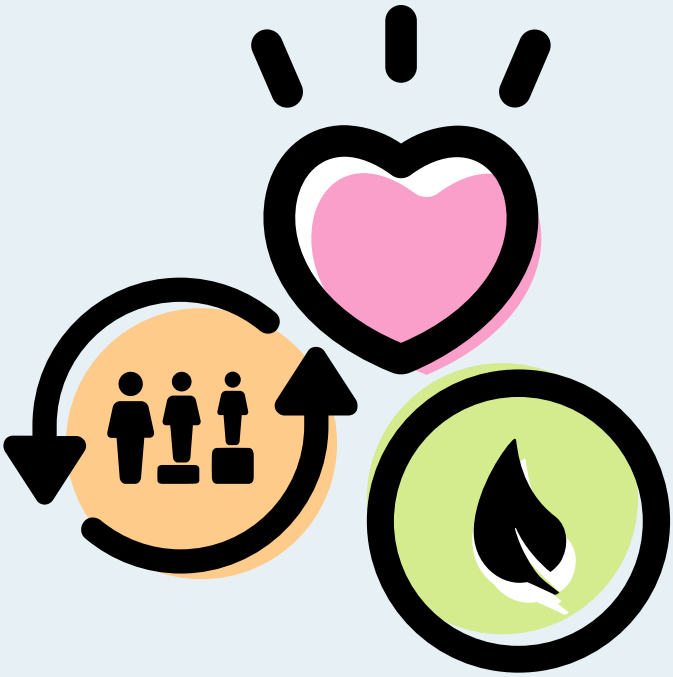

CLIMATE CHANGE, POPULATION HEALTH AND HEALTH EQUITY

Public health strategies and five climate solutions that produce health and health equity benefits

November 2023

CANADIAN PUBLIC HEALTH ASSOCIATION

CHASE
CANADIAN HEALTH ASSOCIATION FOR SUSTAINABILITY & EQUITY

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TABLE OF CONTENTS

ABBREVIATIONS

Chemicals/Pollutants

GHG	Greenhouse Gases
Mt	Million Tonnes or Megatonnes
NOX	Nitrogen Oxides
NO2	Nitrogen Dioxide
PBDEs	Poly-brominated Diethyl Ethers
PM2.5	Fine Particulate Matter
TRAP	Traffic-Related Air Pollutants
VOCs	Volatile Organic Compounds

Health Terms

CVD	Cardiovascular Disease
PTSD	Post Traumatic Stress Disorder
BMI	Body Mass Index

Technology/Methodology Terms

BAU	Business as Usual
Can-ALE	Canadian Active Living Environment
ccASHP	Cold Climate Air Source Heat Pump
HVAC	Heating Ventilation Air Conditioning system
IEQ	Indoor Environmental Quality
NDVI	Normalized Difference Vegetation Index
NZEB	Net Zero Emission Building
UHI	Urban Heat Island
VKT	Vehicle Kilometres Travelled
VMT	Vehicle Miles Travelled
ZEV	Zero Emission Vehicle

Organizations/Positions

CPHO	Chief Public Health Officer
EHO	Environmental Health Officer
FNIM	First Nation, Inuit or Metis Indigenous Communities or organizations
HEI	Health Effects Institute
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
MOH	Medical Officer of Health
MHO	Medical Health Officer
PHAC	Public Health Agency of Canada
SMDHU	Simcoe Muskoka District Health Unit

Geographic

BC	British Columbia
CVRD	Cowichan Valley Regional District
GTHA	Greater Toronto and Hamilton Area
US	United States

GLOSSARY

Built Environment has been described as the human-made or modified physical spaces of the environment where people live and perform their activities.*

Climate Change or Global Warming refers to long-term shifts in temperatures and weather patterns, which, since the 1800s, have been driven mainly by human activities, primarily due to the burning fossil fuels like coal, oil and gas.†

Climate Change Mitigation is achieved by either reducing emissions of greenhouse gases or by enhancing their storage in "carbon sinks" such as forests.

Climate Adaptation or Resilience is the ability to prepare for, recover from, and adapt to, the deleterious effects of climate change impacts such as extreme weather events.‡

Green space is the "land that is partly or completely covered with grass, trees, shrubs, or other vegetation" which includes "parks, community gardens, and cemeteries".§

Health equity is the absence of unfair systems and policies that cause health inequalities. Health equity seeks to reduce inequalities and to increase access to opportunities and conditions conducive to health for all.¶

Health inequalities are the differences in the health status of individuals and groups due to genes, behaviour, or social determinants of health.¶

Health inequity refers to health inequalities that are unfair or unjust and modifiable.¶

* Habash R. 2022. Chapter 9. Urbanization as an intelligent system. Sustainability and Health in Intelligent Buildings. Woodhead Publishing Series in Civil and Structural Engineering. Pages 239-257

† United Nations. Climate Action.

‡ NASA, Global Climate Change. Responding to Climate Change.

§ US Environmental Protection Agency.

¶ Canada. Website. 2023. What is Health Equity.

EXECUTIVE SUMMARY

Project goals and focus

The primary goal of this report is to encourage and support public health agencies to integrate the mitigation of climate change (i.e., the reduction of greenhouse gas (GHG) emissions) more visibly into their work. It also seeks to foster alliances between public health professionals, other professionals who work in the municipal sector, and local community groups.

The public health imperative

Climate change is already having a significant impact on human health around the world. In Canada, climate change is increasing the frequency and intensity of extreme climate-related events, melting permafrost, increasing our exposure to air pollution, wildfire smoke, and pollen. It is changing the range and transmission of infectious diseases, increasing risks to water supplies, and threatening the safety and security of food. Climate change is also increasing stress on mental health and amplifying the health inequities already experienced by many people in our communities.

The good news is that many of the actions needed to prevent climate change can produce immediate and significant population health and health equity benefits in the jurisdictions that act. Health evidence and inter-sectoral collaboration are key enablers. Public health agencies can help garner support for public policies that create healthy, equitable and sustainable communities.

Public health strategies

This report presents the strategies and approaches being used by nine public health agencies in Canada to make policy changes at a local level that can mitigate climate change while also improving population health and/or health equity. Case studies were developed on 14 different initiatives that aimed to improve population health and reduce health inequities while also reducing greenhouse gas emissions that cause climate change (see Table 1). Six themes emerged from these case studies:

- Inter-sectoral collaboration is essential;
- Senior management plays a pivotal role;
- Resources need to be committed and relationships cultivated;
- Structurally disadvantaged populations need to be engaged;
- Specialized training can be helpful; and
- The need for increased and sustainable funding for public health.

The health and health equity case for climate action

This report also provides a comprehensive review of evidence related to some of the population health and health equity benefits that can be associated with five local climate solutions:

1. Public transit;
2. Walkable neighbourhoods;
3. Active transportation infrastructure;
4. Green space; and
5. Green buildings/building retrofits.

This evidence can be used to gain support for, and to inform, the policies, programs and investments that are needed to create healthy, equitable and sustainable communities.

Conclusion

Given the critical need to halve GHG emissions by 2030, and the immediate and significant health and health equity benefits that can be associated with the five local climate change solutions discussed, there is much more that public health agencies could do to accelerate and shape action on these fronts. To realize this potential, public health professionals and their agencies must be trained, authorized, and funded to do so.

TABLE 1: CASE STUDIES

Organization	Situation	Context	Policy or Program Goals	Climate Solution Highlighted	Strategies Employed
Ottawa Public Health	Department of the City of Ottawa	Urban with rural	• Incorporate 15-minute neighbourhoods into the OP	• Walkable Neighbourhoods • Transit	• Co-locating public health in planning • Co-developing Policies & Implementation Tools
Ottawa Public Health	Department of City of Ottawa	Urban with rural	• Incorporate heat resiliency into the OP • Develop a high performance building standard	• Green Buildings • Green Space	• Co-locating public health in planning • Co-developing Policies & Implementation Tools
Niagara Region Public Health & Emergency Services	Department of Niagara Region	Urban and Rural	• Fold health-equity informed planning into regional operations	• Active transportation infrastructure • Transit	• Establishing a health-equity planning process for regional operations • Managing Health Equity Impact Assessments
Peel Health	Department of Peel Region	Urban and Rural Areas	• Bring health and health equity considerations into green space and tree planting policies and tools	• Green Space	• Inter-sectoral collaboration within a regional municipality • Supporting Development of Policies & Implementation Tools
Hamilton Public Health Services	Department of City of Hamilton	Urban with Rural	• Support development of complete streets policies and plans	• Active transportation infrastructure	• Inter-sectoral collaboration within a local municipality • Supporting Development of Policies & Implementation Tools
Vancouver Coastal Health	Arms-length Agency of Province	Large Urban	• Use the social & environmental determinants of health to influence municipal policies related to transit, active transportation, and buildings	• Transit • Active transportation Infrastructure • Green buildings	• Provincial public health agency collaborating with municipal agencies • Formal Comments • Government Relations
Saskatchewan Health Authority	Arms-length Agency of Province	Urban Centre	• Bring health and health equity considerations into land use and transportation planning processes	• Walkable neighbourhoods • Active transportation infrastructure	• Provincial public health agency collaborating with municipal agencies • Formal Comments • Supporting the Development of Policies & Implementation Tools • Government Relations
Island Health	Arms-length Agency of the Province	Rural and Remote	• Use social and environmental determinants of health to create healthy built environments	• Building Retrofits	• Collective Impact • Building Retrofits
Haliburton Kawartha Pine Ridge District Health Unit	Public Health Agency with Independent Board of Health	Rural	• Bring health equity considerations in transportation planning	• Active transportation infrastructure	• Collective Impact • Engaging with Under-serviced Populations
Simcoe Muskoka District Health Unit	Public Health Agency with Independent Board of Health	Rural Area	• Weave climate change mitigation and adaptation into all public health programs		• Collective Impact • Weaving climate Lens into all programming • Researching Indigenous Lens
Nova Scotia Community Transportation Association	Non-Profit Organization	Rural and Remote	• Provide intra-municipal and inter-municipal transit service for rural and remote communities	• Transit	• Collective Impact • Working with partners to provide transit for rural and remote communities • Government Relations
Powell River, BC	Municipality	Small Urban	• Pilot on-demand transit service to improve ridership and service	• Public transit	• On-Demand Transit Service
BC Alliance for Healthy Living	Non-profit	Rural and Remote	• Strategies for improving active transportation infrastructure and transit in rural communities	• Active Transportation Infrastructure • Transit	• Collective impact • Capacity Building • Advocacy
Cowichan Valley Regional District	Municipal Government	Rural and Remote	• Reducing air pollution and GHGs in communities that use wood to heat their homes	• Building Retrofits	• Collective Impact • Wood Stove Swap-outs for Heat Pumps

I INTRODUCTION

Building public health capacity on climate change mitigation

This report discusses the prevention or mitigation of climate change where less work is being done overtly by the public health sector. The primary goal is to encourage and support public health agencies to integrate the mitigation of climate change more fully into their work.

Public health agencies across Canada are working to create healthy built environments that address health equity, support physical activity, encourage healthy eating, foster social cohesion, and decrease air pollution and vehicle-related injuries and deaths. Many of the interventions directed at the built environment also reduce greenhouse gas (GHG) emissions and improve climate resiliency. As such, public health agencies are well-positioned to promote policies that mitigate climate change and minimize the health risks associated with the changing climate.

Increasing inter-sectoral collaboration

This report also seeks to foster alliances between public health professionals, other professionals who work in the municipal sector, and local community groups by increasing awareness among all three groups of the:

- Health and health equity risks that climate change presents for people in Canada;
- Different ways in which public health agencies can support the development and implementation of public policies that reduce GHG emissions;
- Immediate and significant health co-benefits that can be associated with five local climate solutions; and
- Health inequities that can be reduced when climate solutions are implemented with consideration for social equity.

Focus on five local climate solutions

Local action is the focus of this report because this is where much of the work of public health agencies is conducted. Five local climate solutions that can produce population health and health equity benefits have been selected:

1. Public transit;
2. Walkable neighbourhoods;
3. Active transportation infrastructure;
4. Green space; and
5. Green buildings.

The report includes a comprehensive discussion of some of the immediate population health and health equity benefits that can be associated with each of these five climate solutions.

Case studies and public health strategies

Fourteen case studies that touch on one or more of the five climate solutions have been prepared and released as part of this project. This report includes portions of those case studies. Ten illustrate the different strategies and approaches being used by public health agencies to promote interventions that can improve population health and/or health equity while also reducing GHGs. Four showcase innovative work being done on public transit, active transportation, and building retrofits by non-governmental organizations and municipalities that have to potential to improve health equity.

II INTEGRATING CLIMATE CHANGE MITIGATION WITH HEALTH PROMOTION

1. Climate solutions can produce immediate health benefits

There are affordable solutions to fight climate change

The Intergovernmental Panel on Climate Change (IPCC) concluded that the world must reduce GHGs by 45% by 2030 and to net zero by 2050 if we are to limit global warming to 1.5°C and avoid catastrophic levels of global warming.[1] The IPCC Working Group that focused on the mitigation of climate change concluded that the world has the solutions it needs to cut global emissions by more than half by 2030. It concluded that the climate change solutions needed are cheaper today than ever before and that more than half of the reductions can come at a low cost, no cost, or with cost savings. For example, it noted that solar and wind power, low carbon transportation, and energy efficient housing, can actually save money when compared to current options.[2]

Climate solutions recommended for local action

The IPCC Working Group reported that communities can help fight climate change at a local level by transforming infrastructure, supporting new technologies, and promoting sustainable lifestyles. Its list of climate solutions that can be promoted at a local level include:

- Investments in local and inter-city public transit;
- Development of walkable communities;
- Creation of safe and connected cycling and pedestrian infrastructure;
- Developing or retrofitting buildings to reduce energy use and prepare for the changing climate with low-carbon energy, architectural design and materials, and nature-based solutions such as green roofs; and
- Enhancing carbon sinks with nature-based infrastructure such as trees and forests.[3]

Local climate solutions produce immediate health benefits

The first *Lancet* Countdown on Health and Climate Change report published in 2015 emphasized the need to transform the way that we generate power, travel, build communities, eat and grow our food, if we are to protect humanity from climate change.[4] That report, along with other peer-reviewed research published since then, noted that many of the actions needed to reduce GHGs will also produce immediate and significant public health benefits for the jurisdictions that take action.[5]

The Lancet report notes, for example, that steps taken to increase transit use, walking and cycling can improve population health by increasing physical activity, reducing air pollution, and increasing access to jobs and essential services, while also reducing GHG emissions.[6] Some studies have concluded that the health-related cost savings that can result from climate action can, at times, outweigh the costs of the measures taken to reduce GHG emissions.[7,8] As will be discussed in this report, a number of the local climate solutions can also produce health equity benefits if they are developed and implemented with that intention.

Health professionals can increase support for climate action

By engaging in climate change mitigation and adaptation processes, public health agencies can help gain public support for climate solutions, and work to ensure that the potential health and health equity benefits are considered and realized.

Communication research indicates that people are more likely to support climate solutions when they know that those solutions can produce immediate health benefits for them and their families. For example, a US study found that the public can be motivated to support climate solutions when presented with the health risks presented by climate change, the health benefits associated with climate solutions, and clear calls to action. That study found that communications were most effective when all three messages were combined and that the combined messages appeared to appeal to "people across the political spectrum".[9] Communication surveys also indicate that health professionals are highly respected by the public in Canada.[10] This suggests that public health can play an important role in gaining public support for climate solutions by educating them about both, the health risks presented by climate change, and the immediate health benefits that can be associated with the solutions.

Public health can influence policies

Public health agencies can be effective policy influencers. A comprehensive 2011 report examined how ten public health agencies in Ontario were able to influence policies that impact the built environment to help create communities that improve population health by encouraging physical activity and healthy eating, reducing emissions of air pollutants and GHGs, fostering social cohesion and health equity, and/or protecting water supplies, green space, and farmland.[11]

Similar outcomes were demonstrated with the Healthy Canada by Design – Coalitions Linking Action & Science for Prevention (CLASP) initiative that was funded by the federal government from 2009 to 2014. It found that public health agencies could have a substantial impact on local policies related to the built environment when they brought health considerations into the land use and transportation planning processes and worked in collaboration with those departments responsible for the planning and development of their communities and transportation networks.[12]

2. What is meant by health inequities?

Within the public health sector, it has long been understood that health status is strongly influenced by socio-economic characteristics. Income, for example, is closely linked to health outcomes because it affects so many of the factors that shape health such as the quality of housing and food, the safety of one's workplace and neighbourhood, and the control or agency that people have in their lives. These are factors that can also affect stress levels and immune systems, making people more or less susceptible to disease and illness.[13]

Studies have demonstrated that health outcomes such as infectious diseases, chronic diseases, and premature deaths, are shaped more by socio-economic, environmental, and cultural factors, than by choices within the control of individuals. In fact, factors such as income, working conditions, food insecurity, gender, access to health services, housing conditions, race, and immigration status, can have a greater impact on health outcomes than lifestyle choices related to diet, physical activity, tobacco use, and alcohol use.[14]

These socioeconomic and environmental factors, which are often called the social or environmental determinants of health, are also intersectional. They can overlap and compound one another. For example, in Canada, the rates of infection with COVID-19 were much higher in low-income neighbourhoods in Montreal that were home to many essential workers who were unable to avoid exposure at work and unable to isolate from their families at home.[15]

CPHO on systemic racism, colonization, and discrimination

"Canada has a history of systemic racism, colonization, and discrimination. Indigenous peoples in Canada continue to live with the legacy of forced displacement from traditional territories, residential school experiences of abuse and neglect and the disruption of traditional culture and practices, the trauma of which continues to affect their health and well-being."

Chief Public Health Officer (CPHO). 2020. From Risk to Resilience: An Equity Approach to COVID19.

A report published by the National Academy of Sciences, Engineering, and Medicine categorizes the root causes of health inequities into two clusters. It identifies the interpersonal, institutional, and systemic biases, based on factors such as race, gender, income, and immigration status, as the structural inequities that determine how power and resources are distributed in society as the first cluster. It places the determinants of health as "the unequal social, economic, and environmental conditions" that result from the unequal allocation of power and resources, including goods, services, and societal attention, in the second cluster.[16]

When combined, these two clusters influence everything: the income and working conditions deemed acceptable for employees; how educational qualifications from other countries are treated by employers; the amenities, infrastructure, and services that are provided to different neighbourhoods in a community; and the rules that apply to resource extraction industries in remote areas of Canada – all of which differentially impact the health and well-being of different groups within our society.

By addressing the structural inequities and the determinants of health, we can reduce the avoidable negative health outcomes experienced by people, reduce the health care and social costs that are born by society, and create a more equitable and just society.

Health inequities and the built environment

Much of the health equity research conducted on the built environment in Canada to date has focused on people who live on low incomes. When considering the findings from those studies, it is helpful to remember what groups of people are included among those low-income populations.

In 2019, 20% of the population in Canada were families or unattached adults living on net incomes of $21,000/year or less. This group of people included:

- one third of lone parents;
- one quarter of the people who have not completed high school;
- nearly one quarter of recent immigrants; and
- more than one quarter of Indigenous people living off reserve.[17]

In 2021, 7.4% of people in Canada were living below the poverty line. This population included:

- 21.6% of unattached adults (i.e., defined as those older than 16) and 7% of families;
- 17.2% of female lone parent families and 11.6% of male lone parent families;
- 13.9% of all Indigenous adults;
- 9.5% of adults who belong to a racialized group; and
- 10.6% of adults who have disabilities.[18]

3. Climate change health risks

Climate change health risks globally

Climate change is one of the greatest public health threats of this century and an important area of prevention work for public health agencies. On a global scale, climate change is already having catastrophic impacts on human health. The 1.2°C increase in global warming that has occurred to date has amplified extreme climate events such as hurricanes, floods, heat waves, and droughts. These events are now claiming the lives of hundreds of thousands of people each year, increasing food insecurity for tens of millions, escalating conflicts, and forcing people to flee from their homes.[19]

The five hottest years on record have occurred since 2015, the year the Paris Agreement on Climate Change was signed. Over the last 20 years, heat-related mortality in people over 65 has increased by 54%, resulting in nearly 300,000 additional deaths in 2018 alone.[20] New attribution studies have found that 76 floods, droughts, storms and heat waves that occurred between 2015 and 2020 were made more severe by the warming climate.[21]

In 2020/21, floods on several continents gave rise to thousands of deaths, displaced hundreds of thousands of people, and produced billions of dollars in economic losses. In 2021 alone, extreme weather events caused damage estimated at US$253 billion and placed a particularly heavy burden on lower-income countries. In 2020/21, devastating wildfires and record-breaking temperatures also hit many countries around the world. The warming climate is also making coastal waters more amenable to bacteria that can poison seafood, increasing the season for malaria transmission in the Americas and Africa, and increasing the risk of dengue fever on three continents.[22]

Climate change is also threatening global food security as higher temperatures and more frequent extreme events reduce yields for major crops. In 2020, up to 19% of the land around the world was stricken by extreme drought; a 6% increase over any year between 1950 and 1999. Higher temperatures have also decreased the yields for the world's major crops; maize, winter wheat, soybean and rice.[23] An analysis covering 103 countries indicated that 98 million more people experienced moderate to severe food insecurity in 2020, relative to 1981-2010, because of extreme heat that has increased in frequency and intensity due to climate change.[24]

The impacts of climate change are often born disproportionately by those who have contributed the least to the problem. Populations in lower-income countries that emit relatively small amounts of GHGs have faced the greatest increases in heat vulnerability over the last three decades with health risks amplified by limited access to cooling technologies and urban green space.[25]

Climate change health risks in Canada

Climate change is no longer some distant health threat in Canada. Temperatures across the country are increasing at a faster rate than global averages and Canada's North is warming even faster. Between 1948 and 2016, the annual average temperature in Canada increased by 1.7°C while the annual average in Canada's North increased by 2.3°C.[26]

Increasing extreme climate-related events

Global warming is already increasing the frequency and intensity of extreme climate-related events across Canada. Extreme heatwaves are being felt by millions each year with deadly consequences for hundreds.[27] Hurricanes, tornadoes,

ice storms and storm surges can lead to immediate injuries and death, contaminate water sources with harmful chemicals and bacteria, and flood homes that can become structurally unsound or unhealthy because of fungi or mould. Power outages resulting from these events can result in accidents, hypothermia, and carbon monoxide poisoning when people use barbeques, camp stoves or outdoor heaters indoors to cook or heat their homes.[28]

Melting permafrost

Increasing temperatures are also melting permafrost that covers 40% of Canada's land mass. This harms the integrity of buildings, roads, and infrastructure for water, wastewater, and power lines, which can in turn, disrupt transportation routes and access to food supplies and clean water. Melting permafrost can also release infectious diseases, heavy metals, and radon that have been stored in frozen plants, animals, and ground.[29,30]

Increasing air pollution and allergens

Rising temperatures and humidity experienced in many regions of the country can increase levels of ground-level ozone and fine particulate matter ($PM_{2.5}$); the primary components of smog that have been clearly and consistently associated with a broad array of acute and chronic health impacts.[31] Global warming is also increasing the exposure of people in Canada to wildfire smoke as greater areas of forests are burned[32] in response to higher temperatures and deeper droughts.[33] These exposures are increasing risks for a broad range of negative health outcomes including asthma episodes, respiratory infections, and chronic obstructive pulmonary disease, as well as premature deaths. Health Canada estimates that short-term and long-term exposures to $PM_{2.5}$ from wildfire smoke has caused 54-240 and 570-2500 premature deaths/year, respectively, in recent years.[34]

The warming climate is also increasing the length and intensity of allergy season in many parts of the country. It is expected that global warming has increased, and will continue to increase, the number of people who experience allergies and asthma, the frequency of those incidents, and the costs to the health care system. All of these changes in outdoor air quality will also affect indoor air quality as outdoor air pollutants and allergens infiltrate homes and other indoor spaces.[35]

Increasing temperatures and infectious diseases

Global warming is changing the range and transmission of infectious agents by changing environmental factors such as air and water temperatures, the range of different types of vegetation, and the movement of different animal populations. One systematic review found that climatic hazards such as floods, droughts, warming, and rising sea levels, can aggravate or worsen 218 out of the 375 infectious diseases that affect people worldwide. These diseases can be triggered by agents such as viruses, bacteria, parasites, and fungi, which can be transmitted by water, air, food, and direct contact, or by vectors such as mosquitoes and ticks.[36] In Canada, changing climatic conditions have already led to the spread of infectious diseases such as Lyme disease, which is spread by ticks, and West Nile Virus, a mosquito-borne disease.[37]

Climate change is also harming Canada's economy

Canada's Parliamentary Budget Officer has estimated that extreme climate-related events lowered Canada's GDP by 0.8% ($20-25 Billion) in 2021. These losses resulted from reduced outputs from farms, higher energy bills, more lost-time, power outages, damaged roads, and impacts on the tourism industry.

Robson, Mia. Canada's economy took $20-billion hit from climate change last year, PBO says. The National Observer. Nov 8, 2022.

Climate change, water supplies and food security

Canada's changing climate poses a risk to water quality and water supplies. Intense rainfall, rapid snowmelts, rising sea levels, melting permafrost, and deep droughts can impact the availability of water and increase the risk of contaminating ground water and surface water that is used for drinking water, domestic use, and/or recreation. About 14% of Canada's population rely on small drinking water systems that serve fewer than 300 people. Many of the communities that rely on small drinking water systems have long-standing challenges accessing safe drinking water supplies. This is particularly true for many Indigenous communities.[38]

Climate change is also expected to reduce food security globally as rising temperatures, drought, floods, and rising sea levels decrease crop yields and foster pests and invasive species. Climate change is particularly concerning for Indigenous communities that rely heavily on traditional food sources that are affected by changing temperatures and

disrupted ecosystems.[39] Food-borne illnesses can also occur when extreme events such as floods, wildfires, or snowstorms disrupt the food supply cold chain that is used to keep perishable foods refrigerated or frozen during storage and distribution from the farm field to the consumer.[40]

Climate change, mental health, and eco-anxiety

The Mental Health Commission of Canada estimates that 7.5 million people in Canada may experience mental health problems in any given year. Several studies suggest that climate change is dramatically increasing the risk of developing mental health problems. These studies have documented:

- Post-traumatic stress disorder (PTSD) among those who have lived through extreme weather events;
- Grief and anxiety among people who are concerned about climate change; and
- A sense of loss among those who find their homes, communities, and way of life disrupted by climate change.[41]

Climate change health inequities

Climate change presents health risks for everyone, but it amplifies the health risks experienced by some populations. For example, young children, older people, and people with physical or mental health challenges can be more vulnerable to stresses such as extreme heat and wildfire smoke. In addition, some populations within Canada are more susceptible to harm from climate-related impacts because of the challenging conditions or social disadvantages they experience such as low-paying jobs, unsafe working conditions, crowded housing, or homelessness, have increased their risk of illness, chronic disease, and premature deaths.[42] These populations may also experience greater exposure to climate-related impacts such as heat waves, floods and wildfires, and may not have the resources needed to protect themselves, or recover, from those events.[43]

III CASE STUDIES AND PUBLIC HEALTH STRATEGIES

1. Case studies: Introduction

For this project, 14 case studies were developed based on interviews with 13 different organizations. The case studies showcase innovative work being done to improve population health and/or reduce health inequities that is likely to reduce GHGs as well. Ten of the case studies examine work being done by public health agencies, while two cover work being done by non-profit organizations and two feature work being led by local municipalities.

While the 10 public health case studies may not be representative of the work being done by public health agencies across the country, they highlight strategies and approaches that have been used effectively to influence local policies that affect GHG emissions, population health, and/or health equity in their communities. They provide valuable lessons that are likely to apply to other public health agencies.

An attempt was made to collect case studies that were related to the five local climate solutions selected for this project – public transit, active transportation infrastructure, walkable neighbourhoods, green space, and green buildings. With most of the public health agencies interviewed, it was difficult to separate out their work on any one of these climate solutions from their overall work on the built environment, but an effort was made to focus on examples that fell under one of the five climate solutions.

Case studies: Transit, active transportation infrastructure, and walkable neighbourhoods

Many public health agencies in Canada have been working for a decade or more to promote policies related to public transit, active transportation infrastructure, and/or walkable neighbourhoods. This work has been done with health goals related to physical activity, air pollution, health equity, social cohesion, and climate change.[44] In these processes, public health professionals have taken on different roles and responsibilities. For example, they have estimated the health benefits associated with investments in transit,[45] conducted systematic reviews on the features that make neighbourhoods walkable and transit-supportive, and identified the policies, programs, and infrastructure that can be used to foster active modes of transportation, walkable neighbourhoods, and equitable transit service. They have also developed policy papers to support official/community plans, provided comments on official/community plans, master plans, subdivision plans, and site plans, and developed tools that can be used to assess subdivision plans and guide the development of active transportation infrastructure.[46]

For this report, several case studies examine how public health and allied organizations have worked to both deepen and expand their work on these fronts.

Case studies: Green space and green buildings

For several years, a number of public health agencies in Canada have been working to protect, expand, and enhance green space, parks, tree canopies, and urban forests in their communities.[47] This work is being driven largely by climate change vulnerability reports that have identified extreme heat and flooding as growing risk factors in Canada.[48] These interventions are also supported by a growing body of health literature that demonstrates that greenness and green space can provide substantial mental and physical health benefits at a population level.[49] Several public health agencies have also engaged in processes directed at greening new or existing buildings in their communities. This work has been done to reduce outdoor air pollution, improve indoor environments, and/or decrease GHG emissions.[50] This report examines a few of these cases.

Case study: Weaving climate change mitigation into programming

Some public health agencies are working to weave climate change mitigation into their built environment work or into all of their programs. We have included one case study for a public health agency that is working to do this while also trying to incorporate an Indigenous perspective into their climate change adaptation work.

2. Public health strategies

Intersectoral collaboration is essential

In all ten case studies drawn from public health agencies, people are working across sectors to influence different elements of the built environment. The form of these collaborations varies depending upon the situation of those agencies and the context in which they are working. Three of the nine public health agencies are arms-length agencies of the province, two are departments within regional municipalities, two are departments within local municipalities, and two report to independent boards of health with representatives from several different communities.

In large urban centres, public health agencies are often working directly on policies and implementation documents with staff in other departments or with key officials who are responsible for the policies being developed. In smaller communities, public health staff are more likely to be engaged in collective impact processes; facilitating, or participating in, processes with citizens and community groups, as well as staff and decision-makers from the local communities. The case studies highlight a number of different strategies and approaches employed effectively by public health agencies on one or more of the five local climate solutions. We have divided them into five categories:

- Co-locating public health staff in planning;
- Establishing an equity-based planning process for regional operations;
- Inter-sector collaboration within municipalities;
- Provincial public health agencies collaborating with municipal agencies; and
- Collective impacts.

Co-locating public health staff in planning: 15-minute neighbourhoods

Two of the case studies feature work done by Ottawa Public Health (OPH). OPH is a department of the City of Ottawa with a semi-autonomous Board of Health. With over 1 million residents, Ottawa is the fourth largest city in the country and the second largest in Ontario. OPH co-located two of its staff within the City's Planning, Real Estate and Economic Department for three years with the goal of having the City's new official plan (OP) rooted in a framework that creates healthy, inclusive and resilient communities.

"It was seminal to the achievement of public health's goals that we were assigned to work with the Planning Department for the entire OP process," noted Inge Roosendaal, Senior Planner with OPH. Roosendaal. "In the past, we were consulted only. This time, we were fully engaged at every stage in the process."

"This allowed us time to gather relevant health evidence and to prepare one of the background papers that informed the development of the OP," said Roosendaal. "But more importantly, it gave us time to engage in discussions with colleagues in other departments and participate in meetings with consultants, the public, and developers at every stage in the process."

The two public health staff had the support of senior staff in public health, including the Medical Officer of Health (MOH), as well as the support of the General Manager (GM) for the Planning, Real Estate and Economic Development department. The GM expressed the view that his goal was to have a new OP that ambitiously supports positive health outcomes as well.

"We consulted with other staff in public health, including senior staff, but ultimately, we were the people in the room, dealing with a wide range of complex and interconnected issues," noted Roosendaal. "Our senior staff understood that the process could not work if we were not empowered to make decisions with staff from other departments."

Ottawa is one of the first communities in Canada to enshrine 15-minute neighbourhoods into its OP. The concept was captured in a high-level policy directions report called the "5 Big Moves" that was approved by Ottawa City Council in September 2019 and became the framework around which the OP was built.

"We were consulting with the public on the 15-minute neighbourhood concept during the pandemic, so residents were really feeling the impact that their neighbourhoods were having on their daily lives," said Roosendaal. "That helped people appreciate how neighbourhood design affects their physical and mental well-being by influencing whether they can walk and cycle safely, access essential services, connect with others outdoors, get relief from extreme heat, or enjoy parks and green space."

The new OP, which was approved by Ottawa City Council in November 2021, will guide development in the City until 2046.

The City's vision, to become the most livable mid-sized city in North America over the next century, was guided by five broad policies:

- Accommodate more growth with intensification of existing neighbourhoods rather than with greenfield development.
- Ensure that the majority of trips in 2046 will be made by sustainable modes of transportation such as walking, cycling, transit or carpooling.
- Use sophisticated urban and community design principles to create stronger, more inclusive and vibrant neighbourhoods and villages that also reflect and integrate Ottawa's economic, racial and gender diversity.
- Embed environmental, climate and health resiliency and energy into the framework of planning policies to support walkable 15-minute neighbourhoods with a diverse mix of land uses, mature trees, green spaces, and pathways, that help the City achieve its net zero climate commitment for 2050 and its 40% urban forest canopy cover target, and increase the City's resiliency to the effects of climate change.
- Embed economic development into the framework of the planning policies.

The OP includes six cross-cutting strategic policy directions that will be advanced with implementation policies that are captured in multiple sections of the OP. Three of these policy directions are: Healthy and Inclusive Communities, Climate Change and Energy, and Gender and Racial Equity

The OP includes specific policy 'hooks' for these cross-cutting policies to help ensure that the strategic goals are implemented through multiple planning aspects and levers. Because the OP sets the broad policy framework for how Ottawa grows, these policy hooks will be supported by other policies and plans that have been, or will be, developed by the City. For example, the City released a 15-Minute Neighbourhoods Baseline Report in September 2021 that analyzes existing neighbourhoods using newly developed criteria and methodology for assessing 15-minute neighbourhoods and identifies the next steps for implementing the policy goals enshrined in the OP.

Ottawa describes 15-minute neighbourhoods as: "compact, well-connected places with a clustering of a diverse mix of land uses; this includes a range of housing types, shops, services, local access to food, schools and day care facilities, employment, green spaces, parks, and pathways. They are complete communities that support active transportation and transit, reduce car dependency, and enable people to live car-light or car-free."

"The 15-minute neighbourhood is the key lever for advancing climate resiliency, public health, and health equity at the community level," noted Roosendaal. "Many of the features needed to improve public health and health equity, such as walkable neighbourhoods rich in amenities, cycling infrastructure, efficient transit service, well-developed tree canopies for shade, and green space, are the features needed to reduce greenhouse gases and increase climate resiliency." [51]

Co-locating public health staff in planning: Green buildings and green space

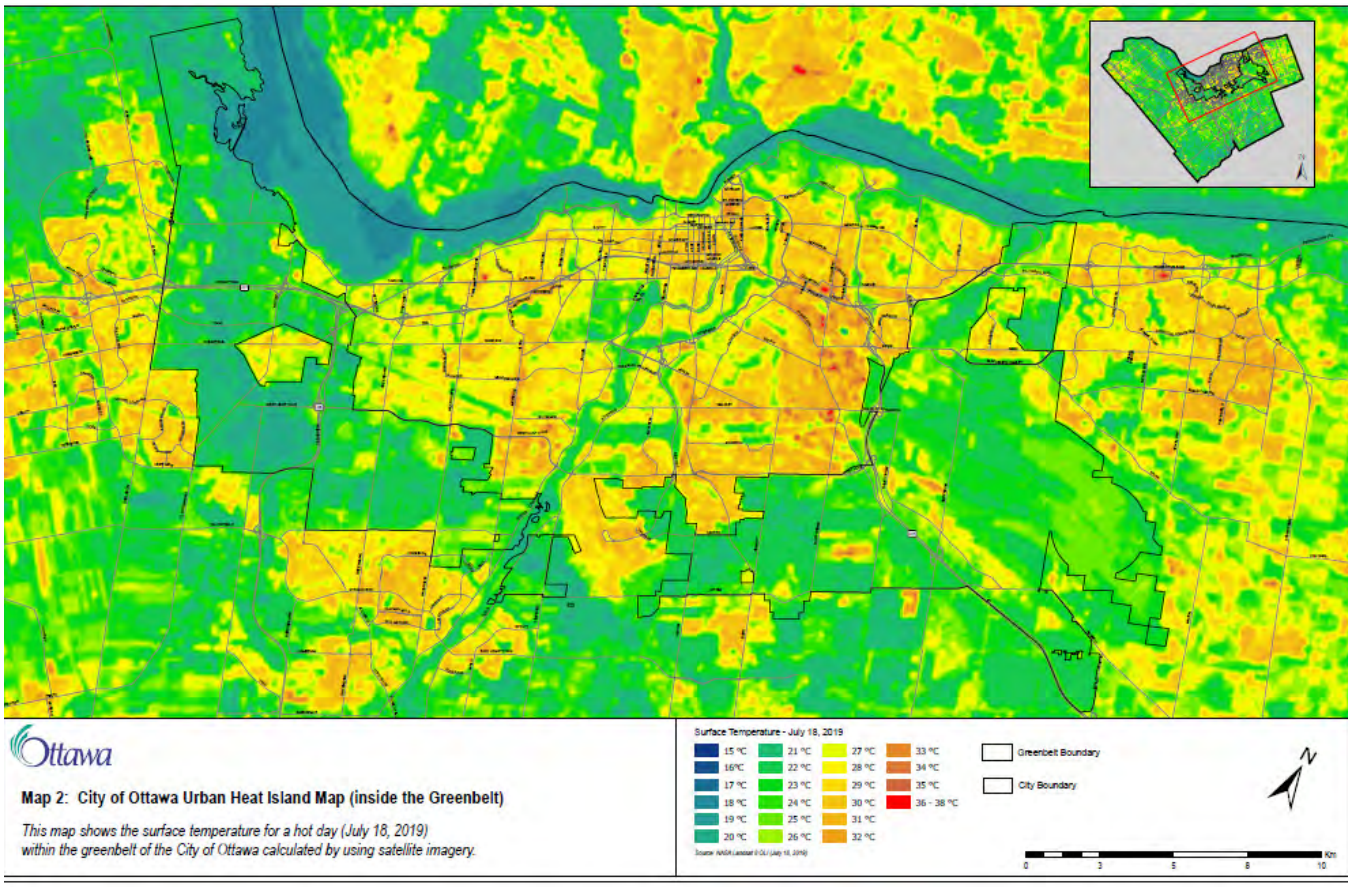
The second OPH staff person assigned to work with the planning department. Birgit Isernhagen, Program Planning and Evaluation Officer in Health Protection Services, was focused on addressing heat and health hazards related to climate change and resiliency in the OP. This led to her involvement in the development of a green building standard that will promote green buildings and green space in Ottawa.

Isernhagen was involved in all aspects of the OP's development. She reviewed, and provided comments from a health hazard and health equity perspective, on every draft of various sections of the OP. She participated in meetings with the staff from other departments, developers, and the public. She also led the development of the OP policies related to extreme heat and worked to ensure that those policies were effectively supported with policy hooks in other sections throughout the OP.

Isernhagen was also an active participant in the inter-departmental committee that developed a High-Performance Development Standard for new buildings. This standard, which was developed over many months, involved about 30 people with various areas of expertise and meetings with developers and the public. She played a key role in the standard's development by chairing a number of sub-groups that were focused on issues such as air pollution, soil volume, equitable access, and sustainable roofing.

"We have learned from past experience that we cannot gain the public health policies we want without participating in every step in the process," Isernhagen explained. "There are other experts at the table – hired consultants and staff from other

FIGURE 1: URBAN HEAT ISLAND MAP, OTTAWA, 2019



departments – but they are all focused on the issues of concern to them. We had to bring our issues up time and time again to make sure they were not lost or watered down. And we had to be at the table to hear what the other experts were saying to understand how we might collectively meet their needs as well as our own."

"I don't believe any other OP in Canada has a section dedicated to extreme heat," said Isernhagen. "We focused on trees, shade, and heat mitigation measures for areas that need them the most. We used the Urban Heat Island maps (City wide, inside Greenbelt) that OPH initiated to support this policy."

The Urban Heat Island maps will also be used as a tool to help inform climate change adaptation strategies, tree planting plans, parks and recreation plans, and health-supportive policies.

The new OP policy which commits the City to "Build resiliency to the impacts of extreme heat", includes a high-level summary of the health concerns associated with extreme heat and a brief description of the urban heat island effect. It states that: "The built environment should be developed to provide protection against extreme heat, reduce the urban heat island effect, build climate resiliency and safe outdoor recreation and active transportation."

It includes three mitigation measures:

1) Trees will be retained and planted to provide shade and cooling by:
   a) Applying the urban tree canopy policies in Subsection 4.8 and other sections of the plan;
   b) Prioritizing them in the design and operation of parks and the pedestrian and cycling networks and at transit stops and stations for users wherever possible; and
   c) Encouraging and supporting maintenance and growth of the urban tree canopy on residential, commercial, and private property.
2) For transit stops where the planting of trees is not feasible, shade structures should be considered subject to funding

and available space in the right-of-way in order to provide shelter from the sun as to ensure comfort and transit mobility during extreme heat conditions.

3) Office buildings, commercial shopping centres, large-format retailers, industrial uses and large-scale institutions and facilities, shall incorporate heat mitigation measures.

The second major advancement in this area was the authorization and development of a new implementation tool called the High Performance Development Standard. This standard contains a set of mandatory and voluntary measures to advance sustainability, public health and safety, environmental protection, and climate change objectives in the design of new buildings.

"Buildings make up 45% of GHG emissions in Ottawa today. New buildings built today will carry their emissions profile with them for the next 50+ years. Currently, new buildings are constructed following the minimum energy efficiency requirements set out by the Ontario Building Code," noted Isernhagen. "New buildings that are built to a higher energy efficiency standard over the next 30 years are expected to account for about 8% of the City's overall 2050 carbon reduction target of zero emissions."

The new standard is viewed as an effective tool to transform the development industry and build capacity within the sector to integrate sustainability and resiliency into the design of new buildings. Modelled after Toronto's Green Standard, which is considered the most ambitious standard in the province, Ottawa's standard uses a tiered approach with mandatory and voluntary components that help raise the minimum design requirements. It also sets the direction for future updates, where the levels of performance advance (e.g., Tier 2 becomes Tier 1), enabling industry to prepare and plan for developments that are to be higher performing over time.

"The standard will also support improved health outcomes because it requires builders/developers to mitigate potential health impacts for both, the occupants of the building, and residents in the broader community as well," explained Isernhagen. "Among the issues that must be considered are access issues for all users, the protection of fresh air intakes from traffic-related air pollution, adequate soil volumes needed to protect long-term tree growth, support for community energy planning, sustainable roofing, and bird safe designs."

The standard will apply to all projects requiring Site Plan and Plan of Subdivision approval. It will not apply to projects that are applying solely for Building Permits.[52]

Intersectoral collaboration within municipalities: Health equity-informed planning for regional operations

Located in Southern Ontario, Niagara Region has a population of approximately 485,000. Known for its fruit farms and wineries, Niagara Region also incorporates several urban centres, including Niagara Falls, St. Catharines, and Welland. The region is governed by two tiers of government – the Regional Municipality of Niagara and 12 local municipalities. Public health is a department of the regional government.

Niagara Region Public Health & Emergency Services Department (Niagara PHES) has a long history of work on active transportation and environmental health. In 2010, it had an interdisciplinary team that worked collaboratively to influence land use and transportation planning processes in the region with the goal of improving public health.

In 2018, Niagara PHES developed a Health Equity Strategic Plan to guide operations and programs run by the health department. However, as health equity is impacted by many aspects of society, part of the Strategic Plan was to engage other departments in the health equity mission as well. In 2019, an opportunity to influence the broader regional government planning process presented itself. The goal of the Health Equity-informed Planning (HEIP) Project was to ensure that the health implications of non-health-sector projects undertaken by the regional government are fully considered in the assessment and design phases.

"Niagara Region's Acting Medical Officer of Health, Dr. Mustafa Hirji, is a passionate advocate for health equity and the application of the SDOH to decision-making" noted Kate Harold, Strategic Initiatives Coordinator with Niagara PHES. "Over the years, he has worked to educate Regional Councillors and municipal leadership about the SDOH and the need to address health inequities. He led the creation of the Health Equity Strategic Plan within Niagara PHES, and when Regional Council sought a way to build its vision to create a "healthy and vibrant community" at the start of its term, he seized the opportunity to sell them on health impact assessments as a way to achieve their goal."

The HEIP project was adopted in November 2020 when the Regional Council amended the Budget Planning By-law to include a health equity clause, namely: "Establish social determinants of health as a consideration in program and budget decisions." This clause was added in pursuit of the Regional Council's priority to become a "Healthy and Vibrant Community". By including the social determinants of health (SDOH) as an objective in the by-law, health impact assessments effectively became a necessity in budget decisions.

The goal of the project is to improve health and reduce health inequities by ensuring that the SDOH are considered when assessing projects and programs proposed by the regional municipality. Under the HEIP Project, all non-health projects undergo a Health Impact Assessment (HIA) that was adapted by Niagara PHES from the World Health Organization's (WHO) Health Impact Assessment toolkit.

The project, which was piloted for the first time in 2021, is currently being coordinated by two Niagara PHES staff – an HIA Coordinator and Kate Harold, the Strategic Initiatives Coordinator. There are five steps to the HIA process: Screening, Scoping, Assessment, Recommendations, and Monitoring.

In the first step, a qualitative scan is conducted by the Project Manager for the project being screened, the two public health staff who coordinate the process, and other public health staff who have expertise relevant to the project. The impact of project actions is rated on a scale of -3 to +3, reflecting its potential to amplify or mitigate negative health impacts on priority populations, for each one of the SDOH.

The SDOH to be considered include: environmental determinants (i.e., air, water, topography and natural heritage), transportation, housing, working conditions, neighbourhood safety, education, access to public services, built environment, social supports, family, food security, and economic development.

The priority populations identified by the Ontario Ministry of Health in its HEIA toolkit are those who can be disproportionately affected. The screening scores are summated to determine whether an HIA is needed, and if so, whether a rapid, intermediate or comprehensive HIA should be conducted.

A rapid HIA is a desktop exercise involving secondary data that already exists. An intermediate HIA is one that involves the collection of primary data and community stakeholder engagement as well as secondary data. A comprehensive HIA involves the extensive collection of both qualitative and quantitative primary data, as well as secondary data, structured community stakeholder engagement, and project-specific funding for a more work-intensive and thorough approach.

In 2021, 11 projects were screened for the 2022 budget. It was decided that an HIA would have low value for four which had few and limited potential health impacts identified. HIAs were recommended for seven projects. Two of the pilot HIAs had been completed as of May 2022. The screened projects were related to transportation systems, waste management, water treatment and affordable housing.

Using a road reconstruction project in St. Catharines as an example, the HIA generated a number of recommendations that complemented the environmental assessment. Driven in part by the presence of three schools and four adult living facilities in the study area, the HIA recommended adjustments to encourage active modes of transportation, improve the safety of pedestrians and cyclists, and increase access to services. For example, the HIA recommended:

- Fully segregated active transportation facilities;
- A continuous sidewalk network throughout the area;
- Appropriate signage, lighting and line painting throughout the study area;
- Education on the safe use of Two-Way Left Turn lanes and cycling facilities; and
- Promoting connections to public transit.

"It is our hope that HEIP and the HIA tool will improve health, reduce health inequities, and as a whole, decrease our negative impact on air quality, water quality, and the climate," indicated Harold. "In fact, we are hoping that it might actually improve our impact on the environment".[53]

Inter-sectoral collaboration within municipalities: Active transportation and complete streets

Wrapped around the west end of Lake Ontario, Hamilton is a port city with a population of 569,355. Located nearly 60 kilometres southwest of Toronto, Hamilton is part of the Greater Toronto and Hamilton Area (GTHA). While historically, the local economy was built around the steel industry and heavy

FIGURE 2: BAY STREET BIKE LANE, HAMILTON

manufacturing, in recent years, it has been shifting towards the service sector with a heavy emphasis on health sciences.

Hamilton is a single tier municipality. Promoting and protecting the health of the community is the responsibility of Hamilton Public Health Services (HPHS) which is a part of the City's Healthy and Safe Communities Department.

For over a decade, Hamilton Public Health Services (HPHS) has been promoting active modes of transportation to reduce the risk of chronic diseases in the City of Hamilton.

"About 12 years ago, we conducted a situational analysis within public health to decide how best to influence the levels of physical activity in our community, which can have a significant impact on population health," explained Don Curry, Health Promotion Specialist with HPHS. "At that time, the evidence was telling us that we needed to focus more on creating environments that foster and support physical activity rather than on individual behavior change if really wanted to increase the levels of physical activity at a community level."

Guided by a growing body of scientific evidence which suggested that levels of physical activity were influenced by the design of neighbourhoods, streets and communities, HPHS began cultivating relationships with key staff in the departments responsible for land use and transportation planning within the city.

"We recognized that if we wanted to influence public policies related to transportation and land use planning, we needed to work with people in those departments. We needed to understand their processes and we needed them to understand public health's perspective in the design of streets, neighbourhood, and communities," explained Curry.

Staff in public health became informed about the impact of the built environment on public health. They began reviewing land use planning documents such as the Official Plan, secondary plans, and subdivision plans. They also became engaged directly in the development of transportation plans such as the Pedestrian Mobility Plan, the Cycling Master Plan, and the City-Wide Transportation Master Plan.

"We have now established solid working relationships with our colleagues in the Sustainable Mobility team in Planning and Economic Development who have responsibility for developing transportation plans for the City," explained Curry. "We have a seat at the table along with City staff from other departments to provide input at various steps in the process."

"Within public health, there are staff with different areas of expertise. While I am focused primarily on physical activity, others focus on injury prevention, healthy eating, air quality, climate change, and health equity," explained Curry. "We consult with each other when providing comments on land use and transportation planning documents, or when wrestling with complicated issues that arise in meetings with other departments."

Staff found that the 2014 report, Improving Health by Design, that was released by the Medical Officers of Health from the Greater Toronto and Hamilton Area (GTHA), helped City Councillors, staff in other departments, and the public to understand how land use and transportation planning can impact the health of the community. That report estimated that traffic-related air pollution in the GTHA was causing negative health outcomes valued at $4.6 billion per year, while physical inactivity and obesity were producing negative health outcomes valued at $4 billion per year. It explained how health benefits valued at about $2 billion per year could be created by the investments proposed for public transit by Metrolinx in the GTHA.

"We have cited this report many times when commenting on land use and transportation documents," noted Curry. "By estimating the number of negative health impacts and applying an economic value to them, it helped people to appreciate the significance of the health impacts, and the importance of addressing public health's concerns."

In 2015, Hamilton's City Council directed staff to incorporate health into the transportation planning process. The Vision of the new Transportation Master Plan includes a commitment: "To provide a comprehensive and attainable transportation blueprint for Hamilton as a whole that balances all modes of transportation to become a healthier city".

The 2018 Transportation Master Plan commits the city to develop complete streets "that balance the needs of all users regardless of age, ability or mode of transportation". It also recommends that guidelines be developed to support the operationalization of that commitment. This led to the development of the Complete Streets Design Manual which was endorsed in July 2022.

"Transportation planning in a large urban centre is complex," explains Curry. "There are many technical issues to be considered – such as the utilities that are under the roads, the trees beside the roads, the needs of emergency workers, street cleaners, and garbage trucks – all on top of the needs of pedestrians, cyclists and drivers. To influence transportation policies and plans, public health staff need to understand the complexities and need to be involved in the discussions about how to balance the competing goals."

"There are so many benefits associated with complete streets," indicated Curry. "They foster physical activity, reduce vehicle-related injuries and deaths, decrease emissions of air pollutants and GHGs, and reduce social inequities. They can also reduce traffic congestion and increase community resiliency."[54]

Inter-sectoral collaboration within municipalities: Green space and tree planting prioritization

Located to the west of Toronto, the Regional Municipality of Peel is a rapidly growing upper-tier municipality. With a population of 1.4 million people, Peel Region includes the Cities of Mississauga and Brampton and the Town of Caledon. Peel Health, the agency responsible for community health, is embedded as a department within Peel Region and its Board of Health is the Regional Council.

For over 20 years, Peel Health has been actively engaged in land use and transportation planning processes across the region with the goal of creating communities that support health, health equity and healthy living. The department's inter-sectoral work focuses on policies and plans that influence physical activity, healthy eating, air quality and climate change. Policies and plans related to natural heritage such as the tree canopy, parks and green space in the Region advance many of these priorities.

In 2012, in response to a recommendation in Peel Region's Climate Change Strategy, Peel Health prepared a Climate Change Vulnerability Assessment. This report identified relevant climate-related vulnerability indicators of exposure, sensitivity, and adaptive capacity in the Region. It has since been used to inform other Peel-specific vulnerability assessments related to water/wastewater, natural heritage, agriculture, and two community-specific vulnerability

assessments. Prior to the COVID-19 pandemic, Peel Health was working to update this assessment.

"This first assessment report identified extreme heat, insect-borne diseases such as Lyme Disease and West Nile virus, extreme weather and natural disasters/hazards, contamination of food and water, and poor air quality as the climate-related health risks we could expect in Peel," said Kiran Ghai, Advisor in the Health Protection division at Peel Health. "The health risks presented by extreme heat led us into discussions about natural heritage policies related to the urban forest, tree planting, and parks in Peel."

Since 2015, climate change has been a strategic priority for the regional government. In 2019, Peel Health published The Changing Health Landscape in Peel, which is a comprehensive health status report prepared for Peel's population for the period 2009-2019. This report includes several environmental and health indicators, such as hospital admissions from extreme weather and the number of cases of insect-borne diseases, which can be used to monitor the impact of climate change on the public's health in the Region. As a result of these inputs, Peel Health identified *"Reducing the health-related impacts of climate change"* as a 10-year strategic priority.

"There is better data available to us today on the climate-related impacts and health risks that can be expected in this Region," explained Ghai. "We plan to use the findings in these new reports to strengthen and fine-tune regional and local policies and plans. We want to use them to support the region's adaptation activities, increase the community's resiliency to climate-related impacts, and promote population health and health equity as much as possible."

Peel Health staff are also members of the Region's Urban Forest Working Group and Climate Change Steering Committee along with staff from other departments, representatives from the three local municipalities, and representatives from the two conservation authorities that operate in the region. Peel Health staff have had the opportunity to influence natural heritage issues raised in the Region's Official Plan and the official plans and climate change adaptation plans of the three local municipalities.

"In all of these processes, we have brought forward the health evidence that supports the need to expand and protect our tree canopies, parks, and green space" explained Ghai. "There is a growing body of health evidence that suggests that trees, parks and green space can improve mental health, foster physical activity and social cohesion, reduce temperatures during extreme heat, and improve air quality. We wanted to ensure that these health co-benefits were included in the rationale in natural heritage strategies and plans."

Climate Change and Health Vulnerability Assessments

"Population-level vulnerabilities, as well as adaptive capacities, to climate change impacts are influenced not only by biological but also social and environmental factors like employment, education, housing, culture, gender, physical environment, and income.

Effective measures to protect populations of concern acknowledge and address social and environmental factors that influence health outcomes so that all people have the opportunity to experience their highest level of health."

Health Canada. 2022. Climate Change and Health Vulnerability and Adaptation Assessments. Workbook for the Canadian Health Sector

When it was decided that a tool was needed to help prioritize tree planting across the region, Peel Region's Planning Department convened a Technical Advisory Committee to help guide its development. Staff from Peel Health were included along with representatives from the conservation authorities and local municipalities. Health Canada also provided technical and financial support for this process.

A systematic review was conducted on the various benefits associated with trees. The findings of the review and feedback from the committee were used by the Project Team to select eight overall benefits, categorize them under one of three sustainability themes – environmental, economic and social – and identify the data sources and weighting for each one. The eight benefits include:

1. Mitigating Air Pollution (Environmental)
2. Mitigating Urban Heat Island Effects (Environmental)
3. Contributing to the Management of Surface Water Quantity and Quality (Environmental)
4. Maintaining and Enhancing Natural Heritage (Environmental)
5. Enhancing Economic Value (Economic)
6. Providing Direct Cost Savings (Economic)

FIGURE 3: BEECH STREET PARK, PEEL REGION

7. Supporting Improved Physical Health and Emotional Well-being (Social)
8. Strengthening Communities and Enhancing Social Equity (Social)

"My role was to bring the health and health equity lens to the table," noted Ghai. "When you look at the list of benefits, it is clear that almost all of them relate to the protection or promotion of public health."

The benefits, data sources and weighting were used to create the Region's Tree Planting Prioritization Tool which is an interactive map. The partners can combine different layers of data for each of the eight benefits to identify the neighbourhoods that should be prioritized for tree planting.

"We know that some populations, such as older people and people with pre-existing health conditions, can be more sensitive to climate-related impacts such as extreme heat. We also know that some populations, such as those who live on low incomes, are more likely to be exposed to higher temperatures because they may not have access to air conditioning or cool spaces. In addition, a number of studies suggest that vulnerable populations are more likely to live in neighbourhoods that have fewer trees and less green space, which can have a cooling effect on air temperatures and a positive impact on health," explained Ghai. "The Tree Planting Prioritization Tool can be used to identify the neighbourhoods that would benefit most from improvements in the local tree canopy from a health and health equity perspective."

Peel Health also participated in the development of a case study quantifying the Health Return on Investments in Green space: Increasing Tree Canopy in the City of Brampton. Health benefits included a reduction in exposure to air pollution and extreme heat as well as benefits to physical and mental health. The case study estimated that the health benefits of more canopy cover equate to $2,437,363 in a scenario where canopy cover is increased by 50% and $3,175,826 when there is an 80% increase in canopy cover.[55]

Provincial health agencies collaborating with municipal agencies: Public transit and green buildings

Nestled on the west coast of British Columbia (BC), Vancouver is a seaport city and the largest city in BC with a population of 613,485 people. It is also part of Metro Vancouver, which includes cities such as Richmond and North Vancouver, and has a population of 2.5 million people. Vancouver is one of the most ethnically diverse cities in Canada with more than half of its population speaking a first language other than English. The City of Vancouver is located on the traditional and unceded territories of the Musqueam, Squamish and Tsleil-

FIGURE 4: COMMERCIAL-BROADWAY SKYTRAIN STATION, VANCOUVER (LAURA CHOW)

Waututh Peoples who have lived on these lands since time immemorial.

Vancouver Coastal Health (VCH) is the public health agency responsible for community health for over 1.25 million people – nearly one quarter of BC's population - including the residents of Vancouver, Richmond, and many communities along the north shore and coastline. VCH is one of five Regional Health Authorities in BC, an arms-length agency of the Province that is governed by an independent Board of Directors who are appointed by the Province. It operates on the traditional, unceded, and occupied territories of 14 First Nations.

Several years ago, VCH established the Healthy Environments (HE) Team to address the physical and environmental determinants of health, including environmental exposures such as air pollution, noise, heat, and wildfire smoke, and the linkages between health and the built and natural environment including community design, housing, transportation systems, parks and green space.

"In public health, we work to prevent illness, disease, injuries and premature deaths by addressing the upstream factors that affect population health," explains Laura Chow, Senior Planner with the HE Team. "The HE Team works to protect and promote health by helping to create communities that have healthy environments, foster physical activity and social cohesion, and provide equitable access to jobs, services, parks, housing and green space."

The Healthy Environments (HE) Team currently consists of eight core members: a Senior Planner, a Planner, two Environmental Health Scientists, a Climate Change and Health Lead, two Environmental Health Officers, and a Project Coordinator. This team works closely with the Medical Health Officer (MHO) for Vancouver and also provides environmental health support to other regional offices across the VCH region.

The HE Team uses health evidence and data, policy research, inter-sectoral collaboration, and advocacy to promote and support policies and plans that can protect people, promote healthy living, and reduce health inequities. It has engaged in a number of strategies, plans and proposals that are expected to have a significant impact on community design, environmental health, and climate action in the Vancouver region including:

- TransLink's Transport 2050 Regional Transportation Plan;
- Metro Vancouver's Regional Growth Strategy (2050), Clean Air Plan, and Climate 2050;

- City of Vancouver's Climate Emergency Action Plan and Climate Emergency Parking Program;
- Metro Vancouver's Non-Road Diesel Engine Emission Regulation; and
- Northwest Ports Clean Air Strategy.

"We use a similar approach in each case, while tailoring our work to the scenario at hand" offers Dr. Schwandt, MHO for Vancouver. "We engage with key people in the organizations responsible for the plans we want to influence. We explain how their work can positively or negatively impact public health and ask how we can get involved. We provide formal comments during consultation processes and then express our support to decision-makers when policies are being considered for approval."

For example, VCH worked closely with TransLink, the agency responsible for planning and managing public transit, major roads, bridges and trip planning for Metro Vancouver, during the development of the long-term regional transportation plan, Transport 2050. The HE Team met early in the process with TransLink staff to identify the positive health outcomes that can be associated with a well-designed public and active transportation network and how the system can best leverage these outcomes. Working with VCH's Population Health team, the HE Team reviewed and commented on several drafts of the plan that were released for stakeholders or public feedback. At the end of the process, VCH presented to the Mayors' Council to express support for the Investment Plan proposed to fund the transportation plan, and to advocate for a more equitable and affordable pass option for public transit users.

"We have addressed a wide range of social and environmental determinants of health in our formal and informal comments on various proposals," notes Chow. "With TransLink, for example, we identified how a well-designed public and active transportation system can increase physical activity, access and social equity, while decreasing air pollution, GHGs, and vehicle-related injuries and deaths. In other processes, such as those directed at climate action plans, we have promoted policies such as equitable access to parks, green space and tree coverage, to improve the mental and physical health of vulnerable populations, and to mitigate the impacts of extreme heat for high-risk neighbourhoods."

When the HE Team commented on the City of Vancouver's proposed Climate Emergency Parking Program, a proposal intended to help fund elements of the City's recently approved Climate Emergency Action Plan, they addressed climate change adaptation, reductions in GHGs, and health equity.

"In a formal letter to City Council, we took the position that the proposal would help the City reach its climate targets, while also creating pathways to a number of health co-benefits," explained Dr. Schwandt. "By building a pollution charge into the cost of parking permits for more expensive and heavily polluting vehicles, we argued that the program would encourage a transition to less polluting vehicles, generate revenue to fund active transportation and an expanded tree canopy, while a number of measures included in the proposal would avoid the negative impacts that permit costs might have on social equity."

The HE Team has also consulted closely with BC Housing, the City of Vancouver, and Metro Vancouver on new building design and existing building challenges related to climate change adaptation, health equity, and the reduction of air pollutants and GHGs.

"In informal discussions and formal submissions, we have promoted the idea that new buildings should be built to reduce, and ideally eliminate, air pollution and avoidable GHG emissions. We have pressed for technologies such as heat pumps and air filtration systems to protect people from extreme heat and wildfire smoke. We emphasized that this was particularly important for rental units for low-income populations," indicated Emily Peterson, one of the Environmental Health Scientists on the HE Team. "The new Vancouver Building By-law will provide additional protection from extreme heat and wildfire smoke, by 2025, for multi-unit residential buildings, while also implementing important requirements to reduce GHGs."[56]

Provincial health agencies collaborating with municipal agencies: Public transit and active transportation

Saskatoon is the largest city in the province of Saskatchewan with approximately 245,000 residents. The Saskatchewan Health Authority (SHA) is an arms-length and autonomous agency of the provincial Ministry of Health. The Saskatoon Area of the Saskatchewan Health Authority (SHA) has been working with the City of Saskatoon for several years to incorporate population health and health equity into the land use and transportation planning processes.

FIGURE 5: TRANSIT BUS BIKE RACKS, SASKATOON

The Saskatoon Area of SHA established a team of staff with representatives from different disciplines to develop a Health Equity in Healthy Built Environment Framework to guide their work. The goal was to create built environments that mitigate harm, improve population health, reduce health inequities, and encourage health-promoting choices.

"We really wanted to focus our resources on creating environments that are supportive of health and foster health-promoting choices," explained Cora Janzen, Population Health Promotion Practitioner with the SHA. "We also wanted to ensure that health equity was embedded in all elements of our built environment work."

"Our framework identifies health equity goals for planning decisions affecting transportation, housing, neighbourhood design, and food systems in the city," said Janzen. "Unfortunately, to date, we have only had the resources to deeply implement the transportation and neighbourhood design elements of our framework."

While a multi-disciplinary team worked to develop the framework, the implementation has been carried out largely by one staff person to date.

The health authority applied the framework to the Growth Plan proposed for the City of Saskatoon in 2016. This growth plan was creating a vision and the policies that would shape the city's development for 30 to 40 years into the future. Staff from the Saskatoon Area of SHA worked in collaboration with the non-profit organization Think Upstream to conduct a Health Equity Impact Assessment (HEIA) on the proposal.

The project team used the HEIA developed by Ontario's Ministry of Health and Long-Term Care and included some adaptations developed by the Wellesley Institute. A multi-disciplinary team that included an Epidemiologist, a Population Health Practitioner, an Environmental Health Officer, an MHO, and two staff from Think Upstream was established to conduct the assessment. A brief report that includes 17 recommendations was submitted to the city. Among the recommendations were the following:

Corridor Growth

- Increase neighbourhood green cover as corridor growth occurs in order to mitigate the urban heat island effect and improve mental health and air quality.

Public Transit

- Focus the shift to an intensity model of service on neighbourhoods with lower socio-economic status, thus improving their access to transportation.
- Encourage development along bus rapid transit routes that improves the availability of services like grocery stores, community gathering places, and employment centres.

Active Transportation

- Direct early investments in new and rebuilt active transportation infrastructure to lower income neighbourhoods and remove physical barriers to active transportation in these areas.
- Ensure active transportation infrastructure is well integrated with public transit and facilitates connectivity between neighbourhoods, employment areas, and services such as grocery stores.

"The relationship fostered between health and the municipality has increased the opportunities to be involved in developing plans and providing public health's perspective, including a health equity lens," indicated Janzen. "We were invited to participate directly in the development of the city's Active Transportation Plan. Our MHO was offered a seat at the Steering Committee, which included Directors from several departments in the city, while I was offered a seat at the Advisory Committee where details of the plan were discussed."

"This two-tier involvement worked well for us," said Janzen. "The MHO and I would meet beforehand to discuss our recommendations, then the MHO would articulate our high-level recommendations and principles at the Steering Committee, particularly with respect to health equity, while I would provide detailed comments on the plan at the Advisory Committee."

Since that time, the Health Authority has provided comments, at meetings or in writing, on a number of proposed plans including Neighbourhood Sector Plans and the Bus Rapid Transit Plan to name a few.

"Once a policy or plan has been developed, we will check with our colleagues at the city to see if there are ways that we can support its approval," explained Janzen. "Sometimes a letter of support to a Council Committee and/or Council is warranted, other times a deputation. If health data, such as transportation-related injury hospitalizations or deaths, can support the decision, we will work collaboratively to include that information in the body of information that is used to support decisions."

"While Cora is the content expert on this file for Saskatoon and area, I will go to Committee or Council meetings to articulate our support for a policy or a plan recognizing that the office of the MHO carries weight with City Councillors and members of the public," said Dr. Jasmine Hasselback, MHO for Saskatoon and surrounding communities with the SHA. "We will often ask our colleagues in planning and transportation departments to identify the specific policies that need our support because they understand the concerns of their decision-makers and the public on these issues better than we do."

"While our healthy built environment work is directed at improving population health and reducing health inequities, we do believe that our overall goals – the creation of green, walkable, bikeable, and transit-supportive communities – can reduce GHGs and increase the resiliency of our communities," noted Janzen.[57]

Collective impact: Healthy built environments and building retrofits

Vancouver Island is home to about 900,000 people. Surrounded by the Pacific Ocean on the west coast and the Strait of Georgia and the Queen Charlotte Strait on the east coast, it has a rugged geography with many coastal towns, a large number of First Nations communities, and several cities including Victoria, Nanaimo and Campbell River.

Vancouver Island Health Authority (Island Health) is one of five regional health authorities in British Columbia (BC) that operate with the Provincial Health Services Authority and BC Centre for Disease Control (BCCDC) alongside the First Nations Healthy Authority. Island Health has responsibility for community health on Vancouver Island and the Gulf Islands in BC. While the regional health authorities are directed, funded, and supported by the BC Ministry of Health, they each have operational responsibility for their region and work closely with local communities to carry out those responsibilities.

In 2013, Island Health established the Healthy Built Environment (HBE) Portfolio to address the many ways in which the design and development of communities can impact public health and health equity.

"From the outset, we had very broad goals for this portfolio. We wanted to improve health and health equity by working to ensure that neighbourhood design, transportation networks, housing, food systems, and natural environments protect health and support healthy living," explained Jade Yehia who was the Healthy Built Environment Consultant for Island Health from 2013 to late in 2021. "We focused on different issues in different communities; on active transportation and access to healthy foods in some; on air pollution, climate resiliency, and social well-being in others."

There are several layers to the HBE Portfolio. There are staff working in the provincial agencies who are preparing policy positions and resources to support the regional health authorities. Within Island Health, 1.5 FTEs are focused on building capacity on healthy built environments across the regional health authority who also offer support to staff who are working in the field. The field staff, who are working with local communities, are Environmental Health Officers (EHOs).

"My job as HBE Consultant was to develop internal capacity within the region and to provide technical and strategic support to EHOs in the field," explained Yehia. "We have encouraged EHOs to work through existing community networks or other tables in their communities so they can engage directly with people in their communities."

The community health networks that have been developed over time have been initiated by Island Health or started by community champions focused on addressing the social or environmental determinants of health. These networks include elected leaders, First Nations representatives, community groups, staff from local municipalities, and citizens.

Island Health has co-developed a comprehensive HBE training program for staff that includes workshops, webinars, and educational resources such as the provincial Healthy Built Environment Linkages Toolkit that was developed with the BCCDC. This training program and the resources have been well received by Island Health staff and by public health professionals in other provinces. Island Health also provides information on healthy built environments to the public through its website.

"At the beginning of the program, we provided formal written comments on Official Community Plans (OCPs) as they came up for review using health evidence," said Yehia. "But our role has evolved over time. Now we are involved in the review of master plans, urban forest strategies, active transportation plans, poverty reduction strategies, and parks and open space master plans. We are also supporting airshed roundtables and climate action plans. We are now seen as a trusted voice and collaborative partner by many of our communities."

"As local partners have gotten to know us, understand our interests, and appreciate the health expertise we bring to the table, they are asking us to get involved earlier in the process and often bringing us in as partners," said Yehia.

The HBE program has also given rise to some significant collective impacts that were not originally anticipated. For example, in Cowichan Valley, where air pollution can become problematic during weather inversions due to the use of wood-burning stoves and open burning, the HBE team participated in a roundtable process with local governments, First Nations, industry, and non-government organizations to develop a regional air strategy. The strategy includes everything from public education to an incentive program that aims to shift home-owners from wood stoves to heat pumps.

"This roundtable has been very successful at addressing the air pollution issue in the Cowichan Valley and really demonstrates the power that collective impact can have on an issue," said Yehia. "Much of this work came about as a result of community champions, a keen desire to address the issue of air pollution in the Cowichan Valley, and a shared leadership/governance structure built on the collective impact model."[58]

Collective impact: Weaving health equity into active transportation

Haliburton Kawartha Pine Ridge District Health Unit (HKPR) is an independent health unit serving an aging population in a mostly rural area in central Ontario that is comprised of three local municipalities: the City of Kawartha Lakes and the Counties of Haliburton and Northumberland. Within the counties, there are 11 lower-tier governments. HKPR is directed

by a Board of Health composed of elected representatives from the communities in its catchment area.

Public health staff at the HKPR have been working to improve health in their district by promoting active transportation for nearly 20 years. Over the years, the HKPR staff have worked with the Communities in Action Committee (CIA) to promote, plan and advocate for active transportation in Haliburton County. An HKPR staff person chairs the CIA and has cultivated relationships with community partners and staff from local governments to make their communities more walkable and bikeable. This work has contributed to the improvement of walking and cycling infrastructure and amenities throughout the county.

In 2015, HKPR the had the opportunity to weave health equity into its active transportation work. The Toronto Committee for Active Transportation (TCAT), supported by the Montreal Urban Ecology Centre (MUEC), led an Active Neighbourhoods Canada (ANC) project in 2015. When the ANC project issued a request for proposals to communities across the country, the CIA/HKPR submitted a proposal for the Village of Haliburton that was accepted.

Nestled in cottage country about two hours north of Toronto, the Village of Haliburton is governed locally by the Municipality of Dysart and regionally by Haliburton County. The county has a year-round population of 17,000 that expands to 45,000 during summer months.

The proposed 'neighbourhood' was a 5 km section of a County Road 21 that leads into the village (see figure 6). This stretch of roadway serves two incompatible functions; it is a major roadway that connects the village to other towns in the county, and it increasingly serves the village as a 'linear neighbourhood'. The challenge was to make this stretch of highway into a more complete street that accommodates pedestrians and local businesses while also allowing efficient travel for vehicles passing through the village.

"There was a lot of development happening along County Road 21 at the time with the addition of a coffee shop, grocery story, and hardware store," noted Sue Shikaze, who was a Health Promoter with the Healthy Communities team at HKPR at the time. "Students in a local neighbourhood were bussed to school even though their school was within walking distance because it was on the opposite side of County Road 21."

"There was also an affordable housing complex for individuals, seniors and families – the Whispering Pines Assisted Living Residence – that was home to a number of seniors who used mobility devices," said Shikaze. "These people had no way to get into town without travelling along the road using their mobility devices."

"We wanted to develop an active transportation plan for this corridor with an equity perspective," explained Shikaze. "We wanted to ensure that this road corridor, and the destinations along it, were accessible to everyone including those who cannot drive."

ANC made two people with expertise in community planning available as resources to the project. The ANC team worked with the CIA and HKPR to develop the project that included three phases.

In the first phase, demographic and travel data was collected, and focus groups were convened at a local restaurant, with students at the high school, with residents at the assisted living residence, and at a local neighbourhood association meeting. At these meetings, people were asked to identify what was and was not working with travel in their neighbourhoods.

"We made a point of engaging with the residents most directly affected by the existing street design with a particular focus on those who cannot or do not drive," said Shikaze. "We took the focus group meetings to them to make it as easy as possible for them to participate."

In the second phase, a charette-style workshop was convened with local planners, engineers and architects. Participants were taken on a walking tour slide show of the neighbourhood, and presented with data, findings from the focus groups, and visualizations of possible design options. The professionals, which included staff from the county and the local municipality, were asked to brainstorm potential solutions.

In the third phase, ideas generated from the workshop were developed further by the ANC team and taken back to the community for review in the form of visualizations. These options were presented to residents at the local farmer's market and the assisted living residence.

The findings and recommendations were summarized in a report prepared by the ANC team with the CIA and HKPR.

FIGURE 6: HIGHWAY 21, HALIBURTON (ACTIVE NEIGHBOURHOODS CANADA)

The report included a number of short-, mid- and long-term recommendations designed to improve safety, increase access to services, and encourage walking and cycling as modes of transportation along the corridor and into the village.

Recommendations were directed at traffic calming, making intersections and parking lots safer for pedestrians and cyclists, and adding safe infrastructure along the roadway for active transportation. The report was provided to the county that was concurrently preparing to work on a corridor study for the area selected.

While the recommendations had the potential to increase physical activity and reduce dependence on vehicles for all residents in the village, they were particularly beneficial for those residents who cannot drive or do not have access to motorized vehicles.

"While we have been focused on increasing levels of physical activity and access for people of all ages and abilities in our community, we appreciate that this work reduces GHGs that contribute to climate change as well," said Shikaze. "Every trip that is made using active transportation is a trip that is not made in a motorized vehicle that emits air pollutants and greenhouse gases."

"While the county was conducting its own corridor study for the area, they did not have the capacity to engage the community to the extent that we did," noted Shikaze. "Our consultations provided a voice to people who are impacted by transportation projects but not often heard. It was very rewarding to hear the active transportation needs of some of the under-served residents in our community and to see their needs reflected in the county's corridor study."[59]

Collective impact: Weaving climate change and an Indigenous perspective into public health programming

Located directly north of Toronto, the Simcoe Muskoka District Health Unit (SMDHU) is a local public health agency that reports to an independent Board of Health. SMDHU has responsibility for population health in a fast-growing district that is feeling development pressure for full-time and recreational properties in 'cottage country'.

SMDHU serves 26 municipalities composed of two upper tier (Simcoe County and District of Muskoka), two single tier (cities of Barrie and Orillia), and 22 lower tier municipalities across rural and urban settings. SMDHU also serves four distinct First Nations communities and urban Indigenous population as well as a defined French-speaking community.

For several years now, the SMDHU has been working to address climate health guided by a theory of change that incorporates three strategies: reorienting public health practice; influencing healthy public policy; and building collective impact.

Climate change was identified as a priority public health issue in the SMDHU 2012-2016 Strategic Plan, with the perspective that an agency-wide response would enhance its ability to effectively respond to this important and complex issue. As

a component of this work, SMDHU developed a multi-phase climate change action plan, with an initial phase resulting in the completion of a comprehensive climate health vulnerability assessment published in 2017. In 2018, SMDHU used a theory of change approach to provide a clear focus and direction for ongoing climate change efforts.

Like other health units in Ontario, SMDHU has been challenged to adequately resource climate-health work. Currently, the work is supported by a Climate Change Public Health Promotor position with part-time support from a Program Manager and an Epidemiologist.

"Our ultimate goal is to support a climate-resilient community," explained Brenda Armstrong, Program Manager for Healthy Environments and Vector-borne Diseases at SMDHU. "When implementing our theory of change, we initially focused on knowledge sharing on climate health among public health professionals and building collaborative actions by establishing a multi-stakeholder committee with partners across our district."

Internally, staff development on climate health aims to ensure that staff in all programs across the public health unit recognize the health risks associated with climate change, the capacity that people have to protect themselves from climate-related impacts such as floods, extreme heat, and Lyme disease, and the policies and programs that can be used to increase community resiliency to climate change and/or to reduce climate emissions.

"We approached staff development on climate health by learning from previous training for our healthy built environment work and health equity work," said Armstrong. "We recognized that much of our public health program work increases community resiliency to climate-related impacts, BUT our staff did not recognize it as such. We wanted them to understand climate health; to know how their work was already related to it, and to think about ways their program work could more explicitly or more effectively address it. We want climate change to be seen as a big picture issue that has to be considered in all of our work in the same way that we now do with health equity."

SMDHU indicated that there is still a lot of work to be done to re-orient its programs internally. The successful integration of climate-health into public health programs and services is ultimately constrained by current public health funding models and provincial program mandates.

"We lost ground with the pandemic," explains Armstrong. "We all had to drop everything to address COVID-19, and it will take some time before staff return fully to their program areas. But when we do, we want to re-engage with our internal programs to address climate-health vulnerabilities. We want to fold climate health into our thinking in the same way that we have worked to fold the social determinants of health (SDOH) into our work."

SMDHU also updated its healthy built environment tools to ensure that climate health messaging and actions were clearly and explicitly addressed. Originally developed in 2014, the healthy built environment tools included a Policy Statement Document that provides evidence-based statements that can be used by upper- and lower-tier municipal partners to build healthy community considerations into their official plans. In 2018, working with a consultant, SMDHU updated its built environment tools and used this opportunity to apply a climate-health lens to the agency's built environment work.

"We wanted the policy document and other tools used by staff to include messages and strategies related to climate health as well as chronic disease prevention, injury prevention, health equity, and environmental health," explained Armstrong. "We want our municipal partners and the public to understand the climate co-benefits of policies and strategies that address issues such as active transportation, green space, and parks."

SMDHU initiated a regional multi-sectoral collaborative network, named the Simcoe Muskoka Climate Change Exchange (CCE). The CCE was developed to address an identified need for local information exchange and collaboration, particularly because SMDHU is not integrated into a regional governance structure. To support the development of the network, SMDHU provided dedicated resources through the Master of Public Health practicum position.

The CCE network now consists of about 40 members representing municipal and local organizational partners (e.g., educational institutions, watershed management and conservation authorities, and hospitals) that are working to address climate change. Key activities include quarterly

meetings, educational presentations, peer-to-peer mentoring, collective projects, and development of a regional climate change charter and action framework to support the CCE's collective efforts.

"The CCE meets formally on a quarterly basis, but there are a lot of informal discussions and collaborations occurring among partners between meetings," noted Sarah Warren, the Climate Change Public Health Promoter who reports to Brenda Armstrong at SMDHU. "Partners share information about funding opportunities, share educational resources, and leverage the expertise from different organizations on separate and joint projects. A number of smaller work groups have also been created to address issues of common interest."

SMDHU also invested substantial time into health and policy research related to climate change to inform and support their work and that of other public health agencies across Ontario. Working with the Public Health Agency of Canada (PHAC), they conducted a scoping review to synthesize knowledge on climate-health adaptation strategies and related gaps in the scientific literature to inform public health practice, decision-making, and future research. One component of the project, led by an Indigenous consulting agency, Cambium Indigenous Professional Services, identifies Indigenous perspectives and the importance of including these perspectives into climate adaptation plans. The findings from this work and lessons learned have been captured in a detailed report, a blog published by the National Collaborating Centre for Environmental Health (NCCEH), and a journal article recently published in the *Journal of the Canadian Institute of Public Health Inspectors*. They have also been communicated in a webinar and at two conferences.

"The scoping review project was very big so we have been working to digest and synthesize the findings into smaller reports, journal articles, and presentations that can be shared broadly across the public health sector," explained Warren. "PHAC commissioned the second piece, Indigenous Lens on Climate Change Adaptation Planning, when the research team recognized that the scoping review did not adequately capture work being done by First Nation, Inuit or Metis (FNIM) Indigenous Communities or organizations. The research team believes that we did not use search terms needed to capture work lead by FNIM Communities and organizations, and that much of this work may not be published in written reports and journals. The next step is to figure out how to apply what we have learned in our everyday practice."[60]

3. Other common themes

Promoting climate change mitigation

Most of the people interviewed for this project believe that the interventions they are promoting will reduce GHGs emissions that are causing climate change. In most of the public health agencies included, however, climate change mitigation is not openly identified as a goal for their work, although climate change adaptation may be. In most cases, the work is being done to improve population health and reduce health inequities. For three of the 10 public health cases, climate change mitigation is an overt goal, along with climate change adaptation and promoting health and health equity.

Senior management support is pivotal

A common theme in many of the case studies was the valuable role that senior management such as directors, MOHs/MHOs, chief executive officers, can play when public health is engaging with other sectors to advance policies that address population health, health equity, and/or climate change. For example:

- In Niagara Region, Harold explained how the Acting MOH laid the groundwork for the Equity-Informed Planning Process by educating regional councillors about health equity and the SDOHs and recognizing and seizing the opportunity to fold equity-informed planning into the region's operational plans.
- On Vancouver Island, Yehia noted that the MHOs have been pivotal to the success of Island Health's HBE program: *"They helped ensure that health promotion and engagement are rooted in evidence and provided support to staff at a local level, which has increased the chances of health priorities being incorporated into local plans."*
- In both Vancouver and Saskatoon, staff described how the MHOs have leveraged the credibility of the MHO's office and made deputations at city council meetings to express support for proposed policies that have the potential to advance population health, health equity, and/or climate change mitigation.
- In Ottawa, Roosendaal expressed how useful it was to have the open support of the MOH for the work they were doing, and permission from senior management to make commitments on behalf of OPH when engaging in planning processes with other departments and experts:

"Policy windows can open and close quickly, and issues are often very complex; as such, senior staff have to be willing to empower staff to make decisions at working group and committee meetings".

Resources need to be committed and relationships cultivated

When discussing lessons learned from their work, most of the public health professionals identified the importance of cultivating relationships across sectors in order to have a positive influence on policies and plans that shape their communities. Many expressed the view that this requires time, resources, and a long-term commitment on the part of the public health agency. For example:

- *"Staff have discovered that they are much more likely to have health priorities and language included in official community plans and master plans when they participate directly in committee meetings" said Yehia from Vancouver Island.*
- *"By developing strong working relationships with staff in other departments, the local municipalities, and conservation authorities, public health is informed about opportunities and included in processes that allow staff to weave health goals, evidence, and considerations into policies and plans that influence population health, health equity, and climate change," said Ghai from Peel Region.*
- *"In the planning field, there are so many factors and tensions that need to be weighed and considered. We can't just pass along the health evidence and walk away," explained Roosendaal from Ottawa. "We need to be in the room, to understand the other factors that need to be considered, inform conversations, and find a way that balances health goals with all of the factors, needs, and realities."*
- *"With some organizations, we have regularly scheduled meetings where we can check in with each other," noted Chow from Vancouver. "Sometimes these meetings involve an informal exchange of ideas about plans or strategies before they have even been drafted. Other times, we learn about valuable opportunities for collaboration or action."*
- *"We have demonstrated to local municipalities that we are credible sources of information," noted Shikaze from Haliburton. "We have helped staff and councillors in local governments understand public health's interest in land use and transportation planning, the value that public health can bring to those processes, and the role that municipalities have in creating healthy and active communities."*

Structurally disadvantaged populations need to be engaged

In the case studies that employed collective impact processes, people described the broad network of people engaged in those processes and the importance of engaging those citizens and groups that are frequently marginalized in our society. For example:

- On Vancouver Island, where Island Health has worked with many small and remote communities, they have encouraged Environmental Health Officers to work through community committees that include citizens, local community groups, First Nation representatives, as well as staff and decision-makers for the communities.

  Yehia indicated, "Staff have learned that context is everything; the issues of concern to a small, coastal community are very different than those for a large urban centre such as Victoria. Staff can be most effective when they focus their time and energy on issues that align with the priorities of the community or the stumbling blocks for local planners."
- In the small Town of Haliburton, where the public health staff and their community members wanted to address health inequities in their active transportation work, they found that it was essential to take consultation processes to high school students, adults living in long-term care, and people with mobility challenges.

  "It is critical to engage under-served populations within the community that might be affected by the existing infrastructure or proposed changes. It is important to take the consultation processes to those populations," said Shikaze. "Do not presume that these residents will have the time or capacity to attend and articulate their needs at one consultation meeting planned in a central location for the entire community."
- Speaking from Barrie in Ontario, Warren described how it was decided that a second report prepared by an Indigenous consultant was needed to bring an Indigenous perspective into their agency's work on climate change adaptation.

Specialized training can be helpful

Several public health agencies have staff with specialized or trans-disciplinary training doing inter-sectoral policy work. For example:

- In Ottawa, Roosendaal, who worked to incorporate 15-minute neighbourhoods into the official plan has a master's degree in planning, while Isernhagen, who

worked to address extreme heat, has a master's degree in geography.

- *"Public health needs to recognize the interconnections between public health, built environment, climate change, biodiversity and health equity in its approach to public policy in keeping with the World Health Organization's Geneva Charter of Well-being, "noted Roosendaal.*
- *"It helps if the public health staff engaged in these processes have expertise in planning so they understand how to ensure that a policy is effective and what is allowed," noted Isernhagen.*
- In Vancouver, Chow, who is the Senior Planner on the Healthy Environments team, has a master's in planning, while Peterson, who is an Environmental Health Scientist on the team, has a master's degree in public health where she specialized in environmental epidemiology.
- On Vancouver Island, Yehia, who was the Healthy Built Environments Consultant, has a master's degree in geography where she examined how health impacts can be incorporated into environmental assessments.

Increased and sustainable funding for public health

The public health sector in Canada requires increased and sustained funding to meet the growing demands for public health expertise and service.

Almost every public health person interviewed mentioned the strain that the COVID-19 pandemic placed on their resources. More than half of those interviewed indicated that all of their policy work came to a halt in 2020, until well into 2023, because they were re-assigned to support the pandemic response. Several public health staff from other public health agencies declined the invitation to be interviewed in the latter half of 2022 because their agency's resources were still directed towards the pandemic.

With global warming causing more severe health risks and impacts in communities across the country, most public health agencies are stretched to the limit. Not only do they need to respond to health-related impacts associated with wildfires, floods, and extreme heat, but they also need to be involved in the development and implementation of climate change vulnerability assessments and adaptation plans to ensure that population health and health equity considerations are identified and properly addressed.

While it is essential that public health prepare for, and respond to, emerging and urgent situations such as those presented by the pandemic and by extreme climate-related events, chronic diseases are responsible for a significant and growing share of the health impacts and health care costs in Canada, and that global warming poses an existential threat to life on the planet. These issues demand a preventive policy response from public health along with all other sectors in society. Public health has demonstrated that it can help achieve healthy public policies that can both, reduce chronic diseases and GHGs, by bringing health evidence to the table. If public health is not involved in local discussions related to the design and development of our communities, however, opportunities to improve health and health equity may well be missed.

IV HEALTH AND HEALTH EQUITY BENEFITS - PUBLIC TRANSIT, ACTIVE TRANSPORTATION INFRASTRUCTURE, AND WALKABLE NEIGHBOURHOODS

Introduction

This section addresses the three climate change solutions – public transit, active transportation infrastructure, and walkable neighbourhoods – together because they are inter-related in terms of their impact upon one another and their impacts on population health and health equity.

While these three climate change solutions can impact population health in many ways, two well-researched risk factors that are common to all three are physical inactivity and air pollution. These two risk factors are discussed along with an examination of the climate change mitigating, population health and health equity benefits that are specific to each of the three.

1. Physical inactivity and population health

The health benefits of physical activity are well known. Regular physical activity is known to reduce the risk of developing several chronic conditions including diabetes, cardiovascular disease (CVD), several cancers, and premature deaths from all causes.[61] Drawing on data from many different epidemiological studies, in 2011, researchers estimated that 150 and 300 minutes of moderate to vigorous physical activity per week can reduce the risk of premature death from all causes by 14% and 26% respectively.[62] Physical activity is also good for mental health. It can improve self-esteem, sleep, and cognitive functioning in older adults, and delay the onset of dementia. It can also relieve depression, anxiety and stress, and support drug and alcohol rehabilitation.[63]

Many people in Canada do not engage in the levels of physical activity needed to maintain good health. Less than half of the adults in Canada get the 150 minutes/week of moderate to vigorous physical activity that are recommended in the new Canadian 24-hour Movement Guidelines.[64] Before the pandemic, a little over one half of the youth (12-17 years of age) in Canada were getting the 60 minutes/day of moderate to vigorous physical activity recommended by the guidelines, but that percentage dropped to 37.2% during the pandemic.[65]

Chronic diseases claim a heavy toll in Canada. Of people over 20 years of age, 60% will develop a chronic disease. These diseases, which are largely preventable, steal many healthy years from people and give rise to over 150,000 premature deaths/year. They also result in approximately $68 billion/year in direct health-care costs and $122 billion/year in income and productivity losses.[66] It has been estimated that physical inactivity results in approximately $6.8 billion/year in health-related costs based on its contribution to seven chronic diseases alone.[67]

Type 2 diabetes is a particular concern in Canada because of its debilitating impact on people and its significant costs to the health care system. Over a 10-year period, 10% of people in Canada (2.16 million people) are expected to develop Type 2 diabetes, and their treatment and care will cost society about $15.36 billion. Researchers estimate that a population-level intervention that could reduce average body weights by 5% could reduce the risk of developing diabetes over a 10-year period to 8.67%. This would decrease the number of new cases to 1.9 million and avoid $2.03 billion in health care costs.[68]

2. Air pollution and population health

Air pollution's toll

Outdoor air pollution, caused in large part by the burning of fossil fuels such as coal, oil, gasoline, diesel and natural gas, affects almost every organ in the body. People can be affected by both, short-term exposure to high levels of air pollution and by long-term exposure to very low levels of air pollution.

Short-term exposures can cause respiratory infections, reduced lung function, and aggravated asthma symptoms, while long-term low-level exposures can increase the risk of developing chronic diseases. Long-term exposure to lower levels of air

pollution have been clearly associated with an increased risk in premature deaths from ischaemic heart disease, strokes, lung cancer, chronic obstructive pulmonary disease, and all causes. With some air pollutants, there is no safe level of exposure.[69] People who have pre-existing health challenges and those who have experienced material deprivation or social disadvantage may also be more susceptible.[70]

Health Canada estimates that outdoor air pollution in Canada gives rise to 15,300 premature deaths, 2.7 million asthma symptom days, and 35 million acute respiratory symptom days each year. The economic costs of these health impacts have been valued at $120 billion/year.[71]

Traffic-related air pollution

Traffic-related air pollution (TRAP) is a major source of air pollution in Canada, particularly in large urban centres. High volume traffic corridors are a principal source of variation in levels of air pollution within urban centres. While TRAP has its greatest effect on populations that live or work within 100-500 metres of high-volume traffic corridors,[72] it can affect air quality at the neighborhood, urban, and regional scale as well.[73]

TRAP is a complex mixture of air pollutants composed of tailpipe emissions (i.e., vehicle exhaust) and non-tailpipe emissions (i.e., from the fuel, re-suspended road dust, particles released from wear and tear on vehicle brakes, tires, and road surfaces). The mixture includes nitrogen oxides (NOx), elemental carbon, fine particulate matter ($PM_{2.5}$), ultrafine particles, heavy metals, volatile organic compounds, and polycyclic aromatic hydrocarbons.[74] Some of these pollutants are transformed in the air into $PM_{2.5}$ and ground-level ozone, the primary components of smog. Nitrogen dioxide (NO_2) is often used as an indicator of TRAP because local traffic sources are responsible for up to 80% of the ambient air levels of NO_2 in urban settings.

Tailpipe emissions from individual vehicles have been decreasing over the last several decades in response to air quality and emission-control regulations. These decreases have not, however, offset the emissions associated with the growth in vehicle kilometres travelled (VKT) and traffic congestion that is occurring in many large urban areas. The shift to zero emission vehicles (ZEVs) will have a significant impact on TRAP over time, however ZEVs will not eliminate the non-tailpipe emissions that are associated with TRAP.[75]

CPHO on Transit, Cycling and Walkable Neighbourhoods

"By advocating for healthy environments, like walkable neighbourhoods, cycling, and public transit, we can reduce the burden of cardiac and respiratory disease, premature deaths and hospital admissions, promote positive mental well-being, and reduce air pollution."

CPHO. 2022. Mobilizing Public Health Action on Climate Change in Canada.

TRAP harms health

Hundreds of health studies have examined the impact that TRAP can have on human health. A systematic review and meta-analysis released by the Health Effects Institute (HEI) in 2022 concluded with "high or moderate-to-high level of confidence" that long-term exposure to TRAP increases:

- premature deaths from all causes, circulatory diseases, ischemic heart disease, and lung cancer;
- the onset of asthma in both children and adults; and
- acute lower respiratory infections in children.

The HEI panel also found with a "moderate level of confidence" that TRAP increases the risk of:

- low birth weights and small gestational size in children;
- diabetes, increased rates of asthma, and respiratory deaths; and
- poorer cognitive function and autism spectrum disorder among those exposed prenatally or in early childhood.

Over 20 high quality studies have also explored the association between TRAP and dementia and Parkinson's disease with mixed results. While the HEI panel had low to moderate confidence in the association between these two health outcomes and TRAP, that assessment could change as more studies are directed at the neurodegenerative impacts of TRAP.[76]

Health costs of TRAP in Canada

Health Canada estimates that TRAP is responsible for over 1,200 premature deaths, 2.7 million acute respiratory symptom days, 1.1 million restricted activity days, and 210,000 asthma symptom days each year. These health impacts have been valued at $9.5 billion/year.[77] One third of the premature deaths linked to TRAP are attributed to light-duty vehicles while

two thirds are attributed to heavy-duty diesel vehicles such as commercial trucks and buses.[78]

Health Canada has also concluded that exposure to elevated levels of TRAP is likely to cause leukemia in children and lung cancer in adults and may also cause breast cancer in adults.[79] Given that 40% of people in Canada live within 250 metres of a high-traffic road that is associated with elevated levels of TRAP,[80] these health risks represent a significant concern.

Air pollution and health equity

While everyone can be affected by air pollution, some populations are more susceptible to the negative impacts including children, older people, and pregnant women. People who have pre-existing health challenges and those who have experienced material deprivation or social disadvantage may also be more susceptible.[81]

A 2022 analysis by Health Canada found that 8%, 25% and 44% of the Canadian population resides within 100, 250, and 500 metres of high-traffic roads. Huge variation was observed between provinces. Approximately, 40% of the population in Ontario and British Columbia live within 250 metres of a high-traffic road, compared with 9% for the other provinces and the territories.[82]

When Canada's population was broken into five groups using a Deprivation Index based on income, education, and other socio-economic factors, the study team found that populations that are materially deprived are more likely to live near high-traffic roads than more privileged populations.[83] Another Canadian study found that the lowest-income neighbourhoods in Toronto and Montreal were 3.5 and 2.8 times, respectively, more likely to be situated within 200 metres of a highway, than were the highest-income neighbourhoods.[84]

Health Canada found that one third of the schools in Canada, that house children for several hours each school day, are located within 100 metres of a high-traffic road, while almost one half are within 200 metres. It also found that 40% of long-term care facilities that house older populations for up to 24 hours per day are located within 100 metres of a high-traffic road, while 60% are located within 200 metres.[85]

3. Public transit

Public transit decreases greenhouse gases

Public transit has been identified by many organizations, including the IPCC and The Lancet Countdown, as one of the major solutions to climate change. The transportation sector is responsible for 24% of the GHGs emitted in Canada. While kilometres travelled per vehicle in Canada have decreased over the last 20 years, the total number of vehicles on the road has increased by 42%, leading to an increase in the total kilometres driven in Canada.[86]

Modelling studies have found that improved transit, when combined with road pricing (i.e., road tolls) and improvements to the built environment, can reduce total vehicle-kilometres travelled (VKT) and GHG emissions by 7-23% over 10 years and 15-26% over 30 years.[87] In Vancouver, for example, modelling found that the city could hold VKT constant until 2030 by investing in transit, increased density, cycling infrastructure, and road networks despite a rapidly growing population. It was estimated that, by 2050, these actions could cut GHGs from the transportation sector by 15% relative to the emissions expected without them.[88]

There is also evidence that traffic volumes can be reduced substantially at little cost and without changing traffic speeds by reallocating road space to transit and active modes of transportation.[89] Extensive experience in Europe has demonstrated VKT can be reduced without the use of road tolls by reallocating road space to public transit, cyclists, and pedestrians. Drivers gradually shifted into other modes of travel over time in response to the reallocation of road space.[90] In the US, transit lanes have been found to increase the reliability and speed of transit vehicles, which has encouraged greater ridership and ultimately improved traffic flow for all vehicles on the roads.[91]

Public transit improves air quality and health

Public transit investments can reduce air pollution in a few different ways. First of all, less air pollution is emitted per passenger-kilometre travelled in public transit than in private vehicles.[92] Secondly, residents who live in communities with high-quality, well-integrated public transit tend to own fewer vehicles, drive fewer kilometres, walk and cycle more frequently, and use public transit more often, than residents in more car-dependent communities.[93]

In the Greater Toronto and Hamilton Area (GTHA), it was estimated that a transit-focused plan could avoid 154 premature deaths and $1 billion in health-related costs per year by reducing traffic-related air pollution in the region.[94] The air quality health benefits could be even greater if transit vehicles were electric-powered. A modelling study estimated that 143 additional premature deaths per year could be avoided in the GTHA if 100% of the transit buses were replaced with electric-powered vehicles that emit no air pollutants. The social benefits of this shift were valued at $1.1 billion/year.[95]

Public transit fosters physical activity and health

Transit use increases physical activity because most transit trips begin and end with some form of active travel. A study in Montreal found that a round trip on public transit required, on average, about 2,500 steps, and could provide 25% of the daily physical activity recommended for good health.[96] These findings are consistent with a US study that found that adults who use public transit, walk on average 19 minutes a day in the process of taking public transit, with nearly one third of them achieving the 30 minutes of daily physical activity recommended for good health.[97]

The health benefits of transit-related physical activity can add up, particularly when combined with investments in active transportation. In the GTHA, for example, it was estimated that a transit-focused transportation plan for the region could avoid 184 premature deaths and $1.2 billion in health-related costs per year by increasing physical activity.[98] In Ottawa, it was estimated that policies in the city's Transportation Master Plan that aim to increase the use of public transit, walking, and cycling, could reduce diabetes cases by 4% (i.e., 1,620 cases) over 10 years. About two thirds of the avoided cases were attributed to people who switched from vehicles to public transit.[99]

Transit can also improve mental health by increasing levels of physical activity and providing more affordable access and reducing barriers to jobs, essential services, education, and recreational activities.[100]

Public transit increases road safety

In 2021, vehicle related collisions were responsible for 1,768 deaths, 8,185 serious injuries, 108,019 total injuries in Canada. Approximately 50% of those killed were drivers, 15% were passengers, 16% were pedestrians, 2.5% were cyclists, and 13% were motorcycle drivers.[101]

Germany's €9 Monthly Transit Passes

When Germany dropped the price for monthly transit passes from €107 to €9 for 3 months to provide its citizens with financial relief from inflation:

- 52 million people purchased passes;
- Air pollution levels dropped by 7%; and
- GHG emissions dropped by 1.8MT - equivalent to those from 350,000 homes over 1 year.

Spencer Feingold. 2022. Germany's 9 Euro Transit Cut 1.8 MT of CO2. World Economic Forum. August 31.

Public transit makes roads safer for all users. One US study found that passenger fatality rates on buses was about 20 times less than that in automobiles.[102] In addition, traffic fatalities for pedestrians, cyclists, and automobile occupants, as well as transit users, decline significantly as transit ridership increases in a community. It has been suggested that this decline occurs because people who live or work in communities that support efficient and affordable transit tend to drive fewer kilometres, drive at lower speeds, and have travel options that allow them to avoid high-risk driving, such as driving while impaired.[103]

Public transit increases access and health equity

It has been estimated that 20-40% of the people in our communities do not drive because of their age, income, ability, or personal choice.[104] Statistics indicate that newcomers to the country and women who commute to work, rely more heavily on public transit than other groups in Canada.[105] An efficient and reliable public transit system can provide these populations with a more affordable and independent way to access jobs, schools, essential services, and recreational opportunities.[106]

Public transit can also save people money. It typically costs between $6,000-$13,000 per year to own and operate a car in Canada.[107] An efficient public transit system can eliminate the need for people to own and operate one or more vehicles. Households can save, on average, $10,000 per year by replacing one car with public transit.[108] By eliminating the need to own a car, public transit allows people living on lower incomes to direct more of their income to essentials such as food, clothing, and rent.[109]

Women's travel needs can differ from those of men because of the various roles they may assume for their families. Women

FIGURE 7: CHAD TRANSIT, INCLUSION SERVICE, NS

Providing Transit to Rural Communities in Nova Scotia

Most communities in Nova Scotia have local community transit service with access to a nearby hub where they can access health care services and other essential services.

The rural transportation providers offer local transportation within their rural or remote communities and will offer transportation between local communities and a major urban centre such as Halifax or Sydney when there is a need. Some offer direct route service, but all offer door-to-door service. All of them offer an accessible service to everyone in the community.

> *"The transportation services offered by our partners are used by a broad group of people in our communities," noted Leslie Carlyle-Ebert with the Nova Scotia Community Transportation Network (Network). "People who cannot drive, retired people who do not want to drive in winter months, people who don't own cars, students, and people with mobility challenges – all use these services."*

Transportation services are being provided to people who cannot drive because of age, ability or income in most rural and remote communities in Nova Scotia, making all levels of education, health care services, and other essential services more accessible to all. Transportation services are also being provided in a culturally sensitive way to a First Nation community and two unilingual Francophone communities.

In 2021, the Network, the Rural Transportation Association, and their transportation partners, collaborated with public health to help transport people in rural Nova Scotia to their COVID-19 vaccine appointments. The provincial government offered a Vaccine Fare Subsidy to support the transportation fare so that travel costs for passengers could be limited to $5 per round trip to a vaccination site within or outside their communities.

While the Network has not evaluated the impact of its services on climate emissions, they believe that their partners are reducing transportation-related climate emissions by reducing the number of single-passenger vehicle trips that are taken in the province, and by utilizing low-emission fuels whenever possible.

Perrotta K. 2023. Providing Transit to Rural Communities in Nova Scotia. CPHA, CHASE, OPHA.

may fold multiple trips into their days to cover grocery stores, medical appointments, schools, or childcare. When transit is designed to focus on commuting to and from work with a single destination, it can result in greater costs and less access to public transit for women. Some communities have helped alleviate this inequity by implementing time-based transfers that allow passengers to travel for one to two hours on a single ticket.[110]

Unfortunately, at present, about 5% of Canada's population in its eight largest cities (nearly one million people) are living in lower-income households that are in neighbourhoods with poor access to public transit.[111] This combination amplifies the disadvantages faced by these populations and increases their health risks. Public transit can be designed to meet the needs of these populations, as well as those who live in rural or remote communities, senior populations, and those who are physically or mentally unable to drive.[112]

4. Active transportation infrastructure

Active transportation reduces greenhouse gases
Active modes of transportation emit no GHGs, so they have the potential to substantially reduce the GHGs associated with the transportation sector.

Several modelling studies have found that, in large urban centres where significant population growth is expected, an active transportation strategy, when combined with investments in public transit, road pricing, and improvements in the built environment, can substantially reduce VKT and GHG emissions.[113]

For example, a study conducted for San Francisco, California, estimated that, if the region could increase walking and cycling for shorter trips from the existing median of 4.5 minutes/day to 22 minutes/day, it could reduce Vehicle Miles Travelled (VMT) by 15% and GHGs emissions from the transportation sector by 14.5%, while reducing premature deaths by 13% because of increased levels of physical activity.[114]

Active transportation fosters physical activity and health
Most Canadians do not engage in sufficient levels of physical activity to maintain good health.[115] For many people, it is difficult to find the time to exercise. Active transportation can allow people to incorporate physical activity into their daily schedule by replacing automobile trips with active modes of transportation.[116]

Over the last two decades, several cross-sectional studies and several long-term studies have identified linkages between active transportation, levels of physical activity, and positive health outcomes.[117]

One cross-sectional study, published in 2011, examined health and travel data for 14 countries, 50 states in the United States (US), and 47 of the 50 largest cities in the US. It found a statistically significant relationship between:

- Active travel and obesity at a national, state, and city level; and
- Active travel, increased levels of physical activity, and decreased levels of diabetes at a state and city level.

The authors concluded that, when considered along with many other studies, active travel can produce important health benefits and support the development of policies designed to encourage walking and cycling for daily travel.[118]

Evidence supporting the health benefits of active transportation has mounted over the last decade. For example, a long-term study published in 2017, that followed more than 250,000 people from 22 communities across the United Kingdom over five years, identified strong relationships between active travel, physical activity, chronic diseases, and premature deaths. After adjusting for a wide range of health, demographic, and behavioural confounders, this study found that:

- Approximately 90% of cycling commuters and approximately 80% of mixed mode cycling commuters reached physical activity levels recommended by health guidelines;
- Approximately 54% of walking commuters and approximately 50% of mixed mode walking commuters met physical activity guidelines with their commutes;
- Commuting by cycling was associated with a lower risk of CVD and cancer, and a statistically significant lower risk of premature death from all causes; and
- Commuting by walking was associated with a lower risk of CVD, but only among those who walked more than six miles or two hours per week.

The authors concluded that policies designed to affect a population level modal shift to more active modes of commuting, particularly cycling, "may present major opportunities for the improvement of public health".[119*]

FIGURE 8: MULTI-USE PATH BRIDGE, POWELL RIVER, BC (SHANE O'BRIEN)

Promoting Active Travel in Rural and Remote Communities

In 2020, the BC Alliance for Healthy Living (Alliance) initiated the Small Towns, Big Steps in Active Transportation project.

> *"The literature scan found that many of the community design factors that support active transportation in a large urban centre, such as density, do not apply to small, rural communities," explained Rita Koutsodimos, the Alliance's Executive Director.*

The scan found that small towns have a number of advantages that can be used to support and foster active transportation including compact urban centres; access to parks, green space and trails; and strong community connections and close relationships between local leaders and citizens.

The municipal survey indicated that small communities have a strong interest in developing active transportation in their communities with many of them (50-62%) recognizing that active transportation can:

- Enhance community connectivity;
- Increase traffic, cyclist and pedestrian safety;
- Improve quality of life; and
- Support climate and environmental stewardship and public health.

However, the survey also found that over one third of small communities (38%) have little or no capacity to work on active transportation, while only one quarter have staff, funding, and/or resources that could be used to promote active transportation.

> *"This project identified strategies that can be implemented by small communities to increase their progress on active transportation, but it also identified the need for policy and funding support for small towns from senior levels of government," said Koutsodimos.*

Perrotta K. 2023. Promoting Active Travel in Rural and Remote Communities. CPHA, CHASE, OPHA.

Active transportation improves air quality and health

A number of studies have indicated that a modal shift to active modes of transportation can have a substantial impact on air quality and human health. For example, a modelling study focused on the Midwestern United States estimated that $7.35 billion/year in health-related benefits could be gained for the 31.3 million people living in the region, if all vehicle trips that were 8 kilometres or less were eliminated, and one half of those were replaced with cycling. Nearly one half of the health benefits were attributed to reductions in air pollution while the other half were attributed to increases in physical activity.[120]

Concerns have been expressed about the air pollution exposure that cyclists can experience when travelling along roadways. A few studies have found that while cyclists can be exposed to higher levels of air pollution when travelling beside roads, the health benefits gained from their increased levels of physical activity, far outweigh the health risks posed by their increased exposure to air pollution. This held true for all but a few countries that have exceptionally high levels of air pollution.[121,122]

Active transportation infrastructure increases safety and modal shifts

Vehicle-related collisions with pedestrians are more likely to occur near schools and in commercial areas where there is heavier traffic, more pedestrians, and a greater density of intersections. Studies have demonstrated that pedestrian safety can be improved with infrastructure such as overpasses, barriers, fences, streetlights, traffic lights, and sidewalks. Research has also demonstrated that people are more likely to walk if their route is safe and attractive.[123]

Studies from several countries have found that the number of cyclists killed or seriously injured decreases as the number of cyclists increases. This pattern is attributed to both, the increased visibility of cyclists, and the increased awareness among drivers when the number of cyclists is high.[124]

Cycling facilities also play a pivotal role in cycling safety. In the US, where there has been relatively little investment in cycling facilities, cyclists have much higher serious injury and fatality rates than in European countries that have made significant investments in cycling infrastructure. In 2010, for example, there were 4.7 cyclist deaths/100 million kilometers cycled in the US compared with 1.0, 1.1 and 1.3 respectively in the Netherlands, Denmark, and Germany.[125] In Boston, the growth of the bicycle infrastructure from 2007 to 2014 was associated with both a large increase in cycling levels and a reduction in the cyclist injury rate.[126]

A 2012 study on Toronto and Vancouver found that cycle tracks (i.e., on-street bicycle lanes that are physically separated from motor vehicles by raised curbs, bollards, or concrete barriers) were the safest type of cycling facility. When compared to major streets with parked cars and no cycling facilities:

- Cycle tracks were 89% safer;
- Unprotected cycling lanes on major roads without parked cars were 53% safer; and
- Residential streets with light traffic and no cycling facilities were 56% safer.[127]

Similar outcomes were found with a 2011 study conducted in Montreal, a city which had the most extensive system of cycling infrastructure in North America at that time. The cyclist injury rate on cycle tracks was 28% lower than the rate on parallel roads and were used for 2.5 times as many cycling trips.[128]

A 2019 study based on 13 years of data from 12 large US cities, found that cities with a high-cycling modal share* have roads that are safer for all road users, including cyclists. After examining 17,000 fatalities and 77,000 severe injuries related to vehicle crashes, the research team concluded that the roads in these cities were safer because they have a greater prevalence of protected and separated bike facilities. These cities also have higher intersection density that tends to be associated with more compact built environments that have lower traffic speeds. The research team noted that road safety is associated with gentrification, which suggests that there may not be equitable access to the safer roads.[129]

Several studies conducted over the last 15 years have found that designated cycling infrastructure is essential to encourage reluctant cyclists, particularly new cyclists, to engage in cycling as a mode of transportation. Those studies have also found that cycling modal share is associated with the length of a cycling network.[130,131] A 2019 study that examined the relationship between cycling networks and cycling modal share in 167 European cities, found that a maximum cycling modal share of

* Modal share (also known as mode split, mode share, or modal split) is the percentage of travelers using a particular type of transport, or the number of trips using that type. https://academic-accelerator.com/encyclopedia/modal-share

Snow clearing and gender equity

In Sweden, it used to be that cities would plow major highways and roadways first, especially near large employers, then walkways and bike paths. When these policies were subjected to a "gender-balanced budgeting" process, it was concluded that they disadvantaged women, who are more likely to walk. It was also found that people walking in icy conditions were three times as likely to be injured than people driving. In addition, the cost of those injuries was much greater than the cost of snow clearance. Now, many Swedish cities clear walkways and bike paths first, especially those near bus stops and primary schools, then local roads, and then highways.

Angie Schmidt. 2018. Why Sweden Clears Snow-Covered Walkways Before Roads. StreetsblogUSA

24.7% could be achieved with a cycling network composed of 315km of cycle track/100,000 people.[132]

Active transportation and health equity

A 2022 scoping review that focused on long-term studies that evaluated the different health outcomes associated with active transportation interventions based on race, ethnicity, or socio-economic status, identified only 10 studies. These studies examined the impact of health promotion programs, improvements to pedestrian and cycling infrastructure, and increased transit infrastructure or access. Eight studies found a positive impact on health outcomes for all populations. Nine found no significant difference or a favourable impact on the health of the disadvantaged [sic] groups relative to the overall population. The researchers concluded that there is a significant gap in the literature about how health inequities might be reduced with respect to active travel. It also noted that more research is needed to understand if active travel infrastructure is inequitably distributed.[133]

In the City of Toronto, it has been acknowledged that the historic practice of investing in on-street cycling infrastructure in the downtown core has resulted in the inequitable distribution of active transportation infrastructure; that a number of lower income neighbourhoods in the city's suburbs have not been well served by cycling investments. The city is now working to address this problem by developing a Cycling Network Plan that applies an equity lens to its decisions.[134]

The needs of older adults are not always considered when communities are designed. A 2020 study directed at older populations living in different types of neighbourhoods across Canada found that their use of active modes of transportation was influenced by the presence of cycling infrastructure, well maintained sidewalks, and traffic safety.[135] People with mobility challenges are another group whose needs are not always reflected in neighbourhood design, and yet 14% of people in Canada who are 15 or older live with a disability that limits their daily activities. Evidence suggests that neighbourhoods with less traffic, uncrowded spaces, good accessibility, and high quality and safe streets, can increase the activity, social interaction, and productivity of people with disabilities.[136]

The perception of traffic safety can be an important deterrent to cycling, particularly among women. In countries where cycling can be perceived as unsafe, men cycle at much higher rates than women. In the GTHA for example, fewer than 30% of cyclists are women. In countries that have higher cycling modal shares and separated cycling infrastructure, women cycle at rates similar to those for men. In the Netherlands and Denmark for example, women make 55% and 45% respectively of all bike trips.[137]

5. Walkable neighbourhoods

Introduction

Different terms have been used to describe neighbourhoods and communities that encourage active modes of transportation and transit use. The health science literature often uses the phrase "walkable neighbourhoods", while transportation guidelines sometimes refer to "walkable and transit-supportive communities",[138] and planners talk about the need for "complete communities". In the public health sector, the phrase "healthy built environments" often includes walkable neighbourhoods, transit-supportive communities, and complete communities. More recently, the phrase "15-minute neighbourhoods" has been applied to neighbourhoods that have many of the common amenities such as schools, grocery stores, and restaurants, and transit-service, within a 15-minute walk of residents' homes.[139]

Walkable and transit-supportive communities reduce GHGs

The impact of urban form on climate change is a crucial issue because, on a global scale, cities are responsible for approximately 80% of energy related GHGs. That contribution is expected to grow over time given the current global trend of

migration from rural areas to urban centres. Most of the GHGs emitted within urban centres are related to the fuels used for transportation and the heating and cooling of buildings. The volume of fuel used in both sectors is related to some extent by factors such as population density, job density, land use mixtures, and the overall design of communities and transportation systems.[140]

Feng and Gauthier conducted a systematic review of studies directed at the relationship between urban form and climate change over a 40-year period. Published in 2021, the study noted that, while "urban sprawl" was defined in many different ways in various studies, the common characteristics were low-intensity land development patterns, low population density, the segregation of different types of land uses, and dependence upon automobiles as the primary form of transportation. Communities with an urban form that is the opposite of "urban sprawl" were frequently characterized by higher population densities and a diversity of land uses in close proximity to one another that are organized in a way that supports walking and public transit. These researchers found that, while the relationships between specific indicators of urban form are hard to clearly delineate because definitions vary from one study to the next, much of the evidence demonstrates that urban sprawl is associated with "indisputable environmental costs, including climate change".[141]

A study conducted by the Urban Land Institute found that more compact development patterns can reduce the distance travelled by vehicles by 20-40% and that people in the most walkable neighbourhoods drive 26% less often than those who live in more sprawling neighbourhoods.[142] A 2007 study found that the travel of people who live in the dense inner-city neighbourhoods of Toronto with easy access to public transit generated 1.31 tonnes of GHGs/year, while the travel of people living in the outlying suburbs with poor access to transit generated 13.02 tonnes of GHGs/year.[143] Research conducted for Toronto Public Health in 2012, found that residents from the most walkable neighbourhoods walk for utilitarian reasons 2.7 times more frequently, use transit 2.5 times more often, drive 4 times less often, and drive one sixth the distance, as residents who live in Toronto's least walkable neighbourhoods.[144]

Walkable neighbourhoods increase physical activity

Many studies published over the last two decades suggest that people who live in walkable neighbourhoods are more likely to be physically active. From these studies however, it was not clear if those associations were sufficient to have a meaningful impact on health. A Canadian study published in 2016 was designed to address this issue. It examined the levels of physical activity for a large population, that included people from 6 to 79 years of age, drawn from urban areas across the country. The respondents were divided into five categories based on the walkability of their neighbourhoods using the Street Smart Walk Score® values.

In all but the youngest group, people who lived in the most walkable areas engaged in significantly more physical activity than those in the less walkable areas. Among the adults 30 to 44 years of age, those living in the most walkable neighbourhoods were physically active for almost 15 minutes/day more, on average, than people living in less walkable neighbourhoods. These 15 minutes/day account for over two-thirds of the 150 minutes/week of moderate to vigorous physical activity that are recommended as a minimum for adults to maintain good health. The authors concluded that highly walkable areas can have a meaningful impact on the risk of chronic disease.[145]

Another study published in 2021 suggested that walkable neighbourhoods also have an important impact on the commuting behaviour of school-aged children. It examined the school commuting habits of 11,006 children, 11 to 20 years of age, in Ontario. It used the Canadian Active Living Environments (Can-ALE) measure that combines intersection density, dwelling density, and proximity to destinations of interest as a measure neighborhood walkability. The study found that students who attend schools in more walkable neighbourhoods are more likely to walk or cycle to school. These are important findings when one considers that only 20% of children in Canada currently walk or cycle to school.[146]

Walkable neighbourhoods improve metabolic health

Many studies have examined the impact that walkable neighbourhoods have on obesity, hypertension, and Type 2 diabetes, all of which are risk factors for CVD. A 2022 review concluded that:

- A large number of studies have found higher levels of physical activity that are clinically important among residents who live in highly walkable neighbourhoods;
- A growing body of research suggests that walkable neighbourhoods can improve metabolic health when compared to car-oriented suburbs;

Walkability and diabetes

A study that followed diabetes-free adults from five urban areas in Ontario over a 10-year period, found a 15% lower weighted incidence of diabetes over a 10-year period in highly walkable neighbourhoods when compared to neighbourhoods with low walkability.

Booth GL et al. 2019. Neighbourhood walkability and the incidence of diabetes: an inverse probability of treatment weighting analysis. J Epidemiol Community Health.

- Many studies have found that walkable neighbourhoods are associated with decreases in Body Mass Index (BMI), obesity, prediabetes, diabetes, and hypertension, suggesting that walkable neighbourhoods can support metabolic health and weight management;
- Walkable neighbourhoods appear to reduce the risk of diabetes, although the results vary across countries; and
- Lower income neighborhoods appear to be associated with increased risks for weight-related outcomes and diabetes, although these results are also mixed.[147]

Walkable neighbourhoods reduce premature deaths and health inequities

Several studies conducted in recent years suggest that neighbourhood walkability may also be associated with a reduced risk of premature deaths, and that these benefits may be greater for structurally disadvantaged populations. A long-term study, published in 2022, adds strong evidence to these findings. It followed 1.8 million adults who live in Canadian urban areas over 15 years. Walkability was defined using the CAN-ALE index and the associations were corrected for air pollution and greenery. The study found that, relative to people living in the least walkable neighbourhoods, people who live in the most walkable neighbourhoods were:

- 9% less likely to die prematurely from CVD;
- 13% less likely to die prematurely from a stroke; and
- 3% less likely to die prematurely from all non-accidental causes.

The researchers also identified an "exposure" gradient within this study. Premature deaths among people who were 35 to 64 and 75 to 89 years in age decreased progressively as neighbourhood walkability increased. This trend was more pronounced for structurally disadvantaged populations. The people living in the most walkable neighbourhoods who had little education, low household income, or lived in highly deprived neighbourhoods, were 9%, 15% and 25% less likely respectively to die prematurely from CVD than similar populations living in the least walkable neighbourhoods.

The study team concluded that Canadian adults who live in walkable neighbourhoods have lower rates of premature deaths from CVD and all other non-accidental causes, with the greatest benefits occurring among those in the lowest socioeconomic groups.[148]

Neighbourhood characteristics that foster active travel

The relationship between urban design and transportation networks on active modes of travel, including public transit, have been documented in a robust body of literature. The features of interest are often referred to as the 5Ds:

- Density of population and jobs;
- Diversity of land uses;
- Design of transportation networks;
- Accessibility of destinations of interest; and
- Distance to transit.

Overall, studies have found that people walk more and drive less when their neighbourhoods have:

- Sufficient densities to support local businesses and efficient transit service;
- Stores, restaurants, and community services located in close proximity to homes;
- Supportive street designs (e.g., grid pattern) and infrastructure (e.g., sidewalks, crosswalks, good street lighting, and street furniture) that make walking safe, pleasant and convenient;
- Transit stops within a short distance (e.g., less than 10-minute walk) of homes and workplaces; and
- A transit network that can deliver them to popular or common destinations, particularly if the service can rival driving for comfort and convenience.[149,150]

A systematic review published in 2023 found that improvements in neighbourhood walkability, the quality of parks and playgrounds, and active transportation infrastructure are likely to have a positive impact on the levels of physical activity among children and adults. In particular, the review identified the following interventions as those that "show

FIGURE 9: ZUNGA BUS, POWELL RIVER, BC

On-demand Transit Service in Powell River

The Zunga Bus on-demand service was launched in Powell Review in early 2021.

"We initiated this project because our existing transit service was not being used by many residents in our community," said Anastasia Lukyanova, Sustainability Planner for the City of Powell River. "At first, our goal was to increase ridership to reduce emissions of air pollutants and greenhouse gases associated with travel."

"In a small community such as ours, with residents spread over relatively long distances, it is difficult to provide efficient and convenient transit service," explained Lukyanova. "Fixed route service can be efficient on the direct routes used most frequently but excludes a good portion of the community. HandyDart, on the other hand, is for people with mobility challenges only, and does not provide very convenient service. People have to book the day before, they may have to wait for 30 minutes for their rides, and the rides can take a long time."

"On-demand transit serves trips as they are booked with no fixed routing or schedule, and can offer either door-to-door or stop-to-stop service, or a combination of the two. The limitation of on-demand service is that it cannot optimize wait times and travel times when passenger volumes exceed approximately 8 to 10 passengers per hour."

"The project has been very well received by the community," reported Lukyanova. "Through the evaluation, we have learned that the Zunga Bus can improve the physical and mental health of residents by increasing their access to essential services, recreational facilities, and social opportunities. Community groups who serve youth, older people and people with mobility challenges have expressed strong support for this service."

Perrotta K. 2023. Increasing Mobility and Sustainability with On-demand Transit Service in Powell River, BC. CPHA, CHASE, OPHA

promise" for increasing physical activity and active travel among children and adults:

- The provision and/or improvement of crosswalks, sidewalks, bike parking, traffic calming features, and parking bays;
- The creation of safe places to walk, bike boulevards or lanes, traffic free bridges, and boardwalks;
- The installation of fitness/playground equipment, walking tracks, fencing, and landscaping in parks;
- Temporary road closures and play equipment;
- Increased access to, and the availability of, public transport;
- Increased density of residences, destinations, and recreational facilities; and
- Increased street connectivity and increased land use mix.[151]

Greenbelt policies foster active travel and metabolic health

A number of studies have found that greenbelt policies can support the development of walkable and transit-supportive communities. A 2020 study conducted in South Korea suggested that greenbelt policies can help improve metabolic health by fostering transit use and active travel. This study was directed at greenbelt districts that were established in 1971 around eight metropolitan areas in South Korea. Obesity was selected as an indicator of population health. The researchers found that several factors were associated with significant reductions in the rate of obesity including:

- Increased rates of public transit use;
- Increased rates of residence in apartments;
- The presence of a greenbelt area and living in an area that is bounded by a greenbelt.

The research team found that rates of obesity dropped as the size of the greenbelt increased. They concluded that greenbelts, that have been associated with higher population densities, mixed land uses, greater accessibility, and increased walkability in other studies, have reduced obesity by increasing rates of active transportation and public transit use. They also suggest that greenbelts provide citizens with more opportunities for active leisure.[152]

Many neighbourhoods lack land use diversity

Recognizing the important relationships between population health and proximity to amenities (such as grocery stores and schools) access to services, and social inclusion, Statistics Canada collaborated with the Canada Mortgage and Housing Corporation to develop a Proximity Measures Database that can be used to estimate the distance by walking or driving between residences and a variety of essential services and amenities.

Using the new database, Statistics Canada estimated in 2021 that only 20% of people in Canada live in amenity-dense neighbourhoods that have:

- A grocery store, pharmacy, park, and public transit stop within a 1 km walk;
- A childcare facility, primary school, and library within a 1.5km walk;
- A health facility within a 3 km drive; and
- Employment within a 10 km drive.[153]

Walkable neighbourhoods and health equity

In a typical community, 20-40% of people do not drive because of income, age, or ability.[154] This means that many people within our communities are dependent on active modes of transportation or public transit to access jobs, essential services, and recreational opportunities.[155] Research suggests that people living on low incomes are more likely to live on the edges of communities where there is poorer access to schools, stores, and other essential services.[156] When low-income neighbourhoods are more walkable and bikeable in their design and serviced with efficient transit services, social and health inequities can be reduced because those who cannot drive or afford a car have greater access to jobs, health services, grocery stores, and recreational facilities.[157]

IV HEALTH AND HEALTH EQUITY BENEFITS: GREEN SPACE AND GREEN BUILDINGS

Introduction

This section addresses two broad types of climate solutions: the greening of our communities with vegetation, street trees, urban forests, and parks; and the greening of new buildings and the retrofitting of existing buildings. While interventions directed at these two climate solutions can produce a variety of population health and health equity benefits, the health risks they have in common are air pollution (discussed earlier in this report) and extreme heat.

1. Extreme heat

Extreme heat, population health, and health equity

Global warming presents a substantial health risk for people in Canada. Extreme heat can produce skin rashes and heat stress, increase hospital admissions for cardiovascular and respiratory conditions, and increase the risk of premature deaths. It has also been associated with adverse reproductive outcomes such as miscarriages and congenital defects, and increases in aggressive behaviour, including violent and non-violent crime.[158,159]

A study of 26 Canadian cities found that an extreme heat event can increase the risk of premature deaths by 2 to 13%. Another study estimated that extreme heat events can increase premature deaths by 3 to 16% depending on how those events are defined.[160] Analyses indicate that extreme heat events in Quebec in 2018 and 2010, and British Columbia (BC) in 2021 gave rise to 291, 86 and 619 premature deaths respectively.[161,162]

A study that focused on the "heat dome" that hit BC in 2021 estimated that indoor temperatures reached 30 to 40°C with little cooling at night because outdoor temperatures remained high overnight and most homes in greater Vancouver do not have air conditioning. It also found that deaths in the community (i.e., excluding those that took place in institutions such as long-term care facilities) increased by 440% during that week. Much higher death rates were observed among people in the 65 to 74 age range and among low-income populations. Death rates among populations considered "materially and socially deprived" were several times greater than those of materially and socially privileged populations, 28.1% and 6.1%, respectively. Death rates were also higher in homes that lacked air conditioners and in neighbourhoods with lower levels of greenness and higher building densities that were closer to major roads and further from large bodies of water.[163]

Urban heat islands (UHIs) are communities or areas within communities that experience higher air temperatures because they have more impervious surfaces (e.g., concrete), more surfaces that absorb heat (e.g., dark-coloured pavement), and lower levels of vegetation. UHIs have been associated with greater health risks for residents. In Montreal, for example, death rates from respiratory diseases were 1.4 to 14 times greater in the UHIs within the city that were 6 to 8°C hotter and had higher concentrations of ground-level ozone, than the cooler areas within the city.[164] In Toronto, during extreme heat events, the number of emergency calls have been 18 times higher from neighbourhoods with fewer trees than from neighbourhoods with a tree canopy greater than 70%.[165]

In Canada, where there are provincially-mandated minimum indoor temperatures to protect people from extreme cold, there are currently no provincially-mandated maximum indoor temperatures to protect people from extreme heat.[166] Given that an indoor temperature greater than 26°C has been associated with increases in emergency calls and premature deaths, it has been suggested that a policy that limits indoor temperatures to 26°C would protect most occupants from heat-related injuries and deaths, including those who are most sensitive to heat.[167]

In the 2022 heat dome report by the Chief Coroner of British Columbia, it was recommended that the CleanBC Better Homes and Home Renovation Rebate Program should include "both passive and active cooling measures as eligible for rebates, and that rebates be prioritized on census areas in the lower quintiles of material deprivation index and targeted to low-income households and the least energy efficient residential building stock." It was also recommended that the BC Building Code "incorporate both passive and active cooling requirements in new housing construction, and that the release

of the Alterations Code for Energy Efficient, Resilient Buildings explicitly identify both passive and active cooling standards for existing home renovation."[168]

2. Green space

Urban green space absorbs climate emissions

Green space can play an important role in the fight against climate change by acting as a sink for GHGs. A study of 10 cities in the US estimated that urban trees store 700 million tonnes (Mt) of carbon and sink about 22.8 Mt of carbon/year. It found that, on average, urban forests can store about 25.1 tonnes of carbon/hectare of land, compared with forests which store about 53.3 tonnes/hectare.[169]

Green space cools and cleans air

A systematic review published in 2015 found that a wide variety of urban green spaces can cool and clean the air at a site, neighbourhood, or city level, and provide substantial health benefits by doing so. The health benefits were found to be directly related to the size, quality, and density of the green space provided. The evidence suggests that "closely spaced and connected smaller green spaces" can provide greater cooling effects for adjacent neighbourhoods than large individual parks with open, grassy areas.[170]

The review found that local air quality can be improved by increasing forest density, particularly in neighbourhoods that have little green space. It noted that trees are particularly good at capturing and filtering air pollutants including the common air pollutants, ground-level ozone, sulphur dioxide, nitrogen oxides, and particulate matter. Trees are also strongly associated with reduced air temperatures and relief from heat stress at a street and neighbourhood scale. The review highlighted the growing body of evidence that suggests that greater heat- and air-pollution-related health burdens are associated with neighbourhoods that have less green space, and that dense, low-income inner-city neighbourhoods are more likely to be less green while also being home to populations that are more likely to suffer harm from environmental exposures.[171]

Green space improves health and health equity

A 2015 systematic review conducted for Toronto Public Health focused on the relationship between different types of green space and a wide range of health outcomes. It concluded that green space improves the physical health, mental health, and well-being of urban residents. It found that green space is associated with decreased stress, healthier births, and a decrease in premature deaths from all causes. It also found that children who live near parks and playgrounds tend to have healthier weights, improved cognitive function, fewer symptoms of attention-deficit/hyperactivity disorder (ADHD), and reduced levels of stress.

While all members of a community benefit from exposure to green space, the review found that children and low-income populations appear to benefit the most. The evidence suggests that increasing access to nearby green space, particularly in low-income neighbourhoods, offers considerable opportunities to reduce health inequities. One exception was noted; when green space is poorly maintained or perceived as unsafe, it does not provide health benefits. In these situations, it can increase stress and decrease the health and well-being of residents.[172]

Green space fosters physical activity and metabolic health

A robust body of evidence suggests that urban green space can increase physical activity and reduce negative health outcomes such as obesity, diabetes, and other chronic diseases. A systematic review published in 2021 examined 19 articles that focused on metabolic health. Seven suggested that people living in neighbourhoods with greater levels of greenness or in close proximity to parks or sports amenities have a reduced risk of developing diabetes. Four of the five studies that looked at physical activity found that "the vast majority of people" who have access to local green areas use those areas and increase their levels of physical activity. The studies analyzing weight and obesity found that neighbourhood access to green areas was associated with a lower prevalence of obesity in children, with mixed results for adults.

The authors noted that there is still no consensus on the best way to measure green space or greenness. Studies have used distance to parks, the Normalized Difference Vegetation Index (NDVI), the density of trees in a neighbourhood, and the size of parks as indicators of greenness. These various measures of green space can make it difficult to compare studies and their results. The researchers concluded, however, that "there is significant evidence supporting the protective role of green space in the urban context against diabetes and other chronic health conditions such as obesity and sedentarism".[173]

Walkable neighbourhoods and access to parks improve metabolic health

A study conducted in the Metro Vancouver region and the Fraser Valley in BC examined the relationships between walkability and park availability with physical activity, obesity, and diabetes. Published in 2022, the outcomes included walking, moderate to vigorous physical activity, BMI, and diabetes.

The researchers found that an increase in walkability was associated with:

- significantly lower odds of diabetes and obesity;
- significantly higher odds of walking as a mode transportation; and
- greater levels of moderate to vigorous physical activity.

Park availability was associated with:

- lower odds of diabetes and obesity;
- higher odds of leisure walking; and
- increased levels of moderate to vigorous physical activity.

The researchers note that the results support investments in walkability through active transportation and transit infrastructure, land use policies that support compact mixed used development, and equitable access to parks and high-quality transit service.[174]

Greenness improves birth outcomes

A recent study adds weight to the suggestion that residential greenness contributes to healthier pregnancies in all women. Published in 2022, it used data from 2.2 million livebirths from Canadian cities and the NDVI for greenness to examine the relationship between birth outcomes, greenness, and air pollution. It found that mothers who live in greener areas have a reduced risk of giving birth to small babies or babies with low birth weight regardless of the socio-economic status of their neighbourhoods. These associations held after they were corrected for air pollution.[175]

Greenness improves mental health and health equity

A 2022 Canadian study affirms the suggestion that urban greenness produces mental health benefits and reduces health inequities. It examined the relationship between neighbourhood greenness, socio-economic status, health behaviour, interactions with one's neighbourhood, and mental health. It combined data for nearly 27,000 residents, 45 to 86 years of age, who live in urban areas, with measures of greenness within 500 metres of participants' homes, and three self-reported measures of mental health. It found that:

- residents' perceptions of their mental health were more favourable for those who lived in greener areas;
- perceptions of depression decreased as neighbourhood greenness increased;
- the positive response to greenness was consistent across all age-groups, races, and sexes; and
- the strongest association between the beneficial impacts of greenness on mental health were among those living on lower incomes.[176]

CPHO on Green Buildings and Green Space

"By supporting more tree canopies and building retrofits, we can promote and protect health while mitigating greenhouse gas emissions. Green building certification can reduce emissions, improve air quality, and reduce respiratory-related morbidity and mortality. These compelling co-benefits are win-wins for many facets and sectors of society."

CPHO. 2022. Mobilizing Public Health Action on Climate Change in Canada

Greenness reduces premature deaths

Many of the studies that have demonstrated associations between greenness, green space or nature, and premature deaths have been ecological or cohort studies and few have been national in scale. To address this gap, a research team in Canada conducted a long-term study that followed 1.3 million healthy, non-immigrant adults from 30 large urban centres across Canada over time. The aim was to examine the relationship between green space, premature deaths, and income. Greenness was measured using the NDVI within 250 and 500 metres of participants' residences for each year from 2001 to 2011. The results were adjusted for education, income, and three common air pollutants.

Published in 2017, this study found a significant decrease in the risk of premature deaths with increased greenness around the homes of participants in the study. The risk of premature death from six common causes each decreased by 8 to 12%. This reduced risk was found with greenness within both 250 and 500 metres of peoples' homes. The protective association for greenness increased when the results were corrected for air pollution.

The study also found that greenness was more protective for men then women and that the protection increased as income increased. The research team posited that men may have more leisure time to interact with green space than women, and that people with higher incomes may have greater access to higher quality green space than people with lower incomes. They noted that the NDVI scale identifies the presence of vegetation but does not rate the quality of that greenness or access to it. The authors concluded that the findings support the development of policies to create greener cities and more equitable access to greenness to promote health and health equity.[177]

Distribution of greenness, air pollution, and walkability, and health equity

A 2020 study of Toronto, Montreal and Vancouver examined neighbourhood walkability, air pollution, and greenness, across different socio-economic conditions to clarify the connections between several environmental exposures and their distribution across a community based on material deprivation.* It found that less deprived neighbourhoods were more likely to be highly walkable, have lower levels of air pollution, and have higher levels of greenness, while highly deprived areas were more likely to be less walkable, have higher levels of air pollution, and lower levels of greenness. The researchers noted that past studies have demonstrated that materially deprived populations are more susceptible to the health effects associated with air pollution, low walkability, and low greenness. They concluded that inequitable access to greenness can amplify the negative impacts of extreme heat events and reduce levels of physical activity among materially deprived populations. The findings highlight "the importance of considering environmental inequity in city planning and urban public health decision-making".[178]

Trees, health, and health equity

A 2020 scoping review focused on the health outcomes associated specifically with urban trees. The 201 included studies varied in design and were conducted in several different countries. Overall, they suggest that urban trees are positively associated with physical activity, weight management, mental health, reduced stress, healthy birth outcomes, and reduced indicators for chronic diseases. The review found that there are disparities in the distribution of trees with greater tree coverage in higher-income neighbourhoods. The authors note that these disparities can exacerbate existing health inequities and increase the vulnerability of lower-income neighbourhoods to extreme heat. They also note that trees can produce negative health outcomes in some situations. Tree pollen can exacerbate allergies for some people and unhealthy trees can emit greater volumes of volatile organic compounds that can contribute to air pollution. The authors recommend that urban forestry and public health professionals collaborate to select the best trees and the best locations for trees to maximize health and health equity benefits as well as environmental benefits.[179]

Quantifying the health benefits of trees

Recognizing trees as one of the most consistent and beneficial elements in green space, one study conducted in Toronto focused on identifying and quantifying the health benefits specific to trees alone. It combined high-resolution satellite imagery and individual tree data from Toronto with self-reports of general health perception, cardio-metabolic conditions such as hypertension, high blood glucose, obesity, heart disease, and diabetes, and mental illnesses from the Ontario Health Study, and socio-economic and demographic data. It found that people who live in neighbourhoods with a higher density of trees on their streets are significantly more likely to report better health and to have fewer cardio-metabolic conditions such as CVD or diabetes. The study team estimated that having 11 more street trees in a city block is equivalent to have a $20,000 increase in income in terms of the impact on cardio-metabolic health.[180]

3. Green buildings and building retrofits

Energy efficiency and building retrofits reduce greenhouse gases

On a national scale, buildings are responsible for 13% of the GHGs emitted in Canada;[181] 18% when the electricity used in buildings is included.[182] In large urban centres, the contribution of buildings is even greater. In the GTHA, which is home to 7.7 million people, buildings are responsible for 44% of the GHGs emitted. About 90% of these emissions come from natural gas: 71% from on-site use in furnaces, water heaters, and stoves, and about 10% from the generation of electricity used in buildings.[183]

In 2019, the International Energy Agency (IEA) concluded that the Canadian energy system has large energy efficiency

* The material component of the Material and Social Deprivation Index, developed by the Institut national de santé publique du Québec (INSPQ), was used *to* define deprivation in this article. It is a composite index of Census data on income, education, and employment.

savings potential, especially in the building, transportation, and industrial sectors. It found that energy demand in Canada had grown by 0.8% per year for the past 15 years and projected that GHG emissions would be 17.4% higher by 2050, relative to 2016, unless additional policies were introduced to reduce energy demand.

The IEA also estimated that GHG emissions in Canada could be reduced by 30% by 2050 with investments in economically- and technologically-feasible energy efficiency investments alone. It predicted that 90% of the energy demand avoided with these investments would result from the reduced use of oil and natural gas. It noted that buildings use about one third of the oil and natural gas produced in Canada and predicted that those emissions could be reduced by 60% by 2050 with the correct policies.[184]

Households in Canada use energy to heat homes (64%), heat water (18%), run appliances (13%), light their homes (3%), and cool their homes (2%). Natural gas (i.e., methane) is most often used to heat air and water, while electricity is used for most other household activities.[185] The IEA estimates that households could make significant reductions by shifting away from oil- and natural gas-fired furnaces to high efficiency, electricity-based systems such as heat pumps. It estimated that energy demand for space heating could be reduced by 85% by 2050 by improving building envelopes and shifting to heat pumps for space heating.[186]

Energy demand from the building sector could also be reduced with requirements such as net-zero energy ready buildings, passive energy design, district heating, green roofs, more efficient appliances, buildings with passive energy design, increased urban density, reduced floor space per occupant in homes and businesses, and decentralized energy production that would reduce energy lost with transmission of electricity over long distances.[187,188]

Building retrofits reduce air pollution

Air pollution continues to be a significant source of illness, chronic disease, and premature deaths in Canada. Buildings that are heated with oil and natural gas can release substantial quantities of pollutants into the air.[189] This pollution can be particularly problematic in urban areas that are also impacted by air pollution from heavy traffic, heavy industry, and/or upwind sources. Energy analysts note that extensive building retrofits that substantially reduce the use of oil and natural gas can result in important reductions in air pollution.[190]

Prefabricated Net-Zero Affordable Rental Units

Plainsview is a pilot project in Regina, Saskatchewan, that aims to create six net-zero energy rental units within a 48-unit affordable housing development. The units will be fitted with solar cells to generate energy and constructed with housing panels that are prefabricated at an offsite manufacturing facility. Prefabricated components will be used to reduce waste, improve quality control, and reduce trucking costs and emissions.

Bonasia C. 2022. Saskatchewan Prefab Pilot Offers Green Model for Affordable Housing. The Energy Mix. Aug 28

Using emissions data, health statistics, and modelling, researchers have estimated that 3,000 to 4,200 people in the US died prematurely in 2017 from exposure to fine particulate matter in outdoor air created from the burning of natural gas in residential buildings. They placed the social cost of these impacts at US$47 billion.[191]

Indoor environments impact health

In Canada, people spend nearly 90% of their time inside homes, schools, offices, and other workplaces[192] so the quality of indoor environments can have a significant impact on their mental and physical health.

Indoor environments are shaped by the quality, placement, and design of buildings. A broad range of negative health outcomes can result from extreme temperatures, allergens and infections, dampness and mould, and air pollution that can be encountered indoors. Housing conditions can also amplify or mitigate health inequities. Pollutants found in indoor environments have been associated with acute and chronic health impacts such as eye and respiratory irritation, hay fever, asthma, respiratory infections, and CVD. Sources of indoor health risks can include:

- Outdoor air pollutants that enter the building through windows and ventilation systems;
- Air pollutants such as carbon monoxide, particulate matter, and nitrogen oxides that can be emitted from fireplaces, cooking appliances, and heating equipment;
- Volatile organic compounds such as formaldehyde and persistent organic compounds such as polybrominated

diphenyl ethers (PBDEs) that can be released from products such as rugs, floor tiles, furniture, and building and consumer products;
- Radon and methane that can enter buildings through the soil, cracks in foundations, or drinking water;
- Carbon dioxide from high occupant density and poor ventilation;
- Allergens such as dust mites, pests, pollen, mould, and pet dander that can be introduced from outdoors or generated indoors from dampness, poor ventilations, and indoor activities;
- Viral, bacterial and fungal Infections that can be introduced or spread through over-crowding, poor ventilation, contamination of heating, ventilation and air conditioning (HVAC) systems, or dampness and mould; and
- Second-hand tobacco smoke.[193]

Indoor environments contribute to health inequities
Populations such as older people, individuals with pre-existing health conditions, people who are living in crowded conditions, and those living in socio-economically deprived conditions, are at greater risk for negative health outcomes associated with poor indoor environments. They can be more sensitive to the health risks presented by poor indoor environments and they may also experience greater exposure to poor indoor environments. In addition, these populations may not have the resources needed to protect themselves from climate-related events such as heat waves or the resources needed to recover from climate-related events such as floods and wildfires.[194]

Green buildings create health benefits
High-efficiency buildings can improve indoor air quality, comfort, and noise levels with better ventilation, air filtration, and high levels of insulation. The correct ventilation rates can reduce levels of indoor air pollutants, efficiency filters can limit infiltration of outdoor pollutants and allergens, and high levels of insulation can minimize the penetration of cold, heat and sound.[195]

A study of workers in Germany and Hungary found that investments in high-efficiency buildings, passive houses, "nearly zero-emission buildings" (NZEB), and deep-retrofitted buildings that achieve passive house or NZEB standards can produce significant health-related benefits. It estimated that:

- Germany could avoid about 5 million sick days in 2030 by increasing the number of high-efficiency residential buildings by 3% relative to the number expected with a business-as-usual (BAU) scenario, while Hungary could avoid 0.4 million sick days with a 4% increase in high-efficiency residential buildings; and
- Germany could avoid around 5 million sick days in 2030 by increasing the number of high-efficiency commercial and institutional buildings by 7%, relative to the BAU number expected, while Hungary could avoid 0.2 million sick days with a 5% increase in high-efficiency commercial and institutional buildings.

Combined, the avoided health outcomes were valued at €735 million/year for Germany and €10 million/year for Hungary.[196]

Building retrofits can improve health and health equity
Studies have found that interventions that improve the comfort and quality of indoor environments can improve overall health, respiratory health, and mental health, with particular benefits for those with pre-existing respiratory conditions. For example, a modelling study conducted in England estimated that an initiative to improve building envelopes and retrofitting ventilation systems to ensure adequate ventilation could reduce net mortality and morbidity by 2,241 quality-adjusted life-years per 10,000 people over 50 years.[197]

These retrofits must be made with care because steps to increase the airtightness of homes can produce negative health impacts by increasing levels of indoor air pollutants. These negative effects can largely be avoided with mechanical ventilation that includes heat recovery and air filtration, although they can be more effectively addressed by removing the indoor sources of air pollution.[198]

Energy retrofits improve health in multi-unit buildings
Several studies have found that energy retrofits are associated with an increase in occupant comfort and/or health in multi-unit buildings.[199] One study examined the experience of occupants in 39 multi-family buildings in Finland and 15 similar buildings in Lithuania that had energy retrofits that included insulation and updated windows, heating and/or ventilation systems. After the retrofits, the study found that occupant satisfaction with indoor temperature increased, indoor environmental quality

(IEQ) factors such as indoor temperature and rate of air changes improved, negative upper respiratory symptoms decreased, and lost-time from work or school for respiratory infections decreased.[200]

A Canadian study directed at seven multi-unit residential buildings had similar findings. Energy efficiency retrofits were conducted on three buildings for seniors, two for families, and two for adults without children. After the retrofits, reports of fatigue, tiredness, headaches, irritated eyes, dry cough, dry skin, and runny noses decreased by 28 to 57%, absences from work or school due to illness decreased by 35 to 81%, and the use of portable heaters during winter months decreased by 69%. Air conditioner use increased by 4% in the summer months, but this increase was attributed to the hotter weather experienced in the post-retrofit summer, relative to the pre-retrofit summer.[201]

Building retrofits improve health equity

A study conducted in Phoenix, Arizona, examined the impact of energy retrofits on the IEQ, comfort, and health of residents in affordable housing for older adults. The renovations were directed at increasing energy efficiency and reducing air levels of volatile organic compounds (VOCs) by replacing indoor materials with low- or no-VOC products. A post-renovation survey conducted with 57 residents from 53 apartment units one year later found that the retrofits reduced energy consumption by 19%, significantly stabilized temperatures in apartments, reduced temperature extremes of 27.2°C and higher, and improved the reported health of residents. The retrofits did not, however, change the residents' perceptions of thermal comfort.[202]

Another study examined the impact of minor residential energy efficiency improvements to the homes of low-income, older, and/or frail people who live at home with the support of community care services in Victoria, Australia. It included 13 control households and 16 intervention households. It found that an energy retrofit program that is framed around health and equity, and combines retrofits, tariff optimizations, and household practices, can reduce GHGs, improve comfort, and reduce energy costs for structurally disadvantaged populations. However, it noted that the effectiveness of the program can be decreased by heating and ventilation practices that remove temperature control and cost incentives from the equation.[203]

Heat pump retrofits in Manitoba First Nations

Aki Energy is a First Nations social enterprise that has installed 500 ground source heat pumps in Manitoba First Nations. Ground source heat pumps (sometimes called geothermal energy) move heat from below the frost line into a building to heat it in the winter and cool it in the summer. Ground source heat pumps have reduced electricity consumption in these homes by nearly 50%. Lessons applicable to other programs:

- Aki Energy has the upfront costs financed through Manitoba Hydro to make the retrofits more affordable to low-income households;
- The utility charges a monthly fee to each retrofitted home's electricity bill until the upfront costs are repaid. The net bills are lower than the household's original bill.
- Aki builds government and utility incentives into the back end of the project, rather than after the fact. This reduces administration and makes it simpler for the clients. Manitoba Hydro has an incentive for people who install ground source heat pumps.

Loney S Wood D. 2022. Making heat pumps ordinary: The Aki Energy story. National Observer. May 24

Building retrofits increase climate resilience

Building retrofit programs can be designed to strengthen climate resilience as well as energy efficiency. There are a number of changes in buildings and building operations that can be adopted to mitigate health risks associated with climate-related extreme events such as heat waves, storms, floods, and wildfires. Improved roof insulation, roof coatings that reflect more solar energy, and air conditioning, can mediate indoor temperatures. Particle filtration systems can reduce exposure to wildfire smoke.[204] Backflow valves, installed in basement drains to prevent water backup through sewers in areas prone to flooding, can prevent flooding of basements and exposure to mould, which can aggravate asthma and other respiratory conditions. And fire-resistant roofing materials can be used to help protect people and their property from wildfires. Measures such as these can help avert adverse health impacts, while reducing financial costs, disruption, and mental health stress that can result from property damage.[205]

Heat pumps reduce greenhouse gases and increase climate resilience

To achieve net zero GHGs by 2050, all buildings in Canada will have to shift away from fossil fuels such as natural gas. The IPCC, and many other organizations that have considered the alternatives, recommend the use of electric heat pumps for heating air and water and cooling air in buildings.

Both ground-source (i.e., geothermal) and air-source heat pumps have been around for a long time. Ground-source heat pumps have always been efficient and capable of heating homes in very cold weather. Over the last 5 to 10 years, there have been improvements in the performance of air-source heat pumps in cold climates. These "cold climate air-source heat pumps" (ccASHP) are more efficient at space heating in cold weather than previous generations. They can operate to temperatures as low as -25°C. They can completely replace conventional oil- or natural gas-fired heating systems in Canadian homes while replacing air conditioners in the summer months. In fact, heat pumps were the primary heating source in 32% of homes in New Brunswick and 21% of homes in Nova Scotia in 2021.[206,207]

Heat pumps run on electricity rather than fossil fuels and they are much more energy efficient than both oil- and natural gas-fired furnace and electric baseboard heaters. They use up to 70% less energy than conventional home heating technologies so they can cut costs for homeowners and renters. Because of their energy efficiency, they can cut GHG emissions in provinces that still rely on fossil fuels such as coal and natural gas for some of their electricity. In provinces where electricity grids are run entirely on renewable energy sources such as wind, solar, and water, heat pumps can cut GHG emissions from the heating and cooling of the building sector by 100%.[208,209]

Building retrofits reduce health inequities

Energy poverty is a serious concern in Canada. Almost one in ten households (i.e., 1.2 million households) spend more than 6% of their income on energy. Rates of energy poverty* vary greatly across the country with rates as low as 3% in Alberta and as high as 19% in the Atlantic provinces. Energy poverty may force some households to choose between the energy needed to heat their homes and other essentials such as healthy food, clothing, and medicine. People living in energy poverty have lower incomes (i.e., median household income of $22,407/year) and are more likely to receive government subsidies, live in rural areas, own their own homes, and own homes constructed before 1980. These households spend nearly twice as much on health care equipment, spend less on private vehicles and public transit, and spend nearly twice as much (about $3,600/year) on home energy, as other households in Canada.[210]

Several international studies have shown that energy poverty is associated with an increased risk of cardiovascular and respiratory diseases, hospital admissions, and premature deaths, as well as poor general and mental health. These health outcomes are often attributed to exposure to colder indoor temperatures. The first Canadian study to examine the issue was published in 2023. Using data from the Census, the Survey of Household Spending, and the Canadian Housing Survey, researchers found that all indicators of energy poverty were significantly associated with households that reported poor physical and mental health. When the analysis was corrected for financial hardship, the association was weaker but remained statistically significant for most indicators of energy poverty.[211]

Energy efficiency experts note that energy efficiency programs are often not designed to meet the needs of lower-income households. These programs:

- may not support fuel shifting (e.g., natural gas to heat pumps) that can increase climate resiliency;
- may not fund non-energy retrofits that are needed to qualify for, or complete, energy efficiency upgrades; and
- can involve upfront costs that lower-income families cannot afford.

It is argued that these programs could have a greater impact on population health and health equity if their goals were expanded to include increasing climate resiliency and reducing energy poverty, as well as achieving net zero emissions in the building sector in this country.[212]

Gas-fired stoves affect indoor air quality, children's health, and climate change

For decades, there have been concerns about the health impacts associated with indoor air levels of NO2 that might result from the use of natural gas in stoves and ovens. Nitrogen dioxide (NO_2) is a common air pollutant that is released whenever fuels such as coal, oil, or natural gas are burned for

* Energy poverty metrics vary. Spending 10% of one's income on energy is a common metric. The study cited in this paragraph used 6% of income as the metric for energy poverty.

FIGURE 10: HEAT PUMP REBATE AD, CVRD

Swapping Wood Stoves for Heat Pumps in Cowichan Valley, BC

With funding from the provincial wood stoves exchange program, and in collaboration with BC Lung and Island Health, the Cowichan Valley Regional District (CVRD) established a Wood Stove Replacement Program that encourages residents to swap out wood-burning stoves with heat pumps.

CVRD is an area on Vancouver Island that stretches inland from Victoria to Nanaimo. Most of the region's 83,900 residents live in the Cowichan Valley, surrounded by mountains, in small centres including 10 First Nations communities. The average income of residents in this area is lower than the Canadian average.

Many of the residents in the region burn wood to heat their homes. During certain weather conditions, the air settles in the valley, trapping the air pollution from wood-burning stoves and other sources. These conditions can produce very high levels of air pollution that create significant risks to human health.

In the early years of the program, the goal was to replace old wood stoves with new CSA/EPA certified wood stoves that reduce air pollution while increasing wood-burning efficiency by about 30%.

"For several years, natural gas appliances were added to the alternatives that could be used to replace wood stoves but that option was removed in 2020," explained Ilse Sarady, Senior Environmental Technologist with CVRD . "We felt that we could not justify using tax dollars to incentivize fossil fuel appliances that undermine our climate goals."

In 2019, heat pumps were added to the list of alternatives.

"Heat pumps are highly efficient," explained Sarady. "They can also cool a home in the summer, keeping people safe during extreme heat, something that is becoming increasingly important."

"Heat pumps are expensive. It can cost around $6,000 for a high-efficiency mini-split system with only one head and over $13,000 for a bigger system that is ducted or has more heads," explained Sarady. "The value of the heat pump rebate must be more generous to be meaningful, particularly when being offered to residents who live on lower incomes. It is also unrealistic to assume that people can front that kind of money. Low interest loans and other rebate program designs, like those offered for electric vehicles in BC, may work better".

Perrotta K. 2023. Blog: Swapping Wood Stoves for Heat Pumps in Cowichan Valley, BC. CPHA, CHASE, OPHA.

energy. In its gaseous form, NO_2 is strongly associated with negative respiratory conditions including asthma.[213] Researchers measured the amount of methane and NO_2 that can be emitted from gas stoves to calculate their contribution to climate change and their impact on indoor air levels of NO_2. With over 40 million homes using gas stoves in the US, and each one emitting 0.8 to 1.3% of that gas as unburned methane, it was estimated that collectively gas stoves in the US release approximately 28,100 tons of methane/year. This is equivalent to all the GHGs emitted annually from 500,000 cars in the US. The research team also determined that gas stoves can produce indoor air levels of NO_2 that exceed the 1-hour national standard of 100 ppb that has been set for outdoor air.[214]

A 2013 meta-analysis examined 41 studies of the impact of natural gas stoves on asthma and wheezing in children. This analysis found that children living in homes with gas stoves are 42% more likely to have asthma than those living in homes with electric stoves.[215] While a growing number of studies have found an association between the presence of gas stoves and increased respiratory symptoms or asthma development, not all studies have shown a positive association. Homes with gas stoves do, on average, have NO_2 concentrations that are higher than those with electric stoves, however these NO_2 levels can vary significantly across homes. This variation may explain the inconsistency in health outcome results.[216] A leading air quality researcher in Canada has suggested that while gas stoves appear to be associated with adverse respiratory impacts in children, it may be another toxic substance that is being emitted from natural gas stoves or an air pollutant that is being created in indoor environments from NO_2 that is responsible for the health outcomes being observed.[217] Either way, it does appear that there could be significant climate and health benefits associated with the replacement of gas-fired stoves with electric ones.

VII CONCLUSION

In its *Climate Change 2023: Synthesis Report*, the IPCC emphasizes that a liveable future is still possible if we can limit global warming to 1.5 degrees Celsius above pre-industrial levels. To do so, the IPCC proposes "climate resilient development" which involves integrating measures to adapt to climate change with actions to reduce or avoid GHG emissions in ways that provide wider benefits. Public health is well situated to help achieve this goal.

The five local climate change solutions selected for this report are all associated with positive and immediate health co-benefits that can be realized in the jurisdictions that act upon them. All five solutions also have the potential to produce health equity benefits if implemented with that intention. By promoting these five solutions, public health professionals can help create healthier and more equitable communities, while simultaneously mitigating climate change that threatens the livability of the planet.

The case studies included in this report demonstrate that public health agencies have a critical role to play in the development and implementation of climate change policies. In some cases, public health can foster broader support for climate-friendly policies by helping the public and decision-makers understand the immediate health and health equity benefits associated with them. At other times, public health can ensure that population health and health equity impacts are considered and addressed at each step in the policy development and implementation process.

Given the critical need to halve GHG emissions by 2030, and the immediate and significant health and health equity benefits that can be associated with the five local climate change solutions discussed, there is much more that public health agencies could be doing to accelerate and shape action on these fronts.

These views are supported by the findings and recommendations included in the 2023 Public Health Agency of Canada (PHAC) report, *What we heard: Perspectives on Climate Change and Public Health in Canada*.

Public health agencies could do much to accelerate action on these five climate change solutions with more resources dedicated to climate change and healthy built environments, more staff training on the health and health equity benefits associated with climate-related interventions, more authority to engage in inter-sectoral processes, and more peer-to-peer support on the ways to bring about policy changes in their communities.

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CANADIAN PUBLIC HEALTH ASSOCIATION

Founded in 1910, the Canadian Public Health Association is the independent voice for public health in Canada with links to the international community. As the only Canadian non-governmental organization focused exclusively on public health, we are uniquely positioned to advise decision-makers about public health system reform and to guide initiatives to help safeguard the personal and community health of Canadians and people around the world. Our members believe in universal and equitable access to the basic conditions that are necessary to achieve health for all.

CHASE
CANADIAN HEALTH ASSOCIATION FOR SUSTAINABILITY & EQUITY

CHASE is a Canadian non-profit organization that works to incubate changes needed to transform our society. We collaborate with non-profit organizations, public health units, municipalities and other organizations to promote innovative policies, programs and technologies that help create healthier and more sustainable communities.

OPHA
Ontario Public Health Association
l'Association pour la santé publique de l'Ontario
Established/Établi 1949

Created in 1949, the Ontario Public Health Association (OPHA) is a non-partisan, non-profit organization that brings together a broad spectrum of groups and individuals concerned about people's health. OPHA's members come from various backgrounds and sectors – from the various disciplines in public health, health care, academic, non-profit to the private sector.