Reversing the Course of Type 2 Diabetes:

ENVIRONMENTAL SCAN

November 2021

Preface:

This document was originally prepared to support a Dialogue on Type 2 Diabetes, held in Vancouver Canada on June 17th, 2019. The October 2021 version is the sixth major update.

About IHSTS: The Institute for Health System Transformation and Sustainability is a not-for-profit, independent organization. With partners, IHSTS aims to strengthen the sustainability of BC's health and care system through effective enquiry processes that ignite insights and generate practical solutions. More about IHSTS can be found here: www.ihsts.ca

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Executive Summary

Type 2 diabetes represents a significant threat to the future health of British Columbians. According to Diabetes Canada, over 500,000 of us in BC already live with diabetes, representing over 10% of the population. By 2030, Diabetes Canada estimates that over 700,000 British Columbians will have diabetes. Diabetes is serious; a Canadian with diabetes is 75% more likely to die at any given age than a Canadian not living with the disease.

Type 2 diabetes is a chronic condition strongly correlated with many social determinants of health, and as a result, places an even larger burden on many disadvantaged and minority populations. For instance, those with less than a high school education are 21% more likely to be diagnosed with type 2 diabetes than those who have completed post-secondary education. First Nations people are much more likely to develop the condition than other Canadians, and they tend to develop the condition earlier in their lives and experience more complications.

Despite the predicted growth of the condition, the ever-increasing prevalence of type 2 diabetes is not inevitable. Emerging evidence shows that, far from being an inescapable life-long chronic illness, type 2 diabetes can be prevented, and treatment can result in remission (normalized glucose control without need for medications).

Diabetes prevention programs around the world have demonstrated that lifestyle interventions can prevent or delay type 2 diabetes in at-risk individuals. Innovations such as therapeutic nutrition and gastric surgery have shown that even after the onset of the condition, actions can be taken to put it into remission. Emerging technologies like artificial intelligence can provide more successful personalized interventions, and virtual care can improve access to interventions while remaining as effective as face-to-face care.

The type 2 diabetes trend can also be disrupted at the population level. Government policies such as taxes on sugar-sweetened beverages, regulations on the nutritional makeup of processed foods and laws controlling junk food marketing can change the composition of our diets. Healthy community strategies can encourage more active transport and physical activity. Smartphone applications that encourage healthy eating and exercise can engage thousands of people in lifestyle modification challenges, and mass media campaigns can change the way people think about food.

In the past few years, a number of organizations including Diabetes Canada and The American Diabetes Association have started to talk about type 2 diabetes remission. Diabetes Canada acknowledges that remission is possible and a worthwhile goal for many living with the condition. In the United Kingdom, the National Health Service has been the global leader in accelerating and spreading type 2 diabetes remission programs. This changing dialogue is critical to helping reverse the upward trend in the number of people who live with type 2 diabetes.

Unfortunately, there has been no coordinated, scaled effort of any of these promising interventions to the level necessary to reverse the type 2 diabetes trend in Canada. The Canadian government has committed to developing a national diabetes framework, but it has not yet been published or implemented. Similarly, there is no province-wide diabetes strategy endorsed by the British Columbian

government, though there is some indication that the Provincial Health Services Authority is exploring the space.

Given the burden of type 2 diabetes on society, and the emerging interventions that show enormous potential, IHSTS believes now is the time to act to address type 2 diabetes in British Columbia. Addressing the challenge will require strategic leadership, rigorous evaluation of prevention, treatment and remission programs, government policies to encourage healthy lifestyles, the leveraging of new virtual technology and a multidisciplinary approach to team-based diabetes care. Through a network of those dedicated to the cause, we believe it is possible to reverse the trend of type 2 diabetes in our province.

BACKGROUND AND OBJECTIVES

Background

Type 2 diabetes is a largely preventable chronic condition resulting in poor health outcomes for individuals and substantial costs to the health system. While there is important work being done across many sectors in British Columbia to meet the challenge of increasing prevalence, there are opportunities for enhanced collaboration, systematic sharing of knowledge, and acceleration of leading practices in the prevention, management and treatment of type 2 diabetes.

This Environmental Scan was undertaken as a step towards supporting conversation and collaboration amongst clinicians, researchers, policy makers, population health experts, educators and those living with type 2 diabetes to better enable system-level change.

Objectives

The primary objective of this scan was to identify and document clinical practices, policies, guidelines and research in the area of type 2 diabetes. A secondary objective was to identify emerging innovations which may have promise to change the trend of increasing type 2 diabetes prevalence.

The scan provides a snapshot of the current status of type 2 diabetes prevention and management in terms of the following overlapping areas:

- Strategy and policy
- Clinical interventions
- Population interventions
- Organizations and programs

METHODOLOGY

Scope

The scan was scoped to capture:

- Programs and research focused on type 2 diabetes.
- Programs and research focused on prevention, management or remission, or any combination of the three.
- Programs and research with a focus on:
  - Programs that have been rigorously evaluated
  - Landmark work that is frequently cited in reports and analyses
  - Local and recent work
  - Reports and publications written in English
- Programs and research in the realm of the health system, or targeting specific health outcomes.

Assumptions

It was assumed a very broad range of factors interact and cause type 2 diabetes in individuals. The scientific evidence supporting a deep understanding of these factors is still emerging and far from complete. For this scan, medical and non-medical determinants of an individual's health status were included.

Much of the work in chronic disease prevention focuses on underlying risk factors rather than specific diseases or conditions. As a result, much of the relevant published research is often not specifically tied to type 2 diabetes. In order to capture this relevant work, it was assumed the following interventions contribute positively to addressing type 2 diabetes:

- Population or individual Interventions that successfully induce weight loss
- Population or individual Interventions that successfully encourage healthier diets, including consumption of fewer calories or consumption of more fruits and vegetables
- Population or individual Interventions that successfully promote an increase in physical activity

Data Collection

Information collected and reviewed for this scan includes project summaries, best practices, evidence for effectiveness and evidence for cost-effectiveness. In developing the scan, we analysed over 300 publications and organizations.

Limitations

While an effort has been made to ensure that the review was comprehensive and reflective of the current type 2 diabetes environment, there are thousands of published reports and articles related to type 2 diabetes and, as a result, many have not been included in the analysis. A mix of database searches and expert recommendations were used to source and curate the material.

CONTEXT – DIABETES IN BRITISH COLUMBIA

Defining Diabetes

Most cases of diabetes are either type 1 diabetes or type 2 diabetes. Type 1 diabetes is a disease in which cells in the pancreas produce little or no insulin. While the causes are not fully understood, there is a genetic component with type 1 diabetes and there are no known major modifiable risk factors. Type 2 diabetes occurs when the pancreas does not make insulin well and/or when insulin has become less effective at controlling glucose in the blood. Type 2 diabetes usually develops over time, with weight, age and inactivity being the most common risk factors. Other risk factors include family history, ethnicity, diet composition, intergenerational trauma and depression.[1, 2]

While this scan focusses on type 2 diabetes, most of the statistics available in BC and Canada include both type 1 and type 2 diabetes. The combined statistics can still provide valuable information as over 90% of Canadians with diabetes have type 2 diabetes.[3]

Incidence and Prevalence

Prevalence is defined as the portion of the population with a diagnosis, whereas incidence is the rate of new diagnoses. This scan reviewed data from Public Health Agency of Canada, British Columbia Centre for Disease Control, Statistics Canada Community Health Survey, Diabetes Canada reports and Health Authority reports. While there are some differences in the data, all these sources indicate that diabetes prevalence is increasing.

In 2021, approximately 558,000 British Columbians were living with a diabetes diagnosis, a total of 11% of the population.[4] This represents an increase in prevalence of over 75% since 2007. In some minority communities, prevalence is even higher, specifically in First Nations, South Asian and Chinese populations. A recent University of Toronto study found that the incidence of prediabetes, defined as blood sugar that is higher than normal, was 40% higher among recent immigrants to Canada relative to long-term Canadian residents. Another recent study from Ontario concluded that the lifetime risk of diabetes among First Nations people is almost 30% higher compared to the rest of the Canadian population.[5] The genetic contribution to type 2 diabetes remains poorly understood, and researchers estimate genetic variation is responsible for anywhere from 30% to 70% of type 2 diabetes cases.[6]

Prevalence is expected to increase another 34% by 2030. Additionally, one in three people with diabetes is undiagnosed, and in 2017 approximately 765,000 British Columbians had prediabetes, a precursor to type 2 diabetes. In all, in 2021 over 1.5 million British Columbians, or 31% of BC's population, are living with diabetes or prediabetes.[*7]

A 2015 study by researchers at Providence Health Care (PHC) showed that type 2 diabetes has drastically increased in people under 30, even surpassing type 1 diabetes.[8] In Caucasian youth with diabetes, 62%

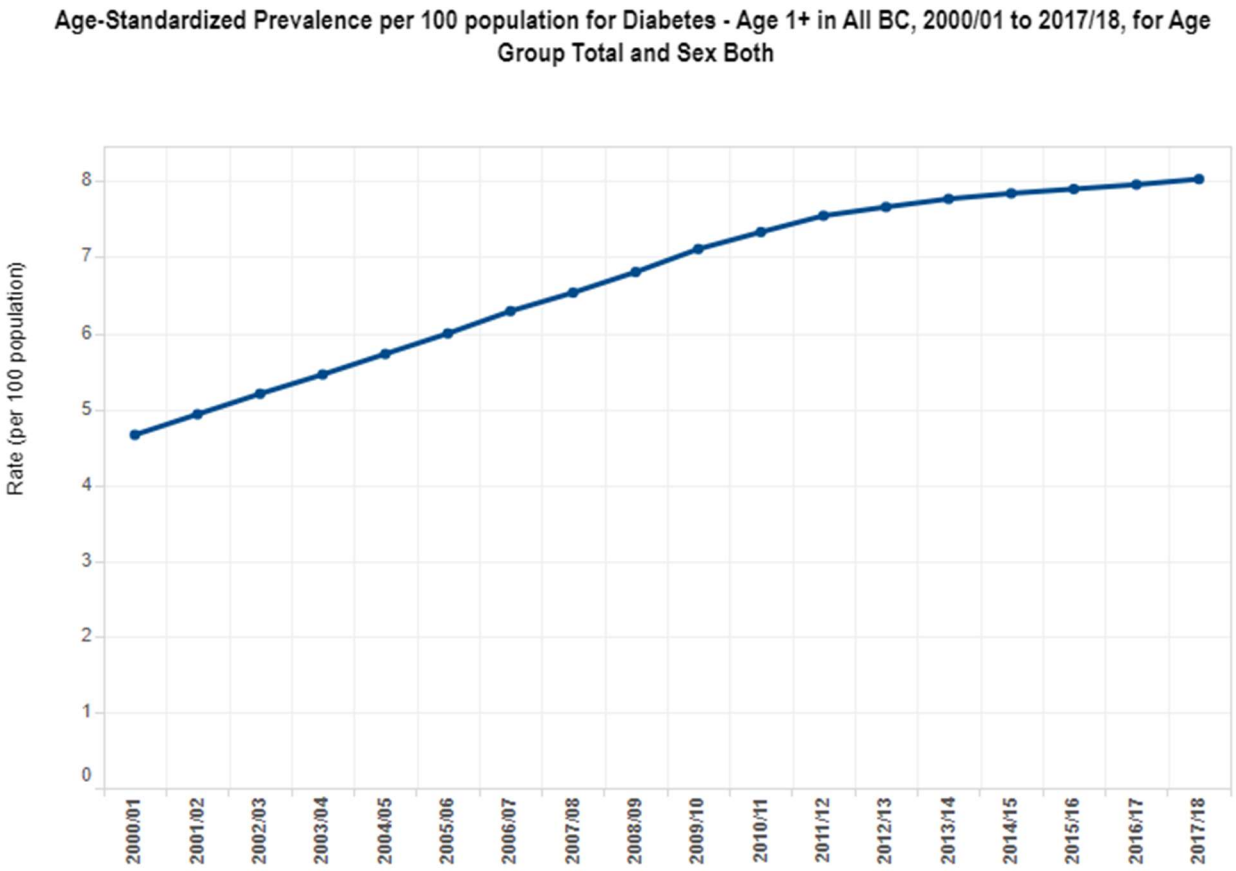
[*] Prediabetes is a controversial topic. The Canadian Diabetes Association sees it as a progressive marker of metabolic illness. For a dissenting view see https://pharmawatchcanada.wordpress.com/2012/06/27/industry-influence/ and https://jamanetwork.com/journals/jamainternalmedicine/article-abstract/2775594

have type 2, among South Asian youth that number increases to 86%, and among Chinese youth it is 87%. A look at the impacts of those diagnosed with type 2 diabetes in their youth found that 60% of them were experiencing diabetes-related complications by the age of 26, and that complications increase steadily over time.[9]

A 2021 study looking at almost 10 million patient records in Ontario found that age-standardized diabetes with major comorbidities increased 17% between 2008 and 2017 [10], and a study in the United States found age-standardized prevalence of diabetes increased from 9.8% to 14.3% between 1999 and 2007.[11] These findings demonstrate that the aging population alone doesn't explain the increased burden on both individuals and our health system.

The historical rise in age-standardized prevalence is shown in Figure 1.

FIGURE 1: AGE-STANDARDIZED PREVALENCE OF DIABETES IN BC[12]

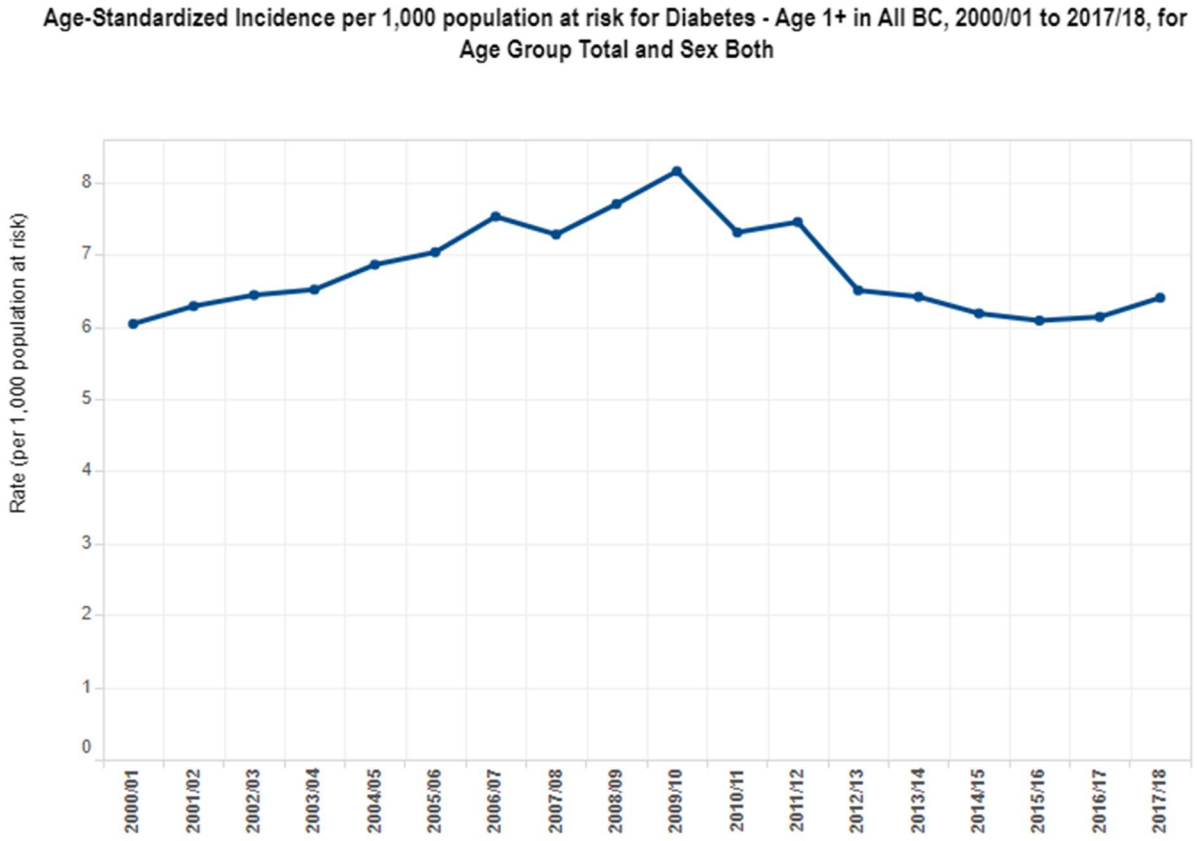


While age-standardized prevalence is expected to rise, the trend in age-standardized incidence is more complicated. As shown in Figure 2, the incidence rate in BC is down from its peak in 2009 of .83% to .64% in 2016. The increasing prevalence over the past few years can be partially attributed to an aging population, while those living with type 2 diabetes, despite living with a chronic illness, are living

longer.[13,14,15,16] However, the incidence pattern is not fully understood and a similar 2009 spike and subsequent decline in incidence has been seen in other provinces and was also reported in the United States. Some have suggested that this pattern may be an artifact resulting from increased awareness and/or diagnosis.[17] Others, including the authors of recent publications in the British Medical Journal (BMJ), believe that the declining incidence rates over the past decade are a legitimate reflection of the success of diabetes prevention policies and programs.[18,19] Regardless, it appears that the incidence rate has at best stabilized and may again be trending upward. Without significant improvements in type 2 diabetes prevention and management, the incidence rate is likely to remain at or above 6 new diagnoses of type 2 diabetes per 1000 population every year.

COVID-19 may also be a catalyst for new type 2 diabetes cases, as some have hypothesized a related increase in population-wide average BMI. A 2021 study published in the Lancet supports this idea, showing that the average body weight of those entering the NHS' Diabetes Prevention Programme has increased over the course of COVID-19.[20]

FIGURE 2: AGE-STANDARDIZED INCIDENCE OF DIABETES IN BC[21]

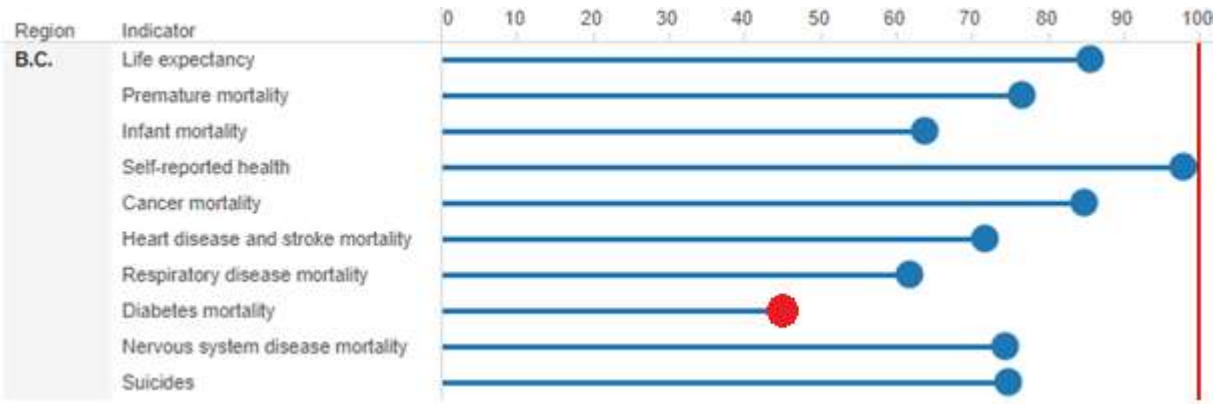


Also hidden in the high-level statistics is prevalence variability between regions. The province-wide age-adjusted prevalence is 8.03%, but this varies from as low as 5.76% in Kootenay Boundary to as high as 10.36% in Fraser South.[22] Some of the differences in regions can likely be attributed to different ethnic

makeup of the populations but there is some evidence that behavioural differences also contribute. For example, according to the Ministry of Health, 70% of those living in Kootenay Boundary are physically active, the highest rate of any region in BC.[23]

According to the Conference Board of Canada, BC has the lowest prevalence rate of diabetes and overall is the healthiest province in Canada. BC has Canada's highest share of those who are physically active, the lowest obesity rate in the country, and the fewest per capita smokers and heavy drinkers. The only comparable regions in the world that received the same "A" health grade are Switzerland and Sweden. It is especially notable then that BC's only "C" grade in the health report card comes in diabetes mortality, shown in Figure 3.[24]

FIGURE 3: BC'S CONFERENCE BOARD OF CANADA HEALTH REPORT CARD



Diabetes and the Social Determinants of Health

As with most chronic conditions, type 2 diabetes is inextricably linked with socioeconomic status and the social determinants of health. A recent analysis performed by the BC Centre for Disease Control (BCCDC) shows exactly how a number of socioeconomic dimensions impact diabetes rates. For example, those with less than a high school education are 21% more likely to be diagnosed with diabetes than those who have completed post-secondary education. Additionally, being in the top income quartile appears to partially protect individuals from a diabetes diagnosis. When socioeconomic factors are combined using the Material Deprivation Index, the results are even more striking. The type 2 diabetes incidence rate among those who are most deprived is 59% higher than the rate among those who are least deprived. Similarly, a large systematic review of evidence from the United States found that socioeconomic status is a strong predictor of both disease onset and progression.[25] Figure 4 shows the full results of the BCCDC analysis.

While studying the relationship between diabetes and obesity, IHSTS performed a novel analysis of the correlation between diabetes and obesity rates in the Organisation for Economic Co-operation and Development (OECD), a group of mostly rich countries. The analysis showed that while obesity rates were correlated with diabetes rates, obesity alone only explains a small amount of variance in diabetes rates across countries. However, a country's Gini coefficient, which groups like the World Bank and

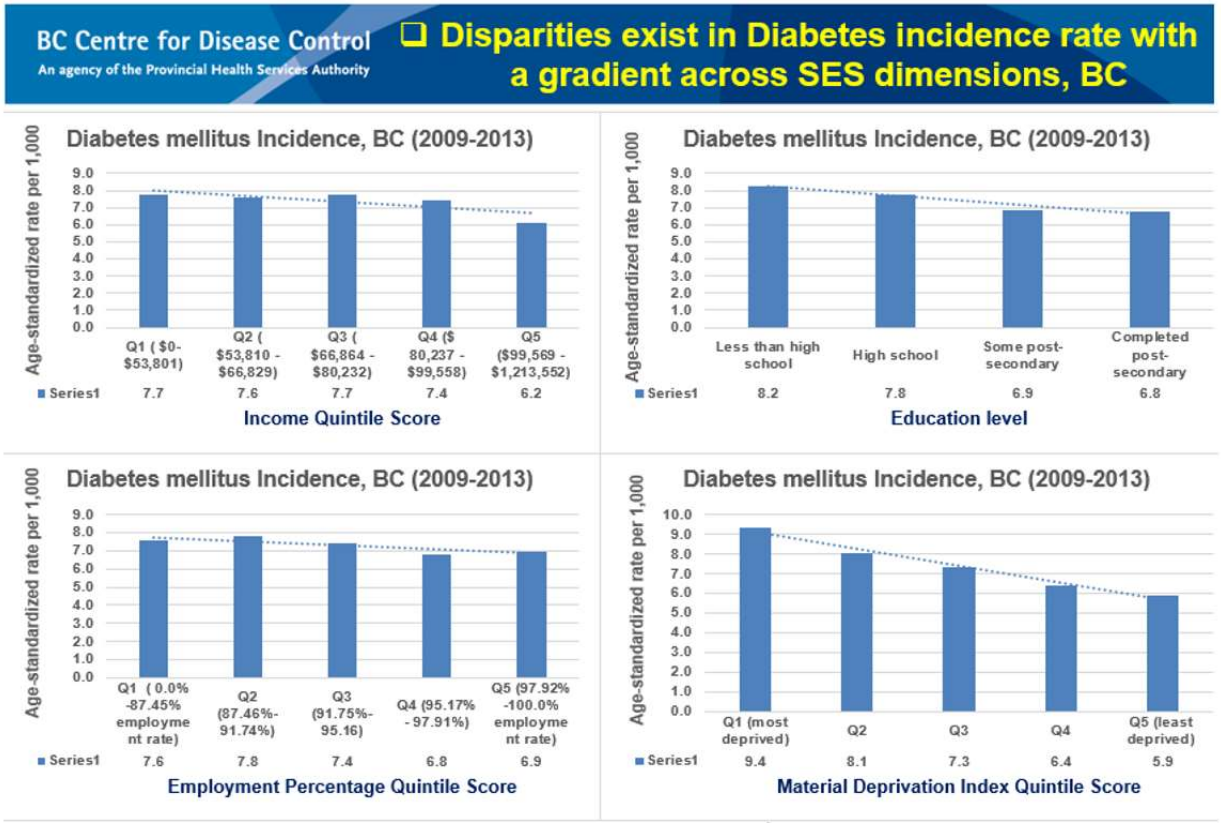
United Nations use to measure income inequality in a society, was twice as effective as a predictor of diabetes rates.

There are many mechanisms through which the social determinants of health influence diabetes rates in populations, and the social determinants themselves are interrelated. Some evidence-supported examples include:

- Those with more education have access to better jobs. Studies have shown that those with higher education and income report higher leisure-time physical activity.[26, 27]
- Those with higher income have greater access to healthy whole foods and research shows consumption of processed foods is correlated with the development of type 2 diabetes.[28] The BC Centre for Disease Control has determined that the average monthly cost of a healthy diet for a family of four is over $1000, showing that a major factor in household food insecurity is lack of income.[29] Poverty is also correlated with social isolation and poor mental health, both of which are in turn correlated with less healthy dietary makeup and increased rates of chronic illness.[30,31,32]
- Those with higher levels of education are more likely to learn about healthy behaviours and how to manage them. Studies have shown that those with more education are more adherent to self-management programs and less likely to switch to less effective treatments.[33]
- Those living with homelessness and diabetes are more likely to have poorly managed diabetes, have challenges accessing healthy food, and are more likely to experience major diabetes-related complications.[34, 35]
- Environmental risk factors may trigger epigenetic changes that can be passed on to offspring.[36]

Because of this inextricable link between the social determinants of health and type 2 diabetes, many of the interventions studied have some component of addressing the related social determinants of health. For example, many food security initiatives attempt to make healthy foods more widely available, and diabetes prevention programs often focus on improving access to healthy food in less affluent communities. The scan did not find any evidence of attempts to directly influence the social determinants with a goal of reducing type 2 diabetes prevalence. For example, there were no studies found that looked at how universal basic income or free post-secondary education would influence type 2 diabetes prevalence or incidence. We did find one report that examined how interventions targeting the social determinants of health impacted health system spending, and it found some positive impact from interventions that targeted those most in need and those that had a health-education component.[37]

FIGURE 4: ANALYSIS OF SOCIOECONOMIC DIMENSIONS AND DIABETES IN BC



As noted in a 2021 article published in Nature, "a diagnosis is rarely a solution to problems caused by poverty and inequality".[38] It's for this reason that IHSTS believes any meaningful, long-term solution to the type 2 diabetes epidemic will involve socioeconomic elements traditionally not seen as part of the health care system.

Impact of Diabetes on Individuals and Society

The most significant negative impact of rising diabetes prevalence is the associated morbidity and mortality. Those living with diabetes are more susceptible to a host of negative health outcomes including vision problems, cardiovascular events, limb amputations, renal failure, cancer progression and bone fractures.[39, 40,41] Diabetes contributes to 30% of all strokes, 40% of all heart attacks and 50% of a kidney failure cases in Canada.[42] In all, those with diabetes in Canada are 75% more likely to die at any given age than those without it.[43] Detailed mortality tables provided in a recent study demonstrate the importance of lifestyle and treatment, as life expectancy between those with well-managed and those with poorly-managed type 2 diabetes varies dramatically.[44]

A recent study demonstrated that there has been no meaningful improvement in population-level treatment outcomes for those with diabetes in the United States since at least 2005 and the evidence we found suggests a similar lack of improvement in Canada.[45, 46] For instance, one study found the overall rate of diabetes-related amputations in Ontario to have increased between 2010 and 2016.[47]

The burden falls even more heavily on poor and minority populations. For instance, a recent study out of Ontario found that First Nations people with type 2 diabetes were almost twice as likely to require emergency room care from hypo or hyperglycemia as those with type 2 diabetes who are not First Nations.[48] Another recent study found that First Nations pregnancies are twice as likely to be exposed to either type 2 diabetes or gestational diabetes.[49] A study showed limb amputation rates in the lowest-income neighbourhoods in California are 10 times higher than in the wealthiest neighbourhoods.[50] A study looking at pediatric populations in the United States found that black children living with diabetes had poorer blood glucose control than white children living with diabetes, even when adjusting for socioeconomic status.[51]

The economic burden of diabetes in society is also substantial. Diabetes Canada estimates direct diabetes costs to the BC health system of $528 million every year. A large study in Sweden found those with diabetes were more than twice as likely to have a hospital contact as those without it, and a study in Ontario found healthcare costs double for those living with diabetes.[52, 53] A Provincial Health Services Authority (PHSA) study found at least 7 in 10 cases of type 2 diabetes are linked to excess weight, physical inactivity and smoking, and that a 1% relative decline annually in excess weight would avoid over $7 billion in direct and indirect costs associated with chronic illness in BC by 2036.[54] The Canadian Institutes of Health Research (CIHR) estimates not meeting Canadian food guide recommendations was responsible for over $13 billion a year in costs.[55]

Diabetes is also a major driver of price increases for private insurers. An analysis by Telus found that 4.9% of plan members were diagnosed with diabetes. These members were responsible for 18.2% of total drug costs, and diabetes drugs represented the second largest drug category by total costs.[56] They also found that these members took on average seven different medications, were commonly unable to keep up with their drug regimen, and often entered a downward spiral where failure to follow their drug regimens led to more drugs being prescribed.[57] A study in the United States found that antidiabetic medication utilization increased 9% between 2014 and 2019, and average drug costs for those with diabetes rose 48%.[58]

The burden of type 2 diabetes will be felt even more strongly as the trend is amplified by the rise of other chronic conditions. The Milken Institute estimates that by 2030 over 83 million Americans, or almost a quarter of the projected population, will be living with three or more chronic conditions.[59]

The COVID-19 pandemic has increased type 2 diabetes-related morbidity and mortality. A large analysis of data in the UK shows COVID-19 mortality is associated with poor glycemic control.[60] A recent study also found COVID-19 patients with type 2 diabetes required more intervention and were much more likely to die than patients without type 2 diabetes.[61] The American CDC has recently highlighted how COVID-19 comorbidities further demonstrate the importance of chronic diseases prevention, and a recent analysis to American data found 40% or more of the people who have died of COVID-19 also had diabetes.[62,63]

A recent analysis by the BC provincial government and the University of British Columbia of provincial data and experiences provides more insights on health authority and hospital-level diabetes care management.[64] Their work provides a foundation for regional-level planning and improvement opportunities to reduce the burden of type 2 diabetes.

SCAN RESULTS

Strategy and Policy

This scan looked at what guiding strategies and policies are in place for type 2 diabetes in Canada. To a lesser extent, the international landscape was also reviewed.

British Columbia

At the provincial level, the BC Diabetes Care Guidelines and BC's Guiding Framework for Public Health are the most recent and relevant province-wide strategy and policy documents addressing diabetes prevention and management. There is also a province-wide type 2 diabetes network providing opportunities for collaboration and learning in the space.

The BC Diabetes Care Guidelines, published in 2015 and with an update expected by the end of 2021, provide comprehensive clinical guidelines for the prevention, diagnosis and management for adult type 1 diabetes and type 2 diabetes patients. The guidelines include several recommendations and indicate the level of evidence supporting each recommendation. [65]

Key clinical recommendations summarized from the guidelines include:

- Care should be patient-centred.
- A variety of tests can be used for diagnosis based on the patient.
- Screening for type 2 diabetes should occur every 3 years for those >= 40 years old and those at high risk.
- Glycemic targets should be based on patient age, duration of diabetes, life expectancy and risk factors.
- A "systemic" approach is recommended, including lifestyle management, glycemic control, blood pressure control and pharmacological interventions. Care should begin with a 2-3 month trial of lifestyle modification alone for most type 2 diabetes patients before beginning medication.

BC's Guiding Framework for Public Health, written in 2013 and updated in 2017, articulates a long-term vision for public health incorporating all major provincial public health strategies and could be viewed as the current type 2 diabetes prevention strategy in BC. [66]

The most relevant section of the framework for type 2 diabetes is Goal 1: Healthy Living and Healthy Communities, which includes several objectives and measures related to nutrition and physical activity. The objectives focus on improving health through school-based programs, healthy built environments that encourage healthy choices and employer support for workers.

The framework includes a reduction in age-standardized incidence rate for diabetes from 6.3/1000 ppl in 2010 to 6/1000 in 2023 as one of six overarching performance measures.

In an effort to increase collaboration and knowledge transfer, the BC Patient Safety & Quality Council, in partnership with the Institute for Health System Transformation & Sustainability, have created a network focused on sharing, developing and applying innovative practices to improve outcomes for

people living with type 2 diabetes across the province. Details about this network are available on the website at https://bcpsqc.ca/improve-care/diabetes-network/

Other Provinces

A review of all Canadian provinces showed that most provinces do not have an active or published province-wide strategy specific to diabetes. The review did not look at the state of general population health strategies and policies.

Measured by population, Saskatchewan is the largest province with a diabetes strategy. The strategy was originally published in 2004, but the government reaffirmed its commitment to implementation in 2019.[67] The strategy focuses on four components:

- Primary prevention and health promotion to prevent or delay type 2 diabetes.
- Optimum care and prevention through self-management, education and treatment, including risk factor assessment and programs for those at high risk.
- Education for providers to support self-management, care and prevention.
- Surveillance to support planning, delivery and evaluation.

Three of the Maritime Provinces have current strategies, with Nova Scotia's Diabetes Care Program Strategic Plan standing out.[68] The strategy focuses on common topics such as knowledge generation and sharing, integration, data and collaboration.

Even though several provinces do not have an active diabetes strategy, many had strategies at some point in the past. For instance, Ontario had a strategy it was updating as recently as 2012.[69] As these past provincial strategies were unable to reverse the type 2 diabetes trend, it is reasonable to argue that a successful approach in BC should challenge past assumptions and encourage true innovation.

Appendix 1 provides more details on strategies in place for each province.

National

There has been substantial movement in 2021 towards a national diabetes strategy. A report from the Canadian Parliament's Standing Committee on Health recommended using Diabetes Canada's Diabetes 360 strategy as a starting point for a new national strategy to prevent and manage diabetes. Recommendations in the report, which is based largely on expert testimony, included establishing a national diabetes registry, increasing community education and awareness programming with a focus on nutrition, improving provider education, and providing funding to cover the cost of diabetes-related expenses for those living with diabetes.[70]

As a result of these recommendations, in June 2021 Bill C-237 received royal assent. It requires the Minster of Health to work with the provinces and other stakeholders to develop a national diabetes framework that must include measures to:[71]

1. explain what diabetes and prediabetes are;
2. identify the training, education and guidance needs of health care and other professionals related to the prevention and treatment of diabetes, including clinical practice guidelines;
3. promote research and improve data collection on diabetes prevention and treatment;

4. promote information and knowledge sharing in relation to diabetes prevention and treatment;
5. take into consideration any existing diabetes prevention and treatment frameworks, strategies and best practices, including those that focus on addressing health inequalities; and
6. ensure that the Canada Revenue Agency is administering the disability tax credit fairly and that the credit, in order to achieve its purposes, is designed to help as many persons with diabetes as possible

It is anticipated that the framework will be based largely on Diabetes Canada's 360 framework, though it is unclear if it will receive the full $150 million funding requested by Diabetes Canada.[72] The Diabetes 360 targets can be summarized as:

- 90% of Canadians live in an environment that prevents the development of diabetes
- 90% of Canadians are aware of their diabetes status
- 90% of Canadians living with diabetes are engaged in appropriate interventions
- 90% of Canadians engaged in intervention are achieving improved health outcome

As of October 2021, the federal government has committed $10 million over five years to the Public Health Agency of Canada for a new Diabetes Challenge Prize and $25 million over five years to Health Canada for research on diabetes, surveillance, and prevention, and to develop the national framework for diabetes.[73]

The CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) has recently published their 2021–2026 strategic plan. It notes that metabolic health interventions that are not personalized have limited effectiveness. They have a number of research priorities tied to diabetes.[74]

There has also been substantial national diabetes-related work in the past. The federal government spent $115 million between 1999 and 2005 to develop a national diabetes strategy that was largely focused on surveillance and self-management.[75] However, shortly after publishing the framework, diabetes care was incorporated into the Healthy Living and Chronic Disease strategy and the focus shifted from diseases and conditions to risk factors. The federal government did implement several community-based diabetes programs that demonstrated some success, but unfortunately they were not rigorously evaluated and as a result lessons that can be learned from these programs are limited.[76]

More recently, the Public Health Association of Canada's Centre for Chronic Disease Prevention: Strategic Plan 2016–2019 was set out as the federal way forward for diabetes prevention.[77] This plan focused on harnessing new technology, developing financial instruments to be used as policy levers, and engaging across sectors, all with the goal of accelerating discovery, innovation and breakthrough. With no published reporting on plan progress, it is difficult to determine if any work resulting from this plan has meaningfully impacted type 2 diabetes prevention or management. According to PHAC an evaluation is underway, and we will provide an update once it is made available.

Diabetes Canada provides detailed type 2 diabetes glycemic management guidelines. The 2020 update generally aligns with the BC Diabetes Care Guidelines described above. However, unlike the BC guidelines, the Diabetes Canada guidelines for the first time acknowledge that remission of T2D is possible with healthy behaviours and that remission is a worthwhile goal for some patients.[78]

In August 2020, Obesity Canada released comprehensive national clinical guidelines for obesity care. These guidelines focus on reducing stigma, collaborative care and patient outcomes rather than simply weight management. They highlight the lack of health system effectiveness in dealing with Canada's obesity epidemic.[79]

International

While this scan did not attempt to conduct a comprehensive review of diabetes strategies around the world, there were some highlights that emerged as we explored what other nations were doing to address the global epidemic.

Diabetes incidence appears to have stabilized in some OECD countries, but no country has been able to significantly decrease diabetes prevalence. However, a number of countries are putting substantial resources into prevention and management.

England's National Health Service (NHS) has an Action Plan for Diabetes that is focused on quality improvement and reducing variability across the country.[80] It sets out specific roles for NHS as both a commissioner of services as well as areas in which it will provide leadership and support. Since the initial publication of this scan, the NHS has announced substantial new investment to expand its national diabetes prevention programme. This expansion includes large-scale trials of emerging interventions designed to induce type 2 diabetes remission, including expanding these programs to allow individuals to refer themselves.[81] Based on this work, we consider England to be the global leader in population-level diabetes programming. Whether or not this program will result in population-level outcomes however remains to be seen.

Elsewhere in the UK, the Scottish Government has recently published a type 2 diabetes prevention and early detection plan and is focused on promoting a care pathway for those at high risk.[82]

In the United States, the National Institutes of Health (NIH) publish an annual "Emerging Opportunities" report focused on diabetes and kidney diseases, though much of the report is dedicated to biomedical research.[83] The NIH was also responsible for the landmark type 2 diabetes prevention trial, which is discussed in the next section of this report. At the state level there is also work being done. Washington State, for instance, publishes a Diabetes Epidemic and Action Report that makes broad-based recommendations to the legislature related to prevention and care.[84] The National Academies of Science, Engineering and Medicine recently published a scan of emerging practices focused on the obesity pandemic, which has substantial overlap with type 2 diabetes strategies.[85]

Individual and Population Interventions

The Individual and Population Interventions section of this report is broken out into two broad categories of intervention: individual and population. Individual interventions are those that are delivered face-to-face by providers or counsellors, either one-on-one or in small groups. This includes clinical interventions like prescribing medications and lifestyle programs that require physician referral. Population interventions are those that are intended for and delivered to a broader audience, like public education and awareness campaigns, taxes and fiscal policies. Widely available mobile applications may

be individual level tools (coaching) or more general (information) and can be seen as a population intervention because of their one-to-many scalability.

For both individual and population interventions, those related to prevention, management and treatment of type 2 diabetes are included.

Individual Interventions

In 2002, the American National Institutes of Health (NIH) published the results of their Diabetes Prevention Program (DPP) trial, and the intensive lifestyle intervention protocols used in this trial were quickly adopted as best practice for type 2 diabetes prevention.[86,87,88,89] Later, similar protocols were adopted as best practice for type 2 diabetes management.[90,91,92,93] The lifestyle interventions used in these programs include individual or small-group counselling on diet, exercise and behaviour modification skills. Similar programs were replicated in other countries and settings, most notably in another large trial in Finland.[94,95] Many of these programs implemented multi-year interventions, and some of them collected follow-up data as far as 15 years out. Diabetes Canada now offers a DPP based on these protocols in most Canadian cities.[96]

In terms of both prevention and management, many of these programs demonstrated some success. With respect to prevention for high-risk individuals, at the 15-year follow-up DPP participants were 27% less likely to have a type 2 diabetes diagnosis than those in the regular care control group. Early reports from the UK-wide NHS diabetes prevention program claim that the 400,000 participants had lost on average 3.4kg of body weight. This success has led to a recent announcement that funding for the NHS program will be doubled for the next five years.[97,98] A systematic review of similar prevention programs found substantial variation in weight loss and incidence rates, though a recent meta-analysis found those with prediabetes are on average around half as likely to develop type 2 diabetes over a three year period if they are entered in a lifestyle intervention program.[99,100] A systematic review looking at type 2 diabetes prevention programs in the South Asian population found that 60% of the studies they reviewed had positive results.[101]

One of the common conclusions these analyses highlight is the ability of these programs to delay, rather than prevent, many cases of type 2 diabetes. An additional concern is that these programs are often unavailable in small, rural communities.[102] Despite these factors, a recent simulation demonstrated that a diabetes prevention program implemented nationwide in the United States would result in significantly fewer cases of diabetes and billions of dollars in cost savings.[103] This approach is supported by a study of over 100,000 individuals that showed a 50-year-old who lives a low-risk lifestyle (exercises frequently, eats a healthy diet, does not smoke, is not a heavy drinker and is a healthy weight) can expect to live free of chronic illness for on average at least 10 years longer compared to an individual who lives a high-risk lifestyle.[104]

Diabetes prevention programs can only be effective if health systems are designed to identify those at risk of type 2 diabetes before disease onset. A position statement out of Australia sets out the case for prediabetes screening, concluding that there is strong evidence for increased screening and intervention.[105] A study out of New Zealand demonstrated a large reduction in cardiovascular disease as a result of type 2 diabetes screening.[106] The BC Lifetime Prevention Schedule recommends obesity

screening begin at age 19 and type 2 diabetes screening every three years beginning at age 40.[107] A recent report from the American Associate of Clinical Endocrinologists provides screening and monitoring guidelines. According to these guidelines, patients with major risk factors such as obesity and hypertension should be placed under close surveillance by their primary care providers. There are many type 2 diabetes risk assessments available that health care providers can use to screen their patients and clients.[108] The NHS has shown that focused promotion of screening tools can lead to dramatic increases in the use of these tools, and the BETTER Program has had success increasing screening rates in some parts of Canada.[109,110] New tests that use markers such as the Fatty Liver Index may be able to better predict who will develop type 2 diabetes earlier in disease progression.[111]

From a management perspective, the results are of a similar scale and impact to the prevention programs mentioned above. Some management programs demonstrated that those diagnosed with type 2 diabetes participating in intensive lifestyle intervention are more successful at losing weight and have improved biochemical markers (HbA1c, glycemic control and blood pressure). These results look durable over a long-term implementation of the study, though the benefits decay slightly over time. The largest trial, called Look AHEAD (Action for Health in Diabetes), found that type 2 diabetes remission was possible but rare, with 4-year sustained remission occurring in 3.5% of those in the intervention group.[112] A number of studies have shown that new models of care for diabetes management such as team-based and telehealth programs can be effective and should be further explored.[113,114]

Diabetes education is a hallmark of the health system and most large hospitals in BC house diabetes education centres. These programs are effective at improving glucose control and reducing major complications for those diagnosed with type 2 diabetes, but they rarely result in remission.[115, 116, 117] Education delivered as part of a comprehensive lifestyle intervention is most effective, and use of evidence-based techniques such as health coaching and cognitive behavioural therapy show promise.[118, 119, 120, 121] A recent systematic review of psychosocial interventions for those with elevated blood glucose found that they can successfully reduce hospital admission rates.[122] Another recent report highlights that glucose control is critical to prevent progression to severe illness.[123] A mobile clinic that visits First Nations Communities in BC to provide diabetes education and lifestyle advice reports improved glucose control and decreased risk of complications.[124]

Historically there have been substantial mitigating factors that must be considered for intensive lifestyle intervention programs. The biggest challenge is that many qualifying individuals may not participate, and most studies successfully recruited less than one out of three individuals they invited. One study found that those members of ethnic minorities and those with less education were less likely to complete lifestyle programs, leading to increases in health inequality.[125] Socioeconomically deprived populations often face barriers to participation including less flexible schedules, lack of access to transportation and challenges expressing themselves in group settings.[126] Moreover, even interventions that successfully recruit participants often fail to generate sustained engagement. One systematic review of a large lifestyle program for veterans found a maximum of 25% of those recruited stayed engaged.[127] It has long been assumed that these low participation and engagement rates were the result of patient preference, but a recent large study of over 16,000 patients with prediabetes found that over 80% of patients were never offered the nutritional counselling that was available, and that treatment

rates reflected provider rather than patient preferences.[128] Regardless, it is hoped that culturally-tailored interventions such as the NaMaSTe-Diabetes trial will experience fewer recruitment and engagement challenges.[129]

Another mitigating factor is that, while it is known intensive counselling and lifestyle management programs for type 2 diabetes patients lead to better outcomes, these initiatives require a large commitment from health professionals. A recent study based in BC showed that simply providing incentives for physicians to deliver better care for chronic disease patients is important but not sufficient.[130, 131] A critical analysis looking at the primary care setting suggests the strong bias of the health system to maintain the status quo is one of the biggest challenges to improving care for those with type 2 diabetes.[132] A multidisciplinary approach that uses allied health professionals to recruit and retain participants to these programs is supported by evidence and aligned with BC's Primary Care Networks.[133 , 134, 135]

Many of the diabetes care guidelines focus on promoting self-management for those living with diabetes. A large systematic review of self-management for type 2 diabetes found it to be effective at changing self-reported behaviour, especially in the short term, and another systematic review found self management programs led to better blood glucose control for those living with type 2 diabetes.[136,137] One analysis of Medicare records in the United States found that those living with type 2 diabetes who had taken self-management classes were more likely to get enough exercise than those who had not.[138] Another study found self-management and education programs with fewer than 10 hours of intervention were unlikely to be successful, while those with 11 or more hours usually resulted in meaningful improvements.[139] Though most self-management programs have demonstrated success, a recent review of self-management interventions for type 2 diabetes patients with severe mental illness concludes that there is insufficient evidence to recommend self-management for all patients.[140]

Regardless of the intervention used, treatment guidelines emphasize that targets should be based on an individual's goals, and providers should deliver care according to these targets. A study from Veterans' Affairs in the United States showed that around half of those who have their diabetes care intensified after a hospital admission are likely to see little to no benefit from the additional treatment.[141]

The emerging lifestyle medicine movement is attempting to implement a more patient-centred approach to intensive lifestyle intervention programs. Early reports indicate that this approach is effective, but more research is needed.[142] Success in this space would likely have an outsized impact on type 2 diabetes, as a recent meta-analysis looking at over 100,000 patient records found a clear, linear relationship between lifestyle and years lived without chronic disease.[143] There are active lifestyle medicine programs and clinics in BC working on addressing these challenges.[144]

From a cost-effectiveness standpoint, the Diabetes Prevention Program intensive lifestyle intervention was found to be cost-effective at $12,900/Quality-Adjusted Life Year (QALY), though the average participant gained only ~.14 QALY, a small effect.[145] A publication found the Look AHEAD trial for type 2 diabetes management cost between $40,000 and $100,000/QALY, rates which are generally not considered to be cost-effective.[146] A report suggested that focusing on high-risk individuals and delivering interventions in group settings can improve cost-effectiveness.[147] Other studies have found

that shifting care away from physicians to community health workers, nurses and physicians' assistants can also improve cost-effectiveness.[148,149]

A promising emerging area of treatment for type 2 diabetes is therapeutic nutrition; the use of evidence-based nutrition therapies to achieve specific health goals. Often these therapies incorporate low-carbohydrate diets, which studies have found can be delivered safely to participants.[150, 151,152] Early studies have demonstrated substantial success in treating those diagnosed with type 2 diabetes, especially if the diagnosis is recent. One study showed average weight loss among participants of 13 kgs after one year, and remission rates as high as 60%.[153] Another study showed remission in 36% of participants at 2-year follow-up, though the number in remission had declined from 48% at 1-year follow-up.[154] A study looking at real-world implementation in a large primary care clinic achieved a remission rate of 46%, and a pharmacist-led intervention in Canada achieved a remission rate of 36%.[155, 156] A systematic review concluded there was evidence that those diagnosed with type 2 diabetes on these diets may experience remission at six months without adverse consequences.[157] A mobile application delivering a therapeutic nutrition intervention found 40% of participants were able to reduce reliance on type 2 diabetes medications and 26% were in remission after one year.[158] Crucially, a study published in late 2020 showed that after one year of remission there may be a significant improvement in pancreatic function, demonstrating for the first time nutrition-based reversibility of abnormal pancreatic morphology in type 2 diabetes.[159] Recent work has demonstrated that similar interventions are also effective at preventing type 2 diabetes in at-risk individuals.[160] Studies show that therapeutic nutrition interventions should always be delivered under the supervision of health care professionals, as often deprescription of medications due to dramatically-changing body chemistry is necessary.[161]

The American Diabetes Association considers the use of therapeutic nutrition for diabetes treatment to be an evidence-based consensus among top experts. [162] The Western Australia Education and Health Standing Committee has recently concluded a focus on therapeutic nutrition is the most viable way forward to reduce the burden of type 2 diabetes on society, and the Spanish Diabetes Society encourages the use of therapeutic nutrition.[163, 164] The Canadian Institute for Personalized Therapeutic Nutrition is attempting to scale therapeutic nutrition interventions in Canada.[165] In May 2020, Diabetes Canada released an updated position statement on low-carbohydrates diets, concluding that these diets are safe and effective for those with type 2 diabetes when monitored by health care professionals, and the updated Diabetes Canada type 2 diabetes guidelines make it clear that remission of type 2 diabetes is possible and a worthwhile goal.[166, 167] Despite these endorsements, therapeutic nutrition remains an emerging concept, and while the long-term benefits of the approach are promising they are yet to be fully evaluated and quantified. Early research shows promise for several intervention designs and in many different socioeconomic and ethnic populations. Authors of a recent review suggest that we now have effective short-term weight loss programs and the focus should shift to medium-term (~5 year) maintenance, noting that weight loss maintenance appears to get easier for an individual over time.[168] Researchers in the space note that there is still much to be learned about how to truly tailor nutrition interventions to meet the unique metabolic needs of each individual.[169]

A recent Lancet publication summarizes the pathophysiological mechanism of type 2 diabetes remission, suggesting that loss of excess fat accumulation in the liver and pancreas can reduce metabolic stress and

normalise blood glucose levels.[170] Given this pathway, we would expect that many diet-based interventions that successfully encourage weight loss will be effective at reducing or treating type 2 diabetes. In practice the results are mixed. A number of trials have found very low-calorie diets effective at treating type 2 diabetes for those that can adhere to them, and the NHS is implementing large-scale trials of very low-calorie diets for the treatment of recently-diagnosed type 2 diabetes.[171, 172] One study found that even diets leading to modest weight loss can lead to remission.[173] An extensive review of family-based behavioural childhood obesity interventions showed that they can be effective at reducing child weight.[174] However a meta-analysis of behavioural weight-loss interventions in primary care settings showed very small effects that the authors conclude are unlikely to be clinically significant.[175] A number of researchers have found low-carb diets to be more effective in the short-term, but equivalent to traditional diets after one year.[176 , 177] However a critical review of this research suggests that most researchers fail to account for the reduction in medication achieved in low-carbohydrate interventions.[178] A recent review of 14 mainstream diet programs found that while both low-carbohydrate and low-fat diets led to short-term weight loss, regardless of the diet chosen most participants regained the weight within one year.[179]

Type 2 diabetes is closely related to gestational diabetes, which is diabetes diagnosed for the first time during pregnancy. Gestational diabetes is not only associated with worse pregnancy and birth outcomes, where poor maternal glucose control can triple the risk of perinatal infant death,[180] but can also cause long-term metabolic harm to both the woman and child. It is on the rise in Canada, with the percentage of diabetes-exposed pregnancies approximately doubling since 1980, and is more common in many ethnic minority populations.[181, 182] Lifetime type 2 diabetes risk among woman with a history of gestational diabetes is up to 20 times higher, and children exposed to maternal hyperglycemia are more likely to develop type 2 diabetes over their lifetimes. In girls, this can lead to a vicious cycle, as they are then more likely to experience gestational diabetes and pass the risks on to their offspring.[183] The evidence shows that risk identification and lifestyle intervention early in pregnancy is critical. A number of virtual interventions, including the BC program SmartMom, have demonstrated success at encouraging healthy behaviours in pregnant women and managing gestational diabetes.[184,185,186] Because of the high risk of progression to type 2 diabetes, woman with a history of gestational diabetes are excellent targets for diabetes prevention programs. Metformin is commonly prescribed for management of gestational diabetes, and the little evidence that exists shows a small benefit to mother and child.[187]

Similarly, the evidence supports an early risk detection and obesity prevention approach for children at risk of developing type 2 diabetes, as the lifetime effectiveness of obesity treatment in children remains in question, and it is clear that children who consume sugar-sweetened beverages or fruit juice before one year of age are much more likely to develop pediatric obesity.[188, 189, 190] Delaying type 2 diabetes onset is critical, as each one-year increase in type 2 diabetes age at diagnosis was associated with 4% decrease in all-cause mortality, and researchers have demonstrated a strong correlation between early type 2 diabetes diagnoses and dementia.[191,192]

Many clinics and providers now offer virtual care programs and supports, a trend that has accelerated as a result of the COVID-19 pandemic. Research demonstrates that virtual care is appropriate and effective

for type 2 diabetes prevention and management. A recent meta-analysis that included over 9000 people living with type 2 diabetes found that remote telehealth consults were preferred to conventional care and improved outcomes.[193] Other studies and reports have shown how virtual health programs can improve access to the care system and save the system of millions of dollars.[194, 195] IHSTS has produced a deep dive report, *Virtual Care for Type 2 Diabetes Behavioural Change,* with a detailed analysis of how virtual care has the potential to influence the type 2 diabetes space.

In terms of pharmacology, some medications show a benefit in type 2 diabetes management, but no medications demonstrate consistent success in prevention or remission. Medications are often prescribed to control blood glucose but there is an active debate in Canada and elsewhere regarding the standard of clinical care, with some concluding there is a lack of evidence to support the idea that tight glycemic control leads to better outcomes for those with type 2 diabetes.[196, 197] Researchers have also raised concerns that older patients are often over-prescribed blood glucose-related drugs, seeing little benefit.[198] However, most clinical guidelines still include tight glycemic control. As mentioned in the strategy and policy section, the BC guidelines encourage an attempt at management through lifestyle intervention before resorting to medication. A recent critical analysis suggests that nutritional interventions should be paired with medications to increase pharmacological efficacy and reduce negative side-effects.[199]

In addition to lifestyle intervention, the Diabetes Prevention Program included an arm using the drug Metformin for type 2 diabetes prevention. That arm was 18% less likely to have a type 2 diabetes diagnosis at 15-year follow-up. Interestingly, a cost-effectiveness analysis found Metformin to be not only cost-effective but in fact cost-saving, with no long-term improvement in outcomes but a significant long-term decrease in overall health care costs for those taking the drug for prevention.[200] A recent critical analysis published in the Canadian Medical Associate Journal suggests Metformin should be considered the first-line pharmacological treatment for type 2 diabetes.[201] Another analysis looking at the use of low-carbohydrate diets noted that, unlike most other diabetes medications, Metformin is usually safe to continue even when individuals make dramatic changes to their diets.[202]

A review of early insulin therapy for type 2 diabetes showed better glycemic control early in the course of the disease can lead to long-term benefits. One 20-year follow-up for those living with type 2 diabetes treated with early insulin therapy found a relative risk reduction in all-cause mortality of 13%.[203]

Additionally, some pharmacological interventions to prevent complications resulting from type 2 diabetes are supported by evidence. A number of publications provide evidence that the use of drugs to control blood pressure is effective at reducing mortality,[204] and there is some evidence to support use of other drugs such as Sodium Glucose Co-Transport-2 Inhibitors (SGLT2i) like Empagliflozin to prevent cardiovascular events.[205, 206]

Some emerging pharmacological technologies show promise. Gut hormone therapy has demonstrated some success at treating type 2 diabetes, but the ideal mix of drugs in the space is yet to be determined.[207, 208] Researchers are also working on nanotechnology-based delivery mechanisms that can deliver drugs to specific cell receptors, believing they will dramatically improve bioavailability and reduce side effects, making existing drugs more effective.[209]

Finally, bariatric surgery has been shown to be highly effective at treating type 2 diabetes, especially in very overweight individuals. Evidence shows weight loss from bariatric surgery is as effective at improving metabolic health as weight loss from dieting, and a large systematic review found 78% of very overweight individuals living with type 2 diabetes experienced complete remission after bariatric surgery.[210, 211] A 2021 meta analysis of over 174,000 bariatric surgery patients found a dramatic reduction in morbidity and mortality, with type 2 diabetes patients who received the surgery increasing their median life expectancy by 9.3 years compared to the control group.[212] An extensive report produced by the Belgian Health Care Knowledge Centre concluded that bariatric surgery was by far the most effective long-term treatment for those with BMI > 35, and that those with lower BMI also benefit from the surgery.[213] A recent large trial of 9710 people living with type 2 diabetes found that while many types of bariatric surgery led to high remission rates for type 2 diabetes, gastric bypass was the most effective, achieving remission in 86% of participants.[214] Another recent trial found that over half of those treated remained in complete remission for at least four years post surgery, demonstrating durability of the intervention.[215] According to Obesity Canada, bariatric surgery remains heavily rationed and people can wait up to eight years for specialist referrals, longer than any other medically necessary surgery.[216]

Population Interventions

Few population-level interventions specifically target type 2 diabetes. Most population interventions relevant to the scope of this scan target risk factors and aim to improve diets or increase physical activity.

A number of jurisdictions have recently imposed taxes on high-calorie, sugar-sweetened beverages (SSB).[217,218,219] The results in jurisdictions that have studied the effects of such taxes have been mostly positive. Most jurisdictions show a clear decrease in consumption of taxed beverages, and a recent study showed the change in consumption patterns remained years after the tax was implemented.[220] Notably, a report found that after implementation of an SSB tax in England total sugar consumed in soft drinks fell by 35%, but total purchases in the soft drink category continued to grow, demonstrating these taxes are not necessarily harmful to private industry.[221] Notably, recent analyses have found that in locations with SSB taxes drink manufacturers may reformulate their beverages so that even those sweetened by sugar contain less of it.[222] Taxes are more likely to be successful at modifying consumption if they are large and cover a wide range of potential substitutes. A study simulating the impact of a large (20%) tax on SSBs and sugary fruit juices in Canada found such a tax would prevent 900,000 new cases of type 2 diabetes over the next 25 years.[223] The British Columbia soda tax that was implemented in April 2021 may be far less effective in its current state, as it taxes artificially-sweetened low calorie sodas while leaving many sugar-sweetened substitutes untaxed.[224,225]

While industry groups aggressively lobby governments against such taxes, according to a study by The King's Fund, in the United Kingdom these taxes are often more popular than assumed.[226] A survey by The Heart and Stroke Foundation found that 79% of British Columbians support a tax on sugary beverages.[227] A common criticism is that these taxes may be regressive, but according to a Canadian study those who are socioeconomically disadvantaged actually benefit the most from these policies.[228] Many researchers believe we should apply the lessons learned from SSB taxes to more broadly tax unhealthy foods.[229] Because so much of the burden of chronic illness is borne by society at large, The

Oxford Health Alliance encourages governments to explore creative policy measures that will slow the growth of chronic illness.[230]

Other initiatives to decrease consumption of SSBs, such as improving the availability of drinking water and promoting healthier drink options in retail settings, have seen mixed results.[231]

Food security initiatives are widespread in BC and elsewhere. An extensive review by the BC Ministry of Health found strong evidence that building community capacity through community empowerment has successfully improved food systems in BC communities.[232] Another review noted mixed evidence, showing food insecurity was correlated with obesity in women and children but with lower weight in men.[233] A recent report from the University of Toronto suggests food insecurity is exclusively a problem of food affordability, and claims that there is no association between food skills and food insecurity.[234] This is supported by a recent study looking at over 34,000 children in Ontario that found there is no relationship between food insecurity and type 2 diabetes incidence when controlling for socioeconomic factors.[235] One study in the United States found that those that were food insecure benefited less from a lifestyle intervention, though it is unclear if the study included appropriate adjustment for other socioeconomic factors.[236] All evidence-based reviews in the space agree more evidence is needed to understand the clinical significance and impact of food security initiatives.

Other population-level nutrition interventions show promise but are still in the early stages of implementation. Food reformulation efforts have successfully decreased sodium in the food system and could potentially be leveraged to reduce sugar, especially when attached to industry profit motives.[237] Food labelling strategies and related educational supports require considerable research to identify opportunities. Menu labelling policies that require restaurants to display calorie information on menus and display boards appear to successfully decrease energy consumption among customers in some restaurants.[238] Experimental trials of a 5-colour ("traffic light") front-of-pack nutritional labelling system implemented across much of Europe have shown that the scores are associated with higher nutritional quality of purchases, but evidence that this has impacted population health in a measurable way was not yet found.[239] Other proposals to implement education at point-of-sale show promise in small studies but lack evidence from large scale implementations.[240,241] Many organizations are advocating for bans on junk food advertising targeted at children, though the success of these campaigns is mixed.[242, 243] The UK-based Institute for Public Policy Research recommends more extreme measures such as mandating plain packaging for unhealthy foods and banning fast-food restaurants in proximity to schools, though there is insufficient evidence to assess what impact these interventions would have on population health.[244] Some organizations are critical of efforts that target marketing, noting that these approaches fail to address the true socioeconomic causes of obesity and type 2 diabetes, and that demonization of sugar might result in harm to those who feel they can't reasonably avoid it.[245, 246]

The most recent changes to the Canada food guide appear to be generating considerable discussion and present many important research questions. Health Canada's approach to the reframing of the guide was disciplined and rigorous in the application of the scientific evidence, and the guide recommends a diet consisting mostly of plant-based whole foods. A recent meta-analysis that included over 300,000 participants shows this new guide is a step in the right direction. It concluded that type 2 diabetes prevalence is lower among those who adhere to plant-based diets and other studies have shown plant-

based diets to be beneficial in type 2 diabetes prevention.[247,248] Implementation at the provincial level is currently underway.

Many cities and towns have modified community planning practices or implemented other policies to encourage active transport and physical activity. For instance, a recent analysis from the University of British Columbia (UBC) found those living in more walkable neighbourhoods were 17% more likely to meet the weekly recommended level of physical activity, 42% less likely to be obese and 39% less likely to have diabetes.[249] The study also found diabetes rates were 75% lower for those who live near six or more parks than those who live near zero or one park.[250] It should be noted however that this analysis provides correlative rather than causal evidence, and that overall the data in this area suffers from a lack of randomized trials.[251] Still, a number of programs to improve the built environment, such as modifying cities to make active transport safer, have demonstrated some success in increasing physical activity in populations.[252,253,254,255,256] Policies that specifically target health outcomes rather than policies with less targeted outcomes (e.g. planning for more green space) appear more likely to successfully change behaviour. One review found the construction of bike trails to be the most cost-effective population-level physical activity intervention.

A recent systematic review of interventions to improve physical activity concluded that there is no single best way to encourage physical activity.[257] However there is growing evidence that programs promoting the use of pedometers – devices that measure steps taken - encourage people to be more active.[258] The BC government-sponsored Carrot health app was a good local example. The app used participants' phones as pedometers. An evaluation of the program found those using it walked on average 116 more steps/day, with a larger effect for those that were least active at baseline. While some claim that even a small increase in physical activity at the population level will result in better population health outcomes, a trial specifically looking at increased step count and type 2 diabetes found participants needed to increase their step counts by at least 4000 steps per day to see any measurable positive impact.[259] Recent guidelines published by the Canadian Society for Exercise Physiology recommend focusing on a 24-hour movement paradigm in which people are encouraged to move more in all aspects of their lives, rather than simply focusing on specific recommendations for vigorous exercise.[260]

Using online platforms and applications like Carrot to encourage behaviour change is becoming more popular. A 2019 systematic review of 22 studies with over 1800 total participants looked at the ability of publicly available health apps to influence weight loss in people with chronic disease. The review found that the use of these apps resulted in an average weight-loss of 2.5kg.[261] Another analysis found social support through social media to be a useful tool in multifactorial weight loss interventions, and limited emerging evidence shows Facebook groups can be effective tools in type 2 diabetes education.[262, 263] A recent high-quality trial of a rigorously designed web-based self-management program for type 2 diabetes showed improvements in diabetes-related biomarkers and decreased healthcare costs for those using the program.[264] Another recent analysis of a web-based dietary self-management program based on Diabetes Canada's Glycemic Index guidelines showed that those using the tool reported a reduction in daily glycemic intake.[265]

Other virtual care technologies have the potential to scale traditional one-to-one approaches to the population level. For instance, the use of artificially intelligent virtual assistants to support type 2

diabetes self-care is being explored. Researchers believe using virtual assistants will be especially effective for stigmatized conditions like type 2 diabetes as they remove the element of shame from the interaction. [266] A recent report highlighted the fact that only through embracing innovation do we have any hope of meaningfully curbing the type 2 diabetes epidemic.[267]

Mass media campaigns to change health behaviour have shown mixed results.[268] There is some evidence that campaigns have a short-term effect which decays over time after campaigns have ended.

A recent systematic review of all population-level nutrition and physical activity interventions concluded that, while there is some evidence that these interventions can improve diet or increase physical activity, there is not yet any evidence that they can influence behaviour to the extent required to have a significant impact on overall obesity/overweight in the population.[269]

Programs and Organizations

Throughout the process of the scan, several programs and organizations providing different approaches to diabetes prevention, management and research were identified. This section provides a bulleted list and short description of some of the cross-sector organizations responsible for this work, with a focus on organizations active in BC. This is not a comprehensive list and it is likely that much more work is happening at the community level, as demonstrated by our Kelowna Community Profile (Appendix 2).

Organizations and programs in each section are listed in alphabetical order.

Prevention

- The BC Alliance for Healthy Living Society is an advocacy group that looks to hold the government responsible for promoting wellness and preventing chronic disease.[270]
- The BC Food Security Gateway provides information and resources related to food security initiatives.[271]
- The BC Healthy Communities Society's PlanH facilitates local government learning, partnership development and planning for healthier communities.[272]
- The BC Healthy Built Environment Alliance supports the creation of BC communities that promote health.[273]
- The Better Program establishes a new role in primary care, the "Prevention Practitioner", responsible for screening and chronic disease prevention.[274]
- Cities Changing Diabetes, an initiative that includes the City of Vancouver, is a partnership that challenges cities to hold the rise of diabetes prevalence at 10.0% globally.[275]
- Food Skills for Families is a hands-on curriculum focusing on healthy eating, grocery shopping and cooking.[276]
- Healthy Families BC runs programs that encourage individuals and families to make healthier choices.[277]
- The Pan-Canadian Public Health Network Partners in Public Health is a national network of individuals from many levels of government looking to strengthen public health.[278]
- SCOPE is a BC Children's Hospital program that helps communities implement initiatives that make healthy choices easier for children and their families.[279]
- Shapedown BC is a BC Children's Hospital program to help children manage weight.[280]

- The South Asian Health Institute at Fraser Health empowers the community to make healthy choices.[281]
- The University of British Columbia School of Medicine is offering a Graduate Certificate in Primary Health Care to prepare health care professionals for the transformation to interprofessional team-based primary care.[282]
- The Wellness Garage is a lifestyle medicine clinic based on White Rock that offers both virtual and in-person lifestyle programs.[283]

Management

- The Abbotsford Division of Family Practice has developed a team-based care calculator that calculates the multidisciplinary resource needs to care for those with diabetes.[284]
- Aroga is an internist-led clinic in Victoria that provides an 8-week chronic disease reversal program.[285]
- The British Columbia Alliance on Telehealth Policy and Research provides evidence and capacity building for sustainable telehealth services.[286]
- CHANGE BC is the Pacific Northwest Division of Family Practice's year-long physician-led lifestyle change program.[287]
- Child Health BC provides care for children diagnosed with diabetes in the community and school settings.[288]
- Diabetes Canada engages in advocacy, policy and research to help those with diabetes live healthier lives and to push for a cure to diabetes. They now offer a nationwide diabetes prevention program. They also provide a community resource manual for those with diabetes.[289,290,291]
- Diabetes clinics across the province, provided by most health authorities, help individuals manage diabetes through clinical and education programs.[292,293,294,295,296]
- Eat; Different RD provides resources and coaching for low carbohydrate diets.[297]
- ECHO is an online platform for peer-to-peer teaching and sharing. It includes a program for diabetes, providing CME credits.[298]
- Health Link BC is a 24-hour non-emergent health line that includes diabetes resources.[299]
- The Institute for Personalized Therapeutic Nutrition is a multidisciplinary alliance promoting a "food first" culture for treating chronic disease.[300]
- The InterCultural Online Health Network (iCON) provides culturally-tailored chronic disease resources, webinars and forums.[301]
- The Kwakiutl District Council has a community-based diabetes program that aims to increase healthy eating and improve diabetes self-management.[302]
- McMaster University's Aging, Community and Health Research Unit (ACHRU) has a large grant to search for ways to support older adults living with diabetes together with other chronic diseases[303]
- The Medical Weight Management program assesses and treats those with obesity through intensive group therapy.[304]
- The Mobile Diabetes Telemedicine Clinics for First Nations program provides clinical tests as well as lifestyle coaching in BC First Nations communities.[305]
- Self-Management BC is a University of Victoria initiative offering programs to promote self-management of chronic disease across BC, including in-person and telephone-based support.[306]

- Surrey-North Delta Division of Family Practice provides diabetes management programs that include culturally appropriate interventions.[307]
- Westcoast Nutrition provides resources and coaching for low carbohydrate diets.[308]

Research

- The BC Chronic Disease Dashboard provides the most up-to-date chronic disease surveillance data, including geographical breakdown.[309]
- The BC Diabetes Research Network is a group of researchers across BC universities focused on diabetes.[310]
- The Canadian Institutes of Health Research are funding collaborative research project teams focused on tackling diabetes.
- The Community Health Research Team (CoHeaRT) at SFU studies the population determinants of health for obesity and other chronic diseases.[311]
- Diabetes Action Canada conducts Patient Oriented Research focused on complications of diabetes.[312]
- Diabetes BC is a clinic in Vancouver that conducts several type 2 diabetes clinical trials as well as provides clinical management services.[313]
- LIVWELL is a group of researchers at SFU working towards living well with chronic disease.[314]
- The Institute of Nutrition, Metabolism and Diabetes at the Canadian Institutes of Health Research supports research related to primary causes, prevention, screening, treatment and support systems for illnesses including diabetes.[315]
- The Michael Smith Foundation for Health Research funds approximately $12 million in yearly grants for health research.[316]
- The South Asian Health Research Hub designs and implements health promotion programs, including a number of diabetes programs/studies.

DISCUSSION

The objectives of this scan were to identify practices, policies, guidelines and research occurring in the area of type 2 diabetes and to highlight areas that may have promise to change the trend of increasing prevalence rates. To this end, this scan has identified a number of promising practices and recommendations that should be pursued in an effort to reverse the trend in type 2 diabetes:

1. This review identified clinical management strategies that indicate remission is possible and that type 2 diabetes must be reframed as a preventable condition that can be put into remission. More specifically, there is strong evidence that bariatric surgery and therapeutic nutrition can result in type 2 diabetes remission in individuals. Research to establish the sustainability and scalability of these approaches is urgently needed and should be prioritized.
2. Many diabetes prevention and management programs delivered in Canadian communities failed to conduct long-term follow-up with participants or publish evaluations subjected to peer review. As a result, it is impossible to know how these programs impacted diabetes incidence or prevalence. Any future programmatic funding should mandate rigorous evaluation, developed and implemented in partnership with research institutions, with the specific goal of publishing

peer-reviewed outcomes and scale-up simulations to determine the likely impact of the interventions if they were to be delivered at the population level.

3. Given the importance of the social determinants of health in type 2 diabetes prevalence and incidence, and the burden of type 2 diabetes on individuals and society, governments and institutions should explore policies that aim to reduce poverty and increase education with the explicit goal of preventing type 2 diabetes.
4. Taxes on high-calorie or high-sugar products and food reformulation initiatives to remove sugar from the food system are effective tools to change people's diets. The provincial government's expansion of the Provincial Sales Tax to cover sodas is a good start, but a larger and broader tax will likely be needed if they wish to measurably decrease population-wide type 2 diabetes prevalence.
5. Interventions that encourage weight loss by promoting increased physical activity and healthy diets are known to benefit overall health. This is not surprising, as studies show BMI is the single most important health indicator.[317] While their direct impact on type 2 diabetes rates remains unclear, programs in this area should continue to be pursued.
6. Important changes to the Canada Food guide have been recently published by Health Canada. The impact of these changes should be closely monitored, and implementation of the guide should continue to consider emerging evidence.
7. The COVID-19 pandemic has resulted in the rapid expansion of virtual care in Canada. Evidence shows that virtual care is at least as effective as traditional care for prevention and management of type 2 diabetes, while often being much more cost-effective. This expansion of virtual care is therefore a change to the system that should be promoted and leveraged moving forward.
8. There are pilot programs operating in BC at the primary care level using a team-based, multidisciplinary approach that is personalized for the individual and focused on nutrition and lifestyle changes. Early results from these programs show success in preventing and treating type 2 diabetes, often resulting in complete remission.[318] These programs should be supported, funded and spread across the system, as research shows that health care providers committed to lifestyle intervention can drive participation and engagement.

APPENDICES

Appendix 1: Strategic overview of diabetes system at provincial and federal level

Province	Strategic Overview
BC	• BC has no active provincial diabetes strategy or plan • BC Diabetes Care Guidelines (2015) provide clinical care standards. The standards emphasize patient-centred care, and encourage a systematic approach beginning with lifestyle management. • BC's Guiding Framework on Public Health (2013) articulates a long-term vision for public health, including objectives related to health education in schools, healthy built environments and workplace health. A number of outcome measure are related to healthy living and physical activity, and one of the six overarching performance measures is a decrease in obesity incidence.
Alberta	• Alberta had a diabetes strategy from 2003-2013 that focused almost exclusively on prevention. They do not appear to have a current strategy. • Alberta Health Services (AHS) has a Strategic Clinical Network for diabetes, obesity and nutrition. The network is focused on clinical-care innovation through connecting of clinicians and patient advisors.
Saskatchewan	• Saskatchewan has a provincial diabetes plan that was released in 2004 but reaffirmed by the government in 2019. • The plan focuses on four components: Primary prevention of type 2 diabetes; Optimum care through self-management, education and treatment; Education for care providers; Diabetes surveillance. • Diabetes Canada is running a large public awareness and donation drive in 2019 with over 4000 volunteers.
Manitoba	• The most recent diabetes strategy available online is from 1998 • Most of the diabetes activity in Manitoba appears related to Diabetes Canada • The Winnipeg Regional Health Authority offers an extensive education program for children and adolescents with diabetes • University of Manitoba runs a large research group called Diabetes Research Envisioned & Accomplished in Manitoba (DREAM)
Ontario	• The most recent Ontario Diabetes Strategy was published in 2009, with updates as recently as 2012. Priorities included greater access to primary care, testing within guidelines and more how dialysis, supplies and bariatric surgeries. Updated priorities included more focus on prevention initiatives and patient-centred care, including establishment of diabetes regional coordinating centres in each of the 14 health regions. • Ontario has six Centres for Complex Diabetes Care, which provide specialized care to patients including education, monitoring for continuous care improvement, and training for health providers. • Other initiatives and programs include a pediatric initiative for type 1 diabetes, a diabetes complications prevention strategy and an aboriginal diabetes initiative.
Quebec	• No provincial strategies or plans were identified • The Cardiometabolic health, Diabetes and Obesity Research Network, as part of Fonds de recherche Sante Quebec, is a large granting and research organization doing substantial work in the space.

Province	Strategic Overview
New Brunswick	• A Comprehensive Diabetes Strategy for New Brunswickers 2011-2015 provides a vision for diabetes care and prevention in the province. Priorities include capacity building, prevention, detection and management. The plan does not appear to have been renewed.
Newfoundland	• Newfoundland does not have an active or recent diabetes strategy or plan. The most recent strategy was published in 2006, which promoted more provincial coordination in diabetes prevention, screening, management and treatment of complications. • The 2017-2918 Chronic Disease action plan includes specific mention of diabetes in many priorities, including education for providers, remote patient monitoring, case management, wound care and surveillance. They also prioritized the development of a diabetes flow sheet to standardize care (could not find online), and certification in insulin dose adjustment.
PEI	• PEI Diabetes Strategy 2014-2017 focuses on: Prevention through public awareness and personal health management, especially for high-risk populations; Detection through screening according to guidelines; Management through primary care, home care and hospital care innovations. • They are in the process of renewing the strategy, the new strategy is not yet published. • The Provincial Diabetes Program provides education, counselling and personal assessments.
Nova Scotia	• The Nova Scotia Health Authority Diabetes Care Program Strategic Plan (2014-2019) was developed through extensive consultation and provides a vision for diabetes care. It focuses on four strategic directions: Create and share knowledge through collaboration; Lead the development of an integrated system of diabetes management to reduce/delay diabetes development and progression; Use data to set targets; Work collaboratively with other departments and organizations. • They have 38 diabetes centres across the province that provide providers and patients access to multidisciplinary diabetes teams, help coordinate care with other disciplines, promote linkages to community services and provide specialized management.
Federal	• A commitment to develop a national diabetes framework. • As of October 2021, $35 million committed to diabetes innovation and research • The government spent $115 million between 1999 and 2005 to develop a national diabetes framework, largely focused on surveillance and self-management. They implemented a number of community-based programs which were not rigorously evaluated.

Appendix 2: Kelowna diabetes prevention and management community profile

The following Kelowna community profile was developed as an example to illustrate the scope, scale and involvement of organizations in diabetes prevention and management at the community level.

Organization	Program	Details
Interior Health	Diabetes Clinic	• Clinic that offers a diabetes education program as well as clinical care when appropriate. • They have a physician in the office once per week to deal with medication and complex cases. Generally requires a referral.
Interior Health	Diabetes Education Program	• Education and clinical support to manage diabetes and reduce risk of complications through the Interior Health's Diabetes Clinic. • Programs include: Getting Started Classes, Individual Assessments, Staying on Track, Refresher Class, Pre-Diabetes Class, Gestational Diabetes classes and counselling • They refer children to the Small Steps for Big Changes program. • Offered at 3 locations, both appointments and drop in. • Multi-day group class delivered in three parts. First two classes are one week apart, and the final class is a month later. Follow-up 1:1 counselling is then available if needed. Classes are delivered by a diabetes nurse and a dietician. • Must be diagnosed with diabetes or have pre-diabetes elevated blood sugar levels. • Classes are free with MSP. • They encourage drop-in or participants but also accept referrals. • https://kelowna.cioc.ca/record/KNA1095
UBCOK	Diabetes Prevention Research Group	• Run a number of programs in the community, the most notable being Small Steps for Big Changes. http://dprg.ok.ubc.ca/
Canadian Diabetes Association	None	• Canadian Diabetes Association only does donation pickups in Kelowna. They referred to the diabetes clinic.
Kelowna YMCA and UBCOK	Small Steps for Big Changes	• Free program offered monthly at the Kelowna Downtown YMCA and the Kelowna Family YMCA. • The program is an evidence-based lifestyle modification course that uses motivational interviewing techniques. Participants are paired 1:1 with a trained coach and complete 6 sessions of exercise and dietary change counselling over 3 weeks.

Organization	Program	Details
		• Post-program there is a 1-, 6-, and 12-month follow-up. • Track diet and exercise with a health app and fitness watch provided by the program. • Includes 2 types of exercise: 1) Continuous exercise at a steady pace for 20-30 minutes and, 2) Interval exercise that involves alternating between a brief bout of higher-intensity activity followed by a bout of lower-intensity activity for 12-15 minutes. • Recruitment is open to those who are between the age of 18-70, have a BMI between 22-45 kg/m^2, and confirmed in the pre-diabetic range. Individuals can confirm their eligibility by: 1) Speaking with their doctor and complete a blood test to determine their A1c score and/or, 2) contact Small Steps for Big Changes directly at (250-807-8419) or (small.steps@ubc.ca) to complete a risk assessment test and eligibility screening. • Currently in the study phase. They are hoping to demonstrate program effectiveness at the community-level and implement it as a permanent program. • http://ok-smallsteps.sites.olt.ubc.ca/
Self-Management BC, UVic, YMCA	Diabetes Self-Management Program Workshop	• The Diabetes Self-Management Program Workshop hosts weekly sessions over six weeks. • It is delivered in group sessions of 10-16 people. • It is hosted out of downtown YMCA. They run sessions a few times per year. • For people diagnosed with type 2 diabetes • Program guide here.
The Bridge Youth and Family Services	Healthy Together	• Children's Health Program looking to promote achievement and maintenance of healthy weights, particularly for under-served populations including aboriginal, minority and rural groups. • The program is funded through PHAC's education strategy. • Uses prevention, family education and group learning to promote prevention, healthy nutrition, physical activity and support. • The program provides a toolkit and facilitator training. The program is available at over a dozen sites across BC, and many more across Canada. • While their head office is in Kelowna they do not have the program running there. They are hoping

Organization	Program	Details
		to run a session fall 2019.
Pearson Elementary School	Family Hub	• Family hub suggested the hardest thing in the community is finding a family doctor to manage type 2 diabetes. They recommended filling out the application on the Division of Family Practice website http://www.divisionsbc.ca/central-okanagan • They also recommended contacting the YMCA and the Diabetes Education Clinic.
Private insurers	Prevention and management programs	• Many private insurers in BC offer lifestyle management programs as part of their insurance bundles. Some employers also offer fitness or diet reimbursement programs.
Private organizations	Prevention and management programs	• As with elsewhere in the province, those living in Kelowna have access to an array of private for-pay weight loss solutions including gyms and diet programs.

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