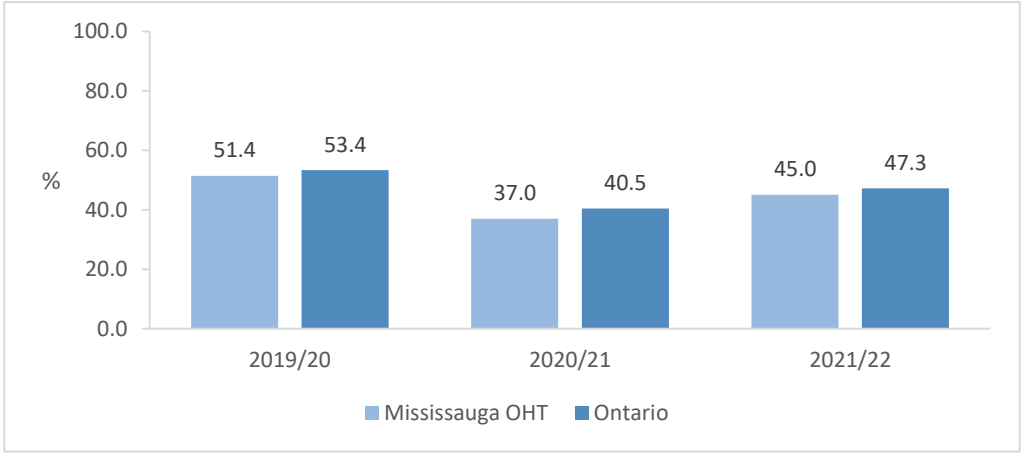
## RESULTS

### *Blood Sugar Monitoring ($HbA_{1c}$ Testing)*

**Key Findings**

- Diabetes Canada's recommended ideal standard for regular blood glucose monitoring ($HbA_{1c}$ testing) was not met in **more than 50% of people with diabetes in the Mississauga OHT.**
- $HbA_{1c}$ testing frequency in the Mississauga OHT was marginally lower than Ontario.
- Within the Mississauga OHT, $HbA_{1c}$ testing frequency was marginally higher among those residing within Mississauga compared to those living outside Mississauga.
- During the peak of the COVID-19 pandemic (2020/21), $HbA_{1c}$ testing frequency dropped by a greater extent in the Mississauga OHT (absolute reduction: 14.5%) than in Ontario (absolute reduction: 12.9%) but partially recovered to pre-pandemic levels in 2021/22.

**A. Blood Sugar Monitoring ($HbA_{1c}$ Testing) in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. Blood Sugar Monitoring (HbA1c Testing) in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

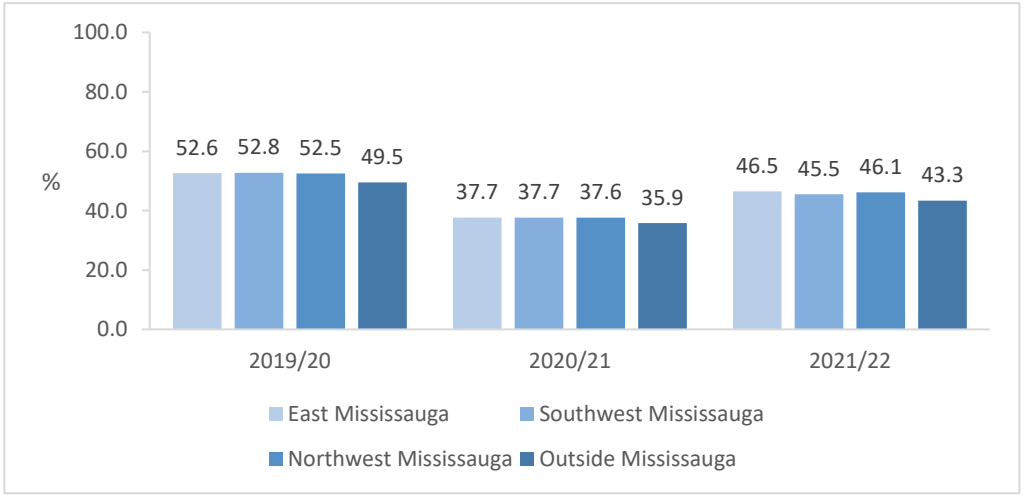


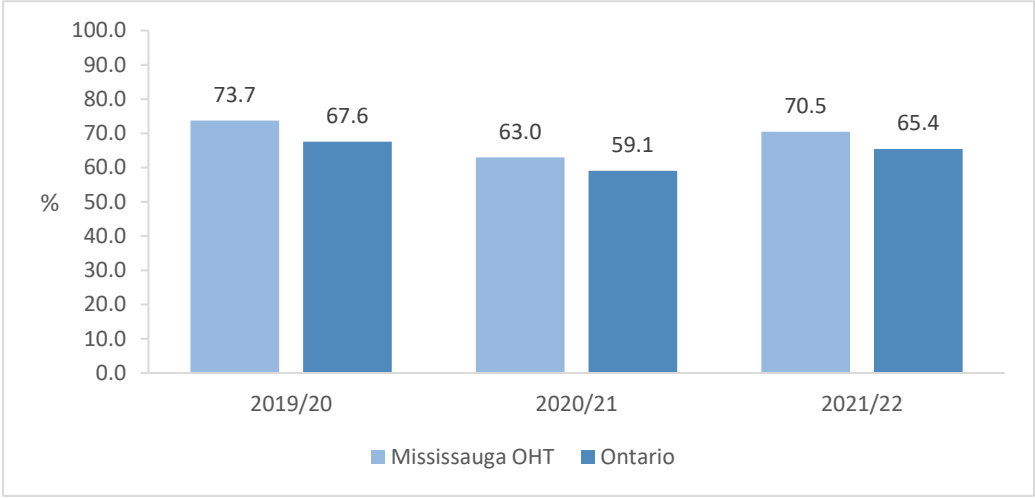

**Exhibit 5.2** Percentage of adults with diabetes (aged ≥40 years) receiving at least two $HbA_{1c}$ tests in the past 12 months.

### *LDL Cholesterol Monitoring*

**Key Findings**

- Diabetes Canada's recommended ideal standard for regular blood cholesterol monitoring (LDL cholesterol testing) was not met in around **30% of people with diabetes** in the Mississauga OHT.
- LDL cholesterol testing frequency in the Mississauga OHT was higher than Ontario.
- Within the Mississauga OHT, LDL cholesterol testing frequency was marginally higher among those residing within Mississauga compared to those living outside Mississauga.
- During the peak of the COVID-19 pandemic (2020/21), LDL cholesterol testing frequency dropped by a greater extent in the Mississauga OHT (absolute reduction: 10.7%) than in Ontario (absolute reduction: 8.5%) but nearly recovered to pre-pandemic levels in 2021/22

**A. LDL Cholesterol Monitoring in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. LDL Cholesterol Monitoring in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

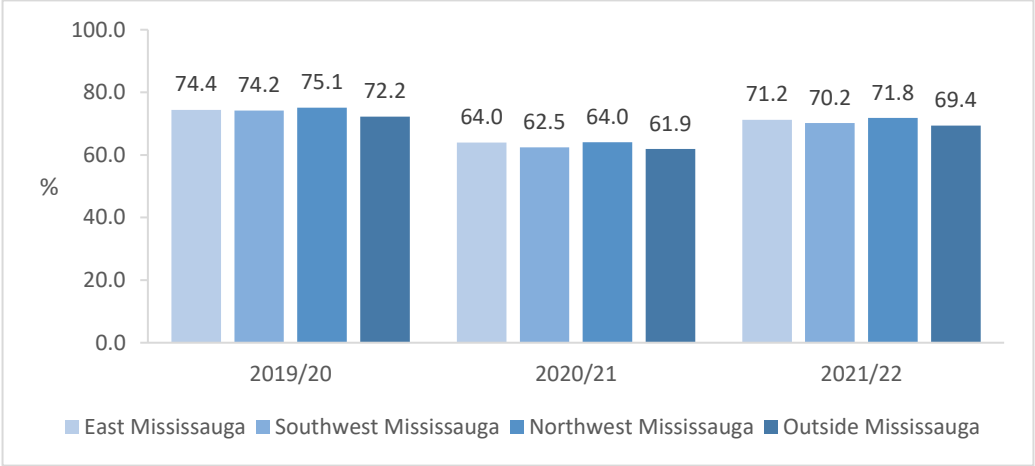


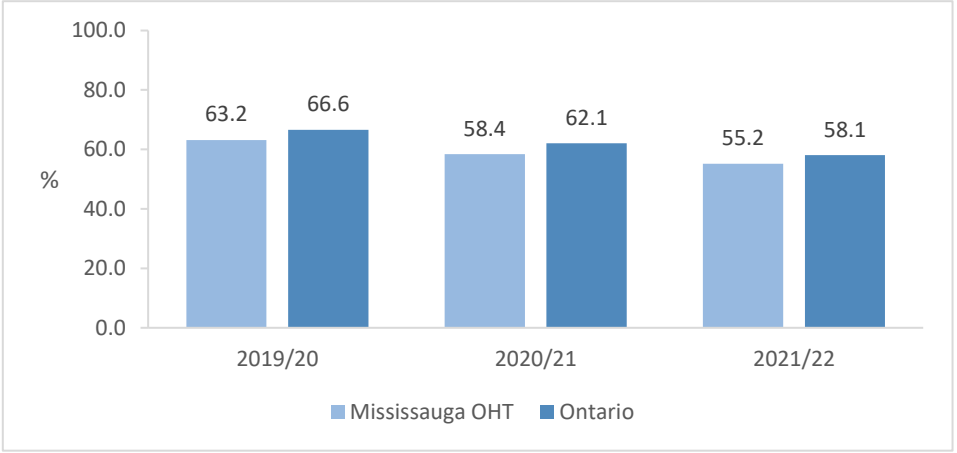

**Exhibit 5.3** Percentage of individuals receiving at least one LDL cholesterol test in the past 12 months among people aged ≥40 years, stratified by year and place of residence.

### *Retinopathy Screening*

**Key Findings**

- Diabetes Canada's recommended ideal standard for regular retinopathy screening was not met in around **45% of people with diabetes** in the Mississauga OHT.
- The proportion of those attending retinopathy screening was slightly lower in the Mississauga OHT than Ontario.
- Within the Mississauga OHT, the proportion of those attending retinopathy screening was higher among those residing within Mississauga compared to those living outside Mississauga.
- During the peak of the COVID-19 pandemic (2020/21), the proportion of those attending retinopathy screening dropped to a similar extent in the Mississauga OHT and Ontario.

**A. Retinopathy Screening in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. Retinopathy Screening in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

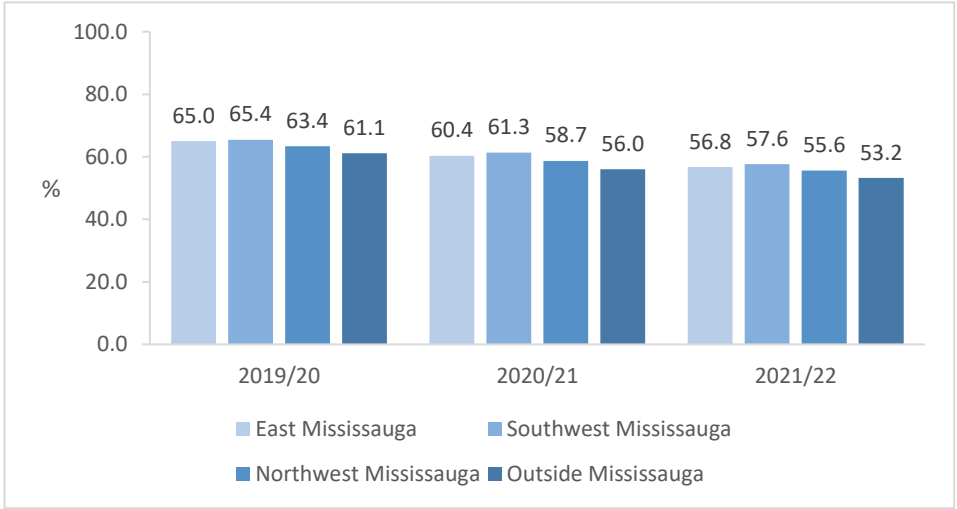


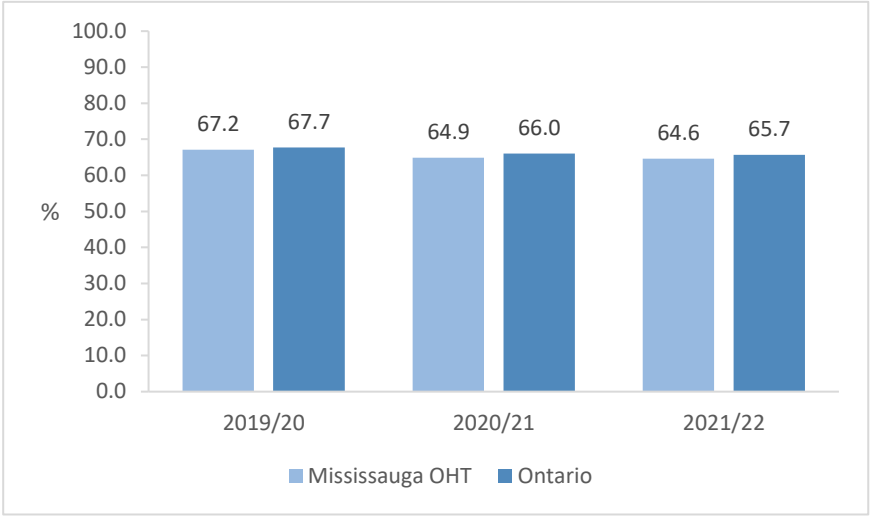

**Exhibit 5.4** Percentage of adults with diabetes (aged ≥40 years) attending screening for eye disease (retinopathy) in the past 24 months, stratified by year and place of residence.

### *Medication Prescriptions*

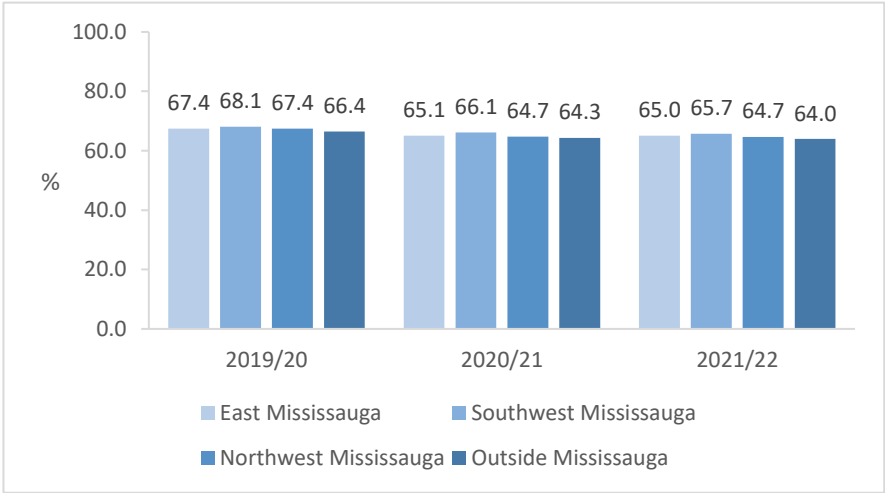
**Key Findings**

- In the Mississauga OHT, 65% and 74% of people with diabetes aged 65 years or older received kidney- and heart-protective medications; these figures fell short of the recommended ideal standard benchmark of 80%, despite these medications being subsidized by the provincial drug benefit plan.
- The proportion of those aged 65 years or older with at least one prescription filled for ACE inhibitor, ARB, or statin was similar in the Mississauga OHT (especially those living in Mississauga) and Ontario.
- During the peak of the COVID-19 pandemic, the proportion of those with at least one prescription filled for ACE inhibitor or ARB dropped more in the Mississauga OHT (absolute reduction 2.3%) than in Ontario (absolute reduction 1.6%).
- During the peak of the COVID-19 pandemic, the proportion of those with at least one prescription filled for statin fluctuated with a slight drop in the Mississauga OHT (absolute reduction 0.8%) and an even smaller drop in Ontario (absolute reduction 0.2%), but has now improved beyond pre-pandemic levels in the Mississauga OHT and Ontario.

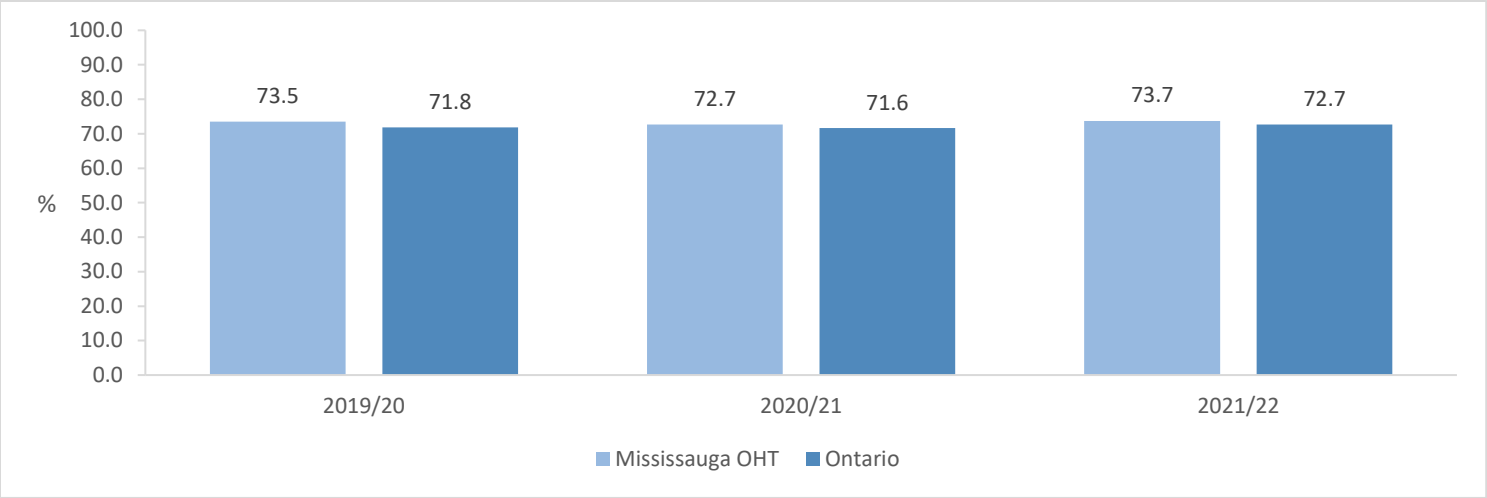
**A. Kidney-Protective Medication Prescriptions in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. Kidney-Protective Medication Prescriptions in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**



**C. Heart-Protective Medication Prescriptions in Adults with Diabetes Aged 65 Years or Older Assigned to Mississauga OHT and the Province of Ontario**




**D. Heart-Protective Medication Prescriptions in Adults with Diabetes Aged 65 Years or Older Assigned to Mississauga OHT, Stratified by Area of Residence**

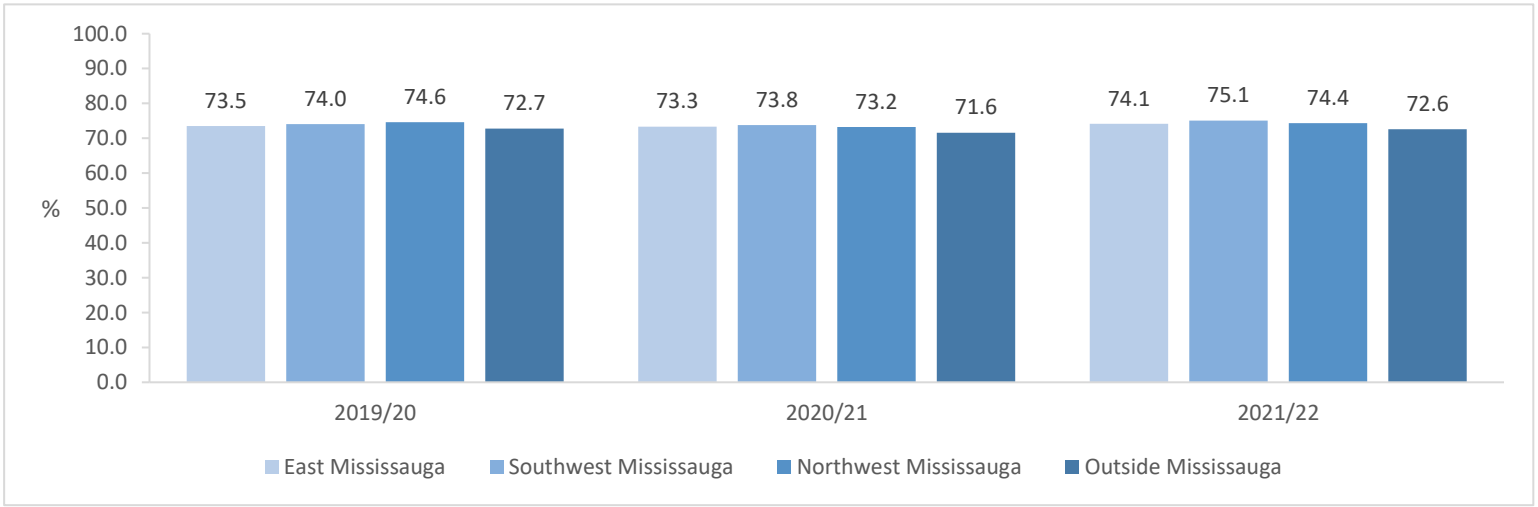


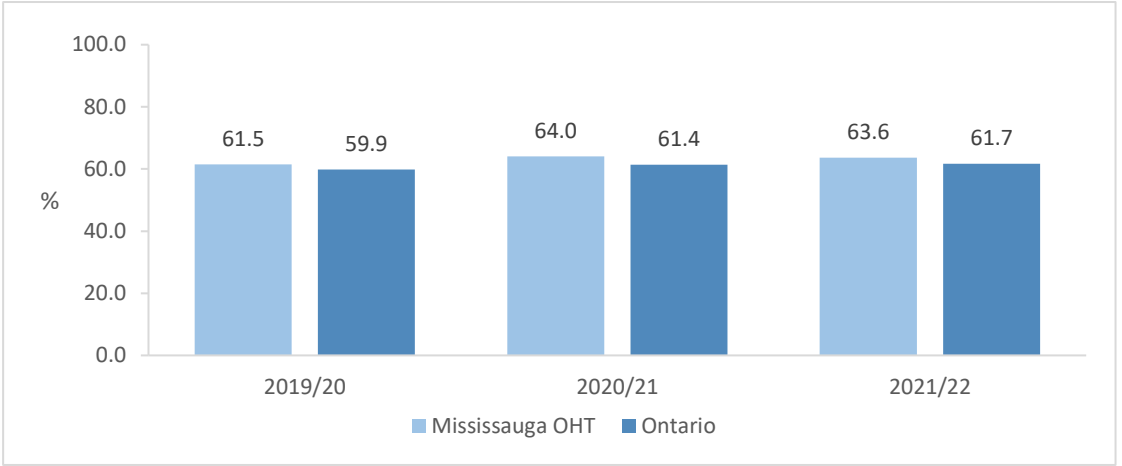

**Exhibit 5.5** Percentage of adults with diabetes (aged ≥65 years) with at least one prescription filled within the past 12 months for (A, B) ACE inhibitor or ARB, and (C, D) statin. Results are stratified by year and place of residence.

### *Blood Sugar on Target*

**Key Findings**

- Nearly 40% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's ideal recommended target $HbA_{1c}$ level.
- The proportion of those achieving $HbA_{1c}$ ≤7% was slightly higher in Mississauga OHT than Ontario.
- Within Mississauga OHT, the proportion of those achieving $HbA_{1c}$ ≤7% was slightly higher among those residing within Mississauga compared to those living outside Mississauga.
- During the peak of the COVID-19 pandemic, the proportion of those achieving $HbA_{1c}$ ≤7% appeared to increase slightly in both Mississauga OHT and Ontario; these proportions remained higher than pre-pandemic levels in both Mississauga OHT and Ontario.

**A. Blood sugar (HbA1c) on Target in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. HbA1c on Target in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

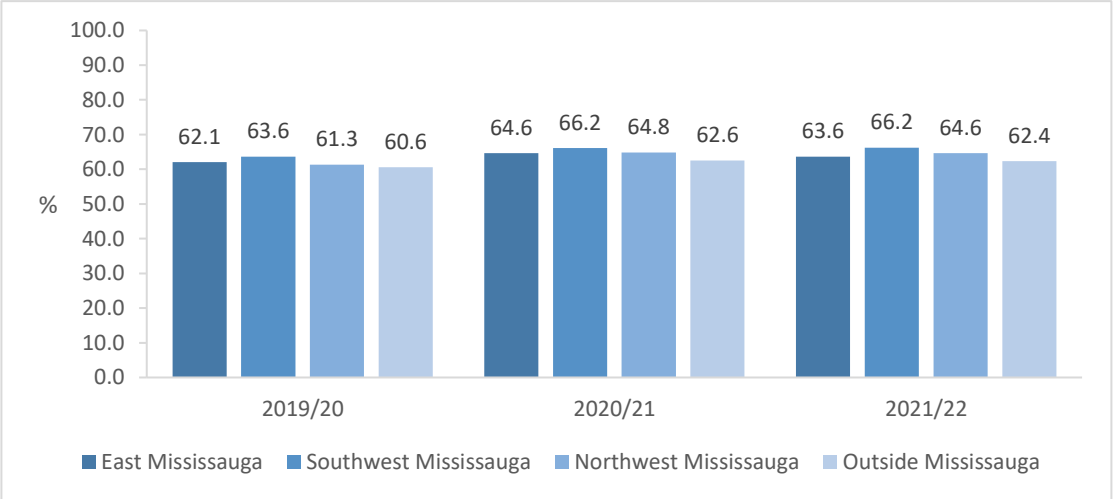



**Exhibit 5.6** Percentage of adults with diabetes (aged ≥40 years) with a mean $HbA_{1c}$ ≤7% among those with at least one test performed,* stratified by year and place of residence.

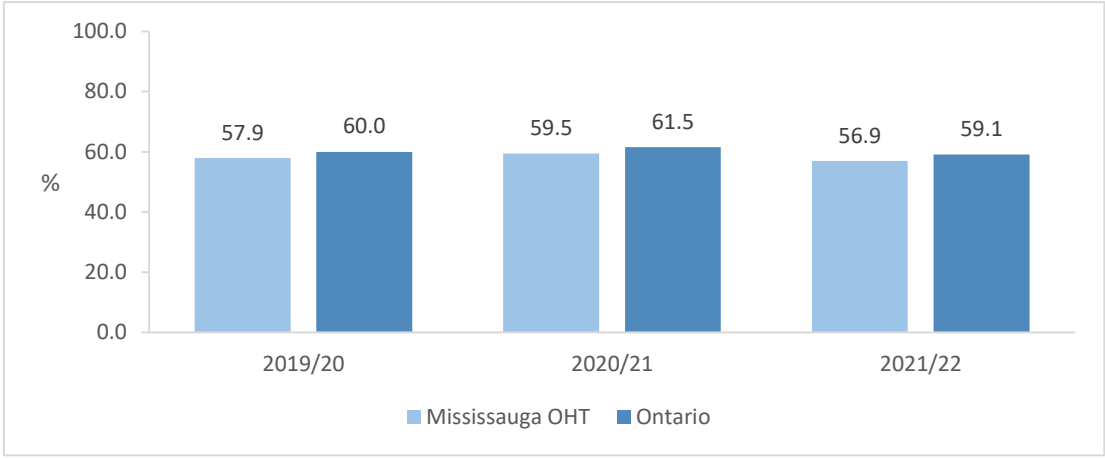
*individuals with missing laboratory tests are excluded

### *Cholesterol on Target*

**Key Findings**

- 43% of people with diabetes in the Mississauga OHT did not meet Diabetes Canada's recommended ideal target cholesterol level.
- The proportion of those achieving LDL cholesterol ≤2 mmol/L was slightly lower in Mississauga OHT than Ontario.
- Within Mississauga OHT, the proportion of those achieving LDL cholesterol ≤2 mmol/L was slightly higher among those residing within Mississauga compared to those living outside Mississauga.
- During the peak of the COVID-19 pandemic, the proportion of those achieving LDL cholesterol ≤2 mmol/L appeared to increase slightly, but this proportion has now dropped to below pre-pandemic levels in Mississauga OHT and Ontario.

**A. LDL Cholesterol on Target in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. LDL Cholesterol on Target in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

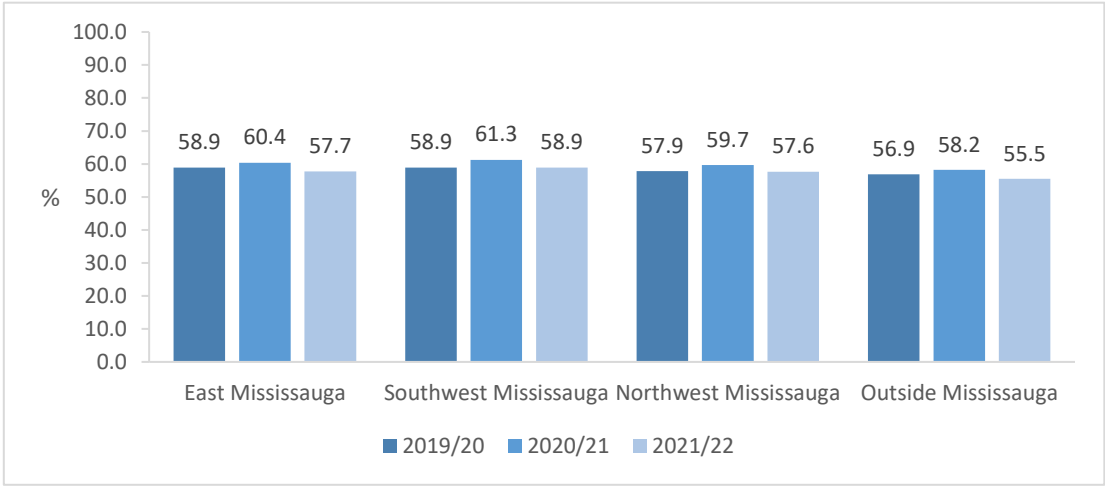



**Exhibit 5.7** Percentage of adults with diabetes (aged ≥40 years) with a mean LDL cholesterol ≤2 mmol/L among those with at least one test performed,* stratified by year and place of residence.
*individuals with missing laboratory tests are excluded

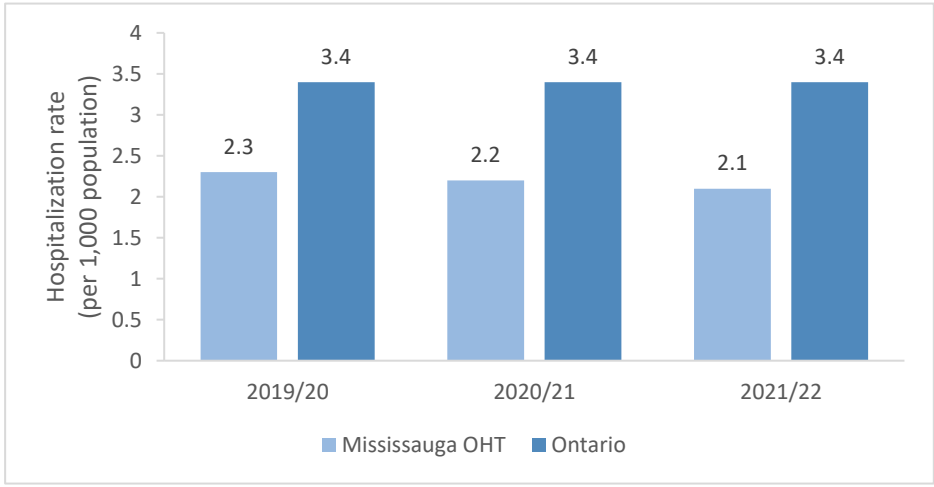
## *Hospitalizations for Complications of Diabetes*

### Key Findings

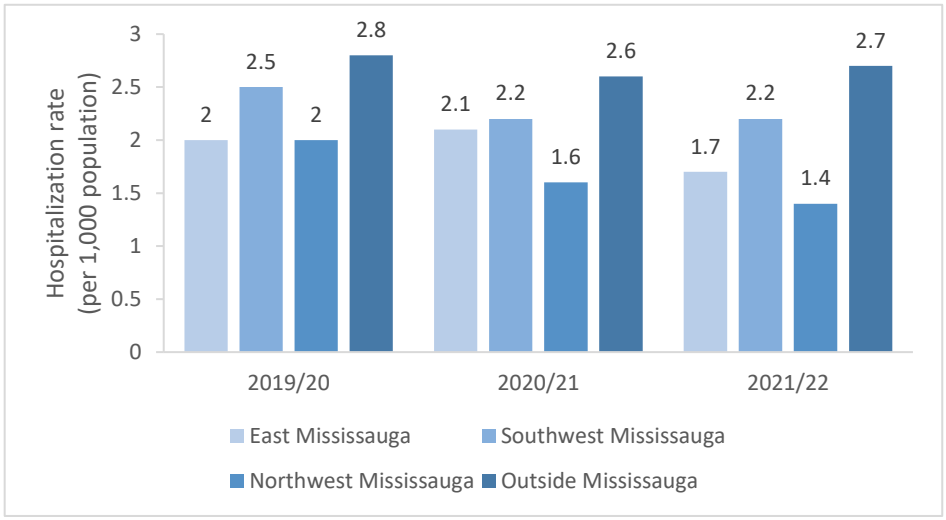
- Hospitalizations for preventable short- and long-term complications* of diabetes, were substantially lower in the Mississauga OHT than Ontario.
- Hospitalizations for long-term complications dropped over time in both the Mississauga OHT and Ontario.

**Short-term complications:* diabetic ketoacidosis, hyperglycemic hyperosmolar state, mixed ketoacidosis, hypoglycemic or insulin coma *Long-term complications*: retinopathy, chronic kidney disease, neuropathy, cardiovascular, or multiple complications of diabetes. All reported rates are crude (not adjusted for age or other factors).

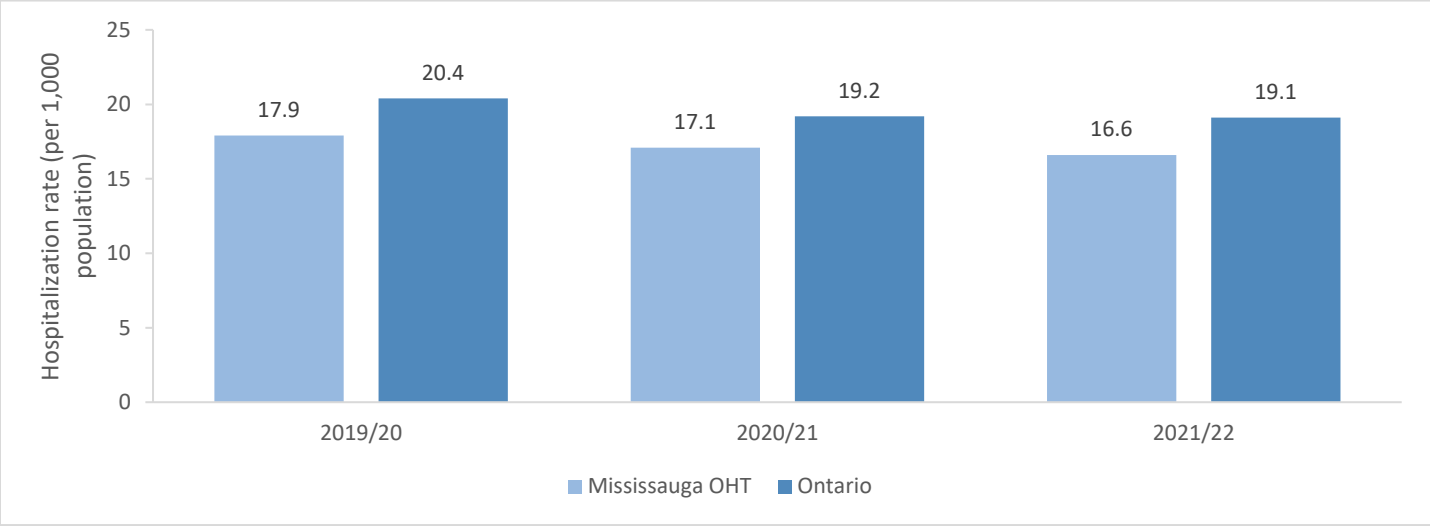
**A. Short-Term Complications* in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**B. Short-Term Complications* in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**



**C. Long-Term Complications in Adults with Diabetes Assigned to Mississauga OHT and the Province of Ontario**




**D. Long-Term Complications in Adults with Diabetes Assigned to Mississauga OHT, Stratified by Area of Residence**

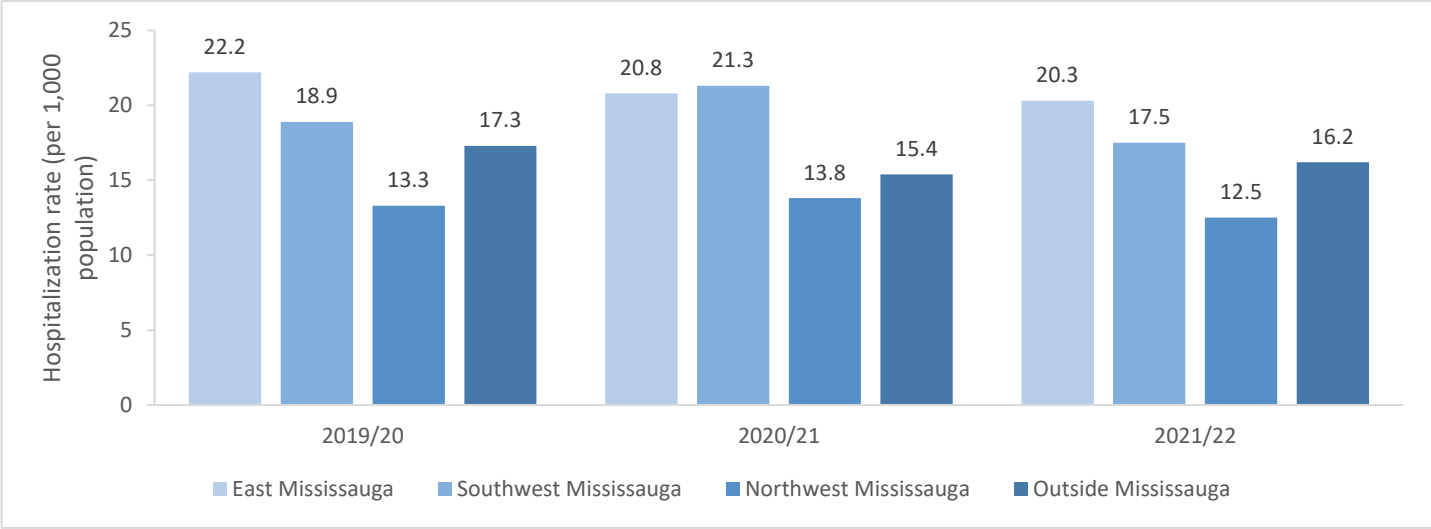



**Exhibit 5.8** Rates of hospitalization (per 1,000 population) of adults with diabetes (aged ≥18 years) for (A, B) short-term complications of diabetes and (C, D) long-term complications of diabetes. Results are stratified by year and place of residence.

## INTERPRETATION

### *Summary of Findings*

In the Mississauga OHT, overall diabetes process and outcome of care indicators were achieved in around half to two-thirds of adults with diabetes, respectively, while 2 and 17 per 1,000 people with diabetes were hospitalized for short- or long-term complications. These findings demonstrate substantial gaps in meeting recommended standards of diabetes care for people with diabetes in the Mississauga OHT. Further research is needed to identify those groups who are more likely to experience disparities in diabetes care and outcomes in the region.

The proportions of individuals achieving care indicators in Mississauga OHT are comparable to or better than those previously reported in other populations. For example, the proportion of patients who achieved target levels for blood glucose and cholesterol was higher in Mississauga OHT than reported among adults of a similar age group in five Canadian provinces and in the US.[10,11] The use of heart- and kidney-protective medications in the Mississauga OHT also exceeded the US and five Canadian provinces, although we only had data on those aged ≥65 years, thus limiting direct comparisons.[10,11]

The quality of diabetes services in the Mississauga OHT is broadly similar to that in Ontario. The frequency of blood cholesterol testing in the Mississauga OHT was marginally better than in Ontario, yet marginally worse for $HbA_{1c}$ testing (which we defined as requiring two tests per year) and for screening for eye disease. For persons 65 years or older with diabetes, prescriptions for heart- and kidney-protective medications, including ACE inhibitors, ARBs, and statins, were similar across the Mississauga OHT and Ontario. We note that the proportion of seniors who filled these prescriptions fell short of the recommended benchmark despite these medications being subsidized by the Ontario Drug Benefit Plan. Hospitalization rates for short-term and long-term complications among adults with diabetes were modestly less common in the Mississauga OHT than in Ontario. These differences may be driven in part by a younger age distribution in the Mississauga OHT compared to Ontario. Within the Mississauga OHT, those living within Mississauga generally appeared to have more favourable indicators than those living outside Mississauga.

Of all the outcomes examined, laboratory testing and eye examinations appeared to be the most negatively impacted during the peak of the COVID-19 pandemic. Yet, despite the decrease in laboratory testing in 2020–2021, blood glucose and cholesterol levels appeared to improve slightly during this period. This pattern may suggest that those who were able to undergo laboratory tests during the pandemic were those who tended to be managing better with their condition—thus reflecting how health inequities were exacerbated during the peak of the COVID-19 pandemic. Frequencies of laboratory testing and eye examinations continued to fall short of pre-pandemic levels in 2021/22. The peak of the COVID-19 pandemic was also associated with small fluctuations in the filling of prescriptions for heart- and

kidney-protective medications and a greater reduction in hospitalization for long-term complications than for short-term complications.

### *Limitations*

We were unable to capture some outcomes, such as prescriptions for adults aged <65 years and processes of care and treatment targets for blood pressure, due to limitations of the data sources. We also lacked data on people living in Peel Region who were not part of the Mississauga OHT. Our analyses were descriptive at this preliminary stage, and we were unable to explore differences based on primary care model, sociodemographic factors, or other potential variables that might influence quality of diabetes care. Finally, we lacked data on patient-reported outcomes.

### *Implications and Future Directions*

These rich preliminary data suggest that the quality of diabetes care in the Mississauga OHT and in Ontario in general falls far below the ideal standards of care recommended by the Diabetes Canada *Clinical Practice Guidelines*. Additional analyses are needed to provide further insights into reasons for the patterns observed and variability by sociodemographic and health care factors. Considering Peel Region's relatively younger age distribution and the high complication risks associated with developing diabetes at younger ages, we will aim to determine how these indicators differed across younger and older adults. We will also conduct further analyses to explore why some indicators, especially hospitalization for complications, appeared to be better in the Mississauga OHT than in Ontario. For example, Peel Region has a large South Asian population, and it has been hypothesized that South Asians may develop a form of diabetes that results in a lower incidence of cardiovascular complications.[12,13] Future analyses may help disentangle the contributions of factors such as ethnicity, immigration, socioeconomic status, and geography to the observed differences in these baseline indicators.

Interventions are needed to address existing gaps in processes and outcomes of care, and our data might inform how interventions could target these gaps in Mississauga OHT. Serial measurement of these indicators could reliably track the impact of future interventions as they are implemented over time. Successful interventions in Mississauga OHT could then be scaled up to address similar gaps across the province of Ontario. For example, in Hong Kong, the use of a structured assessment tool and personalized report that provided tailored feedback was associated with greater likelihood of achieving risk factor management targets and decreased risk of complications.[14,15] This intervention was initially developed in Hong Kong as a local initiative at a single hospital, and evidence of effectiveness motivated the intervention's gradual scale-up across the entire territory with a population of 7.4 million people.[16]

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# CHAPTER 6: CONCLUSION


## AUTHORS

Fatema M. Ali

Ghazal S. Fazli

Lorraine L. Lipscombe

## OVERVIEW

This report presents the current risk and burden of type 2 diabetes in the Peel Region to understand the impact of several upstream, macro (built environment), meso (health behavioural and community-level risk factors), as well as downstream, micro-level indicators (quality of care) that contribute to the rising prevalence and incidence of diabetes in Peel. The findings in this report are a first step in identifying and informing future research and policy priorities and actions necessary for reducing the burden of diabetes in the region.

## KEY FINDINGS

**1. Understanding How to Create Healthy Environments in the Peel Region (Macro Level):**

Across the Peel Region, our findings demonstrate considerable variation in several neighbourhood characteristics explored in this report, including access to green space, transit, walkability, fast food, housing, air quality and housing needs. For neighbourhood walkability, several neighbourhoods in Peel are low-density neighbourhoods with few walkable destinations, and these areas may lead to fewer opportunities for walking, cycling and other forms of active transit. However, there is relatively good access to public parks and greenspace throughout the region. The extent to which residents can and do access these greenspaces must be explored further.

In addition, access to frequent transit is present only in certain parts of the regions (i.e., along the lakeshore and in central areas of Mississauga and Brampton) and completely absent in others (i.e., Caledon). This creates a significant barrier to active transportation as an alternative to automobiles. The spread of other neighbourhood characteristics associated with diabetes risk (i.e., unhealthy food options such as fast foods and unmet housing needs) is also highly variable across the region. This is an important area that requires further investigation to disentangle how these neighbourhood effects are driving diabetes risk and among whom.

Additionally, poor air quality is highly concentrated in communities surrounding the airport and major transportation routes, which warrants a closer look into urban design policies and their health impacts on the populations. In areas where diabetes prevalence appears to be very high, there are one or more neighbourhood characteristics that make it challenging to adopt healthy behaviours. In summary, the spatial overlap between key environmental indicators and diabetes rates underscores the importance of assessing a range of social and environmental characteristics that individually and collectively affect risk of diabetes. Therefore, our findings suggest that there is much to be explored more closely to understand

how these neighbourhood characteristics can be understood further and to investigate the effectiveness of urban planning and policy interventions to create supportive environments that promote healthy living and meet the community's diverse needs.

**2. Understanding the Patterns and Factors that Impact Healthy Living and Behaviours (Meso Level):**

Over half of the population in Peel Region is represented by those who identify as a visible or ethnic minority, and nearly three-quarters of those living with diabetes were immigrants to Canada. In addition, social disadvantages due to low socioeconomic status and food insecurity, and overweight/obesity and physical inactivity were highly prevalent risk factors for diabetes burden among residents in Peel Region.

The 10-year risk of developing new diabetes for residents of Peel Region overall is 11.5%; with an additional 102,000 adults older than 20 years of age estimated to be living with diabetes by 2028. Populations with one or more risk factors are also those who are most likely to develop type 2 diabetes over the next ten years in Peel Region, as elsewhere. In addition to older age groups, persons who identify as visible or ethnic minorities or immigrants, persons with a low household income and experiencing food insecurity, and persons who reported being overweight or obese and physically inactive have the highest risk of developing diabetes.

Therefore, in the ensuing years, new cases of diabetes in Peel are projected to increase rapidly, particularly among those experiencing a greater degree of social disadvantage and inequities in leading healthier lives. Also, the future risk of diabetes is disproportionately elevated among visible minorities and immigrant groups. These findings are important to prompt future research and policy interventions to target these modifiable risk factors to reduce the impact of rising diabetes cases on populations and health care systems as well.

**3. Chronic Disease Care within Mississauga (Micro Level):**

Between 2019 and 2022, the quality of diabetes services in the Mississauga Ontario Health Team (OHT) fell short of guideline recommendations on some key indicators. Less than 60% of patients with diabetes received recommended cholesterol and eye testing, less than half had recommended diabetes testing, and just under two-thirds met targets for diabetes and cholesterol control. These trends were broadly comparable to those seen for Ontario as a whole, with some indicators showing greater differences than others. The COVID-19 pandemic had a more negative impact on laboratory testing in the Mississauga OHT than in Ontario. Within the Mississauga OHT, those living within Mississauga generally appeared to have more

favourable indicators than those living outside Mississauga.

Hospitalizations for short-term and long-term complications were less common in the Mississauga OHT than in Ontario. These differences may be driven in part by a younger age distribution of people with diabetes in the Mississauga OHT compared to the rest of Ontario. There was a larger reduction in hospitalizations for long-term complications than for short-term complications associated with the COVID-19 pandemic. The impact of policy interventions to address gaps in health services and quality of care can be reliably measured over time using a variety of indicators.

## FUTURE DIRECTIONS

Peel's population is heterogeneous and ethnically and culturally very diverse. This offers a unique opportunity for future research and policy interventions to collaborate with community partners across different sectors and agencies and engage with patients and community members in all stages of the research and policymaking process to understand how we can intervene early and identify sustainable, effective, and equitable solutions for diabetes prevention and management that will impact the quality of life of those living in Peel and beyond.

These efforts require a deeper understanding of the needs of local residents and their perceptions of their neighbourhood environment to identify interventions that will meaningfully promote healthy living. This step is vital to understand the meanings and implications of these findings for the community and to co-create knowledge to determine 'research needs and scope,' 'what intervention and prevention strategies are necessary', 'what works for whom,' and 'under what local contexts'.

Such engagements with relevant decision-makers across different sectors and agencies and representations are integral for current and future diabetes research and policy efforts to collectively identify multi-faceted approaches to addressing the projected risk of diabetes in the Peel Region. Moreover, future policy interventions must consider the interconnected nature of the many socioeconomic disadvantages that drive diabetes risk and identify prevention strategies that target the macro, meso, and micro-level determinants of diabetes explored in this report. The benefits of introducing effective approaches to prevention will extend beyond diabetes to reduce risk of other obesity-related conditions such as hypertension, some cancers, gallbladder disease and osteoarthritis.

## NEXT STEPS

NHP aims to continue to understand the burden of diabetes and chronic disease in the Peel Region through a series of key next steps. We aim to further build and develop the preliminary work showcased in this report and ensure that the findings are shared with the community and applied in our upcoming NHP Catalyst grant.

**Baseline Data Strategy Phase 2**: The research streams of this report each focus on a specific level of diabetes and chronic disease burden – from the health care system to communities to living environments. Efforts within each stream overlap and interconnect to address the overall goal of reducing the risk and burden of diabetes and related conditions for healthier populations in Peel Region and beyond.

As the aim of this report was to describe the problem, the next phase will be to identify causes and factors that are contributing to the problem and to map areas of greatest need. Phase 2 of the Baseline Data Strategy, beginning in 2023, will leverage the team's foundational report to support the development of further co-designed research projects. The Network will support additional analyses to identify priorities and unmet needs for the prevention and care of diabetes and other chronic diseases within the region, build on existing or planned initiatives, and leverage resources. Interventions may include community programs, education and outreach initiatives, urban re-design, or new policies. Furthermore, the Network is dedicated to training and preparing the next generation of health leaders to address the rising risk and burden of diabetes and other chronic diseases. Therefore, a key aspect of phase 2 of the Baseline Data Strategy is to build capacity for this research by including undergraduate, medical/health professional students and graduate students in participating and leading key projects.

# TECHNICAL APPENDIX


## AUTHORS

Chris Kenaszchuk

Ghazal S. Fazli

Sarah M. Mah

Calvin Ke

Laura C. Rosella

Ian S. Zenlea

Baiju R. Shah

Lorraine L. Lipscombe

# TECHNICAL APPENDIX

This appendix provides definitions, data sources, and methods for report chapters 2 to 5.

## Comparisons Involving Regional and Sub-Regional Geographies

The report contains geography-based diabetes comparisons where higher-level regions are compared with subregions. The purpose is to enable a comparison between a subregional statistic and an expected statistic. Some examples are Peel Region compared with Ontario overall, and Peel public health data zones compared with Peel Region overall. Indicator statistics that were calculated for the higher-level region are based on retaining the comparison subregion's data and using all of the data points, i.e., pooling data about a comparison subregion with data about the other subregions in the higher-level region. Consequently, statistics for higher-level regions and comparison subregions, were not calculated from fully independent samples, i.e. there is a small amount of data overlap between subregions and higher-level regions. We note that hypothesis testing for geography-based comparisons in this report were not used.

## Chapter 2: Overview of Diabetes Burden in the Peel Region

### Definitions

#### Ontario Health Team (OHT)

An Ontario Health Team is a group of healthcare providers and organizations that self-organize to work as a coordinated team. There are 54 Ontario health teams operating across the province. Four more teams are expected to be approved.[1]

Some of the core component activities of Ontario health teams are to:[2]

- provide a full and coordinated continuum of care within a geographic region
- offer patients round-the-clock access to care coordination and system navigation services
- ensure patients experience seamless transitions throughout their care journey
- improve performance in outcomes like patient and population health; patient, family and caregiver experience; provider experience; and value.

### Peel Public Health Data Zones (PHDZ)

Peel public health data zones (PHDZ) are regions that are used to report health status data and are small enough to be helpful for planning programs and services. PHDZs are contiguous surface areas that are based on census tract boundaries of the 2016 Census. PHDZ boundaries respect census tract boundaries (i.e., PHDZs do not split census tracts). When possible, PHDZ boundaries also respect natural and man-made boundaries such as rivers, highways, and municipal boundaries. PHDZ boundaries and enclosed areas lie entirely within one municipality and are never split across the three municipalities. There are 39 PHDZs with populations that range from 22,900 to over 103,100 people. [3]

### Age Standardized Rate

Age is an important determinant of health and health-related patterns seen across populations. Comparing crude rates for two or more different populations is problematic because the underlying age distributions of the populations may be different and in turn, lead to differences in disease rates. For example, death rates from cancer are lower in young people than in old people. If crude cancer death rates were compared between a region that has a higher proportion of young people and a region that has a higher proportion of older people, the rate difference between the regions will likely reflect differences in age rather than other factors that might be of interest. Therefore, standardized rates are used to facilitate comparisons between two or more populations with different age structures. Standardization can also be used to account for differences based on other characteristics as well, such as different geographic areas or years.[4]

### LICO-AT

LICO-AT is the Statistics Canada low-income cut-offs, after tax. Statistics Canada[5] defines thresholds below which families or persons not in families would probably spend a larger share of their after-tax income than average on food, shelter, and clothing. If after-tax income of a family or person is below the threshold applicable to them, then the family or person is considered to be in low income according to LICO-AT.

### After-tax Income

Statistics Canada[6] provides the following definition:

> "After-tax income refers to total income less income taxes of the statistical unit during a specified reference period. Income taxes refers to the sum of federal income taxes, provincial and territorial income taxes, less abatement where applicable. Provincial and territorial income taxes include health care premiums in certain jurisdictions. For the 2021 Census, the reference period for income data is the calendar year 2020, unless otherwise specified."

### Recent Immigrant

Statistics Canada[7] provides the following definition:

> "An immigrant refers to a person who is, or who has ever been, a landed immigrant or permanent resident. Such a person has been granted the right to live in Canada permanently by immigration authorities. Immigrants who have obtained Canadian citizenship by naturalization are included in this group.
>
> A recent immigrant refers to a person who obtained landed immigrant or permanent resident status up to five years prior to a given census year. In the 2021 Census, this period is January 1, 2016, to May 11, 2021. Information on the age at immigration is derived from the immigrant's date of birth and year of immigration."

### Persons in One-Parent Families

Statistics Canada[8] defines one-parent families as families with a single parent and their child(ren). Such families do not have a married spouse or common-law partner, however other relatives may be present. Families are considered as those live in the same dwelling that are related to each other by blood, marriage, common-law union, adoption or a foster relationship.[9]

### Persons in Private Households Living Alone

Statistics Canada classifies those living alone as a household living arrangement that is distinct from those that include other relatives and/or non-relatives.[10] Private households are made up one or more individuals living in the same dwelling[11]

## Data Sources

### Institute for Clinical Evaluative Sciences

The Institute for Clinical Evaluative Sciences (ICES) is an independent, non-profit research organization. ICES collects, manages, maintains, and provides population-based health and social data to support research on health issues in Ontario and Canada. This report relied on several databases that are accessible through ICES. [12]

### Ontario Community Health Profiles Partnership (OCHPP)

The Ontario Community Health Profiles Partnership (OCHPP) creates and provides detailed health profiles about Ontario communities in formats that are both timely and user-friendly. The organization makes available to the public high-quality, community-level health data that would not otherwise be publicly accessible. Key health indicators are carefully selected

based on relevance to reducing health inequalities, quality, and consistency with user-identified priorities, and are developed in coordination with other information providers to supplement existing community profile initiatives. [13] The indicators are derived from population-based health datasets, de-identified patient records, and clinical and administrative databases, and are available for geographic areas and by sociodemographic characteristics.[14]

### Ontario Diabetes Dataset (ODD)

The Ontario Diabetes Dataset (ODD)[15] is a population-based registry that contains all individuals in Ontario having any type of nongestational diabetes identified since 1991 to December 30, 2020. The database was created using hospital discharge abstracts, Ontario drug benefit claims, OHIP physician service claims, and demographic information about the persons eligible for health care coverage in Ontario. Patients entered the database if they were 19 years of age or older and at least one of the following criteria were recorded about them: (1) two physician claims with diabetes-specific fee codes occurring within 1 year in the OHIP claims[16] database, or (2) one or more claims for a drug related to diabetes mellitus (insulin or an oral anti-glycemic) in the Ontario Drug Benefit[17] database, or (3) a diabetes diagnostic code in a Discharge Abstract Database.[18] The validity of the case identification algorithm was established recently.[19]

### Postal Code Conversion File (PCCF)

The Canada Post Corporation has assigned approximately 900,000 six-character postal codes in Canada. [20] The Postal Code Conversion File (PCCF) is a digital file. It provides a geocoded link between postal codes and Canadian geographic areas that Statistics Canada produces census data and other statistics for. By linking postal codes and data about geographic areas, the PCCF permits data from different sources to be integrated. Integrated data can be used for research, planning, and marketing purposes.

### Region of Peel

The Region of Peel provided definitions and map boundaries of Peel Health Data Zones.

### Registered Persons Database (RPDB)

The Registered Persons Database[21] provides basic demographic information about anyone who has ever received an Ontario health card number. The information includes sex, date of birth, age, residential address, changes in OHIP eligibility, and date of death. Core data are supplied by the Ontario Ministry of Health and augmented with information from other data sets held by ICES. One limitation to note is that data in the ICES-linked RPDB are enhanced at ICES by using a probabilistic linkage between the core RPDB and the Ontario Registrar General's database. The probabilistic nature of the procedure causes

information on a small number of deaths to be unmatched and omitted from the ICES-linked RPDB. Consequently, the RPDB could fail to identify some people as decedents when the inclusion criterion of 'alive' was used to select cohort cases.

**Methods**

Exhibit 2.1 is a map displaying age-standardized diabetes prevalence (per 100 population) for 39 Peel Region public health data zones.

In the prevalence calculation, the numerator – persons aged 20 and over with diabetes – derived from the Ontario Diabetes Dataset 2020. The denominator – persons who were alive and living in Ontario on April 1st, 2019 – is derived from the Ontario Ministry of Health's Registered Persons Database. The OCHPP excluded people with no health system contact for the previous ten years because many of them would no longer be alive and living in Ontario.

To generate population counts for PHDZs, the OCHPP aggregated postal code-level data into Statistics Canada dissemination areas (DAs), and then allocated the data to PHDZs. The OCHPP used Postal Code Conversion File Plus (PCCF+), Version 7A, June 2017.[22]

# Chapter 3: Built Environment and Diabetes

We first describe the data source, derivation, and limitations of each measure presented in this chapter, as each is unique to the environmental characteristic under study. Thereafter, we describe the methodology used to assess spatial variations across Peel, as well as the spatial relationship between environmental characteristics and diabetes rates.

**Measures, Data Sources, and Derivations**

***Neighbourhood Design***

The *Canadian Active Living Environments (Can-ALE) database* is a national set of four individual measures and four summary measures which describe the favourability of neighbourhoods for active living in Canadian communities at the level of the dissemination area (DA). The analyses that guided the selection of measures, data sources, and the methodological approaches for the measures' derivation have been previously described.[23] We selected the composite clustered score that is composed of features related to how well-connected the street network is, residential density, and the number of walkable destinations using 2016 data, which has been shown to correlate with active transportation use, walking, and other health-related outcomes. [24] [25] [26]

**Data Sources**

- Dwelling density: Census 2016 housing data
- Intersection density and points of interest: OpenStreetMap (OSM) Provincial Extracts.

**Derivation**

The measures were derived using ArcMap v10.5 and PostGIS v2.3, which is a geographic information system extension for the PostgreSQL object-relational database management system. Circular (Euclidean) buffers of radius 1000 meters were drawn around the centroids of dissemination areas. The street connectivity component of the measure was derived by calculating three-way intersection density using OpenStreetMap intersections of roads, footpaths and recreational trails, and excluded roads that were of limited access to pedestrians, e.g., highways, freeways. The residential density component of the measure was derived using weighted dwelling density derived from Statistics Canada dwelling counts. Neighbourhoods were grouped into five classes using a *k*-medians clustering algorithm, an iterative process that assigns dissemination areas to a group by minimizing within-group median values and maximizing between-group median values. Five classes ranging from very unconducive (Active Living Environment class 1) to very conducive to active living (Active Living Environment class 5) were used.

***Parks and Natural Environments***

The *proximity of residents to parks and greenspaces* measures the percentage of residents living within a 400-meter network walking distance to any park or conservation area that either contains an active recreation feature (e.g., a playground) or pedestrian infrastructure (e.g., a trail or path). Conservation areas that require paid parking were included in the measure, as payment is only required for automobile parking and not pedestrian entry. Paid-entry green spaces, such as golf courses, are not included in this metric.

**Data Sources**

- Municipal 2018 datasets on parks, conservation areas, active recreation sites, and trails, using information provided by the Town of Caledon, the City of Brampton, the City of Mississauga, the Region of Peel, Credit Valley Conservation, and the Toronto and Region Conservation Authority
- Region of Peel Single-Line Street Network 2016 (SLSNPEEL).

### Derivation

The derivation of this indicator has been described previously[27] and was performed in the geographic information system application ArcGIS Desktop 10.2. In brief, park and greenspace features without active recreation amenities or trails were filtered out of the source datasets to eliminate features within the parks dataset that have restricted pedestrian access. Next, access points for parks and conservation areas were created to determine where pedestrians can access parks and conservation areas that contain a trail feature or network. These access points were then loaded as 'facilities' in a service area layer created from the 2016 Region of Peel Pedestrian Network. Buffer polygons around park access points to a specified distance were created to determine which areas fall within a defined service area catchment of a park access point. The indicator is calculated by dividing the total residential area within the parks and green space service catchment for a dissemination area by the total residential area of the dissemination area, and then multiplying the result by the population for the dissemination area.

#### *Transportation*

The *proximity of residents to frequent transit stops* was derived by Peel Public Health to measure the percentage of population that resides within a five-minute (400 meter) network walking distance to a municipal transit stop, and/or a 10-minute (800 meter) network walking distance to a GO Transit bus or rail stop with frequent service. Frequent service was defined as a transit stop averaging 15-minute headways during peak hours (6:00 a.m. to 9:00 a.m., and 3:00 p.m. to 6:00 p.m.) and 30-minute headway during non-peak hours (9:00 a.m. to 3:00 p.m., and 6:00 p.m. to 12:00 p.m.).

### Data Sources

- Population Data: Census 2016
- Transit stops with frequent service: General Transit Feed Specification (GTFS) feeds for Mississauga (MiWay; June 30, 2016 to September 4, 2016), Brampton (Brampton Transit; May 9, 2016 to September 5 2016), and GO Transit (June 25, 2016 to September 2, 2016)
- Transit stop location: Mississauga (MiWay), Brampton (Brampton Transit), and GO Transit, 2016
- Proximity: Pedestrian Accessible Single-Line Street Network 2016. Includes trails and other pedestrian infrastructure and excludes highways.

### Derivation

The derivation of this indicator has been described previously[27] and was performed in ArcGIS Desktop 10.2. First, GTSF data were used to determine which transit stops fulfilled the criteria for frequent service as defined above. Transit stations located outside of Peel Region were removed prior to calculating the transit service area. Next, valid access points for train stations were created and added to the dataset. These transit stops and train station access points were loaded as 'facilities' in a service area layer created from the 2016 Region of Peel Pedestrian Network. Buffer polygons around transit points to a specified distance were created to determine which areas fall within a defined service area. The indicator is calculated by dividing the total residential area within the frequent transit service catchment for a dissemination area by the total residential area of the dissemination area, and then multiplying the result by the population within the geographic unit.

### *Food Environment*

The *Canadian Food Environment Dataset (Can-FED)* is a national dataset of retail food environment measures that includes relative food outlet proportions and densities of different retail food outlet types.[28] We selected the 5-class clustered measure of the proportion of fast-food and full-service restaurants (also known as $R_{mix}$) as our indicator of interest.

### Data Sources

- Food outlet data: Statistics Canada Business Register, a central repository of baseline information on businesses operating in Canada.

### Derivation

The analyses that guided the selection of measures, data sources, and the methodological approaches for the measures' derivation have been previously described.[29] Briefly, food outlets were extracted from the Statistics Canada Business Register using North American Industry Classification System (NAICS) codes. The codes identify the primary function of a business and can be used to classify the primary business function of companies and enterprises. Food outlets were extracted if they had an operating outlet as of July 2018 and if the NAICS code associated with the outlet indicated that it was a type of retail food outlet. Food outlets were then classified based primarily on NAICS codes and in some cases, further classified using a name-based assignment method that included keyword searches, e.g., "burger" or the name of a chain restaurant that may be further classified as a *fast-food outlet*. Outlets were then imported into ArcMap based on latitude and longitude geocoded location from the Business Register. We chose to focus on the measure generated using 1-kilometer buffers generated from the population-weighted centroid of each dissemination area, representing a 10−15-minute walk from the dissemination area

to a food outlet. Point features for the food outlets were joined to the buffers, and the number of outlets located within each buffer was summed for each food outlet. The fast-food restaurant mix ($R_{mix}$) was calculated as the proportion of fast-food restaurants relative to fast-food and full-service restaurants combined. Five categories were created (0, and groups 1−4) by setting aside scores of zero as a separate category and using a *k*-medians clustering approach to create the four remaining categories of densities for each outlet type. Group 1 represents the lowest non-zero densities of fast-food outlets while group 4 represents the highest densities of fast-food outlets.

### *Housing*

The *core housing need* measure is a 2-stage indicator developed by the Canada Mortgage and Housing Corporation (CMHC) to identify households living in dwellings considered unsuitable, inadequate or unaffordable. Core housing need takes account of whether the household's income level is sufficient to obtain alternative suitable and adequate housing in the community. For a household to be in core housing need, it must fail to meet at least one of three housing standards. They include adequacy, affordability, and suitability standards; and the household would have to spend 30% or more of its total before-tax income to pay the median rent of alternative local housing that meets or exceeds all three housing standards.

**Data Sources**

- Canadian Census 2016
- Canadian Income Survey
- Canadian Housing Survey

**Derivation**

First, a determination was made on whether a household dwelling is adequate, suitable, and affordable. Housing was deemed adequate if the dwelling does not need major repairs for problems like defective plumbing or electrical wiring, or structural elements like walls, floors, and ceilings. A suitable dwelling has sufficient bedrooms for the size and composition of resident households according to National Occupancy Standard (NOS) requirements.[30] The dwelling was deemed affordable if housing costs were less than 30% of total before-tax household income.

Second, a determination is made on whether a household would have to spend 30% or more of its total before-tax income to pay the median rent of alternative local housing that meets all three housing standards. For this determination, the median market rent of rental units with the number of bedrooms the household requires is estimated. When market rents cannot be

estimated, the cost of acceptable local housing is calculated by using the estimated monthly carrying cost of a newly constructed home having the number of bedrooms the household requires.[31]

Some households are excluded from affordability calculations. They include: (1) households with income greater than zero and shelter-cost-to-income ratios (STIRs) of 100% or more, (2) STIRs for households with income of zero or less, and (3) STIRs of households living in non-band housing on reserves. Other households that are not assessed for core housing need are: farms, because farm households cannot be separated from the related costs to other farm structures and buildings; bands, because shelter costs are not collected for households whose housing costs are paid through band housing arrangements; and reserve households, because communal land tenure in most on-reserve communities is less clear than it is for off-reserve households.

### *Air Quality*

Air quality comprises the annual average nitrogen dioxide ($NO_{2)}$ concentration at a postal code in parts per billion, which is achieved using the national $NO_2$ land use regression model developed from 2012 national air pollution surveillance (NAPS) monitoring data. [323334]

#### Data Sources

- 2012 national air pollution surveillance (NAPS) monitoring data available from the Canadian Urban Environmental Health Research Consortium (CANUE).

#### Derivation

As detailed previously in Hystad et al.[32], 2012 national pollutant models for $NO_2$ were created from routinely collected fixed-site monitoring data in Canada. In multiple regression models, satellite estimates and geographic predictor variables were combined to capture background and regional pollutant variation. Deterministic gradients to capture local-scale variation were also used, modeled using deterministic gradients from the literature and kernel density measures. For 2016 estimates, CANUE used the estimated $NO_2$ levels for 2012 as the base year and derived annual adjustment factors for 2013–16 using provincial averages of annual $NO_2$ levels from NAPS monitoring stations.[35] Each postal code was then assigned a province identification, and province-specific annual factors were applied to the 2012 base year. Continuous $NO_2$ values were grouped into quintiles for each map at the level of dissemination area, census tract, and Peel public health data zone.

## Mapping Methodology

Each indicator was initially provided to us at the level dissemination area or postal code. The following aggregation strategy was used to generate census tract- and PDHZ-level maps: For the Parks and Natural Environments and Transportation indicators, the numerator and denominator values were available at the dissemination area level and aggregated to the census tract or PHDZ level using summation. Once the new numerator and denominators were summed, the indicator was recalculated using the initial calculation described in the Data Sources and Derivations subsections of the Neighbourhood Design section above. For the Food Environment and Housing indicators, our team did not have access to the original data, only the pre-calculated average values for each dissemination area. Therefore, indicator values at the census tract and PHDZ level were generated using the average (mean) value for each dissemination area located within the corresponding census tract or PHDZ. Given the nature of the dissemination area—census tract and census tract—PHDZ spatial hierarchy (i.e., no overlap), each dissemination area value contributed to only one mean value calculation for a census tract or PHDZ. For the Air Quality indicator, non-missing values for annual average $NO_2$ concentrations by 2016 postal codes were mapped using latitude/longitude XY coordinates for each postal code in Peel, and each postal code within 5 kilometers of the Peel border, to account for edge effect and ensure a continuous surface for all areas within Peel. The postal code-level $NO_2$ concentrations were then interpolated using inverse distance weighting (IDW) (Spatial Analyst Tools, ArcMap 10.4.1). Given that the postal code-level air quality data was derived from a multiple regression model accounting for large- and small-scale trends, IDW was deemed a suitable interpolation method to generate a surface to provide values throughout the geographic zones (dissemination area, census tract, PHDZ). The *Zonal Statistics as Table* tool (Spatial Analyst Tools, ArcMap 10.4.1), a function that provides descriptive statistics based on the cell values of a raster within the zones of another dataset, was used to calculate descriptive statistics, including the mean for each zone (i.e., dissemination area, census tract, PHDZ). The values were then joined to the matching 2021 geographic boundary files (dissemination area, census tract, PHDZ) and mapped using the mean value. Unless otherwise specified, quintile classification breaks of each indicator were dichotomized (bottom three quintiles Q1—Q3, top two quintiles Q4—Q5) and mapped against diabetes rate ratios dichotomized as low (<1.0) and high (>1.0). Choropleth univariate and bivariate maps were generated using ArcGIS Pro 3.0.0.

## Other Definitions

### General Transit Feed Specification Data (GTFS)

The General Transit Feed Specification (GTFS) is a data format for publishing electronic public transit agency data.[36] GTFS has schedule, fare, and geographic transit information. GTFS data can be used by software applications for purposes like planning trips, creating timetables, visualizing data, and analysis planning.

### Census Tract (CT)

Statistics Canada[37] defined census tracts as,

> "small, relatively stable geographic areas that usually have a population of fewer than 7,500 persons, based on data from the previous Census of Population Program. They are located in census metropolitan areas (CMAs) and in census agglomerations (CAs) that had a core population of 50,000 or more in the previous census.
>
> A committee of local specialists (for example, municipal planners and others) initially delineates CTs in conjunction with Statistics Canada. Once a CMA or CA has been subdivided into CTs, the CTs are maintained even if the core population subsequently declines below 50,000."

There were 282 census tracts in Peel Region.

### Dissemination Area (DA)

Statistics Canada[38] defined a dissemination area as

> "a small, relatively stable geographic unit composed of one or more adjacent dissemination blocks with an average population of 400 to 700 persons based on data from the previous Census of Population Program. It is the smallest standard geographic area for which all census data are disseminated. DAs cover all the territory of Canada."

There were 1,746 dissemination areas in Peel Region.

### Peel Public Health Data Zones (PHDZ)

Peel public health data zones were defined above. There are 39 public health data zones in Peel Region.

# Chapter 4: Demographic, Behavioural, and Social Determinants and Future Risk of Type 2 Diabetes

## Data Sources

### Canadian Community Health Survey (CCHS)

The CCHS is a cross-sectional survey conducted by Statistics Canada. The CCHS collects information about health status, health care utilization and health determinants for the Canadian population. The survey uses a large sample of respondents and is designed to provide reliable estimates at the health region level.[39]

In 2017 the CCHS covered the population 12 years of age and over living in the ten provinces and the three territories. Some people were excluded from the survey's coverage including persons living on reserves and other Aboriginal settlements in the provinces; full-time members of the Canadian Forces; the institutionalized population, children aged 12–17 that are living in foster care, and persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James.[39]

## Definitions

### CCHS

CCHS is the Canadian Community Health Survey – Annual Component for 2017/2018.

### Age

Age refers to the CCHS survey respondent's age at their previous birthday. The CCHS reported age in groups. For ages 20 and older, the groups are 5-year intervals such as 20–24, 25–29, and so on. The oldest group is 80 and older.[40] We made a derived variable for the analysis by recoding age with three categories: 20–44, 45–64, or 65+.

### Sex

Sex means the sex assigned at birth. It is based on a person's physical characteristics and reproductive system.[41] Response categories used for analysis were male and female.[42]

**Ethnicity**

Ethnicity indicates the respondent's cultural or racial background. It excludes respondents who identified as aboriginal. A derived variable used for analysis had response categories of White and non-White (visible or ethnic minority). A category of 'not stated' indicates respondents who did not answer a required question.[40]

**Visible Minority**

Visible minority means a person who is a visible minority as defined in Canadian federal law. In the Employment Equity Act, visible minorities are defined as "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour." The visible minority population mainly includes persons from these groups: South Asian, Chinese, Black, Filipino, Arab, Latin American, Southeast Asian, West Asian, Korean and Japanese. 'Person' means an individual. [43]

**Immigration Status**

The CCHS reported three classifications of immigrant status:[44]

- Non-immigrant: "Persons who are Canadian citizens by birth."
- Immigrant: "Persons who are, or who have ever been, landed immigrants or permanent residents. Such persons have been granted the right to live in Canada permanently by immigration authorities. Immigrants who have obtained Canadian citizenship by naturalization are included in this category."
- Non-permanent resident: "Persons from another country who have a work or study permit or who are refugee claimants, and their family members sharing the same permit and living in Canada with them."

Our analyses used a derived variable that combined landed immigrants and non-permanent residents into a category, and non-immigrants (Canadian born) into another category. A third category, 'not stated,' codes respondents who did not answer the CCHS questions that are needed for the derivation.[40]

**BMI**

BMI is Body Mass Index. BMI is a method of classifying body weight according to health risk. BMI is a calculation involving weight in kilograms divided by height in metres squared. The CCHS did not calculate the BMI of pregnant women. The following categories and class boundaries were used:[4045]

- Underweight: BMI less than 18.50 kg/m2

- Normal weight: BMI 18.50 to 24.99 kg/m2
- Overweight: BMI 25.00 to 29.99 kg/m2
- Obese: BMI 30.00 to 39.99 kg/m2
- Severe Obesity: BMI 40.00 kg/m2 and greater.

**Obesity**

Obesity is a dichotomous variable derived from the BMI variable. Persons having BMI less than 30 kg/m2 were classified as not obese ('No'). Persons having BMI 30.0 kg/m2 and greater were classified as obese ('Yes'). Obesity was not derived for pregnant women, females who did not answer the survey question about pregnancy, respondents who did not report a valid height and weight, and respondents who had an extremely low (<12) or extremely high (>58) BMI.[40]

**Household Income**

Household income is based on the respondent's best estimate of total household income received by all household members, from all sources, before taxes and deductions, during the year ending December 31. Income includes sources such as work, investments, pensions, government programs like Employment Insurance, social assistance, the Child Tax Benefit, and other income such as child support, spousal support (alimony) and rental income. Capital gains are excluded from household income.[46] A derived variable having ordered categories was used for analysis. The income categories were:

- No income or less than $20,000
- $20,000 to $39,999
- $40,000 to $59,999
- $60,000 to $79,999
- $80,000 or more.

There is also a category of 'not stated' for respondents who did not answer one or more required questions.[40]

**Physical Activity**

Physical activity refers to the Canadian Physical Activity Guidelines that are published by the Canadian Society for Exercise Physiology (CSEP). The guidelines hold that to realize health benefits, adults should accumulate at least 150 minutes of

moderate to vigorous aerobic physical activity per week.[47] The CCHS derived a variable to measure respondent physical activity assessed against the CSEP guidelines. The CCHS variable has three levels:[40]

- No physical activity minutes reported
- Physically active below recommended level from CPAG
- Physically active at or above recommended level from CPAG.

We characterized the CCHS variables' categories with these corresponding labels for the report:

- inactive
- moderately active
- active.

The CCHS also used a category of 'not stated' for respondents who did not answer one or more required questions.

**Smoking**

Smoking indicates the type of smoker the respondent is, based on his or her smoking habits. The variable includes lifetime cigarette consumption.[40] Three derived categories were used for analysis:

- Daily smoker
- Occasional smoker
- Non-smoker, i.e., former smokers of any frequency and lifetime abstainers.

A fourth category includes respondents who did not answer one or more required questions.

**Hypertension**

The CCHS survey question was, "Do you have high blood pressure?"[42] Two response categories were used for analysis: yes and no. The CCHS also reports responses of don't know and refused.

**Perceived Health**

The CCHS questionnaire contains this explanation:

> "Perceived health is an indicator of overall health status. It can reflect aspects of health not captured in other measures, such as: incipient disease, disease severity, aspects of positive health status, physiological and psychological reserves and social and mental function. Perceived health refers to the perception of a person's health in general, either by the person himself or herself, or, in the case of proxy response, by the person responding. Health means not only the absence of disease or injury but also physical, mental and social well being."[48]

Response categories used for analysis were:

- Poor
- Fair
- Good
- Very good
- Excellent.

The CCHS also reports a category for respondents who did not answer one or more required questions.[40]

**Perceived Mental Health**

Perceived mental health indicates the respondent's mental health status based on their own judgement. Response categories used for analysis were:

- Poor
- Fair
- Good
- Very good
- Excellent.

The CCHS also reports a category for respondents who did not answer one or more required questions.[40]

**Sense of Belonging**

Sense of belonging refers to local community integration. The survey question was, "How would you describe your sense of belonging to your local community? Would you say it is…?"[49] Response categories used for analysis were:

- Very strong
- Somewhat strong
- Somewhat weak
- Very weak.

The CCHS also reports a category for respondents who didn't know or did not give a response.

**Food Security**

Ten questions elicited the food security situation of the household's adults in the previous 12 months.[40] Response categories used for analysis were:

- Food secure: No, or one, indication of difficulty with income-related food access
- Moderately food insecure: indication of compromise in quality and/or quantity of food consumed (2 to 5 affirmative responses to questions)
- Severely food insecure: indication of reduced food intake and disrupted eating patterns (>= 6 affirmative responses).

The CCHS also reported a category for respondents who did not answer at least one required question.

**Diabetes**

The CCHS survey question was, "Do you have diabetes?" [46] The response options were:

- Yes
- No
- Don't know
- Refuse to answer.

The responses were used to obtain the prevalence of risk factors among respondents living with (Yes) and without (No) diabetes. Respondents who did not have diabetes (No) were used in analyses to predict future incidence of diabetes.

**Incidence (of diabetes)**

Incidence is the frequency of diagnoses of new (diabetes) cases in a given time period.

**DPoRT**

DPoRT is the Diabetes Population Risk Tool.[50] DPoRT is a decision support tool that uses routinely collected population characteristics applied to a validated risk prediction algorithm. DPoRT estimates the number of new and existing physician-diagnosed Type 2 diabetes cases in a population. The purposes of using DPoRT to obtain diabetes estimates include understanding distribution of risk in the population, diabetes prevention, diabetes health resource planning, and setting priorities and making decisions.

The DPoRT algorithm was developed using data from Ontario respondents to the 1996-97 National Population Health Survey (NPHS).[51] It was validated in two cohorts and data sources: a cohort of Manitoba respondents to the 1996-97 NPHS and a cohort of Ontario respondents to the 2000 Canadian Community Health Survey.[52] The DPoRT algorithm was updated to DPoRT 2.0 in 2014.[53] The DPoRT 2.0 risk prediction variables are age, body mass index (BMI), education level, ethnicity, heart disease, hypertension, immigrant status, income level, sex, and smoking status.

DPoRT 2.0 predictions represent community-dwelling residents who lived in the 10 Canadian provinces during the year of CCHS data collection. DPoRT estimates do not represent:

- residents of First Nation reserves
- people who live in institutions such as nursing homes
- full-time members of the Canadian Forces
- residents of certain remote regions, and
- people who may immigrate to Canada in a ten-year period after the CCHS data collection.

# Chapter 5: Health Services and Quality of Care

**Data Sources**

**Ontario Diabetes Dataset (ODD)**

Please see the ODD description for Chapter 2.

**Registered Persons Database (RPDB)**

Please see the RPDB description for Chapter 2.

**Canadian Institutes for Health Information (CIHI) Discharge Abstract Database (DAD)**

The Canadian Institutes for Health Information (CIHI) Discharge Abstract Database (DAD)[18] contains demographic, administrative and clinical data about patients discharged from hospital inpatient stays and day surgeries. A hospital separation is defined as a patient's separation from a hospital because of death, discharge to home, or transfer to another facility. In the DAD, the primary reason for the hospital stay is designated by a code indicating the diagnosis that is the one most responsible for the patient's stay in hospital. Before April 1, 2001, the most responsible diagnosis was coded using the Ninth Revision of the International Classification of Diseases (ICD-9). After this date, the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems, Canada (ICD-10-CA) was used.

Limitations:

The DAD data have several limitations:

(1) Hospitalization data are coarse measures of health conditions for several reasons: A person might be hospitalized several times for the same disease or injury, may be discharged from more than one hospital (when transferred) for the same disease or injury, or may not seek care at a hospital.

(2) The most responsible diagnosis has classification uncertainty because of comorbidity with other health conditions.

(3) Factors that are unrelated to health status, such as availability and accessibility of care and administrative policies and procedures, may influence the data in DAD records.

(4) DAD data available to Ontario researchers does not have information about Ontario residents treated outside of Ontario.

**Canadian Institutes for Health Information (CIHI) National Ambulatory Care Reporting System (NACRS)**

The Canadian Institutes for Health Information (CIHI) National Ambulatory Care Reporting System (NACRS)[54] receives information about patient visits submitted by hospital emergency departments. NACRS began receiving data in July 2000. The patient's main problem or diagnosis, as determined by the emergency department (ED), is the basis for assigning the

main diagnostic code for the ED visit. The code is based on the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems, Canada (ICD-10-CA).

Limitations:

The NACRS data have several limitations.

(1) Data are not considered to be reliable before April 1, 2002.

(2) Ambulatory visit data are coarse measures of health conditions for several reasons: A person might not seek care at an emergency department or may visit several times for the same disease or injury or may visit more than one hospital for the same disease or injury.

(3) The most responsible diagnosis has classification uncertainty because of comorbidity with other health conditions.

(4) Factors that are unrelated to health status, such as availability and accessibility of care and administrative policies and procedures, may influence the data in NACRS records.

(5) NACRS data available to Ontario researchers does not have information about Ontario residents treated outside of Ontario.

**Ontario Health Insurance Plan (OHIP) Database**

Medical services information was obtained from the Ontario Health Insurance Plan (OHIP)[16] file of approved claims. The file has service and payment information on (1) fee-for-service (FFS) claims submitted by physicians and other licensed health professionals, and (2) some of the "shadow billings" submitted from providers in organizations that use alternate, non-FFS payment arrangements. A typical claim in the file has information about the patient, provider, fee schedule code or procedure performed, number of services or units delivered, and some diagnostic information. OHIP uses a unique coding system for diagnoses.

Limitations:

The OHIP database has several limitations:

(1) Only some of the claims from the Ontario Ministry of Health's alternate payment programs or "shadow billers" are included, and total volume for some services may be undercounted.

(2) Some diagnosis codes may have different meanings depending on the health service provider's specialty.

(3) Approximately half of the diagnosis codes are missing from the approved claims since there is no requirement to include the codes.

**Ontario Laboratory Information System (OLIS)**

Beginning in 2006, community, hospital, and public health laboratories in Ontario began submitting information about laboratory test results to the Ontario Laboratory Information System (OLIS).[55] As of 2012 all Public Health Ontario laboratories had joined OLIS. As of August 2016, OLIS had completed connections with hospital laboratories in 13 out of 14 local health integration networks (LHINs). At the time of the Baseline Data Strategy report writing, all community and most hospital-based laboratories were contributing information to OLIS.

Limitations:

There are circumstances that can cause laboratory test results not to appear in OLIS. For example:

(1) tests performed for reasons other than direct patient care, e.g., pre-employment screening and other employment-related testing, clinical trials testing

(2) tests that could not be performed for exceptional reasons, e.g., broken test tubes

(3) tests requested when the Ontario health card was expired, lost, or stolen

(4) laboratory requisitions for out-of-province patients

(5) laboratory requisitions made by out-of-province practitioners

(6) tests on uninsured patients where necessary Ontario patient identification information was unavailable

(7) non-insured tests where necessary Ontario patient identification information was unavailable

(8) pilot sites such as reports from long-term care facilities and hospitals that refer patients to an external lab because they lack an on-site laboratory, and the results are not sent directly to OLIS from the hospital.

**Ontario Drug Benefit (ODB) Database**

The Ontario Drug Benefit (ODB)[17] database contains claims for outpatient prescription drugs received under the Ontario Drug Benefit program. Most are for individuals 65 years old and higher, who have a valid Ontario health card. From 1997 forward the database has information on other ODB insurance programs where individuals may be younger than 65. The ODB program covers drugs listed on the ODB formulary, some nutritional products, and some diabetic testing products. Some primary data elements in the ODB include patient, physician, and pharmacy indicators, the drug identification number, date the drug was dispensed, quantity of drug dispensed, and the cost.

Limitations:

The ODB database does not have information about dispensed drugs that were not paid for by the Ontario Ministry of Health, e.g., drugs paid for out of pocket and by private insurance.

## Methods

*Overview*

This was a retrospective descriptive study using population-based data from ICES.

*Study Population*

Residents were assigned to the Mississauga Ontario Health Team (OHT) using the procedure described below. We included all residents assigned to the Mississauga OHT who were alive and had a diagnosis of diabetes on or before April 1, 2019, or April 1, 2020. Diabetes was diagnosed by inclusion in the Ontario Diabetes Dataset.[19]

Ontario residents were assigned to the primary care physician based on each physician's roster at the midpoint of each year from April 1, 2019 to March 3, 2021.[56] Residents not on any primary care physician's roster were assigned to the primary care physician who provided the most primary care services. Residents receiving no primary care services had no assigned primary care physician. Each primary care physician was linked to the hospital where most of his or her patients were admitted for non-maternal medical care using the method described by Stukel et al.[56] Primary care physicians linked to Trillium Health Partners (located in Mississauga) were defined as being part of the Mississauga Ontario Health Team (OHT). Residents were assigned to Mississauga OHT if their assigned primary care physician was affiliated with Mississauga OHT. Residents without

an assigned primary care provider were assigned to Mississauga OHT if the majority of individuals living in their postal code dissemination area were assigned to Mississauga OHT.

*Data Sources*

Residents of Ontario were identified using the Registered Persons Database. We used the Canadian Institute for Health Information Discharge Abstract Database, National Ambulatory Care Reporting System, and the Ontario Health Insurance Plan database for hospitalization discharge abstracts, emergency department records, and physician billing codes respectively. The Ontario Laboratory Information System includes laboratory results from community, hospital, and public health laboratories from 2007 onward.[57] Over 95% of $HbA_{1c}$ and LDL cholesterol values in Ontario are captured in this database.[55] The Ontario Drug Benefit database includes outpatient prescriptions for insured individuals including those aged ≥65 years and select individuals <65 years.[58] These datasets were linked using unique encoded identifiers and analyzed at ICES.

*Indicators*

For this phase of the NHP Baseline Data Strategy, we examined laboratory, retinopathy screening, prescription, and hospitalization indicators separately for the years of April 1, 2019 to March 31, 2020 and April 1, 2020 to March 31, 2021. The laboratory indicators included percentage receiving at least one $HbA_{1c}$ test within the past 12 months, at least one LDL cholesterol test within the past 12 months, the mean $HbA_{1c}$ level, and the mean LDL cholesterol level, all examined among people aged ≥40 years. The retinopathy screening indicator was defined as the percentage of people aged ≥40 years undergoing at least one retinal examination by an optometrist or ophthalmologist in the past 24 months. The prescription indicators consisted of the percentage of adults aged ≥65 years receiving an ACEi or ARB prescription, and a statin prescription, both within the past 12 months. The hospitalization indicators were classified as long-term complications (retinopathy, nephropathy, neuropathy, cardiovascular disease, or multiple complications of diabetes) and short-term complications (diabetic ketoacidosis, hyperglycemic hyperosmolar state, hypoglycemia) both among adults aged ≥18 years.

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