2011

Diabetes *in* Canada

Facts and figures from a public health perspective

Public Health Agency of Canada
Agence de la santé publique du Canada

Canada

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— Public Health Agency of Canada

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A few words from the Chief Public Health Officer

Over 2 million Canadians are living with diabetes, joining over 285 million people worldwide who share this burden. The 2011 report, *Diabetes in Canada: Facts and figures from a public health perspective*, provides a comprehensive look at the data that describe diabetes in Canada. As you consider the information in this report, I encourage you to think of the broader context of diabetes trends. For example, there has been a substantial increase in obesity rates in Canada, which, as a key risk factor for developing type 2 diabetes, has major consequences for the future health of Canadians.

The impacts of type 1 and type 2 diabetes go far beyond the management of the disease itself. Complications associated with diabetes may lead to disability or lower quality of life. This, together with the increased risk of developing other serious chronic diseases, puts incredible pressure on people who have diabetes and their families. Children and youth diagnosed with diabetes must manage the disease and its risks over their entire lives. Fortunately, continual developments in treatments for diabetes are giving individuals better ways to control their disease.

This is the first comprehensive report on diabetes published by the Public Health Agency of Canada. The 2011 *Diabetes in Canada: Facts and figures from a public health perspective* is a resource to support public health professionals and organizations in the development of effective, evidence-based public health policies and programs for the prevention and management of diabetes and its complications. It provides important information to increase knowledge and understanding of diabetes in Canada.

I would like to take this opportunity to thank the organizations and individuals who have dedicated their time and expertise to collaborate on this report. These include the Canadian Diabetes Association, Juvenile Diabetes Research Foundation, CNIB (previously known as the Canadian National Institute for the Blind), and collaborators from Canadian universities and provincial and territorial programs. The Public Health Agency of Canada is pleased to work with these organizations in our shared commitment to improve the health of Canadians.

Dr. David Butler-Jones
Chief Public Health Officer
Public Health Agency of Canada

Report highlights

This report presents the most recent statistics on the burden and impact of type 1 and type 2 diabetes mellitus ("diabetes") in Canada. It outlines complications attributable to the disease, ways of reducing the risks, and provides some estimates of the economic burden of diabetes. Finally, the report provides information on diabetes among children and youth, as well as among First Nations, Inuit and Métis populations.

The quality of surveillance information on diabetes in Canada has increased substantially over the last decade. The Canadian Chronic Disease Surveillance System uses population-based administrative data from every province and territory to provide detailed, comparative information for assessing the burden, as well as the use of health services and certain health outcomes of chronic diseases, including diabetes. Population surveys provide additional data on diabetes, its risk factors, complications and impacts on the lives of affected Canadians. The combination of these complementary data sources provides information to the Public Health Agency of Canada's diabetes surveillance program.

Chapter 1 – The burden of diabetes in Canada

- In 2008/09, almost 2.4 million Canadians (6.8%) were living with diabetes.
- According to data obtained from blood samples, about 20% of diabetes cases remain undiagnosed.
- While the prevalence increased with age, more than 50% of Canadians diagnosed with diabetes (1.2 million) were of working age, between 25 and 64 years of age.
- The overall prevalence was higher among males (7.2%) than females (6.4%).
- Newfoundland and Labrador, Nova Scotia, and Ontario had the highest age-standardized prevalence rates of diagnosed diabetes in Canada; Nunavut, Alberta, and Quebec had the lowest.
- From 1998/99 to 2008/09, the prevalence of diagnosed diabetes among Canadians increased by 70%. The greatest relative increase in prevalence was seen in the 35 to 39 and 40 to 44 year age groups, where the proportion doubled. Likely, this increase in younger age groups is, in part, a consequence of increasing rates of overweight and obesity.
- In 2008/09, more than 200,000 Canadians were newly diagnosed with diabetes (6.3 cases per 1,000 individuals).
- Just under half of new cases of diabetes were diagnosed in individuals aged 45 to 64 years old. Survey data indicate that in this age group, 47.5% of individuals with diabetes were obese compared to 19.1% of individuals without diabetes, implying that obesity was a major contributor to diabetes in this age group.
- The overall incidence of diabetes during an 11 year period (from 1998/99 to 2008/09) has been slightly increasing, particularly among children aged one to 19 years and among working-age adults aged 30 to 49 years. This increase was seen mainly in Ontario, British Columbia, Saskatchewan, and the Northwest Territories.
- If incidence and mortality rates continue at levels seen in 2008/09 data, estimates suggest that the number of Canadians living with diabetes will reach 3.7 million by 2018/19.

Chapter 2 – The health impact of diabetes on Canadians

- Individuals with diabetes are over three times more likely to be hospitalized with cardiovascular disease than individuals without diabetes, 12 times more likely to be hospitalized with end-stage renal disease, and almost 20 times more likely to be hospitalized with non-traumatic lower limb amputations.
- Diabetes was the primary cause of 34% of new cases of end-stage renal disease in 2009, creating a growing demand for renal replacement therapy (dialysis or transplant) in Canada.
- Because diabetes shares several risk factors with other chronic diseases, 36.5% of Canadian adults with diabetes reported having two or more other serious chronic conditions (hypertension, heart disease, chronic obstructive pulmonary disease, mood disorder, and/or arthritis) in addition to diabetes, and 12.5% reported having three or more.
- Nearly 40% of Canadian adults who reported having diabetes rated their health as “fair” or “poor”, compared to a tenth of the adult population without diabetes (10.3%).
- Although only 3.1% of all deaths in Canada were attributed to diabetes in 2007, more than a quarter (29.9%) of individuals who died had diabetes in 2008/09. Diabetes itself does not typically lead directly to death, but the complications associated with diabetes do.
- At every age group, individuals with diabetes experienced mortality rates at least two times higher than those without. This results in noticeable decreases in life expectancy as well as health-adjusted life expectancy.
- Based on available data, it is calculated that more than one in ten deaths in Canadian adults could be prevented if diabetes rates were reduced to zero.

Chapter 3 – The health system and economic impact of diabetes

- In 2008/09, adults aged 20 to 49 years with diabetes saw a family physician twice as often as those without diabetes, and specialists two to three times more often.
- Individuals with diabetes were three times more likely to have been hospitalized at least once during the year than those without diabetes, and had a longer hospital stay.
- Annual per capita health care costs have been estimated to be three to four times greater in a population with diabetes compared to a population without the disease.
- The most recent cost estimates available for this report are outdated by 11 years, which is a major information gap. Therefore, it is difficult to assess the real economic burden of diabetes. However, it is expected that costs will only continue to rise with the increasing prevalence of diabetes and its associated health care costs.

Chapter 4 – Reducing the risk of type 2 diabetes and its complications

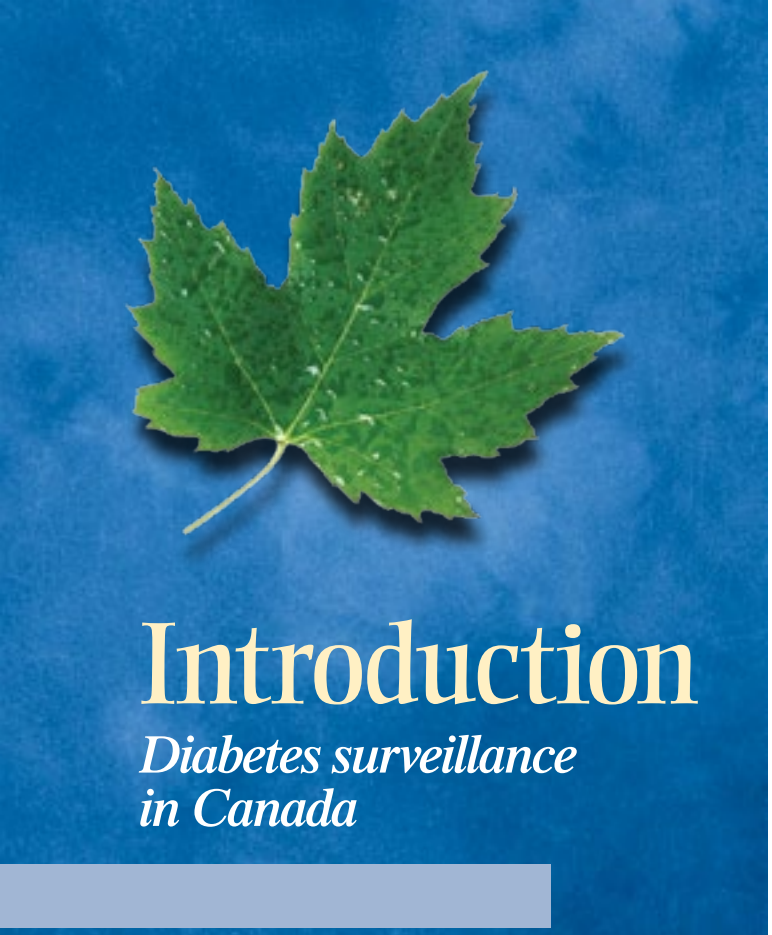
- Social, economic, environmental, genetic and lifestyle factors have a significant effect on the distribution of type 2 diabetes and its risk factors in the Canadian population.
- The causes of type 2 diabetes are complex and its development cannot be explained by any single risk factor. Advancing age, obesity, physical inactivity, certain ethnicities, and a family history of diabetes (or gestational diabetes in women) are all important risk factors.
- Adults who are obese are two to four times more likely to have type 2 diabetes. In 2007–2009, 23.9% of adults aged 18 years and older were obese according to measured weight and height.
- Physical activity is important for both diabetes prevention and management. In 2009–2010, almost half (47.4%) of Canadians aged 12 years and older reported that they were physically inactive (leisure and transportation index).
- In 2009–2010, more than half of Canadians aged 12 years and older (55.9%) reported eating less than five servings of vegetables and fruit a day. Inadequate consumption of vegetables and fruit is used as a proxy measure of unhealthy diet, which is a risk factor for type 2 diabetes, largely through its effects on body weight.
- Smoking has also been associated with an increased risk of type 2 diabetes and its complications. Rates of tobacco smoking have been declining in Canada over the last several years, from 17.9% in 2003 to 15.5% in 2010.
- Socio-demographic factors, including lower socioeconomic status, belonging to certain ethnic groups, and living in rural areas are associated with higher rates of type 2 diabetes, more prevalent risk factors for type 2 diabetes, and higher levels of morbidity and mortality.
- The risk factors for type 1 diabetes are still not well understood but studies have shown that genetic predisposition is necessary but not sufficient for the development of type 1 diabetes. Environmental factors that trigger the auto-immune response are also implicated.

Chapter 5 – Diabetes in children and youth

- Diabetes is one of the most common chronic diseases among children and youth.
- Type 1 diabetes remains the main form of the disease in this population, but type 2 diabetes, historically viewed as an adult disease, has been on the rise globally in children and youth for the last two decades.
- An increase in type 1 diabetes has also been documented in different countries, but the reasons are not completely elucidated. In Canada, the rate of type 1 diabetes among one to nine year olds (in whom type 2 diabetes is very rare) has also increased, from 0.1% (or 3,726 cases) in 1998/99 to 0.2% (or 5,201 cases) in 2008/09.
- In 2008/09, more than 3,000 new cases of diabetes (type 1 and type 2) were reported among Canadian children and youth aged one to 19 years, bringing the number of prevalent cases to just under 26,000.
- For both types, the early onset of the disease increases the risk of related complications and lifelong consequences.
- Children and youth with type 1 diabetes are at a greater risk of life-threatening complications because they rely on daily doses of insulin.
- Adolescence can be a particularly difficult time for management of glycemic levels as teenagers take on this responsibility at the same time as hormonal changes affect glycemic levels and impact insulin requirements.

Chapter 6 – Diabetes among First Nations, Inuit, and Métis populations

- The Aboriginal population in Canada is a diverse group composed of individuals of First Nations, Inuit and Métis heritage. Diabetes prevalence varies between and within each group according to its unique characteristics.
- It is important to account for the younger age structure in the First Nations, Inuit and Métis populations when comparing the prevalence of diabetes to that of the non-Aboriginal population. Age-standardized rates show the prevalence of diabetes was 17.2% among First Nations individuals living on-reserve, 10.3% among First Nations individuals living off-reserve, and 7.3% among Métis, compared to 5.0% in the non-Aboriginal population. The age-standardized prevalence rate of diabetes in Inuit populations was comparable to the one seen in the general Canadian population.
- Aboriginal individuals are generally diagnosed at a younger age than non-Aboriginal individuals, and Aboriginal females experience higher rates of gestational diabetes than non-Aboriginal females. Complications of diabetes are also more frequently seen among the Aboriginal population than in the non-Aboriginal population.
- The socio-cultural, biological, environmental and lifestyle changes seen in the First Nations, Inuit and Métis populations in the last half century have contributed significantly to increased rates of diabetes and its complications.



Introduction

Diabetes surveillance in Canada

This report – *Diabetes in Canada: Facts and figures from a public health perspective* – provides a comprehensive look at diabetes and its impact on the Canadian population. The data presented are intended for health professionals, non-government organizations (NGOs), policy makers, academics, and other interested readers.

Defining diabetes

Impact on human physiology

Diabetes is a chronic disease that occurs when the body is either unable to sufficiently produce or properly use insulin. Insulin, a hormone secreted by beta cells in the pancreas, enables the cells of the body to absorb sugar from the bloodstream and use it as an energy source. If left uncontrolled, diabetes results in consistently high blood sugar levels, a condition known as hyperglycemia. Over time, hyperglycemia can damage blood vessels, nerves, and organs such as the kidneys, eyes and heart, resulting in serious complications and, ultimately, death. Hypertension and hyperlipidemia, which often accompany diabetes and accelerate damage to blood vessels, are also important targets for control.

Types of diabetes

Diabetes occurs in several forms; type 1, type 2 and gestational are the most common (Box I-1). Although all types of diabetes are characterized by the body's inability to maintain appropriate glycemic levels, they may differ in their causes, treatments and complications. It is estimated that 90% to 95% of Canadians with diabetes have type 2 diabetes, while 5% to 10% have type 1 diabetes. Gestational diabetes, which develops during pregnancy and typically disappears afterwards, has been detected in approximately 3% to 5% of all pregnancies that resulted in a live birth.[1;2] Pre-diabetes describes a condition that indicates increased risk of type 2 diabetes. Not all individuals with pre-diabetes will develop diabetes, but the chances increase if steps are not taken to manage it. Fortunately, recent studies have shown that changes in lifestyle (primarily diet, physical activity and weight management) can delay or halt the progression from pre-diabetes to diabetes.[3-5]

Box I-1. Main forms of diabetes

- **Type 1 diabetes**, once known as "juvenile diabetes" or also referred to as "insulin-dependent diabetes mellitus", is an autoimmune disease in which the body's immune system attacks and destroys the insulin-producing cells of the pancreas, thereby leaving the individual dependent on an external source of insulin for life. Type 1 diabetes typically arises in people under the age of 40, most often in children and youth.

- **Type 2 diabetes**, also referred to as "non-insulin-dependent diabetes mellitus", is a metabolic disorder that occurs when the pancreas does not produce enough insulin and when the body does not properly use the insulin it makes. The risk of type 2 diabetes is higher among people who are overweight or obese, physically inactive and of certain ethnic populations. While the onset of type 2 diabetes typically occurs in adults over the age of 40, it can occur at younger ages, and is seen even in children and youth.

- **Gestational diabetes** occurs when hyperglycemia develops during pregnancy. Although elevated glycemic levels typically disappear following delivery, females diagnosed with gestational diabetes are at increased risk of developing type 2 diabetes within five to ten years.

- **Other types of diabetes** are uncommon. They include those associated with genetic defects, other diseases, infections and specific medications that affect the body's ability to produce or respond to insulin, resulting in hyperglycemia.

Diagnosing diabetes

Measurements of glycemic levels (Box I-2) are used to determine if an individual has, or is at risk of, diabetes. The criteria used to diagnose diabetes are defined in the Canadian Diabetes Association clinical practice guidelines. Individuals with glycemic levels that are higher than normal, but not yet high enough to meet the criteria for a diabetes diagnosis, are often diagnosed with pre-diabetes, characterized by impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT).

Diagnosing type 1 diabetes can be done by testing for markers of the autoimmune destruction of insulin-producing cells of the pancreas. These markers include islet cell antibodies, insulin autoantibodies, glutamic acid decarboxylase antibodies, and antibodies against tyrosine phosphatase.[6] The onset of type 1 diabetes is often quite rapid, while typically there is a gradual increase of hyperglycemia in type 2 diabetes. In this case, it can take years before glycemic levels are sufficiently high to present symptoms leading to a diagnosis of type 2 diabetes.[7] Consequently, many individuals who have type 2 diabetes spend a significant period of time unaware that they have the disease.[8;9] Because of this, complications of diabetes often begin to develop before individuals are diagnosed. This highlights the importance of type 2 diabetes prevention and early detection.

Box I-2. Clinical criteria for the diagnosis of impaired fasting glucose, impaired glucose tolerance and diabetes

	Fasting† plasma glucose (mmol/L)		Two-hour plasma glucose in a 75g oral glucose tolerance test (mmol/L)		Casual‡ plasma glucose (mmol/L)
Impaired fasting glucose	6.1 – 6.9	and	<7.8		
Impaired glucose tolerance	<6.1	and	7.8 – 11.0		
Impaired fasting glucose and impaired glucose tolerance	6.1 – 6.9	and	7.8 – 11.0		
Diabetes	≥7.0	or	≥11.1	or	≥11.1; with symptoms of diabetes (polyuria, polydipsia, unexplained weight loss)

† Fasting based on no caloric intake for at least eight hours.
‡ Plasma glucose measured at any time of the day without regard to the interval since the last meal.
Source: Public Health Agency of Canada (2011); adapted from Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2008 clinical practice guidelines for the prevention and management of diabetes in Canada. *Can J Diabetes*.2008;32(Suppl 1):S1-S201.

The diabetes surveillance system

High-quality surveillance data on health status, risk factors, health determinants, and health service utilization are essential for the planning and evaluation of effective policies and programs. The availability of high-quality surveillance information on diabetes in Canada has increased substantially over the last decade. The Canadian Chronic Disease Surveillance System (CCDSS)[i] uses population-based administrative data from every province and territory to provide detailed, comparative information for assessing the scope, as well as the use of health services and health outcomes of chronic diseases, including diabetes. Data from population health surveys and vital statistics provide additional data on diabetes, its risk factors and complications. As this report uses multiple data sources, estimates may be reported for different periods of reference and age groups, and definitions may vary depending on the data source. Technical notes on these data sources (Box I-3) present these considerations.

i The CCDSS was formerly known as the National Diabetes Surveillance System (NDSS).

Box I-3. National data sources and limitations

Period of reference

- Specific conventions are used in this report to distinguish between different periods of reference. This format "200X/0Y" indicates a fiscal year running from April 1, 200X to March 31, 200Y. Data from the CCDSS are reported by fiscal year, on an annual basis.
- When the data collection spans over more than a year, the period of reference is reported as "200X–200Y". The Canadian Community Health Survey (CCHS) collects data annually, but merges samples from two consecutive years to increase the sample size. Similarly, the First Nations Regional Longitudinal Health Survey (RHS) collected data between 2008 and 2010, indicated as "2008–2010".

Age groups

- When possible, standard age groups and cut-offs are used in this report. At times, standardization is not possible depending on the data source. Moreover, depending on the indicator reported, it may be preferable to exclude some age groups or it may not be possible to report on certain age groups due to small sample size.

Confidence intervals

- The 95% confidence intervals presented with these data show an estimated range of values which are likely to include the true prevalence rate 19 times out of 20.

Year of data

- Although published in 2011, estimates in this report refer to various years of data. This may be impacted by the frequency of the data collection of each data source. Further, additional lag time is required by the organization responsible for the data to fully process and release data. Finally, the Public Health Agency of Canada takes time to ensure the quality and accuracy of data, conduct and interpret analyses, and release the final report.

Diabetes definitions

- In this report, "diabetes" refers to self-reported data or the disease in general. In the 2009–2010 CCHS, for example, the term "diabetes" indicates that an individual has self-reported a physician diagnosis of diabetes of either type 1 or type 2 by answering "yes" to the question: "Do you have diabetes?". To exclude cases of gestational diabetes, where respondents said that their diabetes was diagnosed during pregnancy ("Were you pregnant when you were first diagnosed with diabetes?") and that they did not have diabetes other than when pregnant ("Other than during pregnancy, has a health professional ever told you that you have diabetes?"), they were excluded from analyses.
- The term "diagnosed diabetes", which excludes individuals living with the disease but who have not yet received a diagnosis of diabetes by a health professional, is used when CCDSS data are reported. The CCDSS summarizes data on residents of Canada who have accessed the Canadian health care system. Diabetes is deemed diagnosed when there is, at minimum, one hospitalization or two physician claims with a diabetes specific code(s) over a two year period. The CCDSS case criterion excludes women with gestational diabetes, and it does not distinguish between type 1 and type 2 diabetes.
- In all cases, description of diabetes excludes cases of undiagnosed diabetes in the population.

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Chapter 1

The burden of diabetes in Canada

Introduction

Diabetes is a serious chronic disease that is on the rise in Canada. It poses a challenge not only to those living with the disease but also to their families, communities and the health care system.

Diabetes prevalence

Diabetes is one of the most common chronic diseases in Canada. In 2008/09, close to 2.4 million Canadians aged one year and older were living with diagnosed diabetes (either type 1 or type 2), according to the CCDSS (Table 1-1). This represented approximately 6.8% of the population, or 6.4% of all females aged one year and older and 7.2% of all males aged one year and older. When looking only at the adult population aged 20 and older, the prevalence rate was 8.7% (95% CI: 8.72–8.74%), representing one in 11 Canadians.

Table 1-1. Prevalence and number of cases of diagnosed diabetes among individuals aged one year and older, by age group and sex, Canada, 2008/09

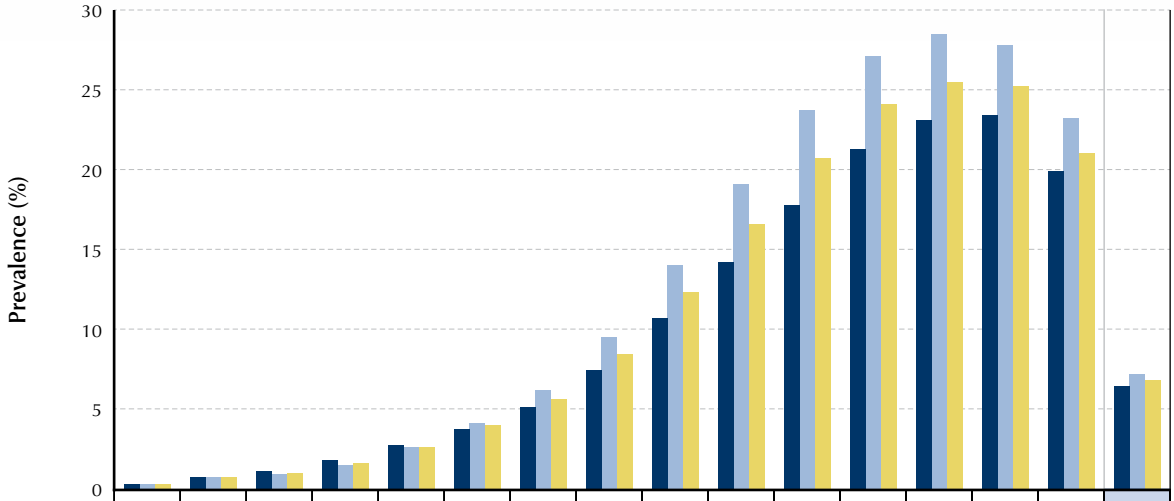
	Prevalence					
	Females		Males		Total	
Age group (years)	Cases	Rate† (%) (95% confidence interval)	Cases	Rate† (%) (95% confidence interval)	Cases	Rate† (%) (95% confidence interval)
1–9	2,366	0.1 (0.14–0.15)	2,835	0.2 (0.16–0.17)	5,201	0.2 (0.15–0.16)
10–19	9,845	0.5 (0.45–0.47)	10,647	0.5 (0.46–0.48)	20,492	0.5 (0.46–0.47)
20–24	8,077	0.7 (0.69–0.72)	7,784	0.7 (0.65–0.68)	15,861	0.7 (0.67–0.69)
25–29	13,194	1.1 (1.09–1.12)	10,590	0.9 (0.87–0.90)	23,784	1.0 (0.98–1.01)
30–34	21,383	1.8 (1.79–1.84)	17,153	1.5 (1.44–1.49)	38,536	1.6 (1.62–1.66)
35–39	33,387	2.7 (2.68–2.74)	31,825	2.6 (2.53–2.59)	65,212	2.6 (2.61–2.65)
40–44	50,355	3.7 (3.72–3.78)	56,421	4.1 (4.11–4.18)	106,776	4.0 (3.93–3.97)
45–49	73,793	5.1 (5.05–5.12)	90,613	6.2 (6.15–6.23)	164,406	5.6 (5.62–5.67)
50–54	97,780	7.4 (7.32–7.41)	125,704	9.5 (9.44–9.54)	223,484	8.4 (8.39–8.46)
55–59	120,871	10.7 (10.61–10.73)	156,389	14.0 (13.94–14.08)	277,260	12.3 (12.28–12.37)
60–64	135,780	14.2 (14.17–14.32)	177,741	19.1 (19.00–19.18)	313,521	16.6 (16.58–16.70)
65–69	127,453	17.8 (17.73–17.93)	161,118	23.7 (23.56–23.79)	288,571	20.7 (20.61–20.76)
70–74	123,319	21.3 (21.18–21.42)	141,631	27.1 (26.98–27.26)	264,950	24.1 (23.97–24.15)
75–79	118,150	23.1 (23.01–23.27)	120,144	28.5 (28.30–28.62)	238,294	25.5 (25.44–25.65)
80–84	96,407	23.4 (23.25–23.55)	78,643	27.8 (27.60–27.99)	175,050	25.2 (25.07–25.31)
≥85	88,266	19.9 (19.73–20.00)	49,588	23.2 (23.01–23.42)	137,854	21.0 (20.84–21.06)
Canada	1,120,426	6.4 (6.42–6.45)	1,238,826	7.2 (7.24–7.26)	2,359,252	6.8 (6.83–6.85)

† Any discrepancy between rate and confidence interval is due to rounding.
Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Prevalence by age

The proportion of people with diagnosed diabetes generally increases with age (Figure 1-1). The body's ability to produce and use insulin deteriorates as one ages, placing older adults at an elevated risk of developing type 2 diabetes. The sharpest increase in the prevalence of diabetes occurred after the age of 40 years. In 2008/09, the 75 to 79 year age group had the highest proportion of people with diagnosed diabetes (23.1% of females and 28.5% of males). Although diagnosed diabetes is more common in older age groups, more than 50% of the affected Canadian population (1.2 million) was of working age, between 25 and 64 years (Table 1-1).

Figure 1-1. Prevalence of diagnosed diabetes among individuals aged one year and older, by age group and sex, Canada, 2008/09



Age group (years)	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85	Canada
Females	0.3	0.7	1.1	1.8	2.7	3.7	5.1	7.4	10.7	14.2	17.8	21.3	23.1	23.4	19.9	**6.4**
Males	0.3	0.7	0.9	1.5	2.6	4.1	6.2	9.5	14.0	19.1	23.7	27.1	28.5	27.8	23.2	**7.2**
Total	0.3	0.7	1.0	1.6	2.6	4.0	5.6	8.4	12.3	16.6	20.7	24.1	25.5	25.2	21.0	**6.8**

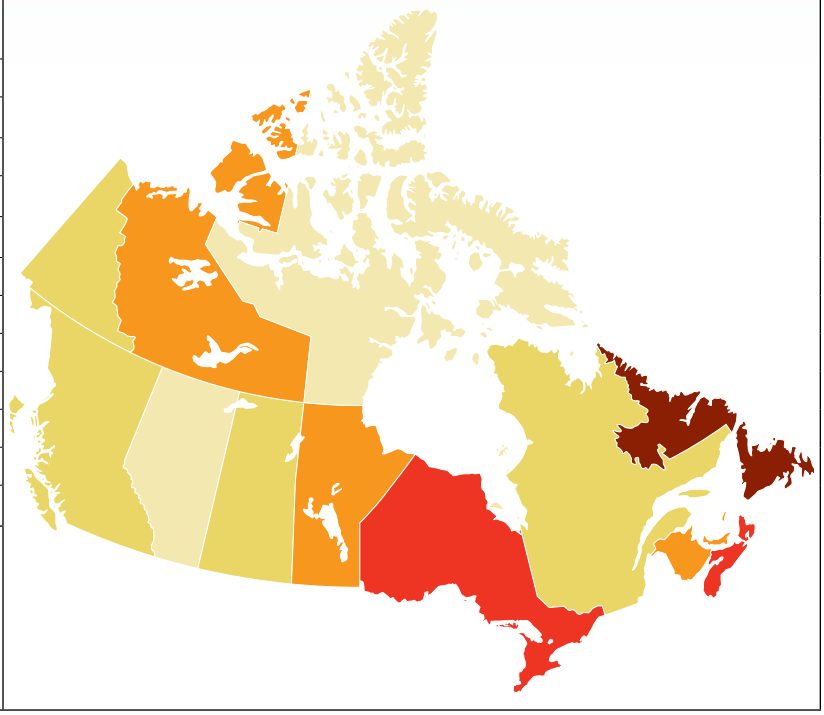
Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Prevalence by province/territory

The prevalence of diabetes varies across Canada. In 2008/09, after accounting for differences in age distribution among the provinces and territories, Newfoundland and Labrador, Nova Scotia, and Ontario had the highest prevalence of diagnosed diabetes, while Nunavut, Alberta, and Quebec ranked lowest (Figure 1-2).

Figure 1-2. Age-standardized† prevalence of diagnosed diabetes among individuals aged one year and older, by province/territory, Canada, 2008/09

	Age-standardized prevalence (%)
Newfoundland and Labrador	6.5
Prince Edward Island	5.6
Nova Scotia	6.1
New Brunswick	5.9
Quebec	5.1
Ontario	6.0
Manitoba	5.9
Saskatchewan	5.4
Alberta	4.9
British Columbia	5.4
Yukon	5.4
Northwest Territories	5.5
Nunavut	4.4

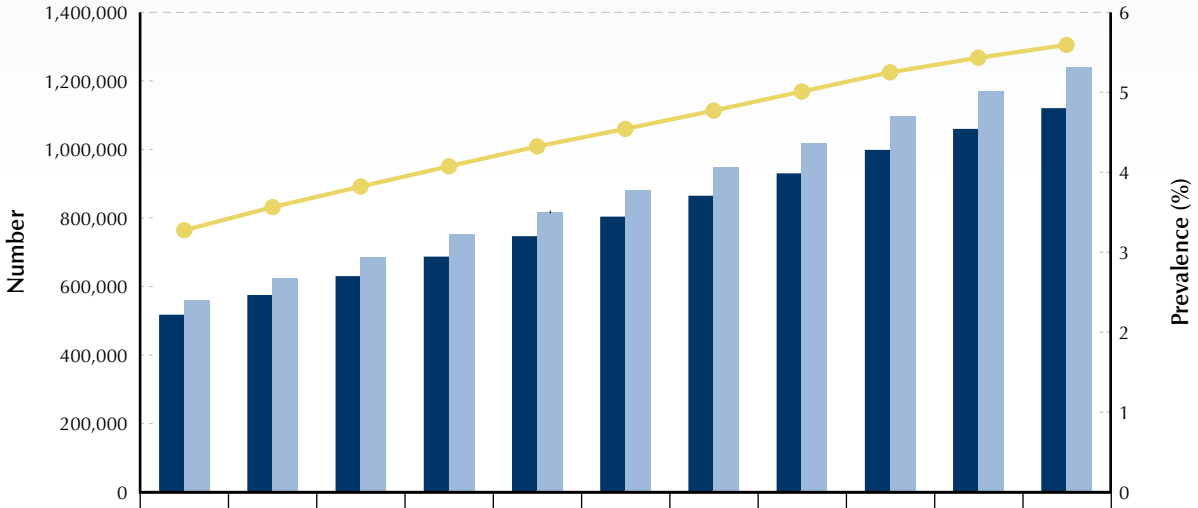


† Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (September 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Prevalence over time

The age-standardized prevalence of diagnosed diabetes among Canadians aged one year and older increased by 70%, from 3.3% in 1998/99 to 5.6% in 2008/09 (Figure 1-3). Prevalence over time was consistently higher among males than among females (Figure 1-3) and increased in every age group (Figure 1-4).

Figure 1-3. Age-standardized† prevalence and number of cases of diagnosed diabetes among individuals aged one year and older, Canada, 1998/99 to 2008/09



Fiscal year	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Number of females	517,854	575,230	630,442	687,273	746,887	803,934	864,935	930,180	998,696	1,059,933	1,120,426
Number of males	560,318	624,405	686,355	751,100	817,526	880,411	946,912	1,018,581	1,097,396	1,168,837	1,238,826
Total prevalence	3.3	3.6	3.8	4.1	4.3	4.5	4.8	5.0	5.2	5.4	5.6

† Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (July 2011); using 1998/99 to 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

The aging of the Canadian population, largely a result of the baby boom cohort, has been one of the factors contributing to the increase in the number of Canadians living with diagnosed diabetes. In recent years, the highest increase in the number of individuals with diabetes was seen in the 60 to 64 year age group, from 127,608 individuals in 1998/99 to 313,521 individuals in 2008/09.[1] In addition to the aging baby boom cohort, the increased longevity of individuals living with diabetes (due to advancements in treatment and earlier diagnosis) has contributed to the increasing prevalence rates of the disease.

Although the actual *number* of Canadians with diagnosed diabetes has increased most rapidly in the older age groups, the *proportion* of individuals with diagnosed diabetes has increased more in younger age groups. Between 1998/99 and 2008/09, the greatest relative increases in prevalence was seen in the 35 to 39 and 40 to 44 year age groups, where the proportions doubled. The increase seen in younger age groups is likely mainly due to increasing rates of overweight and obesity (Chapter 4, Overweight and obesity).

Figure 1-4. Prevalence of diagnosed diabetes among individuals aged one year and older, by age group, Canada, 1998/99 to 2008/09

Age group (years)	1-9	10-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
1998/99	0.1	0.3	0.4	0.6	0.9	1.3	2.0	3.4	5.4	7.7	10.3	12.5	14.0	14.4	13.6	11.2
1999/00	0.1	0.3	0.5	0.7	1.0	1.4	2.2	3.6	5.8	8.4	11.2	13.5	15.2	15.7	14.9	12.3
2000/01	0.1	0.3	0.5	0.7	1.1	1.6	2.4	3.9	6.2	9.0	11.9	14.4	16.3	16.8	16.0	13.4
2001/02	0.1	0.3	0.5	0.8	1.2	1.7	2.6	4.1	6.6	9.5	12.6	15.4	17.3	17.9	17.1	14.3
2002/03	0.1	0.4	0.6	0.8	1.3	1.9	2.8	4.4	6.9	10.0	13.2	16.3	18.3	19.1	18.2	15.2
2003/04	0.1	0.4	0.6	0.9	1.4	2.1	3.0	4.6	7.2	10.5	13.8	17.1	19.2	20.1	19.3	16.0
2004/05	0.1	0.4	0.6	0.9	1.5	2.2	3.2	4.8	7.5	10.9	14.4	17.9	20.2	21.2	20.4	16.8
2005/06	0.2	0.4	0.6	0.9	1.5	2.3	3.4	5.0	7.7	11.5	15.1	18.8	21.2	22.4	21.6	17.9
2006/07	0.2	0.4	0.7	1.0	1.6	2.5	3.6	5.3	8.0	11.9	15.7	19.6	22.3	23.6	22.9	18.9
2007/08	0.2	0.4	0.7	1.0	1.6	2.6	3.8	5.5	8.2	12.2	16.2	20.2	23.3	24.6	24.1	20.0
2008/09	0.2	0.5	0.7	1.0	1.6	2.6	4.0	5.6	8.4	12.3	16.6	20.7	24.1	25.5	25.2	21.0

Source: Public Health Agency of Canada (July 2011); using 1998/99 to 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Undiagnosed diabetes

Undiagnosed diabetes denotes cases of diabetes which have yet to be identified by a health care professional. Using fasting blood samples collected in the 2007–2009 Canadian Health Measures Survey (CHMS), the magnitude of undiagnosed diabetes in Canada was estimated using Canadian Diabetes Association definitions and guidelines (Box I-2).[2] However, this analysis was limited due to the unavailability of a two hour oral glucose tolerance test and by a relatively small sample size. Based on plasma glucose readings, undiagnosed diabetes was found in 0.9% (95% CI: 0.5–1.4%) of the Canadian population aged six years and older, which represents more than 20% of all cases of diabetes (0.9% of the 4.3% cases detected in this analysis).

Diabetes incidence

Over 200,000 Canadians (6.3 new cases per 1,000 individuals) were diagnosed with diabetes for the first time in 2008/09 (Table 1-2). Males (6.8 new cases per 1,000 individuals) had higher overall incidence rates than females (5.7 new cases per 1,000 individuals).

Table 1-2. Incidence rates and number of incident cases of diagnosed diabetes among individuals aged one year and older, by age group and sex, Canada, 2008/09

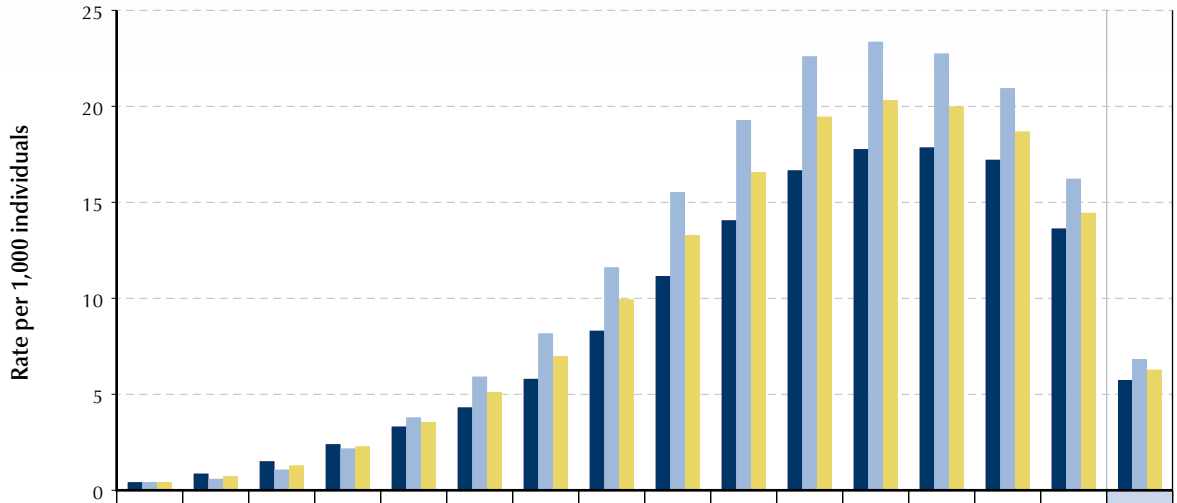
	Incidence					
	Females		Males		Total	
Age group (years)	Cases	Rate per 1,000 individuals (95% confidence interval)	Cases	Rate per 1,000 individuals (95% confidence interval)	Cases	Rate per 1,000 individuals (95% confidence interval)
1–19	1,584	0.4 (0.40–0.44)	1,703	0.4 (0.41–0.45)	3,287	0.4 (0.41–0.44)
20–24	984	0.9 (0.81–0.92)	695	0.6 (0.55–0.64)	1,679	0.7 (0.69–0.76)
25–29	1,784	1.5 (1.44–1.58)	1,266	1.1 (1.01–1.13)	3,050	1.3 (1.24–1.34)
30–34	2,783	2.4 (2.31–2.49)	2,508	2.2 (2.09–2.26)	5,291	2.3 (2.22–2.35)
35–39	3,993	3.3 (3.21–3.42)	4,602	3.8 (3.68–3.90)	8,595	3.6 (3.48–3.63)
40–44	5,600	4.3 (4.20–4.43)	7,756	5.9 (5.78–6.05)	13,356	5.1 (5.03–5.21)
45–49	8,035	5.8 (5.68–5.93)	11,301	8.2 (8.02–8.32)	19,336	7.0 (6.89–7.08)
50–54	10,302	8.3 (8.15–8.47)	14,079	11.6 (11.42–11.80)	24,381	9.9 (9.82–10.07)
55–59	11,422	11.2 (10.96–11.37)	15,145	15.5 (15.29–15.78)	26,567	13.3 (13.13–13.45)
60–64	11,658	14.1 (13.81–14.32)	14,817	19.3 (18.98–19.60)	26,475	16.6 (16.38–16.78)
65–69	9,955	16.7 (16.34–16.99)	12,007	22.6 (22.19–23.00)	21,962	19.5 (19.20–19.72)
70–74	8,244	17.8 (17.39–18.16)	9,105	23.4 (22.88–23.84)	17,349	20.3 (20.02–20.63)
75–79	7,135	17.9 (17.44–18.28)	7,030	22.7 (22.22–23.28)	14,165	20.0 (19.66–20.32)
80–84	5,529	17.2 (16.76–17.67)	4,370	20.9 (20.32–21.57)	9,899	18.7 (18.32–19.05)
≥85	4,921	13.6 (13.25–14.02)	2,705	16.2 (15.62–16.85)	7,626	14.5 (14.13–14.78)
Canada	93,929	5.7 (5.70–5.77)	109,089	6.8 (6.79–6.88)	203,018	6.3 (6.25–6.30)

Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Incidence by age

The incidence rates of diabetes rose steeply after age 40 among both sexes, peaking in the 70 to 74 and 75 to 79 year age groups (Table 1-2, Figure 1-5). Almost half of incident cases of diabetes in 2008/09 were aged between 45 to 64 years old. According to CCHS survey data based on the same age group, among those who self-reported having diabetes, 83.3% were of unhealthy weight (including 47.5% obese) compared to 57.8% with unhealthy weight (including 19.1% obese) among those without diabetes. This suggests that obesity was a major contributor to diabetes in that age group.

Figure 1-5. Incidence rates of diagnosed diabetes among individuals aged one year and older, by age group and sex, Canada, 2008/09



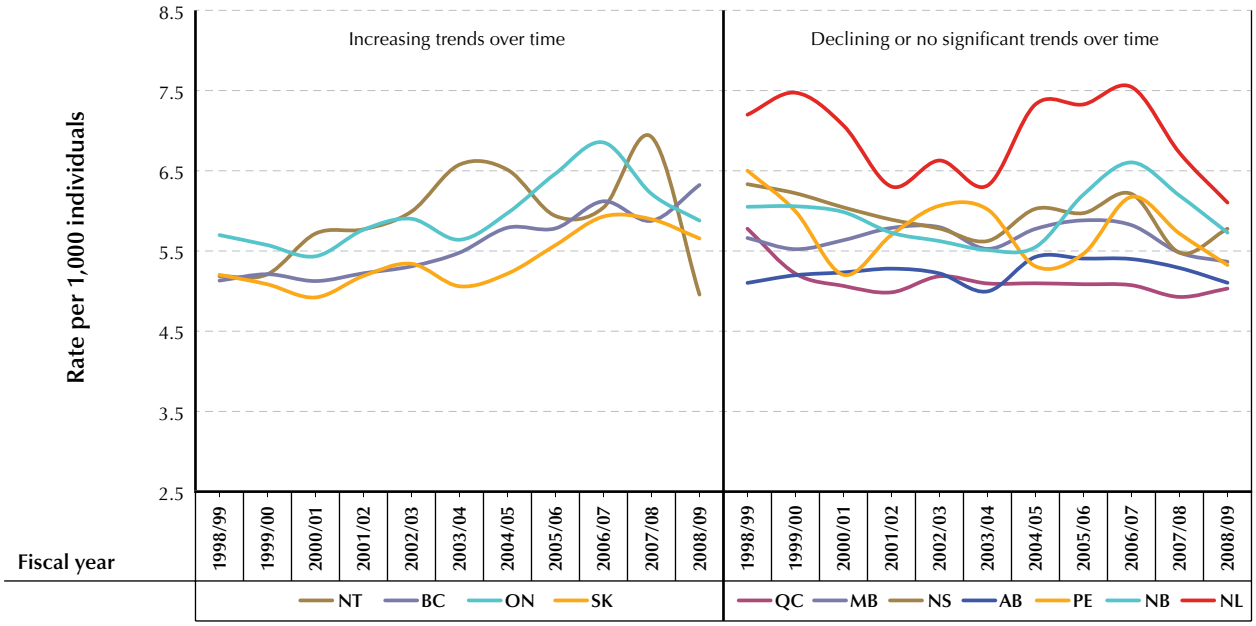
Age group (years)	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85	Canada
Females	0.4	0.9	1.5	2.4	3.3	4.3	5.8	8.3	11.2	14.1	16.7	17.8	17.9	17.2	13.6	5.7
Males	0.4	0.6	1.1	2.2	3.8	5.9	8.2	11.6	15.5	19.3	22.6	23.4	22.7	20.9	16.2	6.8
Total	0.4	0.7	1.3	2.3	3.6	5.1	7.0	9.9	13.3	16.6	19.5	20.3	20.0	18.7	14.5	6.3

Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Incidence by province/territory

Different trends in incidence over time were seen when data were stratified by province/territory (Figure 1-6). Although the overall Canadian trend showed a slight increase over time, this was largely influenced by increasing trends in Ontario, British Columbia, Saskatchewan, and the Northwest Territories. Generally, declining or no significant trends over time were seen in the remaining provinces. However, these data may be unstable over time (with large confidence intervals) due to small populations. Factors that may influence incidence trends in each province/territory include changes in coding, diagnostic changes, incentive programs, or screening effects due to localized campaigns. For example, the Canadian Diabetes Association recommendation for type 2 diabetes screening has changed over time. In 1998, screening was recommended every three years for Canadians aged 45 years and older,[3] while since 2003 the age was lowered to 40.[4] This may increase the number of diabetes diagnoses.

Figure 1-6. Age-standardized† incidence rates of diagnosed diabetes among individuals aged one year and older, by province/territory, Canada‡, 1998/99 to 2008/09

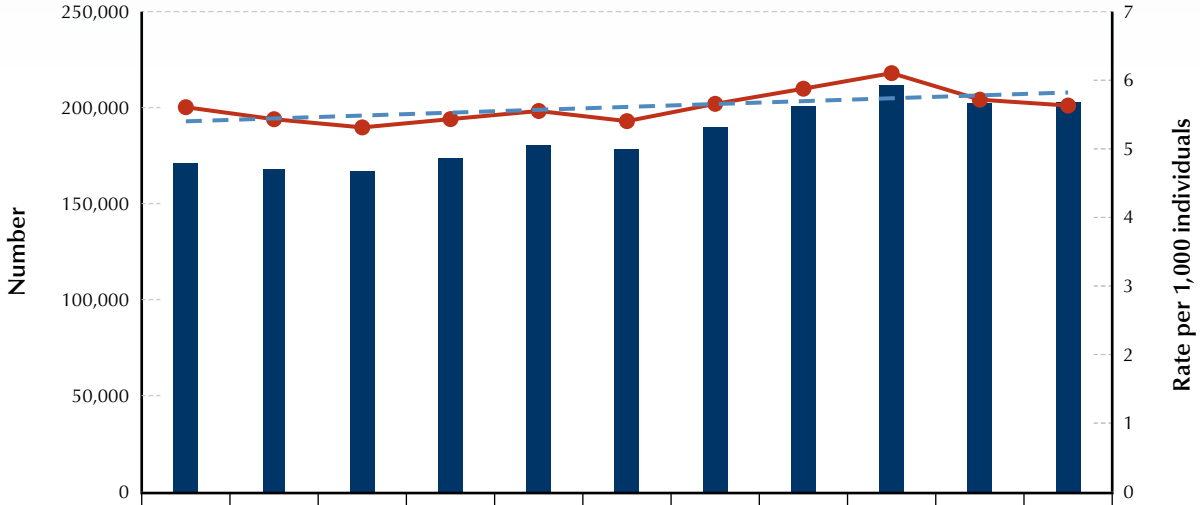


† Age-standardized to the 1991 Canadian population.
‡ Excluding Yukon and Nunavut.
Source: Public Health Agency of Canada (September 2011); using 1998/99 to 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Incidence over time

Between 1998/99 to 2008/09, statistical analyses indicate an overall increase in incidence rates of diagnosed diabetes (Figure 1-7). However, only certain age groups contributed to this overall increase over time, namely children age one to 19 years and working-age adults aged 30 to 49 years old.[1] Diabetes incidence appears to be decreasing since 2006/07, but it is too early to consider the implications of this small decrease at this point. Variations in incidence rates may be related to many data artefacts.

Figure 1-7. Age-standardized† incidence rates and number of incident cases of diagnosed diabetes among individuals aged one year and older, Canada, 1998/99 to 2008/09



Fiscal year	1998/99	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Number	170,929	167,831	166,761	173,570	180,535	178,439	189,849	200,564	211,865	202,325	203,018
Incidence per 1,000 individuals	5.6	5.4	5.3	5.4	5.6	5.4	5.7	5.9	6.1	5.7	5.6

† Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (July 2011), using 1998/99 to 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

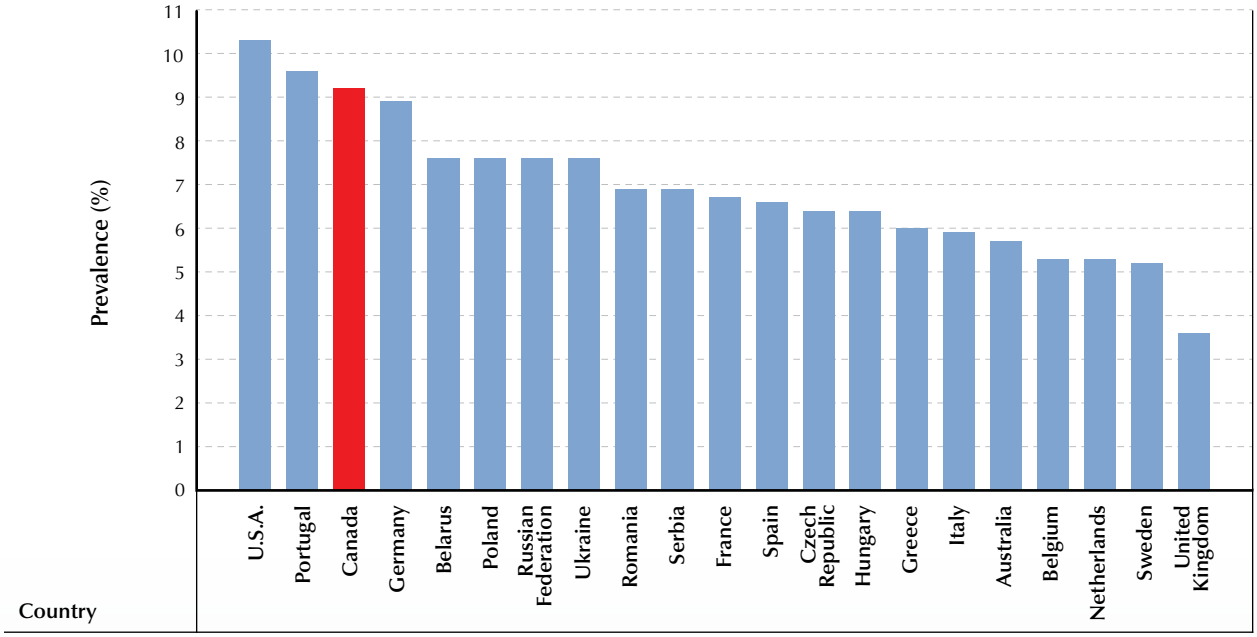
Between 1998/99 and 2008/09, the age-standardized prevalence rate for diabetes increased by 72% for females and 69% for males, while the age-standardized incidence rate remained relatively comparable for both sexes. The increasing number of individuals being diagnosed with diabetes (incidence) does not entirely account for the increase in the total number of Canadians living with the disease (prevalence), indicating that people are living longer with diabetes, or that they are being diagnosed at a younger age.

Diabetes in the world

The seriousness of diabetes has been acknowledged at the global level. In one of its resolutions, the United Nations General Assembly recognized that: *"[d]iabetes is a chronic, debilitating and costly disease associated with severe complications, which poses severe risks for families, Member States and the entire world […]"*.[5] However, providing accurate estimates of the global burden of diabetes, in terms of morbidity and mortality, poses several challenges including the lack of valid and timely data in some countries, as well as the variability of diagnostic criteria used across the globe.

Keeping in mind these limitations, the International Diabetes Federation estimated that the global age-standardized prevalence of diabetes among adults aged 20 to 79 years was 6.4% in 2010, representing 285 million people worldwide.[6,7] Compared with the prevalence of diabetes in European, American and Oceania countries included in this study (Figure 1-8), the rate for Canada was the third highest. Compared to the rate of 9.2% in Canada, rates were much lower in all African countries, as well as in most Asian and Latin American/Caribbean countries. On average, countries in the Middle-East Crescent had higher rates than those seen in Europe, North America, and Oceania countries.

Figure 1-8. Prevalence† of diabetes among individuals aged 20 to 79 years, Europe, North America and Oceania, 2010



† Standardized to the global population.
Source: Public Health Agency of Canada (2011); adapted from Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diab Res Clin Pract* 2010;87:4-14.

According to a report from the World Health Organization (WHO), in 2008, the global age-standardized prevalence of diabetes was 10%, and 1.3 million deaths were attributed to the disease. The prevalence of diabetes for both sexes was the highest in the Region of the Americas (11%), equally ranked with the Eastern Mediterranean Region, and lowest in the WHO European and Western Pacific Regions (at 9%).[8]

Looking ahead

If incidence and mortality rates remain at the levels seen in 2008/09[i], the number of Canadians aged one year and older living with diagnosed diabetes will reach 3.7 million (1.7 million females and 1.9 million males) by 2018/19, representing an increase of 56%. If current incidence and mortality trends continue[ii], the projected number would be higher, at 3.8 million Canadians. The forecasted increase in the number of individuals diagnosed with diabetes in Canada poses a major challenge for health services; major disease prevention efforts should be made to avoid this anticipated rise.

It should be noted that reported prevalence rates for diabetes vary by data source used because of various differences in methodologies. For example, based on results from the 2009–2010 CCHS, the prevalence of self-reported diabetes was 6.8% (95% CI:6.6–7.1%) among Canadians aged 20 years and older. In comparison, using the same age group (20 years and older), 2008/09 CCDSS data indicate a prevalence of diagnosed diabetes of 8.7% (95% CI: 8.72–8.74%).[1] Both sources may in fact slightly underestimate the true prevalence of diabetes in Canada as undiagnosed cases of diabetes (up to 20% based on CHMS data) are not taken into account. More data and research are necessary to determine the magnitude of undiagnosed diabetes cases in Canada.

Although each data source has its strengths and limitations, this first chapter focused mainly on CCDSS estimates as it is the only national population-based data source, and it uses a validated case definition of diabetes. Unlike the CCHS, the CCDSS also allows for the estimation of incidence rates. The Public Health Agency of Canada is collaborating with the provinces and territories, as well other external partners, to improve on an ongoing basis the quality, validity, and comprehensiveness of CCDSS data.

i Using a constant rates projection method, where data from 2006/07 to 2008/09 were used to estimate constant mortality and incidence rates which were then applied to project prevalence based on a Statistics Canada projected population.

ii Using trends in the projection method, where mortality and incidence trends are estimated first, and significant trends are then applied to 2008/09 data to obtain projected rates based on a Statistics Canada projected population.

Reference list

(1) Public Health Agency of Canada. Unpublished analysis using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada); 2011.

(2) Public Health Agency of Canada. Unpublished analysis using 2007–2009 data from the Canadian Health Measures Survey (Statistics Canada); 2011.

(3) Canadian Diabetes Association. 1998 clinical practice guidelines for the management of diabetes in Canada. *CMAJ.* 1998;159(Suppl 8):S1-S29.

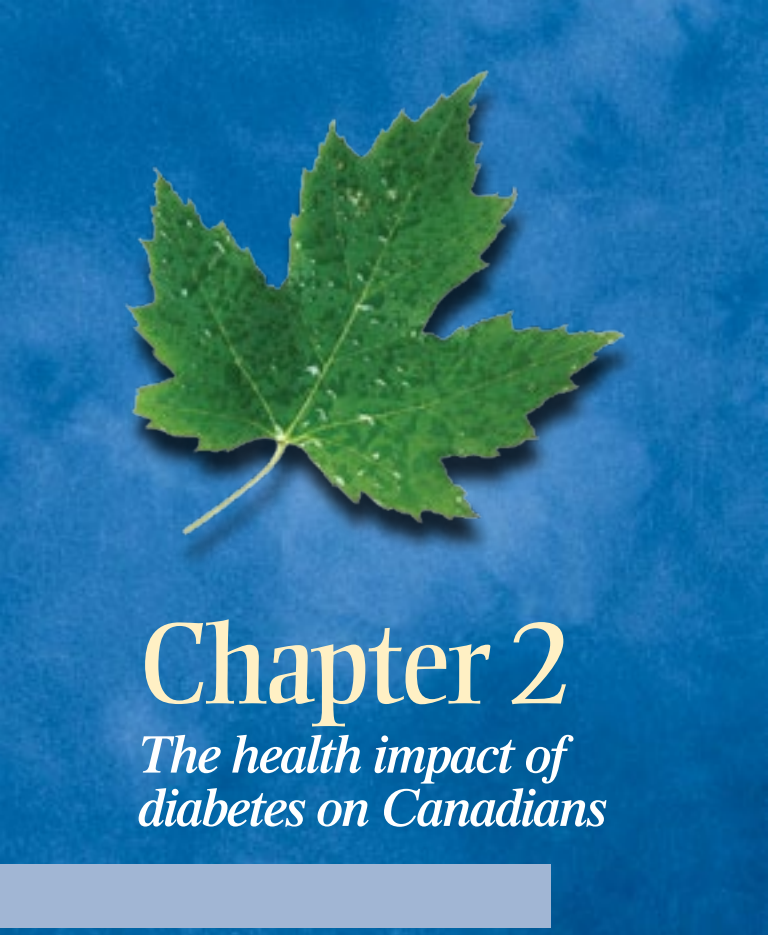
(4) Canadian Diabetes Association Clinical Practice Guidelines Expert Committee. Canadian Diabetes Association 2003 clinical practice guidelines for the prevention and management of diabetes in Canada. *Can J Diabetes.* 2003;27(Suppl 2):S1-S152.

(5) United Nations General Assembly. Resolution 61/225: World Diabetes Day. 2006. http://www.worlddiabetesfoundation.org/media(3892,1033)/UNR_media_kit_0407.pdf. Accessed September 3, 2011.

(6) Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract.* 2010;87(1):4-14.

(7) International Diabetes Federation. *IDF Diabetes Atlas.* 4th ed. Brussels, Belgium: International Diabetes Federation; 2009.

(8) Alwan A, ed. *Global status report on noncommunicable diseases 2010*. Geneva, Switzerland: World Health Organization; 2011.



Chapter 2

The health impact of diabetes on Canadians

Introduction

Diabetes can lead to many complications, including cardiovascular disease, vision loss/blindness, kidney failure, nerve damage, problems with pregnancy, oral disease and depression. These conditions contribute significantly to reduced quality of life, work limitations, and increased risk of death; they also greatly increase the demand for health care resources and add to the costs of diabetes for society (Chapter 3). Although the rates of many complications among people with diabetes have stabilized or decreased in recent years, the increase in the number of individuals with diabetes has led to a continued rise in the number of individuals affected by its complications.[1] Fortunately, it is often possible for individuals with diabetes to live healthy lives and delay or prevent complications through the management of blood glucose, blood lipids and blood pressure levels through lifestyle changes and medication.

Managing diabetes and its complications

The goals of diabetes management for individuals with type 1 and type 2 diabetes alike are to eliminate the symptoms and short-term risks of high or low glycemic levels, and to prevent or at least delay the progression of long-term complications through early detection and treatment. In 2008, the Canadian Diabetes Association published the updated *Clinical practice guidelines for the prevention and management of diabetes in Canada*,[2] providing evidence-based guidelines for optimal diabetes management. Healthy weights, regular physical activity, smoking cessation (where applicable), as well as aggressive control of blood sugar, blood pressure and blood lipid levels are all recommended by the Canadian Diabetes Association guidelines as ways to prevent or slow the progression of diabetes complications.

The association between hyperglycemia and increased diabetes complications is well known, making glycemic control the cornerstone of diabetes management. When blood sugars are poorly managed, diabetes can increase the risk of infection, delay wound healing, and lead to diabetic ketoacidosis. It can also increase the development and progression of micro and macrovascular complications. These complications are more common among individuals who have been living with diabetes for many years, whose diabetes is poorly managed or who were living with previously undiagnosed diabetes. Maintaining glycemic levels within the range recommended by a physician can help prevent the development of complications, slow their progression, and improve prognosis. Although medication may be necessary, lifestyle changes alone can help some individuals with type 2 diabetes to maintain healthy glycemic levels.

Optimal management relies on both self-management by the individual and care from health professionals, including doctors, nurses, pharmacists, dieticians, and diabetes educators. However, the gap between recommended care, as per the Canadian Diabetes Association guidelines, and actual practice has been found to vary according to the type of care.[3-5] Poor management may be the result of limited access to health care providers or the required medications or treatments, as well as the inability to self-manage due to other competing illnesses or demands. In 2007, the CCHS collected additional data from individuals who self-reported a diagnosis of diabetes, and found that 81% of respondents indicated that their HbA1C levels had been checked by a physician in the past year. Individuals who reported using insulin were more likely to have their HbA1C levels tested than their counterparts who reported not using insulin (87% versus 80%).[3] However, a Canadian study looking at diabetes care in family practices found that one in two Canadians with type 2 diabetes did not have their glycemic levels within established targets.[6] The Survey on Living with Chronic Diseases in Canada, which was sponsored by the Public Health Agency of Canada and administered by Statistics Canada, was conducted in 2010–2011 on a population with self-reported diabetes. This cross-sectional survey will provide a national picture of self-reported glycemic control and management strategies used by Canadians with diabetes.

Medication use

Because type 2 diabetes is progressive, most people with the disease eventually require medication to help control glycemic levels. Type 2 diabetes is usually treated with oral medications, at least in its early stages. Insulin, which is given by injection, is required by all individuals with type 1 diabetes since they are unable to produce insulin on their own, but it may also be prescribed to individuals with type 2 diabetes. In 2009–2010, 89.7%[i] of individuals aged 12 to 19 years and 85.1% of individuals aged 20 years or older with diabetes reported being on at least one oral medication, insulin, or both (Table 2-1). The dispensing of diabetes medication has increased steadily over the last decade (Figure 2-1).

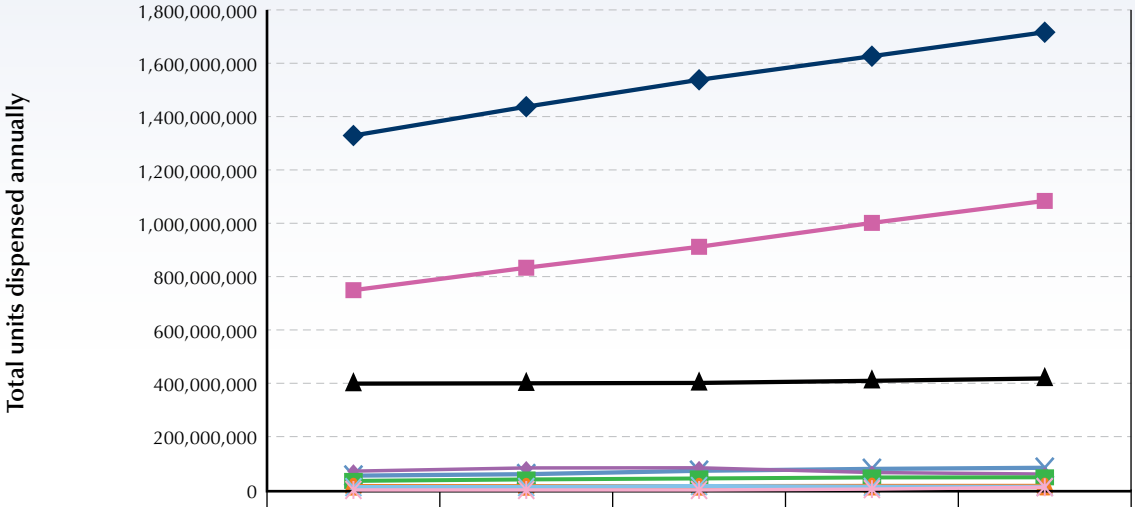
i Proportion differs from the value presented in Table 2-1. due to suppression of small sample sizes.

Table 2-1. Proportion and number of diabetes medications† among individuals aged 12 years and older with self-reported diabetes, by age group and medication type, Canada, 2009–2010

	Medication use			
Age group (years)	**Oral medication only (%) (95% confidence interval)**	**Oral medication and insulin (%) (95% confidence interval)**	**Insulin only (%) (95% confidence interval)**	**No medication, no insulin (%) (95% confidence interval)**
12-19	‡	‡	87.5 (76.6-98.5)	‡
20-29	21.1 (12.2-30.0)§	‡	56.8 (45.6-68.0)	14.8 (6.7-23.0)§
30-39	38.9 (28.8-49.1)	‡	40.3 (27.5-53.0)	15.5 (8.6-22.5)§
40-49	60.5 (53.5-67.5)	5.0 (2.9-7.0)§	14.9 (10.5-19.2)	19.7 (14.2-25.2)
50-59	65.3 (61.4-69.1)	10.6 (8.2-12.9)	8.8 (6.5-11.1)	15.4 (12.3-18.5)
60-69	67.7 (64.8-70.7)	10.0 (8.2-11.8)	8.2 (6.3-10.1)	14.1 (12.1-16.1)
70-79	67.0 (64.2-69.7)	12.3 (10.0-14.6)	7.5 (6.1-9.0)	13.2 (11.3-15.1)
≥80	66.2 (61.5-70.9)	11.3 (7.9-14.7)	7.9 (5.9-10.0)	14.6 (11.4-17.8)

† Individuals who self-reported taking oral medication or insulin to help control glycemic levels.
‡ Value suppressed due to small sample size or large coefficient of variation.
§ Marginal variance estimate; data should be interpreted with caution.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Figure 2-1. Number of units of diabetes medications, by medication type, Canada†, 2005 to 2009



Year	2005	2006	2007	2008	2009
Total units of diabetes medication	1,328,992,544	1,437,090,950	1,537,943,560	1,626,455,223	1,716,346,484
Metformin	749,096,969	833,269,266	911,718,917	1,001,401,133	1,083,792,494
Sulfonylureas	398,681,688	399,847,432	401,293,472	409,241,434	418,042,150
Insulin	53,651,209	59,099,215	71,929,593	78,922,901	83,121,192
Thiazolidinediones	70,532,632	82,572,934	83,062,086	65,405,577	59,604,151
Meglitinides	33,938,775	39,374,093	43,085,613	46,920,886	47,300,648
Alpha-glucosidase inhibitors	12,380,295	12,019,953	12,249,101	12,909,369	13,063,718
Combined formulations	10,710,976	10,908,057	14,604,778	11,653,923	11,422,131
Incretin agents‡	-	-	31	3,139,739	10,249,479

† Data for the Territories were unavailable.
‡ Incretin agents consist of two products: Januvia was launched in December 2007 and Janumet in October 2009.
Source: Public Health Agency of Canada (2010); using 2005 to 2009 data from CompuScript (IMS Health).

A relationship between the type of medication used and quality of care has been shown; individuals on insulin were more likely to receive the recommended level of care from a health professional[ii] than those not on insulin.[3;5] On the other hand, quality of life has been seen to decrease for individuals with type 2 diabetes who use insulin. However, individuals with type 2 diabetes who use insulin are often prescribed insulin due to the progression of the disease and the resulting failure of lifestyle or oral medication management or because complications appeared.[7] A study of people with type 1 diabetes found no association between quality of life and intensity of insulin injection regime.[8]

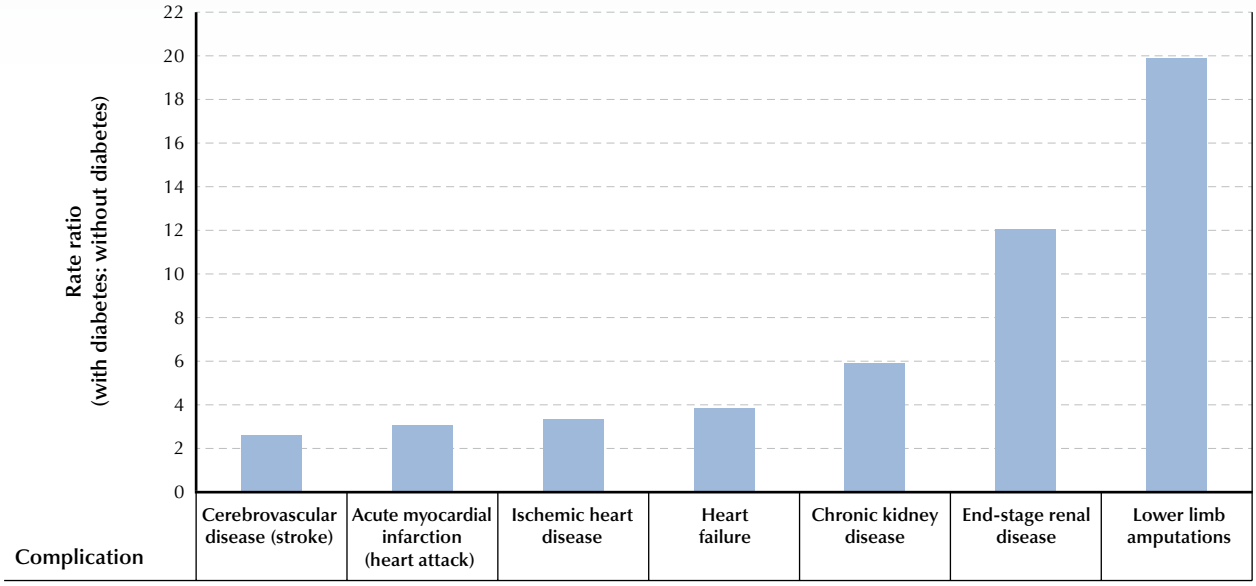
ii Including: one or more HbA1c test, one urine test, or one foot exam in the previous year, and one dilated eye exam in the previous two years.

Complications associated with diabetes

Despite multi-faceted efforts to manage diabetes, the disease can lead to a variety of short-term and long-term complications. Short-term complications of diabetes (such as infection, slow wound healing, diabetic ketoacidosis) can arise from hyperglycemia or from treatments for diabetes (particularly insulin) leading to glycemic levels that are too low (hypoglycemia). These short term complications can be life-threatening if they are not treated quickly. Diabetic ketoacidosis (DKA) and hyperglycemic hyperosmolar nonketotic syndrome (HHNS) are two complications resulting from severe hyperglycemia which can lead to death. Hypoglycemia can lead to confusion, falls, and loss of consciousness, and in extreme cases, also death.

Many long-term complications of diabetes that ensue from hyperglycemia, hypertension, and dyslipidemia are linked to damage to large (macrovascular) and small (microvascular) blood vessels in the body. This damage affects the function of organs, including the heart, kidneys, eyes, and the nervous system. In 2008/09, Canadian adults with diabetes were more likely than those without diabetes to be hospitalized with other health problems affecting these organs (Figure 2-2). Good metabolic control (including glycemia, blood pressure, and blood lipids) reduces the development and progression of this type of damage. Other complications associated with diabetes include problems with pregnancy, such as preterm birth and macrosomia (large newborn), oral disease, and depression.

Figure 2-2. Prevalence rate ratios† of complications among hospitalized individuals‡ aged 20 years and older, by diabetes status, Canada, 2008/09



† Rate ratios based on rates age-standardized to the 1991 Canadian population.

‡ A person with diabetes hospitalized with more than one complication was counted once in each category, except for cases of acute myocardial infarction, where regardless of multiple counts in the acute myocardial infarction category, the individual was counted only once under the broader ischemic heart disease category.

Source: Public Health Agency of Canada (August 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Cardiovascular disease

Diabetes significantly increases the risk of cardiovascular disease – a condition encompassing heart disease, stroke, and peripheral vascular disease. Individuals with diabetes are two to four times more likely to develop cardiovascular disease than those without.[9] Cardiovascular disease is the most commonly reported condition in Canadians with diabetes, the most common cause of death in individuals with type 2 diabetes,[10] and the leading driver of health care costs for people with diabetes.[11] It has been estimated that if diabetes were eliminated from the world population, there would be a 19.1% global decrease in the rate of acute myocardial infarction among females, and a 10.1% global decrease among males.[12]

Diabetes leads to premature narrowing of the arteries (atherosclerosis), which can damage the coronary blood vessels and lead to unstable angina and acute myocardial infarction.[13;14] An individual's risk of cardiovascular disease can increase even before diabetes is diagnosed, when glycemic levels are elevated but not high enough to manifest symptoms or to meet the diagnostic criteria for diabetes. In addition, many risk factors for cardiovascular disease, such as overweight, hypertension and dyslipidemia, are more prevalent

among individuals with, or at risk of, diabetes (Chapter 4). When these risk factors are present in individuals with diabetes, the risk of cardiovascular disease is much higher than when either diabetes or risk factors are present alone. Because diabetes and cardiovascular disease share many risk factors, it is sometimes difficult to disentangle cases of comorbidity from the complications of diabetes.

In 2009–2010, 22.7% of Canadians aged 20 years and older with diabetes reported having heart disease, compared to 6.0% in the population without diabetes.[15] In 2008/09, 64.5% of adults with diagnosed diabetes also had diagnosed hypertension. When adjusted for age differences, this was twice the number of diagnosed hypertension cases in a population without diabetes.[16] Similarly, after age adjustment, cardiovascular disease hospitalizations were three times higher in individuals with diabetes than in those without diabetes.[17]

Eye disease (diabetic retinopathy, cataracts and glaucoma)

Diabetic retinopathy, which can cause blindness, results when hyperglycemia damages the small blood vessels in the retina of the eye. In general, there are no symptoms of retinopathy until it has advanced enough to cause acute vision loss due to bleeding or retinal detachment. In some people with diabetes, swelling in the retina from leaking blood vessels may cause a gradual decline in vision. If undetected or left untreated, this can progress and lead to permanent eye damage and blindness. Early detection and appropriate treatment with laser photocoagulation can prevent vision loss. In 2006, it was estimated that close to 500,000 Canadians had some form of diabetic retinopathy. Of these, 100,000 had a vision-threatening form of the disease (defined as severe retinopathy, diabetic macular edema, or both), and 6,000 were already blind from the disease.[18]

Poorly controlled hyperglycemia and hypertension increase the risk of diabetic retinopathy, while effective treatment of these two factors has been shown to slow its progression.[19] The risk of retinopathy increases with the number of years diabetes has been present.[20] At time of diagnosis, up to 21% of patients with type 2 diabetes already have some form of diabetic retinopathy.[21] For most of these individuals, the condition is not yet sight-threatening, but should be monitored closely by a specialist. In the first 20 years after a diagnosis of diabetes, almost all individuals with type 1 diabetes and more than 60% of individuals with type 2 diabetes develop some form of retinopathy.[21] Cataracts and glaucoma, two other eye diseases that lead to impaired vision, are also associated with diabetes, although the causal relationship is not yet understood.[22-25]

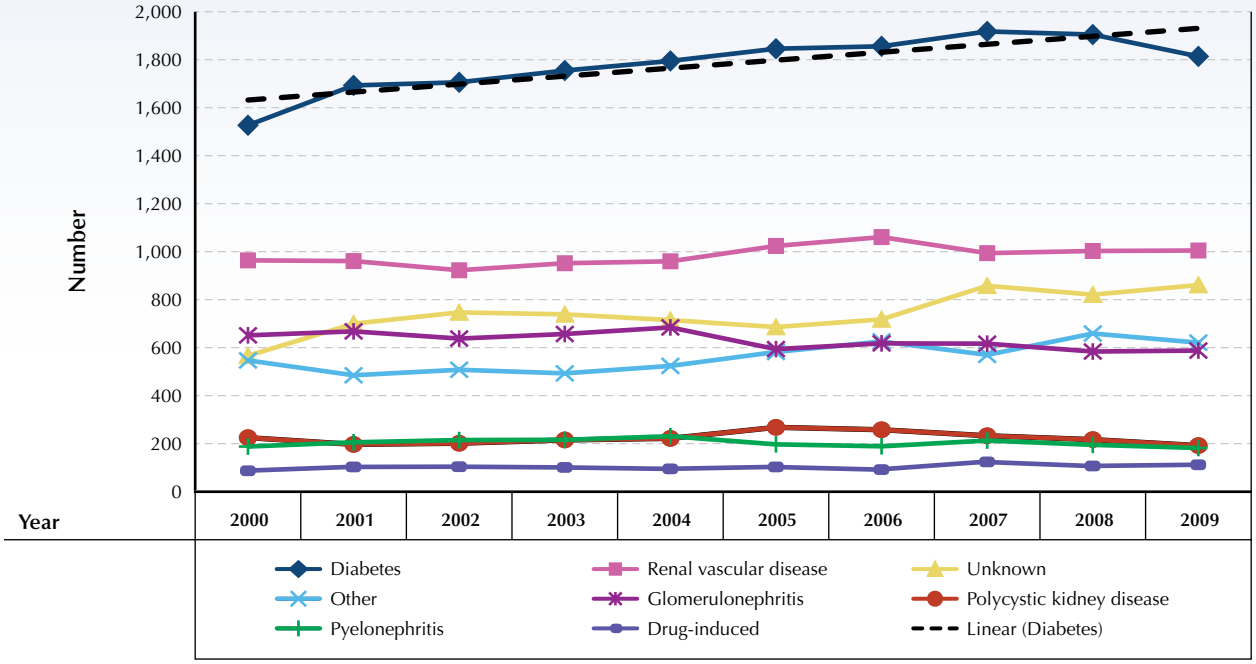
As the population ages and the prevalence of diabetes rises, the number of individuals affected by vision loss and its associated costs will also increase.[26] This underscores the importance of ongoing screening and effective treatment for retinopathy. The Canadian Diabetes Association clinical practice guidelines provide specific recommendations on the frequency and methods of screening individuals with type 1 and type 2 diabetes for retinopathy.[2] Results from the 2007 CCHS showed that only 66% of individuals with diabetes had an eye exam in the last two years as recommended in the clinical practice guidelines.[3;5]

Kidney disease (nephropathy)

Diabetic nephropathy results when hyperglycemia damages the blood vessels that filter blood in the kidneys. Since type 2 diabetes may remain undiagnosed for a long period of time, kidney damage often begins before diabetes is diagnosed. In its early stages, damage to the kidney allows blood proteins to leak into the urine. This leakage is detectable only by laboratory testing of urine. As damage progresses, kidney function can be compromised, eventually resulting in kidney failure and end-stage renal disease. At that point, the kidney no longer works effectively and the individual requires dialysis or a kidney transplant for survival.

In 2008/09, individuals with diabetes were 5.9 times more likely to be hospitalized with renal disease and 12.0 times more likely to be hospitalized with end-stage renal disease than individuals without diabetes (Figure 2-2). In 2009, diabetes was reported as the primary cause of end-stage renal disease in 34% of the incident cases in Canada, continuing to be the country's most commonly reported primary cause of the disease (Figure 2-3). The number of Canadians starting renal replacement therapy (dialysis or transplant) has been increasing steadily since the mid-1990s.[27] The primary reason for this increase has been attributed to the growing number of people with diabetes, rather than a higher proportion of individuals with diabetes being diagnosed with end-stage renal disease or an increasing willingness to dialyse people with diabetes.[28] As the number of people with diabetes continues to rise, so too will the demand for dialysis services.

Figure 2-3. Number of incident cases of end-stage renal disease, by primary diagnosis, Canada, 2000 to 2009



Source: Public Health Agency of Canada (2011); adapted from Canadian Institute for Health Information. Canadian Organ Replacement Register Annual Report: Treatment of End-Stage Organ Failure in Canada, 2000 to 2009. 2011. Ottawa.

Individuals with kidney disease are also at elevated risk of cardiovascular disease mortality.[29] Kidney disease and cardiovascular disease share common risk factors, including hyperglycemia, hypertension and hypercholesterolemia, making the treatment and management of these factors a priority for the prevention of both conditions. Screening for kidney disease and its risk factors is an important part of diabetes management and a key focus of the Canadian Diabetes Association clinical practice guidelines.[2] In 2007, 74% of CCHS respondents with diabetes indicated that they received a urine protein test in the past year, as recommended by guidelines.[3] Screening is important because, when identified early, medications and interventions to control blood sugar and blood pressure have been shown to delay or prevent the progression of kidney disease.[30]

Nerve damage (neuropathy)

In individuals with diabetes, nerve damage most commonly results from reduced blood flow to nerves, which in turn is the result of damage to blood vessels caused by hyperglycemia. Without sufficient blood to provide oxygen and remove toxins, nerve structure and function are impacted. Pain, tingling and numbness are the symptoms most commonly associated with nerve damage. Other symptoms include erectile dysfunction and delayed gastric emptying (gastroparesis). Most neuropathies are asymptomatic, but numbness and the inability to perceive pain or injury are dangerous and are a common cause of foot ulceration.

Lower extremity complications and amputation

In 2008/09, Canadian adults with diagnosed diabetes were almost 20 times more likely to be hospitalized with non-traumatic lower limb amputations than their counterparts without diabetes (Figure 2-2). Indeed, there is a greater risk that even minor injuries can become infected because numbness – caused by nerve damage – can prevent an individual with diabetes from feeling the injury, and decreased blood flow – caused by peripheral vascular disease – can prevent healing once an injury occurs. Non-healing ulcers and deep-seated (bone) infections are the most common reasons for amputation.

Amputations are debilitating and can lead to increased morbidity, mortality, as well as increased treatment and hospitalization costs. Fortunately, many foot complications are preventable with proper foot care, including regular foot exams and aggressive treatment of infections.[2] In 2007, only 51% of individuals with diabetes surveyed in the CCHS met the clinical practice guidelines for physician foot examinations.[3;5]

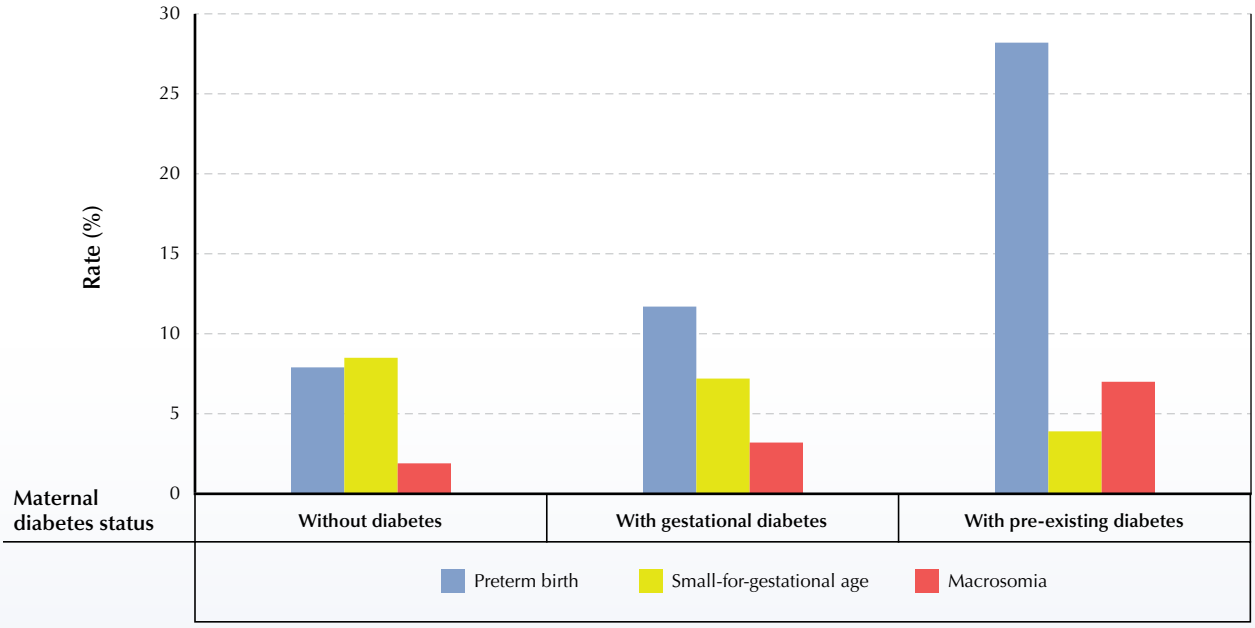
Complications during pregnancy

During pregnancy, glucose crosses the placenta freely, exposing the fetus to glycemic concentrations similar to those of the mother. Hyperglycemia has been associated with complications for both the fetus and the mother. Babies born to women with diabetes are more likely to experience congenital malformations,[31] poorer neonatal health, and macrosomia. All of these increase the likelihood of preterm delivery, caesarean section, and death.[32;33] Women with diabetes during their pregnancy are at increased risk of developing hypertension and exacerbating other diabetic complications.[34] Careful glycemic control, both before conception and during pregnancy, has been shown to reduce the risk of complications.[35;36]

Pregnancy complications are more likely in women with pre-existing diabetes (either type 1 or type 2) than in women who develop gestational diabetes during pregnancy.[37] In 2006, it was estimated that maternal diabetes was present in 5.1% of pregnancies resulting in live births in Canada (excluding Quebec). Of these, the majority (87.8%) were in women who developed gestational diabetes during pregnancy, while the remaining 12.2% were in women with pre-existing diabetes.[36]

In 2006/07, the rate of preterm delivery among women with pre-existing diabetes was 28.2%, more than three times as high as that among women without diabetes (7.9%) and more than double the rate among women with gestational diabetes (11.7%). Similarly, rates of macrosomia were higher in women with pre-existing diabetes (7.0%) than in women with no diabetes (1.9%) or gestational diabetes (3.2%), and the reverse association was observed for rates of small-for-gestational-age (Figure 2-4).

Figure 2-4. Rate of preterm birth, small-for-gestational-age, and macrosomia, by maternal diabetes status, Canada, 2006/07



Source: Public Health Agency of Canada (2011); adapted from Canadian Institute for Health Information. Too Early, Too Small: A Profile of Small Babies Across Canada. 2009. Ottawa.

Oral disease (gingivitis, periodontitis)

Gingivitis, an inflammatory condition of the gums surrounding the teeth, and periodontitis, the destruction of the ligament, bone, and soft tissues that support the teeth, are two of the most serious dental conditions identified in individuals with diabetes.[38] For example, a study using American survey data found that adults with poorly controlled diabetes had a significantly higher prevalence of severe periodontitis than those without diabetes (odds ratio (OR): 2.90; 95% CI: 1.40, 6.03).[39] The pain, discomfort, and eventual tooth loss associated with these conditions can lead to poor diet, nutritional deficiencies, psychosocial problems, and an overall decline in quality of life. Historically identified as a complication of both type 1 and type 2 diabetes, periodontal disease has also been thought to increase the risk of developing type 2 diabetes because the body's inflammatory response to the periodontal bacteria is believed to contribute to insulin resistance.[40] In addition to gingivitis and periodontitis, individuals with diabetes have higher rates of dental caries and salivary dysfunction.[41]

Mental illness

Depression is more common among people with diabetes than among those without,[42;43] and has been identified as a complication of diabetes.[44] However, the causal relationship between these two conditions is still unclear, with the potential that the relationship may in fact be bi-directional.[45;46] The stress of dealing with a diagnosis of diabetes can deteriorate an individual's mental health and lead to symptoms of depression. Furthermore, many complications associated with diabetes significantly impact the quality life of individuals and can also lead to depression. Vision loss alone has been strongly associated with depression.[47;48]

In 2009–2010, while 7.0% (95% CI: 6.8–7.3%) of Canadians aged 20 years and older reported having a mood disorder such as depression, bipolar disorder, or mania, the prevalence was higher among individuals with diabetes (9.6%; 95% CI: 8.7–10.5%) than without (6.9%; 95% CI: 6.6–7.1%)[iii].[15] Together, diabetes and depression can increase the risk of disability, complications, and mortality, and result in higher health care costs when compared to diabetes alone. Depression can lead to poorer diabetes self-care, obesity-promoting health behaviours and poorer glycemic control.[49] Further, some medications used to treat depression cause increases in body weight and in glycemic levels. Recognizing and treating mental illness among individuals with diabetes is especially important for effective disease management.[2]

Other conditions

Other chronic conditions associated with type 1 diabetes include thyroid disease and celiac disease.[50] Chronic conditions associated with type 2 diabetes, mainly through their association with similar risk factors (obesity in particular) include osteoarthritis,[51] chronic obstructive pulmonary disease (COPD),[52] obstructive sleep apnea,[53] and cancer.[54] In 2009–2010, 36.5% (95% CI: 34.9–38.2%) of Canadians with diabetes aged 20 years and older reported having two or more serious chronic conditions (hypertension, heart disease, COPD, mood disorder, and/or arthritis) in addition to diabetes, and 12.5% (95% CI: 11.5–13.5%) reported having three or more.[15] The co-existence of other chronic conditions may hinder the management of diabetes, health services utilization, and health-related quality of life (HRQOL). In general, people with other chronic conditions in addition to diabetes have poorer HRQOL than those without these conditions.[55-57]

The impact on quality of life

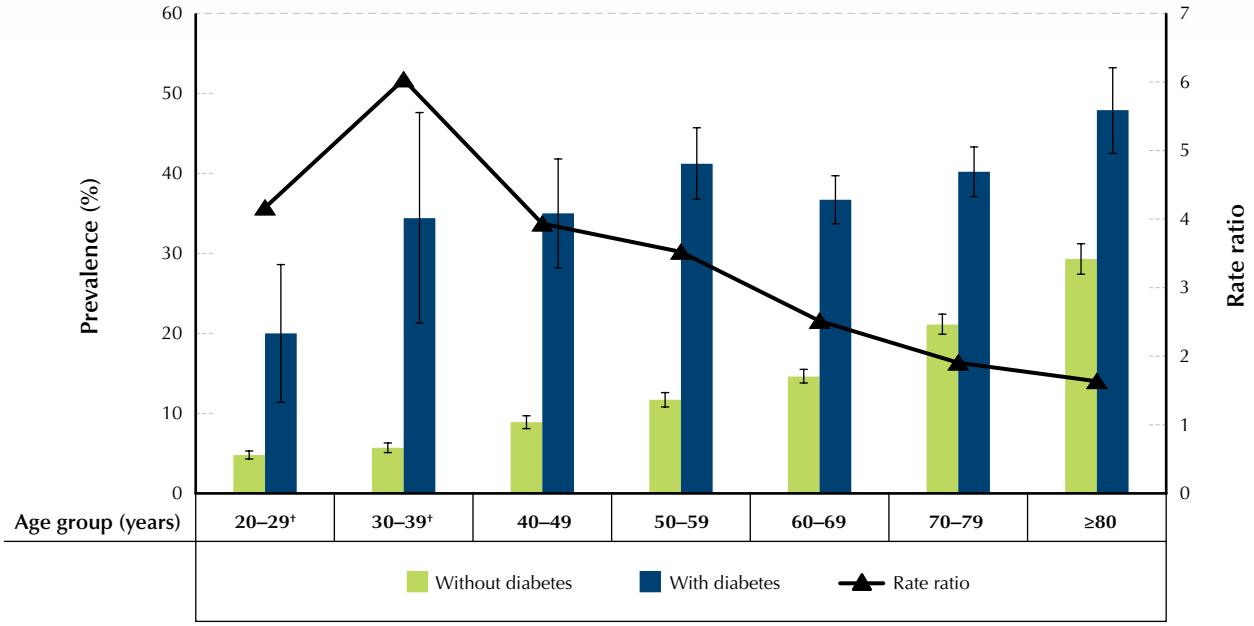
Diabetes and its complications affect people's lives and those of family members in many ways. Making lifestyle changes; managing hyperglycemia, hypertension, and dyslipidemia, as well as other complications and comorbidities; taking steps to help prevent and treat complications; losing time from school and work; and paying for supplies and drugs can place a burden on individuals with diabetes and their families. These stresses can affect the quality of life and overall health of an individual.

iii The prevalence of mental illnesses may be higher than current estimates indicate, given sensitivities to social desirability that may impact the reporting of these conditions.

Self-rated health status

How people perceive their general health provides a good indication of their quality of life. In 2009–2010, nearly two-fifths (39.1%) of Canadians aged 20 years and older who reported having diabetes rated their health as "fair" or "poor", compared to a tenth of the adult population without diabetes (10.3%). Adults aged 30 to 39 years with diabetes were six times more likely to rate their health as "fair" or "poor" than individuals of the same age without diabetes. In the oldest age groups, individuals with diabetes were about twice as likely to self-report their health as "fair" or "poor" (Figure 2-5).

Figure 2-5. Prevalence and rate ratios of self-reported health as "fair" or "poor" among individuals aged 20 years and older, by age group and diabetes status, Canada, 2009–2010



† Marginal variance estimate; data should be interpreted with caution.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

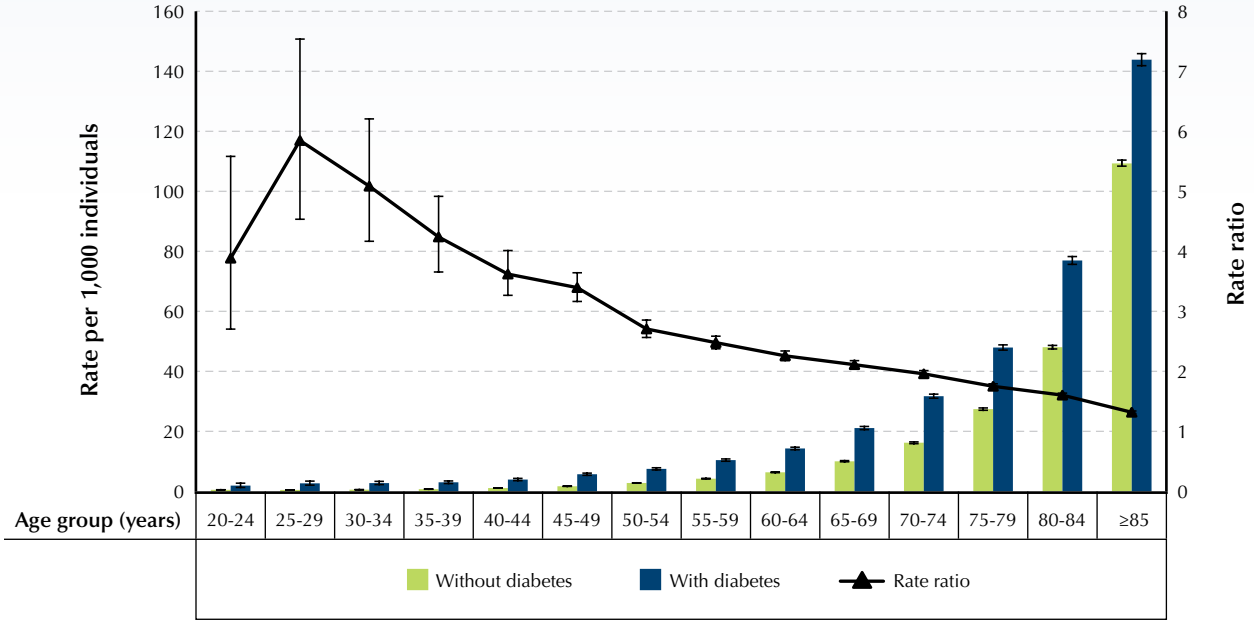
Mortality trends associated with diabetes

Diabetes is not usually the primary cause of death, but many of its complications are associated with premature death.[10] Because diabetes is not commonly recorded as the cause of death on a death certificate, vital statistics data significantly underestimate the relationship between diabetes and mortality in Canada. For example, in 2007, diabetes was recorded as the primary cause of death on the death certificate of only 3.1% (7,394) of all deaths in Canada,[58] even though more than a quarter (29.9%, or 69,992) of all individuals who died in 2008/09 had been diagnosed with diabetes.[17]

Using CCDSS data, it is estimated that at least one in every ten deaths (11.9%) in the Canadian adult population (aged 20 years or older) was attributable to diabetes in 2008/09. Males had a greater population attributable risk (12.6% of all deaths) compared to females (11.1%). Although the exact number of deaths attributed to diabetes is difficult to ascertain, it is clear that individuals with diabetes are at elevated risk of premature death compared to people without diabetes.

People with diabetes are more likely to die prematurely than people without diabetes in every age group. In younger Canadians (aged 20 to 39 years), all-cause mortality rates were 4.2 to 5.8 times higher among individuals with diabetes. In the 40 to 74 year age group, all-cause mortality rates were two to three times higher among people with diabetes (Figure 2-6).

Figure 2-6. All-cause mortality rates and rate ratios among individuals aged 20 years and older, by diabetes status, Canada, 2008/09

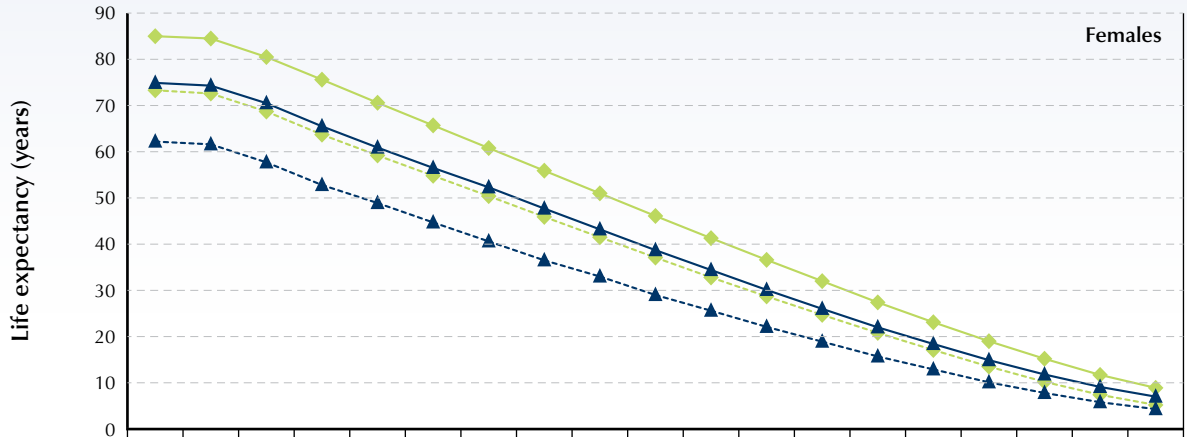


Source: Public Health Agency of Canada (June 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

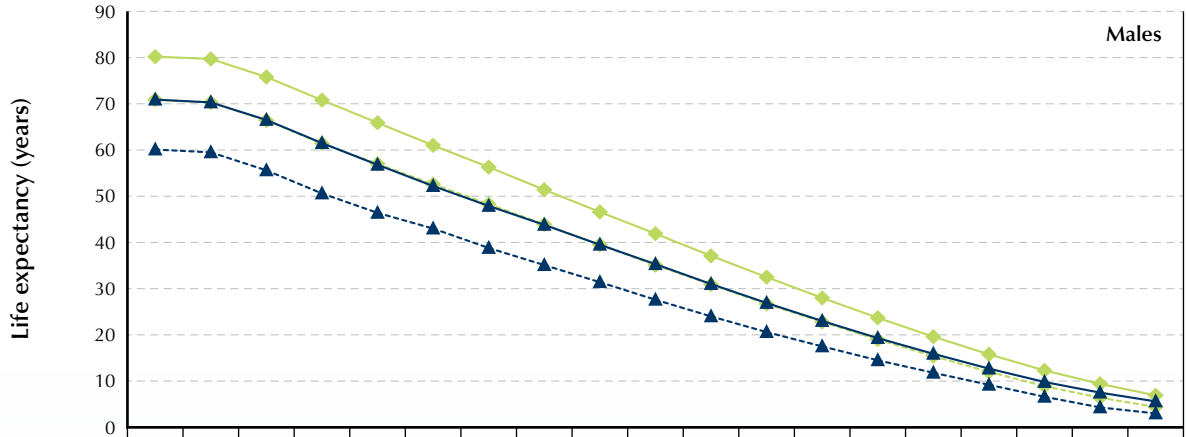
Higher mortality rates among individuals with diabetes resulted in noticeable decreases in life expectancy at all ages. Children aged one to 19 years with diagnosed diabetes had a life expectancy ten to 11 years less than children without diabetes. Working-aged adults (aged 20 to 64 years) with diabetes had a life expectancy five to ten years less than adults of the same age without diabetes.[17] When considering the morbidity burden experienced by individuals with diabetes, their health adjusted life expectancy (HALE)[iv] at birth was also lower compared to those without diabetes at all ages. Overall, it was estimated that females with diabetes would lose 11.1 years in HALE, while males would lose 10.8 years (Figure 2-7).

iv HALE is a summary measure that combines both mortality and morbidity into a single indicator and indicates the average number of years that an individual is expected to live in a healthy state.

Figure 2-7. Life expectancy (LE) and health-adjusted life expectancy (HALE) among individuals from birth and older, by age group, sex, and diabetes status, Canada†, 2004/05 to 2006/07



Age group (years)	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
LE, without diabetes	85.0	84.5	80.5	75.6	70.6	65.7	60.8	55.9	51.0	46.1	41.3	36.6	32.0	27.4	23.1	19.0	15.2	11.7	8.9
HALE, without diabetes	73.3	72.6	68.7	63.7	59.2	54.8	50.4	45.9	41.5	37.1	32.8	28.7	24.7	20.8	17.1	13.5	10.2	7.4	5.2
LE, with diabetes	74.9	74.3	70.5	65.5	60.9	56.5	52.3	47.7	43.2	38.7	34.4	30.1	26.0	22.0	18.4	14.9	11.8	9.1	7.0
HALE, with diabetes	62.2	61.6	57.7	52.8	48.9	44.7	40.6	36.5	33.0	29.0	25.6	22.1	18.9	15.7	12.9	10.1	7.8	5.8	4.3



Age group (years)	<1	1-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
LE, without diabetes	80.2	79.7	75.8	70.8	65.9	61.0	56.3	51.4	46.6	41.9	37.1	32.5	28.0	23.7	19.6	15.8	12.3	9.4	6.9
HALE, without diabetes	70.9	70.3	66.4	61.4	57.0	52.6	48.3	43.9	39.5	35.1	30.9	26.7	22.8	19.0	15.4	12.0	8.9	6.4	4.4
LE, with diabetes	70.9	70.3	66.5	61.5	56.8	52.2	47.9	43.8	39.5	35.3	31.0	26.9	23.0	19.3	15.9	12.7	9.8	7.5	5.6
HALE, with diabetes	60.1	59.5	55.6	50.6	46.4	43.0	38.8	35.1	31.4	27.6	24.0	20.6	17.5	14.5	11.8	9.2	6.6	4.3	3.0

† Data for Quebec, Nunavut and the Northwest Territories were unavailable.
Source: Public Health Agency of Canada (2011); adapted from Public Health Agency of Canada Steering Committee on Health-Adjusted Life Expectancy. Health-Adjusted Life Expectancy in Canada: 2010 Report by the Public Health Agency of Canada. In press. Ottawa.

Looking ahead

The projected increase in the prevalence of diabetes in the coming years suggests an overall continued rise in the number of individuals affected by complications. Individuals affected by diabetes complications may experience reduced quality of life, limitations in their ability to work, and are at risk for premature death. This underscores the importance of managing blood sugar, blood lipids and blood pressure levels through lifestyle changes and medication.

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Chapter 3

The health system and economic impact of diabetes

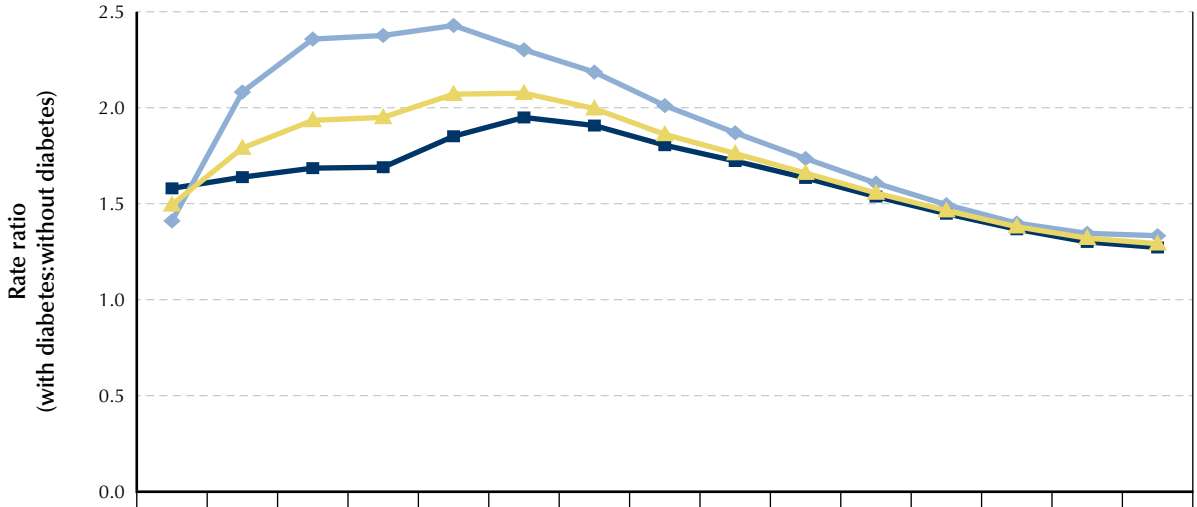
Introduction

In addition to the major impact of diabetes on individuals (Chapter 2), on a population level, treating and managing the disease and its complications also lead to an increased burden on the health care system and the national economy. Individuals with diabetes require a variety of health services, mainly to treat and manage their disease, but also for the diagnosis and treatment of associated complications. This chapter provides an overview of the burden of diabetes on the health care system and attempts to estimate the costs of diabetes in Canada.

Health service utilization

Diabetes management often involves the use of services from a range of health care providers, including family physicians, medical specialists, nutritionists, diabetes educators, and psychologists. In 2008/09, adults aged 20 to 49 years with diabetes saw a family physician about twice as often as those without diabetes (Figure 3-1), and a specialist two to three times more often (Figure 3-2). As expected, visits to specialists were even more frequent among children and youth (aged one to 19 years) with diagnosed diabetes. This group visited specialists four times as often as young people who did not have diabetes (Figure 3-2). This is likely a direct reflection of the specialized care recommended for children with diabetes (Chapter 5). The sex difference in the rate ratios, particularly in women of child-bearing age, is due to the fact that females without diabetes tend to visit family practitioners more often than males.

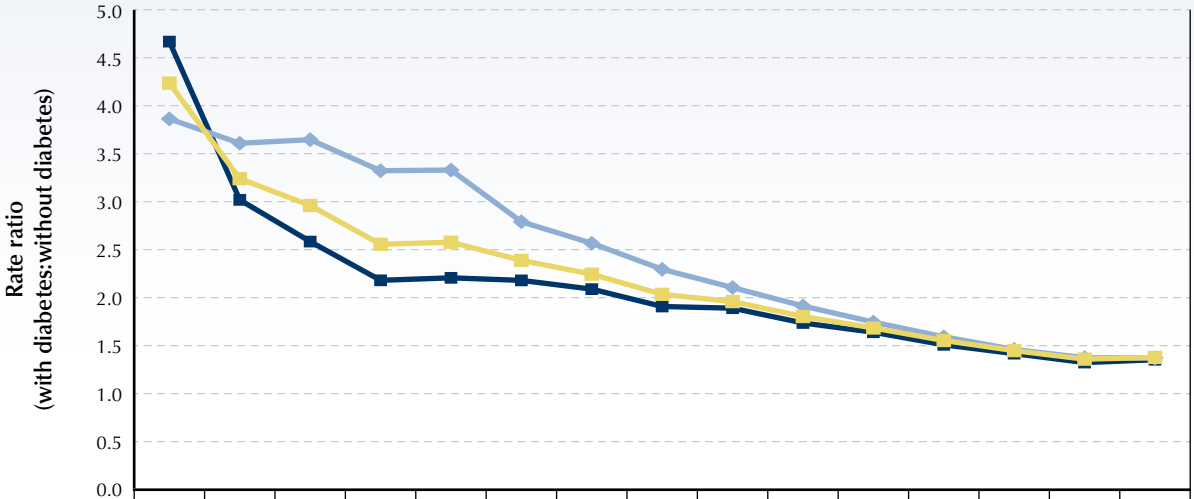
Figure 3-1. Rate ratios of visits to family physicians among individuals aged one year and older, by age group, sex, and diabetes status, Canada†, 2008/09



Age group (years)	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
Females	1.6	1.6	1.7	1.7	1.9	1.9	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.3	1.3
Males	1.4	2.1	2.4	2.4	2.4	2.3	2.2	2.0	1.9	1.7	1.6	1.5	1.4	1.3	1.3
Total	1.5	1.8	1.9	1.9	2.1	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.3

† Data for Quebec were unavailable.
Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Figure 3-2. Rate ratios of visits to specialists among individuals aged one year and older, by age group, sex, and diabetes status, Canada†, 2008/09

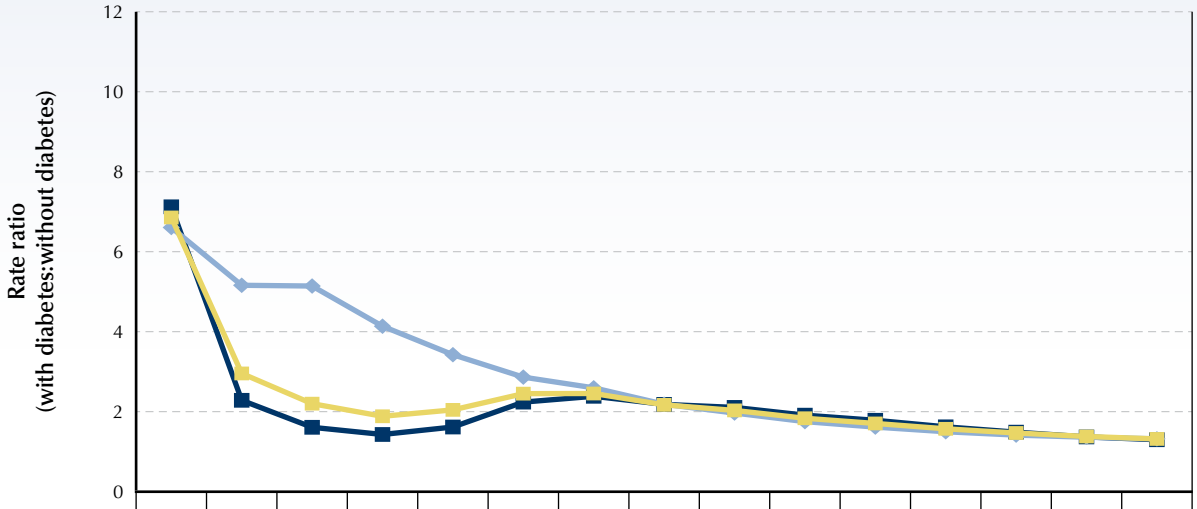


Age group (years)	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
Females	4.7	3.0	2.6	2.2	2.2	2.2	2.1	1.9	1.9	1.7	1.6	1.5	1.4	1.3	1.4
Males	3.9	3.6	3.6	3.3	3.3	2.8	2.6	2.3	2.1	1.9	1.7	1.6	1.5	1.4	1.4
Total	4.2	3.2	3.0	2.6	2.6	2.4	2.2	2.0	2.0	1.8	1.7	1.6	1.4	1.4	1.4

† Data for Quebec were unavailable.
Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Hospital services can be required to treat diabetes when glycemic levels are particularly unstable or when complications lead to acute events. In every age group, individuals with diagnosed diabetes stayed more days in hospital than those without diabetes.[1] In 2006/07, the average length of stay in hospital for younger adults with diabetes (aged 20 to 54 years) was four to six times the number of days stayed by individuals without diabetes. Even after age 65, the average length of stay for individuals with diabetes remained 1.5 to 2.5 times greater than those without diabetes. In 2008/09, the proportion of individuals hospitalized at least once during the year was almost three times higher among those with diabetes than among those without (Figure 3-3). Hospitalizations in children and youth with diabetes were almost seven times higher than in children and youth without diabetes.

Figure 3-3. Rate ratios of hospitalizations† among individuals aged one year and older, by age group, sex, and diabetes status, Canada, 2008/09



Age group (years)	1-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	≥85
Females	7.1	2.3	1.6	1.4	1.6	2.2	2.4	2.2	2.1	1.9	1.8	1.6	1.5	1.4	1.3
Males	6.6	5.2	5.1	4.1	3.4	2.9	2.6	2.2	2.0	1.8	1.6	1.5	1.4	1.4	1.3
Total	6.9	3.0	2.2	1.9	2.0	2.5	2.5	2.2	2.0	1.8	1.7	1.6	1.5	1.4	1.3

† Refers to at least one admission to hospital during the fiscal year.
Source: Public Health Agency of Canada (July 2011); using 2008/09 data from the Canadian Chronic Disease Surveillance System (Public Health Agency of Canada).

Economic costs of diabetes

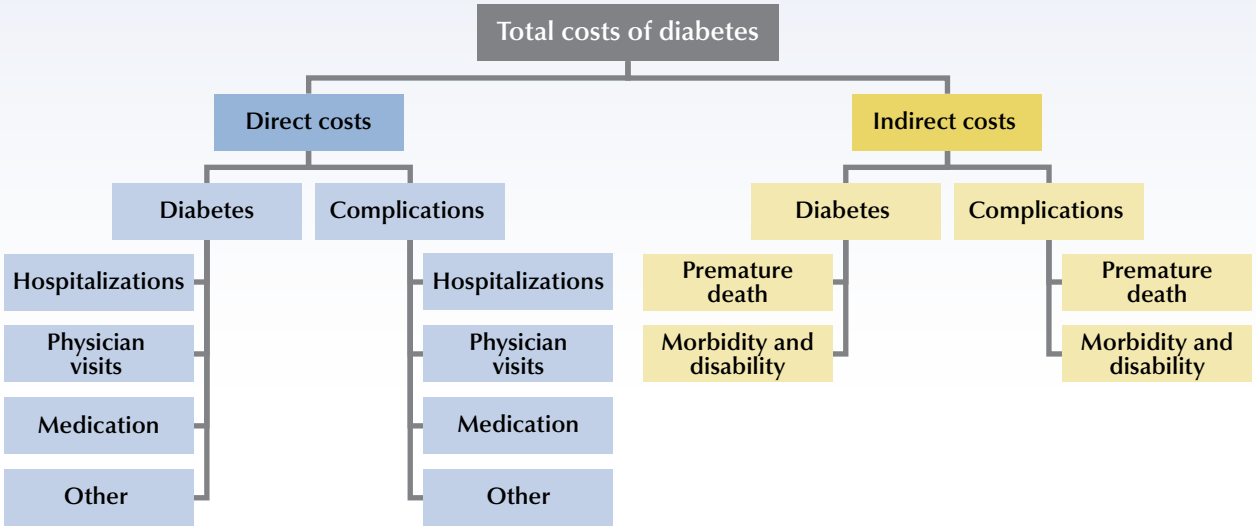
The total economic costs of diabetes are generally divided into direct and indirect costs (Figure 3-4). Direct costs are those associated with health care paid for by public or private health insurances or by individuals and their families. Indirect costs are the non-health care costs that impact the economy and individuals when productivity is lost due to sickness, disability or premature death.

Limitations of economic data

Capturing all the relevant costs of a complex chronic disease like diabetes is challenging. Studies using a variety of methods yield different estimates, not only due to variance in methodology, but also because their samples are typically limited to specific populations.[2] Although the medical billing systems of provinces and territories can be used to estimate the direct costs of health care services, they do not reflect all the relevant and important health services provided for those living with diabetes. For example, diabetes education and nutrition counselling are often provided by non-medical health professionals who are paid through global budgets or private systems. Estimating the indirect costs of a chronic disease such as diabetes is particularly difficult because of the widely varying dollar amounts assigned at the individual level for such things as lost productivity and premature death.

However, the most important limitation to the assessment of the economic costs of diabetes is the lack of recent data. The most comprehensive and recent estimates available when this report was written are based on data that are 11 years old. Attempts to inflate costs to year 2011 Canadian dollar values would not adequately reflect the changing patterns and costs of health service utilization and disease treatment, nor the increased prevalence of diabetes, and therefore would not accurately represent the current costs of diabetes.

Figure 3-4. Components of total, direct, and indirect costs of diabetes



Total costs of diabetes

Data from the Public Health Agency of Canada's Economic burden of illness in Canada (EBIC) 2000[3] provide a conservative estimate of $2.5 billion in year 2000 CAD for the total cost of diabetes, excluding cost associated with diabetes complications. Further to this, because individuals with diabetes are at an increased risk of developing other chronic diseases, factoring in a proportion of the costs incurred to treat these related illnesses, conditions, and complications would result in a larger share of health care costs incurred in a population with diabetes.[4] According to a study conducted in 1998, the total costs of diabetes were 3.6 times higher when the costs associated with long-term complications of diabetes (including neurological disease, peripheral vascular disease, cardiovascular disease, kidney disease, and eye disease) were included.[5] Given the strong association between cardiovascular disease and diabetes, cardiovascular-related care alone was found to account for about a quarter of the total health care costs of individuals with diabetes.[4;5]

Direct costs of diabetes

Direct costs include hospitalizations, drug therapy, physician and emergency room visits, and out-of-pocket costs for supplies and treatment. At the national level, EBIC 2000[3] estimated that the total direct health care costs of diabetes were $769.4 million in year 2000 CAD, for the primary management of diabetes only. Taking into consideration the direct costs of caring for other general medical conditions and complications of diabetes, direct health care costs may be as much as 4.5 times higher than when looking at diabetes alone.[5]

At the individual level, a study estimated annual per capita health care costs to be three to four times greater in a population with diabetes than in a population without the disease.[6] Annual per capita health care costs for type 2 diabetes were found to account for approximately 96% of the total health care costs for all cases of diabetes (both type 1 and type 2) due to the fact that the majority of diabetes cases in Canada are of type 2 diabetes.[7]

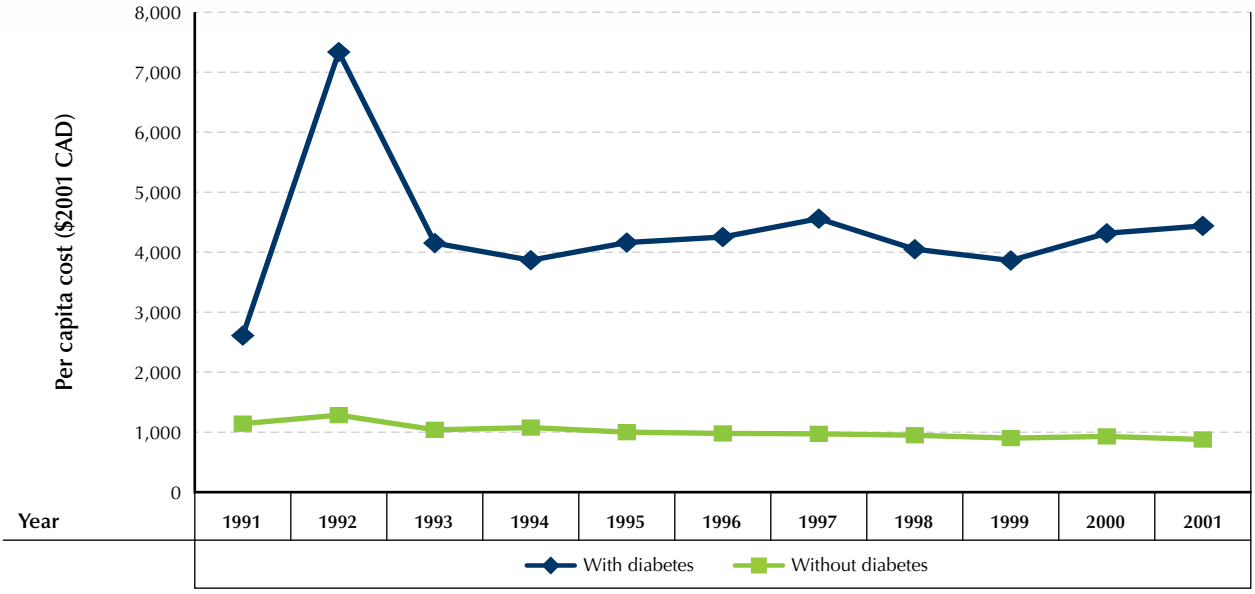
With the aging of the population living with diabetes and an expected increase in long-term complications, the proportion of average per capita health care costs for managing and treating complications, especially costly procedures such as dialysis[8;9] and eye conditions,[5;10] is likely to increase over time. Moreover, Canadian studies have not yet considered costs associated with

mental health, despite the high prevalence of depression in individuals with diabetes, and the fact that individuals with both diabetes and depression are known to require more health services.[11;12]

Direct costs by disease progression

A study based on Saskatchewan data has shown that annual health care costs for individuals with diabetes rise significantly in the first year following diagnosis, decline in the following year, then show minor increases over time (Figure 3-5). The initial spike indicated that costs almost tripled in the first year after diagnosis, likely reflecting hospital care needed in response to the initial diagnosis of type 1 or type 2 diabetes. The minor increases over the years reflect increases in the costs attributable to medication required for the treatment of diseases, day surgeries and dialysis.

Figure 3-5. Annual per capita health care costs of diabetes cases diagnosed in 1992†, Saskatchewan, 1991 to 2001



† The Canadian Chronic Disease Surveillance System diabetes case definition was applied to administrative databases in order to identify incident diabetes cases in 1992. Per capita health care costs (in year 2001 CAD) were estimated one year before the identification of the incident cases (1991) and for ten years afterwards (1992–2001).

Source: Public Health Agency of Canada (2011); adapted from Johnson JA, Pohar SL, Majumdar SR. Health care use and costs in the decade after identification of type 1 and type 2 diabetes: A population-based study. *Diabetes Care*. 2006;29:2403-2408.

Direct costs by cost category

Hospital care accounts for the largest proportion of the total per capita direct health care costs of diabetes.[6;7] At the national level, according to EBIC data, hospital costs attributed to diabetes were valued at $350.1 million, medication spending at $246.4 million and physician care costs at $172.9 million in year 2000 CAD.[3]

Other personal out-of-pocket expenses

Some expenses fall to individuals or families living with diabetes, such as the costs of medication and testing supplies. These expenses are difficult to estimate, and very little has been published on this subject. While some of these expenses may in part be covered by provincial or territorial drug plans,[13;14] programs for individuals living with disability, other social protection programs, or personal insurance plans, the Canadian Diabetes Association/Diabète Québec estimates that an individual with type 2 diabetes can face direct, annual out-of-pocket costs averaging $2,300 in year 2010 CAD.[15]

Indirect costs of diabetes

The indirect costs of diabetes are those related to short- and long-term disability and lost productivity due to illness or premature death. EBIC 2000 estimated that indirect costs of diabetes amounted to $1.7 billion in year 2000 CAD.[3] More than $1.0 billion was attributed to premature death and $671.7 million to long- and short-term disability directly related with diabetes.[3] However, EBIC 2000 did not take into account the indirect costs of complications, which are the main causes of disability and premature death for diabetes. Due to this limitation, EBIC 2000 presents an underestimation of the total indirect costs of the diseases and its complications. In coming years, indirect costs of diabetes could become even more important as more Canadians are being diagnosed at an earlier age (Chapter 1, Diabetes incidence), which may imply that the indirect costs due to loss in productivity will increase.

Looking ahead

Expenditures on hospitalizations, medications, diagnostic services, physician services and other out-of-hospital health services are generally higher in a population with diabetes than in a population without diabetes. Out-of-pocket expenses and lost productivity due to illness, disability and premature death are also generally higher among individuals living with diabetes. While these cost figures for diabetes are already substantial, there is evidence that costs have, and will continue to, greatly increase in the coming years due to the increased prevalence of diabetes in Canada (Chapter 1, Diabetes prevalence) and the aging of the population.[4;16] However, the burden of diabetes on the health care system and the overall economy will increase beyond what can be anticipated from these two factors. Although diabetes in older populations may be a large driver of health care costs, treatment and management of diabetes comorbidities and complications – particularly cardiovascular disease – certainly represent one of the main contributors to costs. In addition, both the direct and indirect costs of diabetes may increase due to a trend toward earlier diagnosis of the disease (Chapter 1, Diabetes incidence). This implies longevity with diabetes, with potential impacts during the years spent in the workforce.

Reducing the prevalence of risk factors associated with diabetes, such as obesity, physical inactivity and smoking, would reduce the incidence of type 2 diabetes, and in turn, its associated costs.[20] Evidence also shows that complications of both type 1[17;18] and type 2 diabetes[19] can be reduced through intensive management (Chapter 2). Therefore, it makes economic sense to invest in effective multi-factorial strategies[21;22] early in the course of the disease to improve health outcomes and reduce future health care costs.[16] The Canadian Best Practices Portal (http://cbpp-pcpe.phac-aspc.gc.ca/about-eng.html) highlights quality health-related programs designed with a population-health focus.

Cost estimates allow not only for better assessments of the relative cost-effectiveness of these interventions and strategies,[16;23] but also for better planning for anticipated future demands on the health care systems. To date, the undertaking of economic analyses has been limited by the lack of comprehensive and timely data on the costs of diabetes in Canada.[16;24;25] Overall, more work is needed in Canada to obtain up-to-date and precise estimates of the costs of disease. As one mean to address this gap in knowledge, EBIC data will be updated in an online cost estimation tool that will be available on the Public Health Agency of Canada website (http://www.phac-aspc.gc.ca/) for public use.

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Chapter 4

Reducing the risk of type 2 diabetes and its complications

Introduction

Type 2 diabetes is caused by a combination of genetic, behavioural and environmental factors. Although no cure exists, there is growing evidence that type 2 diabetes and its complications can be prevented through the reduction of key risk factors. Currently, all the risk factors for type 1 diabetes are not well known, but researchers believe that interactions between genetic and environmental factors are involved (Chapter 5).[1]

Risk factors for type 2 diabetes can be classified as modifiable and non-modifiable. Modifiable risk factors are those that can be changed to reduce an individual's risk of developing type 2 diabetes and include unhealthy weight, physical inactivity, unhealthy eating, and smoking. Non-modifiable risk factors are individual characteristics, such as age, ethnicity, and family history of the disease. Research aimed at better understanding the multiple causes and their interactions continues. Understanding the distribution of risk factors within the population is useful for predicting future trends in type 2 diabetes incidence and prevalence, as well as trends in diabetes complications and mortality. It also provides information that can help in the planning of prevention interventions.

Key modifiable risk factors for type 2 diabetes

Overweight and obesity

Overweight, and particularly obesity, is the most important risk factor for type 2 diabetes and its complications. Excess body weight impairs the effectiveness of insulin use in the body, leading to increased demand on the pancreas to produce insulin. This demand cannot be met indefinitely and insulin production eventually declines, leading to type 2 diabetes. Overweight and obesity also increase an individual's risk of other chronic diseases, such as cardiovascular disease, arthritis, sleep and breathing disorders, depression, and some cancers.[2;3]

When the energy consumed through foods is not balanced by energy expended through physical activity, unused calories are stored in the body as fat, which can accumulate in excess and results in overweight and obesity (Box 4-1). However, the causes of overweight and obesity are complex. Although unhealthy eating and physical inactivity contribute directly to weight gain, many factors influence these behaviours, including individual, environmental, societal, and cultural factors.

Box 4-1. Body mass index

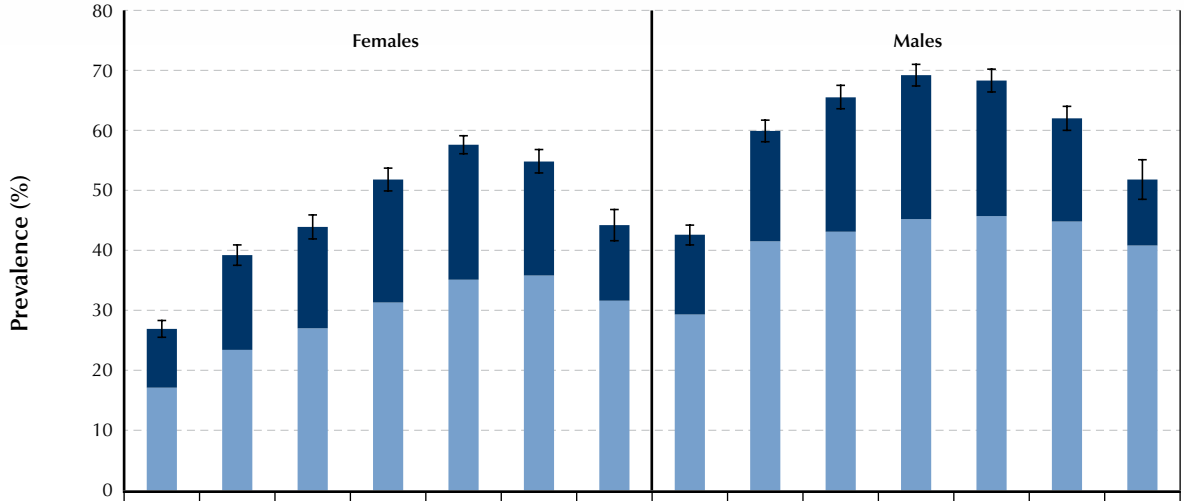
The body mass index (BMI) is used to classify individuals as underweight, normal weight, overweight, or obese in this report. The BMI is a unit of measurement that describes an individual's weight in relation to height, and is calculated by dividing weight in kilograms by the square of the height in metres (kg/m^2). The WHO and Health Canada use standard categories to classify the BMI for adults aged 18 years and older (excluding pregnant women):

Underweight	BMI <18.5 kg/m^2
Normal weight	$18.5 \leq$ BMI <25.0 kg/m^2
Overweight	$25.0 \leq$ BMI <30.0 kg/m^2
Obese	BMI ≥ 30.0 kg/m^2

Overweight and obesity by age

Among Canadians, the prevalence of self-reported obesity increases steadily through adulthood, peaking in individuals aged 60 to 69 years and declining thereafter (Figure 4-1). In 2009–2010, the prevalence of obesity in the 60 to 69 year age group was 22.5% for females and 22.6% for males. Overall, males were significantly more likely to be overweight or obese than females at every age. This difference was mostly due to the much higher proportion of males (40.6%) who self-reported being overweight compared to females (27.2%), as the proportion of males who self-reported being obese (19.5%) was comparatively similar to that of females (16.7%).

Figure 4-1. Prevalence† of self-reported overweight and obesity‡ among individuals aged 18 years and older, by age group and sex, Canada, 2009–2010



Age group (years)	18-29	30-39	40-49	50-59	60-69	70-79	≥80	18-29	30-39	40-49	50-59	60-69	70-79	≥80
Obese	9.8	15.8	16.9	20.5	22.5	19.0	12.6	13.3	18.4	22.4	24.0	22.6	17.2	11.0
Overweight	17.1	23.4	27.0	31.3	35.1	35.8	31.6	29.3	41.5	43.1	45.2	45.7	44.8	40.8

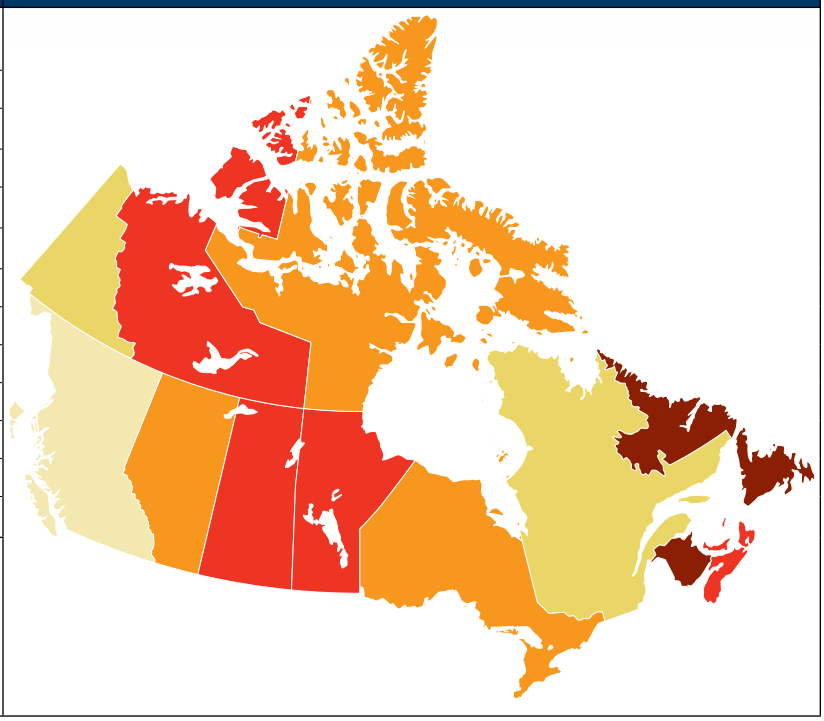
† 95% confidence intervals were based on a proportion that included both overweight and obesity.
‡ Overweight based on a BMI greater than or equal to 25.0 kg/m² but less than 30.0 kg/m²; obesity based on a BMI greater than or equal to 30.0 kg/m².
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Overweight and obesity by province/territory

The geographic distribution of individuals who are overweight or obese is similar to the geographic distribution of individuals with diagnosed diabetes (Chapter 1, Figure 1-2). In 2009–2010, the highest proportions of individuals with self-reported obesity were generally found in the Atlantic provinces, Saskatchewan, Manitoba, and the Northwest Territories (Figure 4-2).

Figure 4-2. Age-standardized† prevalence of self-reported overweight and obesity‡ among individuals aged 18 years and older, by province/territory, Canada, 2009–2010

	Age-standardized prevalence (%)
Newfoundland and Labrador	62.3
Prince Edward Island	55.7
Nova Scotia	57.9
New Brunswick	61.5
Quebec	48.0
Ontario	50.6
Manitoba	58.3
Saskatchewan	58.1
Alberta	52.9
British Columbia	42.9
Yukon	49.0
Northwest Territories	56.7
Nunavut	54.7



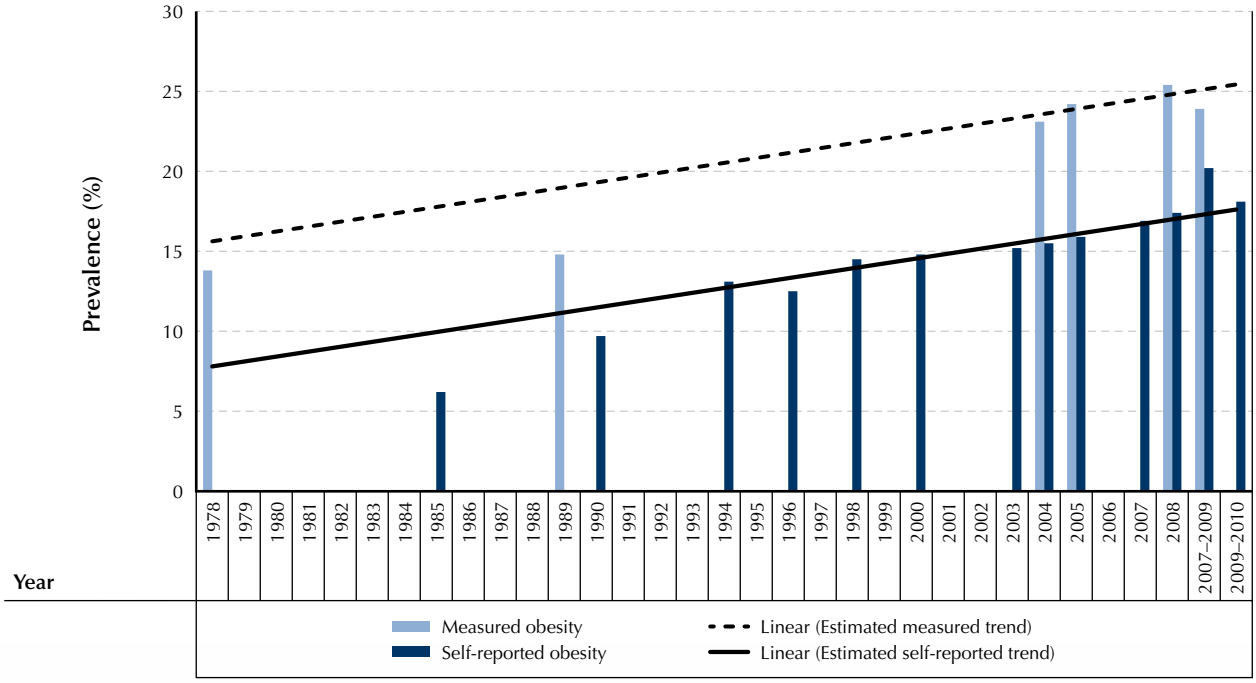
† Age-standardized to the 1991 Canadian population.
‡ Overweight and obesity based on a BMI greater than or equal to 25.0 kg/m^2.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Overweight and obesity over time

Over the last 30 years, there have been significant increases in the rates of overweight and obesity in the Canadian population, including children and youth. The proportion of adolescents aged 12 to 17 years shown to be obese by physical measurements tripled from 3% in 1978 to 9.4% in 2004.[4] Overweight and obesity in adolescence often persists into adulthood,[5-8] placing these individuals at risk of type 2 diabetes and other chronic diseases.[9;10] This increase in obesity is likely contributing to the emergence of type 2 diabetes in youth, a disease that was previously viewed as an adult-onset disease only (Chapter 5, Type 2 diabetes).

Both measured and self-reported obesity among the Canadian population aged 18 years and older increased between 1978 and 2009–2010 (Figure 4-3). Based on self-reported weight and height, 18.1% of adults aged 18 years and older were obese in 2009–2010. However, self-reported measures are known to underestimate the true prevalence of obesity, which can only be obtained through physical measurements. In 2007–2009, based on measured height and weight, almost one in four (23.9%) Canadian adults aged 18 years and older was obese.

Figure 4-3. Prevalence of obesity† (measured, self-reported, and estimated) among individuals aged 18 years and older‡, Canada, 1978 to 2009–2010

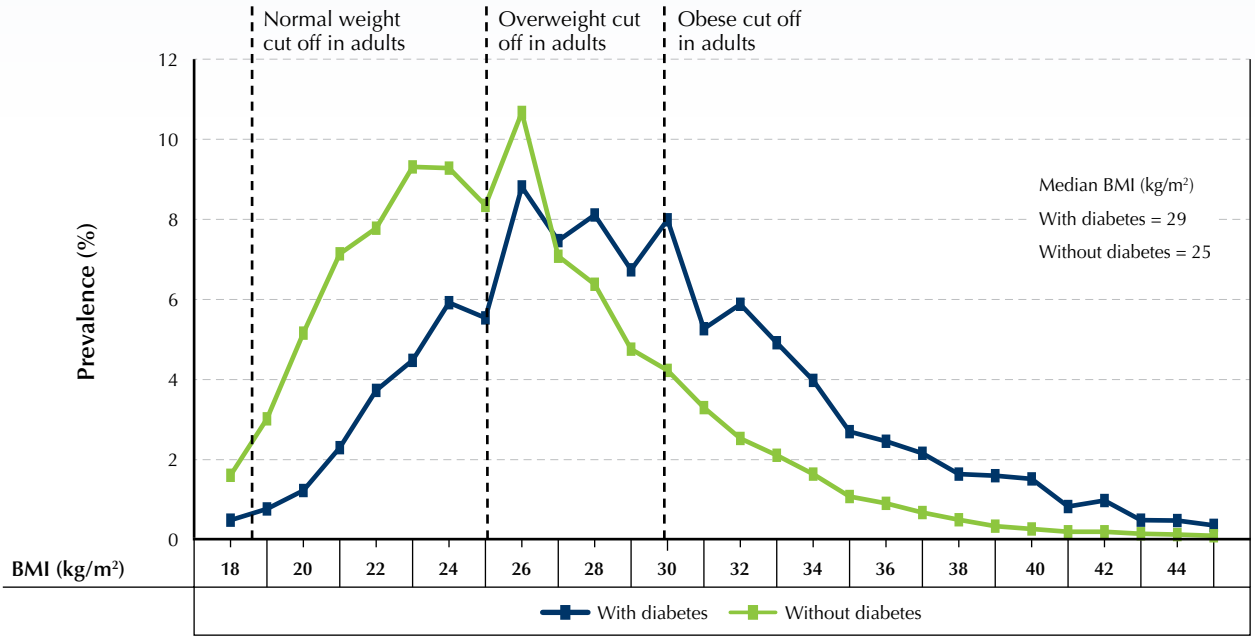


† Based on a BMI greater than or equal to 30.0 kg/m².
‡ Data from the 1989 Canadian Heart Health Survey were based on respondents aged 18 to 74 years.
Source: Public Health Agency of Canada (2011); using measured data from the 1978/79 Canada Health Survey (Statistics Canada), 1989 Canadian Heart Health Survey (Statistics Canada), 2004 Canadian Community Health Survey – Nutrition (Statistics Canada), 2005 Canadian Community Health Survey (Statistics Canada), 2008 Canadian Community Health Survey (Statistics Canada), and 2007-2009 Canadian Health Measures Survey (Statistics Canada); using self-reported data from the 1985 and 1990 Health Promotion Survey (Statistics Canada), 1994/95, 1996/97 and 1998/99 National Population Health Survey (Statistics Canada); 2000/01, 2003, 2005, 2007, 2008, 2009–2010 Canadian Community Health Survey (Statistics Canada), and 2007–2009 Canadian Health Measures Survey (Statistics Canada).

Diabetes and overweight/obesity

Figure 4-4 shows the distribution of BMI for Canadian adults with and without diabetes. The median BMI of 25 kg/m² for Canadians without diabetes indicates that half of all Canadian adults without diabetes are overweight or obese. The median BMI for Canadians with diabetes is four units (kg/m²) higher, at 29 kg/m². In this case, more than three quarters (75.6%) of Canadians with diabetes are classified as overweight or obese.

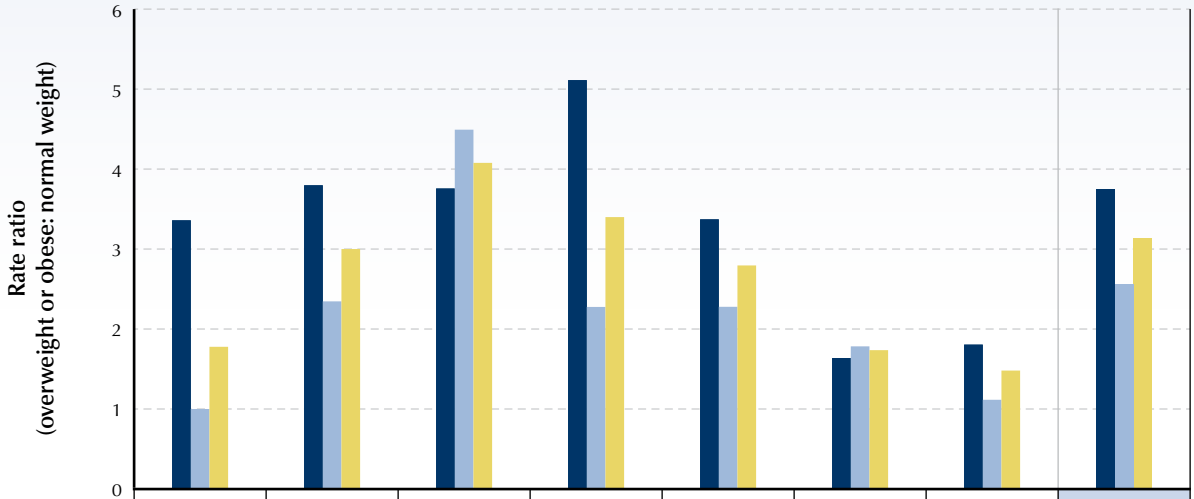
Figure 4-4. Distribution of self-reported body mass index (BMI)† among individuals aged 18 years and older, by diabetes status, Canada, 2009–2010



† Marginal variance estimates for BMI greater than 40 kg/m²; data should be interpreted with caution.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

At every age, the prevalence of diabetes is higher among individuals who are overweight or obese (Figure 4-5). The association is more pronounced among females than males. Among males aged 18 years and older, the prevalence of diabetes among overweight or obese individuals is 2.6 times higher than among those who are of normal weight (9.7% versus 3.8%), while among females aged 18 years and older the prevalence is nearly four times higher among overweight or obese individuals than among those with normal weight (9.6% versus 2.6%).

Figure 4-5. Rate ratios of self-reported diabetes among individuals aged 18 years and older who were overweight and obese versus normal weight†, by age group‡ and sex, Canada, 2009–2010



Age group (years)	18-29	30-39	40-49	50-59	60-69	70-79	≥80	Canada
Females	3.4	3.8	3.8	5.1	3.4	1.6	1.8	**3.7**
Males	1.0	2.3	4.5	2.3	2.3	1.8	1.1	**2.6**
Total	1.8	3.0	4.1	3.4	2.8	1.7	1.5	**3.1**

† Based on a BMI cut-off of 25 kg/m^2.
‡ Marginal variance estimates for data in age groups less than 60–69 years; data should be interpreted with caution.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Physical inactivity

Physical activity helps an individual maintain a healthy weight, strengthen the body, and reduce stress, as well as prevent chronic diseases (including type 2 diabetes), complications, and premature death.[11] Physical activity has also been shown to improve glycemic control, decrease insulin resistance, lower blood pressure, and improve blood lipid levels, regardless of body weight.[12;13;14]

To obtain health benefits, the Canadian Physical Activity Guidelines recommend that children and youth aged five to 17 years practice at least 60 minutes of physical activity (moderate to vigorous intensity) per day; adults should practice at least 150 minutes of aerobic physical activity (moderate to vigorous intensity) in total per week.[15] Physical activity recommendations for individuals with diabetes are presented in the Canadian Diabetes Association clinical practice guidelines.[16]

Given its importance for preventing and managing type 2 diabetes, understanding the barriers to physical activity among Canadians is essential to the development of interventions to encourage regular physical activity. The 2007 Physical Activity Monitor[17] identified the most frequently reported barriers to physical activity for adults in the general population as:

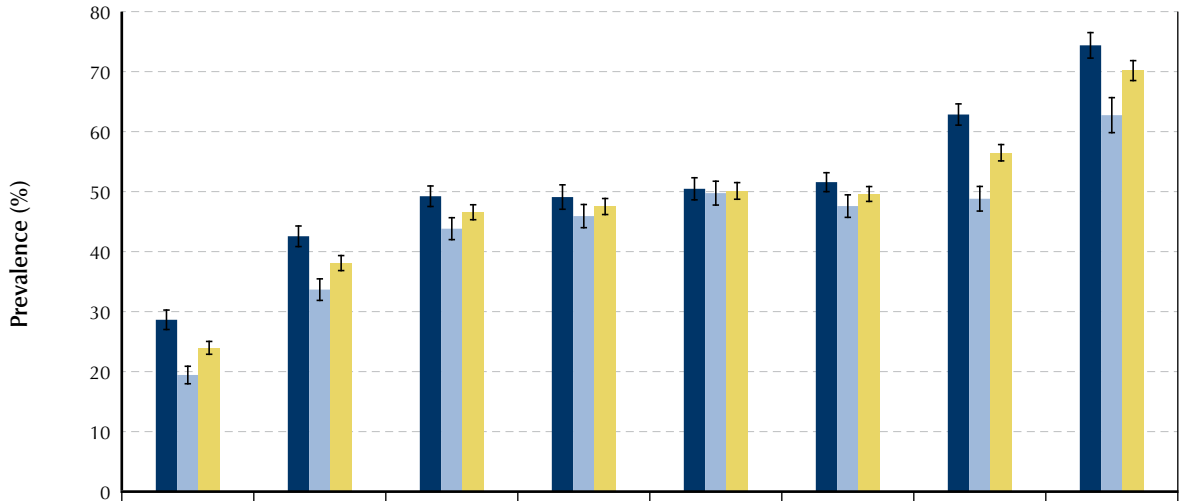
- Lack of time (72%);
- Lack of energy, or fatigue (64%);
- Lack of interest or motivation (62%);
- Long-term illness, injury or disability (60%);
- Cost (41%);
- Feeling ill at ease or uncomfortable (40%);
- Fear of injury (34%); and
- Lack of physical skill (34%).

The barriers to children's physical activity, as reported by parents, were different from those of adults. Safety concerns – such as too much traffic, poorly maintained sidewalks and bike lanes, and poor lighting – ranked highest while perception of a child's lack of skill for doing physical activity ranked lowest.

Physical inactivity by age

In 2009–2010, almost half (45.2%) of Canadians aged 12 years and older reported that they were inactive (leisure and transportation index)[i]. Although youth (aged 12 to 19 years) were more active than adults, almost a quarter (24.0%) were physically inactive. A higher proportion of females aged 12 to 19 (28.6%) than males aged 12 to 19 (19.4%) were physically inactive. Physical activity decreased with advancing age, and females were more inactive than males across all age groups (Figure 4-6).

Figure 4-6. Prevalence of self-reported physical inactivity† among individuals aged 12 years and older, by age group and sex, Canada, 2009–2010



Age group (years)	12-19	20-29	30-39	40-49	50-59	60-69	70-79	≥80
Females	28.6	42.6	49.2	49.1	50.5	51.6	62.9	74.4
Males	19.4	33.7	43.8	45.9	49.8	47.6	48.8	62.7
Total	24.0	38.1	46.6	47.5	50.1	49.6	56.5	70.2

† Based on a leisure and transportation index measure.
Source: Public Health Agency of Canada (2011); using 2009-2010 data from the Canadian Community Health Survey (Statistics Canada).

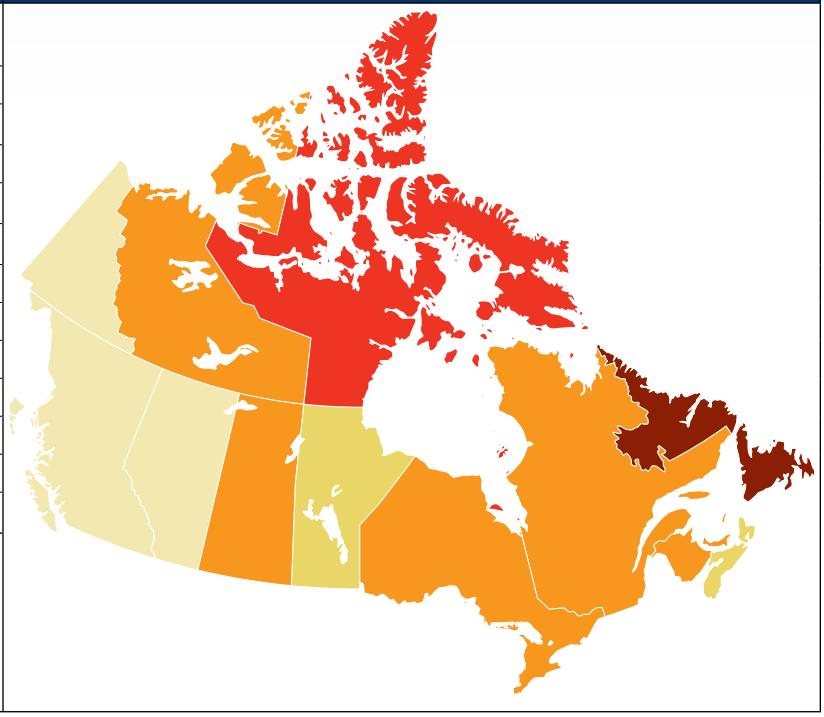
i This measure likely underestimates true daily energy expenditure since it does not capture energy expended in usual daily activities, including work activities.

Physical inactivity by province/territory

The geographical distribution of physical inactivity was similar to that of obesity, with the proportion of the population reporting physical inactivity (leisure and transportation index) generally increasing from west to east and higher in the Northwest Territories and Nunavut (Figure 4-7).

Figure 4-7. Age-standardized† prevalence of self-reported physical inactivity‡ among individuals aged 12 years and older, by province/territory, Canada, 2009–2010

	Age-standardized prevalence (%)
Newfoundland and Labrador	50.0
Prince Edward Island	45.9
Nova Scotia	43.1
New Brunswick	45.5
Quebec	46.0
Ontario	46.3
Manitoba	43.7
Saskatchewan	45.0
Alberta	41.3
British Columbia	36.6
Yukon	38.7
Northwest Territories	45.7
Nunavut	49.6



† Age-standardized to the 1991 Canadian population.
‡ Based on a leisure and transportation index measure.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Unhealthy eating

Healthy weights depend on the balance of calories consumed with energy expended. Unhealthy food choices can increase the risk of diabetes, particularly when over-consumption results in overweight or obesity. Conversely, healthy eating can play an important role in the prevention of many chronic diseases. Consumption of vegetables and fruit, nuts, legumes, fish/seafood, whole grains, poultry, low-fat dairy products are all part of a healthy diet, as defined within *Eating well with Canada's Food Guide*.[18] Soluble fibre, found in foods such as citrus fruits, berries, legumes, oats, and brown rice, helps to regulate glycemia.[19] Foods that are rich in fibre can help to control weight and may reduce the risk of type 2 diabetes. Fibre also lowers total blood cholesterol and protects against heart disease.[20] Some evidence suggests that a lack of vitamin D hinders insulin function and glycemic control, and is a potential risk factor of type 1 and type 2 diabetes.[21;22]

Negative food choices include excessive alcohol consumption and consumption of processed foods. A recent study implicates red meat as a risk factor for type 2 diabetes. After controlling for other lifestyle and dietary factors as well as age and BMI, daily consumption of unprocessed red meat increased risk of diabetes by 19%, while processed red meat increased risk by 51%.[23] Consumption of fat should be limited to less than 35% of total calories consumed.[24] Although daily fat intake represented 31% of caloric intake in 2004, Canadians still exceeded the upper limit for fat intake because overall caloric intake remained above recommended levels. The 31 to 50 year age group had the largest proportion of males (27%) and females (28%) who consumed excess fat. The main sources of fat for adults were from the "meat and alternatives" food group, followed by the "other foods" category, which included salad dressings, butter, margarine, and vegetable oils.[24] The combination of diabetes and hyperlipidemia can increase the risk of cardiovascular disease and kidney disease.

Many factors influence food choices and eating patterns among Canadians, including:

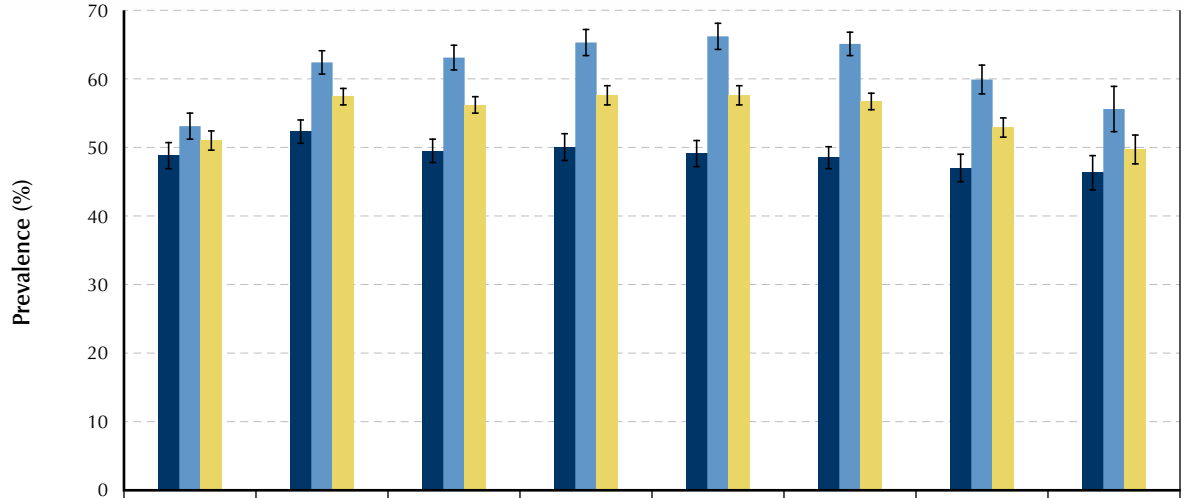
- Awareness of the connections between nutrition and health (nutritional knowledge);
- Perceptions of healthy eating based on current dietary guidance, importance given to freshness, unprocessed and homemade foods, and cultural/traditional meanings attached to foods and health;
- Exposure to media advertising or vendors promoting and selling individual products that tend to be high in energy and low in nutrients; and
- Lower socio-economic status and social inequity, which have been linked to poorer diet and nutritional status and have led to community initiatives such as food policy councils.[25]

Inadequate daily consumption of vegetables and fruit is used as a proxy measure of unhealthy diet. A criticism of this measure is its use of an outdated recommendation of at least five servings daily, which has now been increased to seven to eight servings daily. Further, the CCHS did not examine the quantity consumed, but only indicated the number of times vegetables or fruit are consumed. However, this indicator has been found to be an acceptable proxy for healthy eating habits due to its correlation to the Healthy eating index.[26] A diet that includes vegetables and fruit may help prevent obesity. Also, low frequency of vegetable and fruit consumption is associated with other lifestyle risk factors such as physical inactivity, tobacco smoking, and obesity.[27]

Unhealthy eating by age

Age-standardized rates of vegetable and fruit consumption indicated a marginal improvement over time. Between 2003 and 2010, 58.7% to 56.4% of Canadians did not eat enough vegetables and fruit. Males consistently consumed less vegetables and fruit compared to females.[28] More importantly, in 2009–2010, more than half of Canadians aged 12 years and older (55.9%) were still reporting eating less than the recommended five servings of vegetables and fruit a day. Compared to males, a greater proportion of females aged 12 years and older met the recommendations in every age group, but still almost half (49.5%) did not meet the recommendations. Almost two-thirds (62.6%) of males aged 12 years and older did not meet the recommendations (Figure 4-8).

Figure 4-8. Prevalence of self-reported inadequate vegetable and fruit consumption† among individuals aged 12 years and older, by age group and sex, Canada, 2009–2010



Age group (years)	12-19	20-29	30-39	40-49	50-59	60-69	70-79	≥80
Females	48.8	52.3	49.5	50.0	49.1	48.5	47.0	46.3
Males	53.1	62.4	63.1	65.3	66.2	65.1	59.9	55.6
Total	51.0	57.4	56.2	57.6	57.6	56.7	52.9	49.7

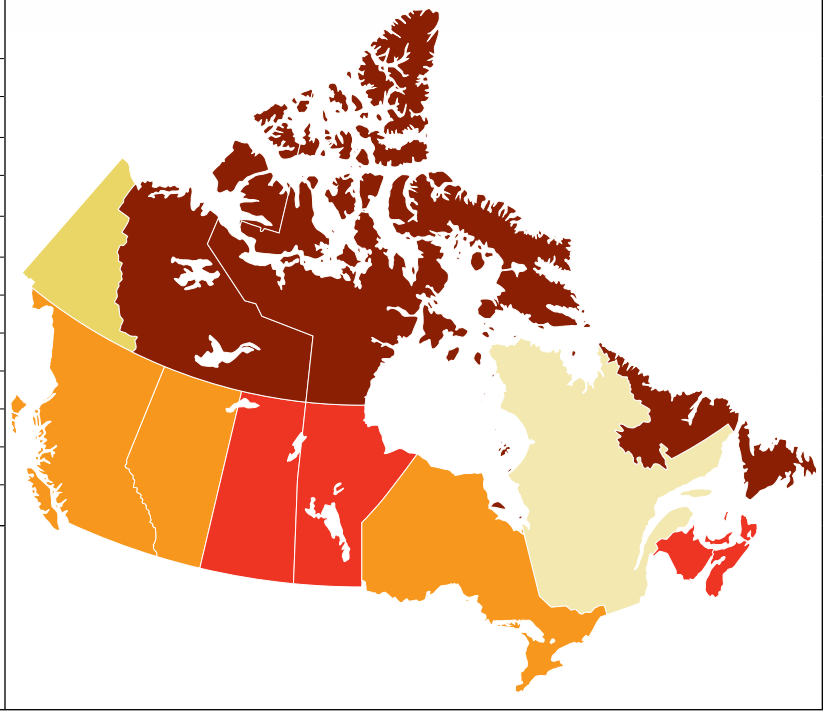
† Based on a vegetable and fruit consumption of less than five times per day.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Unhealthy eating by province/territory

Rates of inadequate vegetable and fruit consumption vary across the country with the highest rates in Newfoundland and Labrador, Nunavut, and the Northwest Territories. The scarcity of fresh vegetables and fruit and the dietary patterns of the Aboriginal population may explain lower consumption rates in the northern areas (Figure 4-9).

Figure 4-9. Age-standardized† prevalence of self-reported inadequate vegetable and fruit consumption‡ among individuals aged 12 years and older, by province/territory, Canada, 2009–2010

	Age-standardized prevalence (%)
Newfoundland and Labrador	69.7
Prince Edward Island	63.3
Nova Scotia	63.9
New Brunswick	61.0
Quebec	47.2
Ontario	57.4
Manitoba	63.6
Saskatchewan	61.0
Alberta	58.6
British Columbia	55.6
Yukon	50.1
Northwest Territories	71.1
Nunavut	75.1



† Age-standardized to the 1991 Canadian population.
‡ Based on a vegetable and fruit consumption of less than five times per day.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Tobacco smoking

Cigarette smoking can increase glycemic levels, impair insulin sensitivity, and promote abdominal obesity,[29] and has been associated with an increased risk of type 2 diabetes.[30;31] The combination of diabetes and cigarette smoking can increase the risk of some of the most serious complications of diabetes: cardiovascular disease, kidney disease, and neuropathy.[32] Thus, smoking cessation is a key element of type 2 diabetes prevention and management.[16]

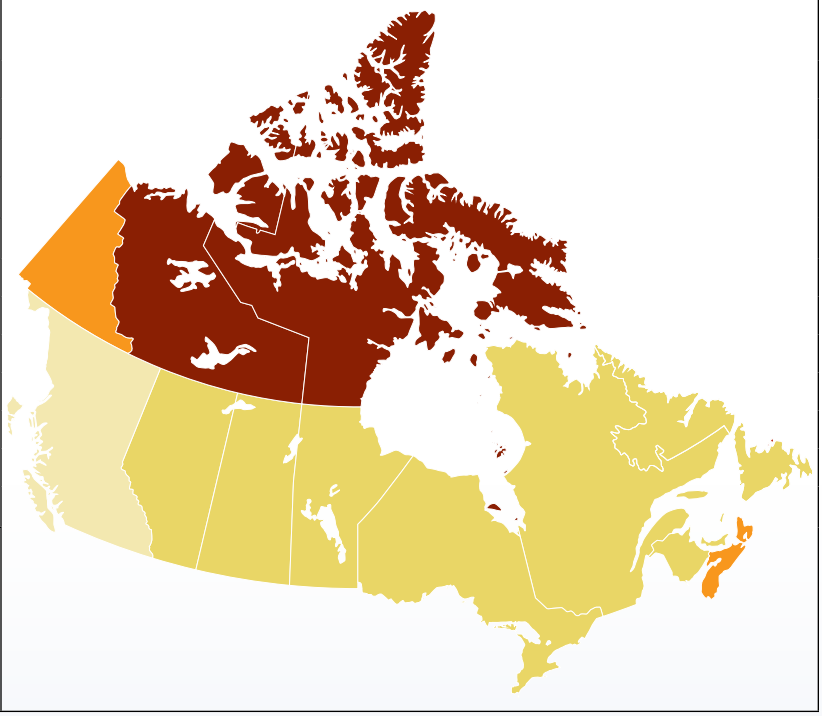
Tobacco smoking by province/territory

The Canadian Tobacco Use Monitoring Survey (CTUMS) is a Health Canada survey specific to the surveillance of tobacco smoking in Canada. Based on CTUMS data, in 2009, 13.6% of Canadians aged 15 years and older were daily tobacco smokers (12.1% of females; 15.1% of males). However, because CTUMS currently does not survey the territories, all subsequent statistics on tobacco smoking in this report are based on CCHS data.

Based on the CCHS, the proportion of individuals who smoked daily varied by province/territory. In 2009–2010, the lowest rates of smoking among individuals aged 18 years and older was reported in British Columbia, Ontario, and Manitoba. The rates of daily tobacco smoking were below 24% in all provinces, while in the territories the rates were all above 30% (Figure 4-10).

Figure 4-10. Age-standardized† prevalence of self-reported daily tobacco smoking among individuals aged 18 years and older, by province/territory, Canada, 2009–2010

	Age-standardized prevalence (%)
Newfoundland and Labrador	19.4
Prince Edward Island	18.6
Nova Scotia	20.8
New Brunswick	19.9
Quebec	18.0
Ontario	15.4
Manitoba	15.9
Saskatchewan	19.1
Alberta	18.0
British Columbia	13.3
Yukon	23.8
Northwest Territories	34.4
Nunavut	50.3

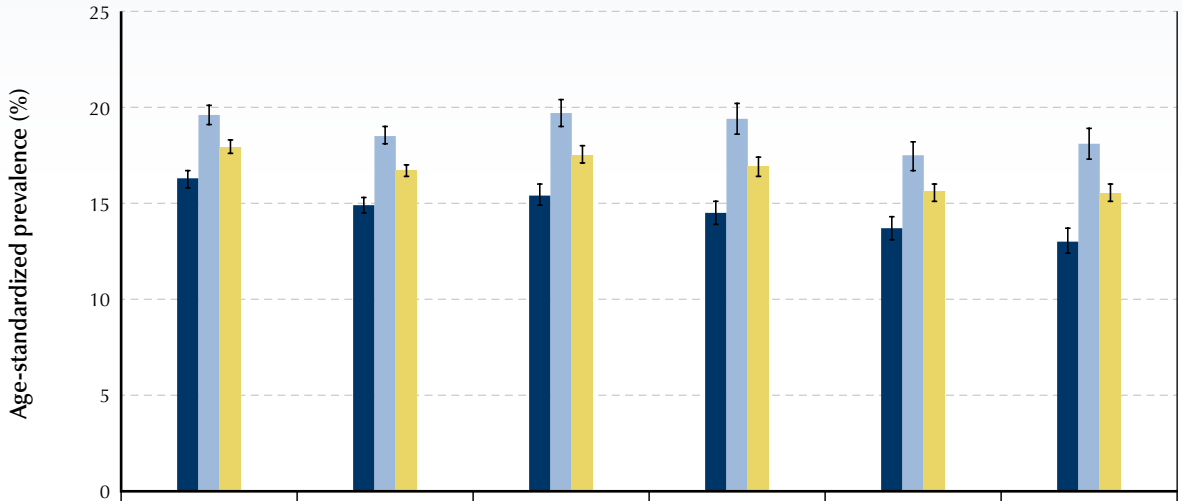


† Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Tobacco smoking over time

Rates of smoking have been declining in Canada, although the decline was more pronounced for females when compared to males (Figure 4-11). Based on age-standardized CCHS data, in 2010 15.5% of Canadians aged 12 years and older were daily tobacco smokers (13.0% of females; 18.1% of males).

Figure 4-11. Age-standardized† prevalence of self-reported daily tobacco smoking among individuals aged 12 years and older, by sex, Canada, 2003 to 2010



Year	2003	2005	2007	2008	2009	2010
Females	16.3	14.9	15.4	14.5	13.7	13.0
Males	19.6	18.5	19.7	19.4	17.5	18.1
Total	17.9	16.7	17.5	16.9	15.6	15.5

† Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (2011); using 2003, 2005, 2007, 2008, 2009, and 2010 data from the Canadian Community Health Survey (Statistics Canada).

Populations at risk for type 2 diabetes

Individuals with pre-diabetes

Pre-diabetes is a state in which an individual's fasting glycemic levels and/or response to a fasting glucose tolerance test are higher than normal, but not high enough for a diagnosis of diabetes. Pre-diabetes is diagnosed if IFG, measured by a fasting plasma glucose (FPG) test, is between 6.1 mmol/L and 6.9 mmol/L or if IGT, measured by a oral glucose tolerance test (OGTT), is between 7.8 mmol/L and 11.0 mmol/L.[16] An individual may have pre-diabetes without knowing it because it is asymptomatic and can only be detected through specific blood tests.

Individuals with pre-diabetes are five to ten times more likely to progress to type 2 diabetes than those with normal glycemic levels,[33] and are also at an increased risk of cardiovascular disease. Only 3% to 5% of individuals with normal glycemic levels will typically develop type 2 diabetes over eight to ten years, whereas 30% of pre-diabetes cases with either IFG or IGT will develop the disease. For high-risk pre-diabetes cases involving

both IFG and IGT, the conversion rate is 60% – 20 times higher than among individuals with normal glycemic levels.[34] These individuals can benefit most from early detection and intervention to prevent or delay the onset of type 2 diabetes and its complications.

It is estimated that pre-diabetes affects roughly 5.0 million Canadians over the age of 20 years. This number is expected to grow significantly over the next decade – to 6.3 million Canadians by 2016, according to some estimates.[35] Among those aged 40 to 74 years, the prevalence is expected to increase by 43.3%, from about 3.0 million in 2004 to 4.3 million in 2016. The forecast increases are largely due to the aging of the population, the growth in obesity, and the increase in non-white ethnicity.

Individuals with metabolic syndrome

Researchers have identified a set of conditions that often occur together and greatly increase the risk of type 2 diabetes and cardiovascular disease.[36] This constellation of risk factors is known as the metabolic syndrome (Box 4-2).

Box 4-2. Clinical criteria for the diagnosis of metabolic syndrome

The presence of three or more of these risk factors indicates a diagnosis of metabolic syndrome:	
• Elevated waist circumference	≥102 cm in males; ≥88 cm in females
• Elevated triglycerides†	≥1.7 mmol/L
• Reduced high-density lipoprotein (HDL) cholesterol†	<1.0 mmol/L in males; <1.3 mmol/L in females
• Elevated blood pressure†	systolic ≥130 mmHg and/or diastolic ≥85 mmHg
• Elevated fasting plasma glucose†	≥5.6 mmol/L

† Drug treatment to control elevated triglycerides, HDL, blood pressure, and plasma glucose can also be considered as an alternate indicator for these risk factors.

Source: Public Health Agency of Canada (2011); adapted from Alberti KG, Eckel RH, Grundy SM, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* 2009;120:1640-1645.

The risk factors for metabolic syndrome – age, family history, overweight or obesity, unhealthy eating and physical inactivity – have been linked to both type 2 diabetes and cardiovascular disease. It is important for individuals to recognize symptoms early and to undertake lifestyle changes, including weight loss and physical activity, to reduce potential risks of both type 2 diabetes and cardiovascular disease. According to laboratory measures from the 2007–2009 CHMS, 15.2% of Canadians met the clinical criteria for metabolic syndrome[ii] (Table 4-1).

ii This analysis did not include drug treatments for elevated triglycerides, HDL, blood pressure, and plasma glucose as alternate indicators for metabolic syndrome risk factors; thus, it likely underreports the true prevalence of metabolic syndrome.

Table 4-1. Proportion of exceeded cut points for metabolic syndrome among individuals aged 20 years and older, by sex and measure, Canada, 2007–2009

	Proportion (%) exceeding cut point			Proportion (%) meeting the criteria† for metabolic syndrome		
	Females	Males	Total	Females	Males	Total
Elevated waist circumference	42.0	31.7	36.8	15.9	14.5	15.2
Elevated triglycerides	22.4	21.8	22.1			
Reduced high density lipoproteins	36.1	25.4	30.8			
Elevated blood pressure	14.6	17.8	16.2			
Elevated fasting glucose	12.7	19.4	16.0			

† Presents with at least three out of five risk factors.
Source: Public Health Agency of Canada (2011); using 2007–2009 data from the Canadian Health Measures Survey (Statistics Canada).

Women with gestational diabetes

Several factors place females at increased risk of gestational diabetes: obesity, a history of gestational diabetes, a history of abnormal glycemic metabolism, a family history of diabetes, belonging to an ethnic group with a high prevalence of diabetes, and age (≥25 years).[37]

Females diagnosed with gestational diabetes are at an increased risk of pre-diabetes and type 2 diabetes in the first five to ten years following the birth of their baby.[38;39] Females with a history of gestational diabetes are advised to have a diabetes screening test (OGTT) within six months following delivery and to be routinely screened for type 2 diabetes thereafter;[16] however, the actual rate of postpartum diabetes screening is low.[40] Children of women with a history of gestational diabetes are also at an increased risk of obesity and type 2 diabetes.[41-44] Canadian Diabetes Association guidelines recommend that all pregnant women should be screened for gestational diabetes, and that females with multiple risk factors should be screened regularly during the pregnancy.[16] Females who have had gestational diabetes can reduce their risk of type 2 diabetes through close postpartum monitoring and maintenance of a healthy lifestyle.[16]

Individuals with a mental illness

Depression and schizophrenia are two mental illnesses that are more common among individuals with diabetes than among those without diabetes.[45-49] Some studies have identified schizophrenia as a risk factor for type 2 diabetes.[16;50-52] In 2005, 11.9 % of Canadians aged 18 years and older with schizophrenia reported having diabetes, compared to 5.3% of those without schizophrenia.[53]

A number of medications used to treat schizophrenia may affect glycemic levels and cause or exacerbate diabetes.[54] The use of second generation atypical antipsychotics increases the risk of diabetes in individuals with schizophrenia by 30% compared to those with diabetes on first generation antipsychotics.[55] Another large study also linked atypical antipsychotics with diabetes risk in individuals with schizophrenia, but found that risk differed by type of drug. Olanzapine and clozapine were implicated with the highest risk for diabetes, while aripiprazole, risperidone, quetiapine and ziprasidone were associated with the lowest risk.[56] The association between schizophrenia and diabetes is multi-factorial and may also be related to behavioural risk factors and living conditions. Individuals with schizophrenia have higher rates of tobacco smoking

(and are more likely to be nicotine dependent), poor diet and physical inactivity.[54] Compared with individuals without schizophrenia, individuals living with the disease are also more likely to have a lower socioeconomic status and to complete less years of education, both of which are known to increase the risk of obesity.[48;52;57] Elevated hormone levels associated with schizophrenia are known to increase appetite, lead to weight gain, and cause insulin resistance.

Depression is common in Canada, with one in eight Canadians (12.2%) reporting symptoms consistent with depression at some point during their lifetime.[57] Depression can also contribute to type 2 diabetes, although it is still unclear what the causal relationship is between these two conditions and whether the relationship may in fact be bi-directional (Chapter 2, Mental illness).[58;59] This may be an indirect relationship, as depression is associated with health behaviours, including smoking, physical inactivity, and unhealthy eating, that can increase the risk of type 2 diabetes. The side effects of medications and biological changes in the body have also put individuals with depression at an increased risk of type 2 diabetes.[46] For example, a study using Saskatchewan health administrative data reported that individuals with newly diagnosed depression treated concurrently with selective serotonin reuptake inhibitors and tricyclic antidepressants were at almost twice the risk of type 2 diabetes[iii] compared to those treated with tricyclic antidepressants alone.[60]

Key non-modifiable risk factors for type 2 diabetes

Ethnicity

Ethnicity has been associated with diabetes, where certain ethnic subpopulations in Canada have higher rates of type 2 diabetes. The influence of ethnicity reflects both biological and behavioural differences that influence diabetes risk. For instance, people of South Asian, Hispanic American, Chinese, and African ancestry are at higher risk of developing type 2 diabetes than those of European descent, and if they do develop type 2 diabetes, it is at an earlier age and with lower BMI values.[11;61] Further, another incongruity was seen with BMI for non-Europeans, where BMI significantly underestimated the greater amount of visceral adipose tissue seen in this group.[62] Genome studies have also pointed to specific ethnic differences in genes that increase risk for type 2 diabetes.[63]

Ethnicity has also been associated with certain behavioural risk factors for type 2 diabetes. Compared to Caucasians, other race or ethnicities tended to have higher rates of physical inactivity, but individuals of Filipino, Chinese, or South Asian descent were between 1.6 to 6.0 times less likely to be obese (Table 4-2). Inadequate consumption of vegetables and fruit was higher among individuals of Chinese and Filipino descent compared to Caucasians, but was generally high in all ethnicities (ranging from 56.0% to 65.5%). Caucasians tended to smoke more than the other groups. Also, self-care behaviour such as home glucose testing or foot examinations, may vary by ethnicity, which could impact the quality of life of those living with diabetes.[64]

iii Adjusted odds ratio: 1.89; 95% CI: 1.35-2.65.

Table 4-2. Prevalence of self-reported modifiable risk factors among individuals aged 20 years and older, by race/ethnicity†, Canada, 2009–2010

	Prevalence (%) by race/ethnicity (95% confidence interval)					
	Caucasian	**African descent**	**Filipino**	**Chinese**	**South Asian**	**Latin American**
Obesity‡	19.7 (19.3–20.1)	18.7 (14.7–22.7)	12.5* (7.5–17.6)	3.3* (2.1–4.4)	9.5 (7.6–11.3)	15.7* (10.3–21.1)
Physical inactivity§	45.8 (45.2–46.3)	57.5 (52.6–62.4)	54.8 (49.0–60.6)	61.9 (58.5–65.2)	60.5 (56.7–64.3)	54.9 (47.9–61.9)
Inadequate vegetable and fruit consumption¶	56.0 (55.4–56.6)	57.8 (53.3–62.4)	62.9 (56.9–68.9)	65.5 (61.6–69.3)	55.8 (52.0–59.5)	57.9 (51.4–64.5)
Daily tobacco smoking	17.5 (17.1–17.9)	9.5 (6.8–12.2)	9.4* (5.9–12.9)	7.8 (5.5–10.0)	6.1 (4.3–8.0)	6.1* (3.2–9.0)

† Race/ethnic categories with unweighted samples greater than 500 were presented; "Korean", "Japanese", "South East Asian", "Arab", "West Asian", "other", and "multiple origin" categories were excluded from this analysis.
‡ Based on a BMI greater than or equal to 30.0 kg/m^2.
§ Based on a leisure and transportation index measure.
¶ Based on a vegetable and fruit consumption of less than five times per day.
* Marginal variance estimate; data should be interpreted with caution.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Immigration

Immigrants to Canada, most of who now originate from non-European countries, are known to have higher rates of diabetes. Results from an Ontario population-based study showed that, after controlling for age, immigration category, education, income and time since arrival, immigrants from South Asia, Latin America and the Caribbean, and sub-Saharan Africa had an increased risk of diabetes compared to immigrants from Western Europe and North America.[65] In addition to genetic susceptibility, there is evidence that recent immigrants tend to have lower incomes and poorer access to health services than the general Canadian population.[66] While the evidence on this topic remains mixed,[67;68] a Toronto study identified high rates of diabetes with these factors, linking them by way of "high risk" built environments that included decreased access to walking and cycling trails, parks, and recreation programs and poorer access to healthy food choices or health education programs.[69] This may make these populations more vulnerable to risk factors for type 2 diabetes. On the other hand, immigrants who have lived in Canada for over 15 years present higher proportions of type 2 diabetes than recent immigrants, implying a "negative acculturation effect".[70]

Social and environmental factors influencing overweight and obesity

The determinants of health

> "Many factors combine together to affect the health of individuals and communities. Whether people are healthy or not, is determined by their circumstances and environment. To a large extent, factors such as where we live, the state of our environment, genetics, our income and education level, and our relationships with friends and family all have considerable impacts on health, whereas the more commonly considered factors such as access and use of health care services often have less of an impact."[71]

The maintenance of a healthy body weight, participation in physical activity, and healthy eating are the primary goals of public health interventions aimed at preventing type 2 diabetes. However, an individual's health and the ability to adopt such healthy behaviours are influenced by many factors, including the social, environmental, cultural, and economic conditions in which the individual lives (the "determinants of health"). These include income, education and literacy; employment and working conditions; food security; environment and housing; early childhood development; social support and connectedness; and access to health care. All have a significant effect on the distribution of risk factors within a population and are, in effect, "the causes of the causes."[72] Consequently, to deal with individual health behaviours and choices, it is necessary to consider the factors that shape them.[73]

Socio-demographic factors

Low socio-economic status (as gauged by level of income, education, and employment status), rural residence and ethnicity have been found to be associated with diabetes, its complications, and its risk factors. In 2009–2010, several type 2 diabetes risk factors, including physical inactivity (leisure and transportation index), inadequate consumption of vegetables and fruit, and daily smoking were more common among Canadians in the lowest income quintile than among those in the highest income quintile (Table 4-3). Individuals with less education were also more likely to have risk factors for type 2 diabetes than those with higher education (Table 4-4). The association was less pronounced between urban-rural residence and the various risk factors (Table 4-5).

Table 4-3. Prevalence of self-reported modifiable risk factors among individuals aged 20 years and older, by income quintile, Canada, 2009–2010

	Prevalence (%) by income quintile (95% confidence interval)				
	Low	**Lower-middle**	**Middle**	**Upper-middle**	**High**
Obesity†	19.4 (18.4–20.4)	18.4 (17.4–19.3)	19.8 (18.7–20.8)	19.1 (18.1–20.2)	18.9 (17.8–19.9)
Physical inactivity‡	58.0 (56.5–59.4)	52.1 (50.8–53.4)	47.6 (46.3–48.9)	42.2 (40.9–43.5)	36.5 (35.2–37.7)
Inadequate vegetable and fruit consumption§	60.6 (59.2–62.0)	58.0 (56.6–59.4)	57.1 (55.8–58.4)	55.3 (54.0–56.6)	52.3 (51.1–53.6)
Daily tobacco smoking	24.3 (23.2–25.5)	18.1 (17.2–19.1)	17.5 (16.5–18.5)	14.2 (13.4–15.0)	11.3 (10.6–12.0)

† Based on a BMI greater than or equal to 30.0 kg/m^2.
‡ Based on a leisure and transportation index measure.
§ Based on a vegetable and fruit consumption of less than five times per day.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Table 4-4. Prevalence of self-reported modifiable risk factors among individuals aged 20 years and older, by education level, Canada, 2009–2010

	Prevalence (%) by education level (95% confidence interval)			
	Less than Secondary	Secondary	Some post-secondary	Post-secondary
Obesity†	23.1 (22.1–24.2)	20.0 (18.9–21.1)	19.5 (17.8–21.2)	17.0 (16.5–17.6)
Physical inactivity‡	63.3 (62.0–64.5)	52.5 (51.1–53.9)	46.4 (44.4–48.5)	43.2 (42.5–43.9)
Inadequate vegetable and fruit consumption§	64.0 (62.8–65.3)	61.9 (60.5–63.3)	58.5 (56.5–60.5)	53.4 (52.6–54.1)
Daily tobacco smoking	26.6 (25.4–27.7)	21.2 (20.1–22.2)	18.4 (16.9–19.9)	13.1 (12.7–13.6)

† Based on a BMI greater than or equal to 30.0 kg/m^2.
‡ Based on a leisure and transportation index measure.
§ Based on a vegetable and fruit consumption of less than five times per day.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

Table 4-5. Prevalence of self-reported modifiable risk factors among individuals aged 20 years and older, by rural/urban residence, Canada, 2009–2010

	Prevalence (%) by rural/urban residence (95% confidence interval)	
	Rural	Urban
Obesity†	23.0 (22.2–23.8)	17.5 (17.0–17.9)
Physical inactivity‡	48.2 (47.2–49.2)	47.8 (47.2–48.5)
Inadequate vegetable and fruit consumption§	58.0 (57.0–59.0)	56.3 (55.6–56.9)
Daily tobacco smoking	19.1 (18.3–19.8)	16.2 (15.8–16.7)

† Based on a BMI greater than or equal to 30.0 kg/m^2.
‡ Based on a leisure and transportation index measure.
§ Based on a vegetable and fruit consumption of less than five times per day.
Source: Public Health Agency of Canada (2011); using 2009–2010 data from the Canadian Community Health Survey (Statistics Canada).

The built environment

Although individual and interpersonal factors such as attitudes and motivation may account in part for levels of physical activity, physical activity is also directly affected by a number of aspects of the built environment, such as urban sprawl[74] and access to walking paths, trails and sidewalks.[75] Built environments that promote high-energy diets, decreased access to healthy food stores, and sedentary lifestyles are known as obesogenic environments. In Canada, higher rates of obesity have been found in rural populations than in urban populations.[76;77] This may in part be due to the reliance on vehicles for transportation to destinations because of the lack of convenient destinations within walking distance. In contrast, supportive built environments can play a facilitating role in encouraging physical activity.[78] For example, communities with a variety of destinations safely accessible by foot are associated with a higher prevalence of walking to work.[79] Research

has also shown that individuals who can easily walk from home to commercial areas have increased levels of physical activity and lower BMI.[80]

The built environment also plays a role in healthy eating, alongside health and social policies that influence food marketing. Access to local shops, health-related stores, and supermarkets[81] has been associated with lower levels of obesity, while the reversed association has been observed between access to fast food restaurants and obesity.[82] The availability and accessibility of affordable nutritious foods is a particular challenge in low-income communities and in remote or northern communities, especially those inhabited primarily by Aboriginal populations, where dietary choice is constrained by high transport costs and spoilage.[25;83]

Interventions for the prevention of type 2 diabetes

Interventions to prevent type 2 diabetes can focus on the individual or on the population as a whole. A population approach examines and addresses the entire range of factors that affect health and aims to reduce risk factors in the population as a whole. In contrast, the individual approach focuses on identifying risk factors and promoting behavioural change. Interventions can include programs that promote healthy eating, regular physical activity and the loss of excess body weight. While not as effective as lifestyle changes for longer term prevention, some medications can be taken in addition to lifestyle changes to manage pre-diabetes. Individual and population approaches are complementary and are most effective when they are integrated.

Primary prevention at the individual and population level is critical. Reducing the prevalence of obesity would reduce the risks of developing diabetes as well as many other chronic diseases. Therefore, the population approach to reducing diabetes focuses on creating supportive environments and communities that enable their residents to maintain an active lifestyle and healthy eating habits. It requires collaboration across sectors (such as the food, recreation and school sectors), multiple strategies coordinated at different levels, and sustained effort over time. Examples of health promotion strategies include:

- Increasing time for physical activity in the school curriculum;
- Providing access to community recreational facilities;
- Forming and supporting networks of community-based organizations and services committed to improving nutrition or physical activity;
- Instituting educational campaigns that enable people to read and understand food labels;
- Teaching young people to cook nutritious, low-fat foods;
- Providing training to staff and volunteers for the skills required to promote population health; and
- Mandating a local health service, such as a diabetes education centre, to work with local community groups to promote walking clubs.[84]

Prevention and health promotion strategies should be tailored to the level of health literacy of the target population in order to better address its needs. Health literacy is a person's ability to find, understand and use written information to promote, maintain and improve their health and is only partially attributed to education level. It differs from the basic ability to read or understand numbers in that it involves other complex skills, such as keeping up with constantly changing information on new diseases and health threats, identifying and resolving contradictory information from various sources, and communicating with doctors, friends, and family about diagnoses and treatment options.

Recognizing differing levels of health literacy in the population plays a role in understanding how healthy attitudes are shaped and, in the context of prevention and health promotion, how knowledge about diet, physical activity and other healthy behaviours can be shared. For example, 60% of Canadian adults do not have the literacy skills needed to adequately manage their health or health-care needs. Seniors, immigrants and the unemployed generally have lower levels of health literacy than the national average. Moreover, a link has been observed between health literacy and diabetes, where health regions with higher than average health literacy scores had lower rates of diabetes.[85]

Looking ahead

The causes of type 2 diabetes are multiple, interlinked, and complex. Therefore, a holistic approach that addresses the social, economic, environmental, genetic and lifestyle factors associated with type 2 diabetes is needed to prevent and mitigate the disease and its complications. Overweight and obesity rates have been increasing over time; reversing the course of this trend and addressing other modifiable risk factors will be a crucial step in limiting the rise of diabetes (Chapter 1). Efforts to prevent and manage diabetes and its complications will not only benefit affected or at-risk individuals and their families, but also the overall Canadian economy by reducing the economic burden of this disease (Chapter 3, Economic costs of diabetes).

The Government of Canada promotes the prevention and control of diabetes through a number of initiatives. The *Canadian Diabetes Strategy* (CDS), a component of the federal government's *Integrated Strategy on Healthy Living and Chronic Disease*, supports both the upstream prevention of type 2 diabetes through healthy eating and physical activity, as well as the targeted prevention of type 2 diabetes and its complications in high risk populations through early detection and self-management. The *Aboriginal Diabetes Initiative (ADI)*, renewed for five years in 2010, supports the prevention and management of diabetes in First Nations and Inuit communities, both on- and off-reserve (Chapter 6, The Aboriginal Diabetes Initiative). Both the CDS and ADI support organizations that work with communities at high risk of developing type 2 diabetes and its complications by providing funding for the development and implementation of diabetes prevention, early detection, and self-management programs to address the unique needs of the populations they serve.

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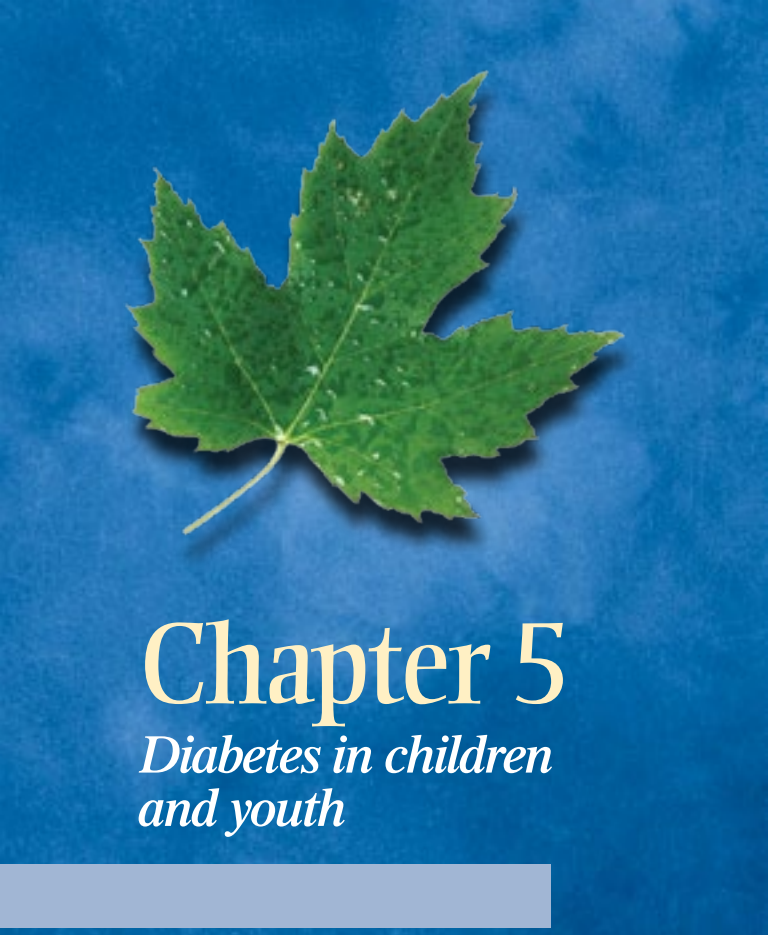

Chapter 5

Diabetes in children and youth

Introduction

Diabetes is one of the most common chronic diseases among children and youth. In 2008/09, the CCDSS reported 3,287 new cases of diagnosed diabetes (including both type 1 and type 2) among Canadians aged one to 19 years, bringing the total number of cases in children and youth to 25,693 (representing a prevalence rate of 0.3%) (Chapter 1, Table 1-1).

Historically, all cases of diabetes in young individuals were believed to be type 1 diabetes. However, for the last two decades, type 2 diabetes has been on the rise globally in this population. Currently, no population-based surveillance study has confirmed the ratio between the two types of the disease in children and youth in Canada. However, one study from British Columbia developed an algorithm to distinguish between type 1 and type 2 cases in administrative data, and estimated that approximately 90% of the cases among children and youth aged one to 19 years were of type 1 diabetes and 10% were of type 2 diabetes in 2006/07.[1] As the rates of obesity increase among children and youth, the rates of type 2 diabetes also increase. Therefore, the ratio of type 1 to type 2 in this population is likely to be impacted.[2]

Research suggests that both type 1 and type 2 diabetes are increasing worldwide in youth.[3] As both forms of diabetes are lifelong diseases, the early onset of either type increases the risk of related complications later in life, with lifelong implications for those with the

disease and their families, as well as for the health care system and the Canadian economy. Although it is currently only possible to prevent type 2 diabetes, optimal management of both type 1 and type 2 diabetes is of primary importance to prevent negative consequences of either disease.

Type 1 diabetes

Most cases of type 1 diabetes are diagnosed during childhood and adolescence, and it is recognized that type 1 diabetes remains the predominant form of the disease in this population.[4] The onset can occur as early as during the first year of life, but generally the onset is most common between ten and 14 years of age.[5] No consistent gender pattern for the incidence of type 1 diabetes in youth was observed.[6]

Estimates of the number of children and youth who have type 1 diabetes in Canada are limited. Currently a national estimate is not available, and existing estimates vary widely across provinces. Between 1989 and 2000, the annual incidence of type 1 diabetes among children aged 18 years and under in Quebec was 15 cases per 100,000 children.[7] Newfoundland and Labrador reported one of the highest incidence rates of type 1 diabetes in the world; for the period between 1987 and 2005, incidence among children aged less than 15 years was identified as 35 cases per 100,000 children. In children aged less than five years, boys (31.6 cases per 100,000 children aged less than five) were more likely to be affected than girls (19.1 cases per 100,000 children aged less than five).[8]

Rates of type 1 diabetes among children and youth have been on the rise globally.[9] Based on study analyses, Canada was found to have one of the highest incidence rates of type 1 diabetes for children under 14 years of age.[6;10] In Canada, the average relative increase in incidence rates has been estimated at 5.1% per year between 1990 and 1999.[6] Children under the age of five were the fastest growing segment of the population with type 1 diabetes.[6;10;11]

Risk factors for type 1 diabetes

Type 1 diabetes is a multifactorial condition, characterized by the presence of autoimmunity against insulin producing cells. Although researchers have not yet identified all of the factors causing type 1 diabetes and the interactions among them, they believe genetic factors and environmental triggers are involved.[9;12] The increasing trend of type 1 diabetes observed in many countries is believed to be associated with a number of factors, such as changes in early feeding patterns, early growth in the first year of life, and hygiene practices such as the use of antibacterial disinfectants, among other influences. Other findings that support the theory of genetic and environmental associations include:

- Type 1 diabetes is most common among children and youth of northern European descent.[13]
- First-degree relatives (parents, offspring, siblings) of individuals with type 1 diabetes have a tenfold greater risk of developing type 1 diabetes than the rest of the population.[14] In particular, children of fathers with type 1 diabetes are at a greater risk of developing type 1 diabetes than children of mothers with the disease.[15]
- No single infection has been linked to an increase in type 1 diabetes,[16] but viruses such as enteroviruses[17] and dietary microbial toxins[18;19] may be factors in the development of type 1 diabetes.
- Studies have identified a number of factors that might reduce the risk of developing type 1 diabetes, such as breastfeeding and vitamin D. Less exposure to the sun[20;21] (a source of vitamin D) and vitamin D deficiency[22-25] are associated with higher rates of type 1 diabetes. Some research has suggested that breastfeeding has a protective effect against the development of type 1 diabetes,[26;27] while short duration of breastfeeding has been implicated as a predisposing factor,[28] especially in children at increased genetic risk.[29]
- It is hypothesized that obesity may promote the development of insulin resistance, which in turn results in the autoimmune destruction of beta-cells trying to compensate for the insulin imbalance.[30;31]

Short- and long-term complications of type 1 diabetes

The long-term complications of type 1 diabetes[32] are the same as those for type 2 diabetes, including cardiovascular disease, retinopathy, and nephropathy (Chapter 2). However, because type 1 diabetes is most commonly diagnosed in childhood, there is an increased risk of long-term complications at earlier ages compared to individuals living with type 2 diabetes. In addition to the long-term complications of diabetes, people with type 1 diabetes are at greater risk of immediate and

acute complications because of their reliance on an external source of insulin. The administration of too much or too little insulin, resulting in extremes in glycemic levels, can lead to life-threatening complications caused by hypoglycemia and DKA.

Hypoglycemia occurs when excess insulin in the blood leads to extremely low glycemic levels. In addition to insulin dosage errors or incorrect estimations, common causes include missed meals, illness, and increased physical activity without a corresponding reduction in insulin or increase in carbohydrate consumption.[33] Episodes of severe or recurrent hypoglycemia, especially before the age of five years, may affect cognitive functions and result in learning problems.[34;35] Severe hypoglycemic episodes have been shown to affect performance and verbal IQ in children with type 1 diabetes.[36;37] DKA, often referred to as diabetic coma, results from hyperglycemia due to a lack of insulin. It is the leading cause of death and permanent disability among children with diabetes.[38] DKA is a preventable complication that occurs at the onset of 15% to 67% of type 1 diabetes cases.[39-41] Among children with established type 1 diabetes, most DKA episodes are associated with insulin omission or treatment error.[42;43]

More frequent emergency department admissions and hospitalizations,[44] decreased quality of life and increased mental health issues such as depression, anxiety and eating disorders,[45] are also more common among children with type 1 diabetes. Fortunately, treatment can prevent acute complications and reduce the development of long-term complications.[46]

Management strategies for children and youth with type 1 diabetes

Intensive daily management of glycemic levels is essential for reducing short- and long-term complications of type 1 diabetes.[47-49] In contrast to the fixed glycemic targets provided for adults, targets for children vary by age.[50]

Meticulous balancing of diet and physical activity with insulin intake is the core of type 1 diabetes management. In Canada, two strategies for administering insulin that are commonly used to manage type 1 diabetes are multiple daily injections (MDI) of insulin using syringes or pen devices, and continuous subcutaneous insulin infusion (CSII) from an insulin pump. An insulin pump, which is a programmable medical device worn outside the body, aims to mimic the natural insulin delivery of the pancreas. It continuously infuses insulin based on the individual's body needs over the course of a 24-hour cycle. Studies have shown that CSII reduces HbA1c levels significantly more than MDI, and that CSII reduces rates of severe hypoglycemia and contributes to a greater quality of life for patients.[51] Optimal management of diabetes implies that the most adequate tools and technologies for each patient should be made available and accessible to those who need it.

Several novel therapies are currently being tested as cures for type 1 diabetes, including pancreatic islet transplantation and the development of an artificial pancreas.[52] Pancreatic islet transplantation was previously limited by the lack of donors and immune rejection of graft, but cell replacement therapy now holds substantial promise with the use of stem cells.[53] Developments in pump therapy with the use of continuous glucose monitoring have advanced diabetes care, and an artificial pancreas could be produced in the foreseeable future.[54;55]

Challenges in management

Children and youth with type 1 diabetes face many of the same challenges in managing their disease as do adults, but face additional issues specific to their age.

Developmental stages of childhood

The physiological, psychological, social and emotional changes that occur as a child ages can be challenging for the management of type 1 diabetes. As a child grows, insulin requirements change and management strategies must be adapted accordingly. During the earlier stages of a child's growth and development, parents inevitably have more responsibility for the management of glycemic levels. As children mature, they become more capable of taking on these responsibilities.[56-58]

Adolescence can be a particularly difficult time for management of glycemic levels as adolescents take on responsibility for the management of their disease at the same time as hormonal changes affect glycemic levels and impact insulin requirements.[34;35;50] Body weight issues and eating disorders, more frequent among adolescent females than males, may incite some adolescents to adopt practices that are detrimental to the management of glycemic levels, such as omitting or modifying insulin doses as a means to control their weight.[45;59]

The stress of caring for a child with type 1 diabetes can also strain the health of a parent.[56;57] Parents or guardians of children with type 1 diabetes live with

the daily demands of round-the-clock monitoring of glycemic levels in their child. Daily activities include administering insulin injections, managing diets and monitoring physical activity levels.

Care in schools

Because children and youth spend a great deal of their daytime hours in school, this setting must meet the needs of children and youth with type 1 diabetes.[60-65] Levels of support and care adjusted to the age and development of a child are essential for the proper management of type 1 diabetes in the school setting. In Quebec for example, guidelines on interventions in school settings for children living with type 1 diabetes have recently been published. This protocol describes the role and responsibilities of the different personnel involved, including parents, school nurses, the school principal and other educators in charge of the children, as well as the children themselves.[66] Nurses, teachers and other personnel who are trained to help monitor and support the needs of children with type 1 diabetes can make a significant difference in the quality of a child's diabetes management and in ensuring that the child's health and performance in school are not compromised. While preventive measures are paramount, access to Glucagon is essential when a severe hypoglycaemic event occurs. Glucagon is not yet universally available in schools across Canada.

Type 2 diabetes

Historically, type 2 diabetes was viewed as an adult-onset disease, and all cases of diabetes in young people were assumed to be of type 1. Although still not common among children and youth, type 2 diabetes is now known to occur in this group, typically developing during or just after puberty, between the ages of ten and 19 years.[5] The development of type 2 diabetes in children and youth is not well understood. The progression from impaired glucose tolerance to type 2 diabetes is faster in children than in adults.[67;68] Also, acute complications, such as DKA, most commonly associated with type 1 diabetes, appear to be more common in newly diagnosed children and youth with type 2 diabetes than among adults.[69] Contrary to the gender pattern observed in the adult population, type 2 diabetes seems more frequent among female children and youth than their male counterparts.[70]

In the last two decades, type 2 diabetes has been on the rise among children and youth globally.[71] Type 2 diabetes in children was first brought to the attention of the scientific community in Canada when a description of 12 Aboriginal children in Manitoba with type 2 diabetes was published in 1992.[72] Since then, several studies in Canada[70;73;74] and internationally[5;13;75] have reported increases in type 2 diabetes in children and youth. In the United States, the incidence of type 2 diabetes is 8.1 cases per 100,000 person-years in children aged ten to 14 years, and 11.8 cases per 100,000 person-years in those aged 15 to 19 years.[5] In the United Kingdom, the incidence of type 2 diabetes in children less than 17 years of age was at least 0.53 cases per 100,000 children per year.[75]

In Canada, trends in type 2 diabetes in children and youth have been reported for specific populations and provinces. In 2004, Manitoba reported 35 to 40 new cases of childhood type 2 diabetes, representing about 30% of all new cases of childhood diabetes in Manitoba annually.[76] Between 2000 and 2002, the Diabetes Care Program of Nova Scotia reported 5.4 new cases of type 2 diabetes per 100,000 children under the age of 19 years. A higher proportion of 10.5 new cases per 100,000 children was reported in children between the ages of ten and 19 years.[77] A Canada-wide population-based surveillance study of new onset childhood type 2 diabetes was conducted from 2006 to 2008.[69] In this study, 227 cases of type 2 diabetes were identified in a two-year period, which was extrapolated to a minimum national incidence rate of 1.54 new cases per 100,000 children under the age of 18 years. In turn, this incidence rate would translate into at least 113 new cases of childhood type 2 diabetes diagnosed in Canada every year. This study found differences in prevalence across Canada, which likely reflect differences in the proportions of children of First Nations or certain ethnic descent who are at higher risk of developing type 2 diabetes. The incidence of children and youth aged 18 and under with type 2 diabetes was higher among Aboriginal children and youth than among Asian, African and Caribbean, and Caucasian children and youth. Similar results were reported in international studies.[5;78] An earlier retrospective study conducted in the Toronto area also showed an overrepresentation of Asian and African children with type 2 diabetes.[70]

Risk factors for type 2 diabetes

The factors that increase the probability that a child will develop type 2 diabetes are the same risk factors seen in adults (Chapter 4). They include overweight and obesity, physical inactivity, a family history of diabetes, certain ethnicities, maternal gestational diabetes and insulin resistance.

Obesity

A recent Canadian surveillance study found that 95% of children newly diagnosed with type 2 diabetes were obese.[69] Overall, in the last 25 years, rates of obesity in children and youth have been increasing rapidly throughout the world. In Canada, the number of obese children aged two to 17 years more than doubled, from 3% in 1978–1979 to 8% in 2004.[79] The emergence of type 2 diabetes in children and youth has occurred concurrently with the rise in rates of childhood obesity.

Family history

Children and youth with a family history of type 2 diabetes show reductions in insulin sensitivity at a younger age than children with no family history.[80] Studies show that more than 75% of children and youth with type 2 diabetes have at least one relative with the disease.[81] In Canada, more than 90% of children and youth with type 2 diabetes have a first or a second degree family member with the disease.[69;70]

Ethnicity

Children from some ethnic groups (First Nations, African/Caribbean, Hispanic, and South Asian) are at higher risk of earlier onset of type 2 diabetes.[13;72] A majority of Canadian children with type 2 diabetes (75%) belong to a high-risk ethnic group.[69]

Puberty

Individuals aged 13 to 17 going through puberty may be more vulnerable to the development of type 2 diabetes.[69;75] Among Canadians under age 18, type 2 diabetes developed at an average age of 13.7 years, with only 8% of children developing it before ten years of age.[69]

Short- and long-term complications of type 2 diabetes

Studies show that diabetes-related complications develop more rapidly in children and youth with type 2 diabetes than in adults.[82-85] Complications also appear to develop earlier in children and youth with type 2 diabetes than in those with type 1 diabetes.[86;87]

Typically, children and adolescents with type 2 diabetes face complications from both diabetes and obesity. They have been shown to have an early and increased risk of cardiovascular disease and its risk factors.[88] One study found that hypertension was up to eight times more common in youth with type 2 diabetes than in those with type 1.[89] In a study of children from the United States with type 2 diabetes, between 18% and 61% had hypercholesterolemia, and between 10% and 32% had hypertension. In a recent study of Canadian children with type 2 diabetes, 45% had dyslipidemia and 28% had hypertension at diagnosis. In addition, 37% of children and youth with a new diagnosis of type 2 diabetes already had at least one co-morbid condition related to their diabetes or obesity, at an average age of 13.7 years.[69]

The development of type 2 diabetes early in life inevitably leads to increased costs to the health care system, as diabetes management and the treatment of its complications require lifelong attention.

Management strategies for children and youth with type 2 diabetes

Lifestyle change is the cornerstone of type 2 diabetes management in children and youth, although medication is sometimes necessary. Children and youth with type 2 diabetes are optimally managed when an interdisciplinary health care team helps the achievement of treatment goals.[50] Education of the patient should be age-appropriate and culturally sensitive, and should focus on the lifestyle and health behaviours of the whole family.

A critical component in the management of type 2 diabetes is screening for, and prevention of, complications. The Canadian Diabetes Association clinical practice guidelines recommend that children and youth with type 2 diabetes be screened for hypertension at every clinical visit, and that they be screened for other risk

factors for type 2 diabetes including hypercholesterolemia, non-alcoholic fatty liver disease, nephropathy and retinopathy when they are first diagnosed and annually thereafter.[50]

In Canada, insulin and metformin (an oral medication) are the only medications approved for use with children and youth with type 2 diabetes.[90] There is limited information on the effectiveness and safety of other oral hypoglycemic medications in children and youth with type 2 diabetes. Children and youth who have high glycemic levels that result in a diabetic coma or persistent hyperglycemia are often placed on insulin therapy.[91]

Limitations of diabetes surveillance in children and youth

With both types of diabetes on the rise, a global effort is underway to conduct population studies to determine the incidence and prevalence of type 1 and type 2 diabetes in children and youth. At this time, there is limited population-based data in Canada to document the trends in childhood diabetes or the demographic, behavioural, clinical and socioeconomic characteristics of this population. Studies that do exist tend to focus on specific subgroups and are not population-based.

Clinically, it may be difficult to distinguish between type 1 and type 2 diabetes. Since type 1 diabetes remains the predominant form in children and youth, cases of type 2 diabetes are sometimes misclassified. This means there may be a substantial number of children and youth whose type 2 diabetes has remained undiagnosed, or who have been misdiagnosed with type 1 diabetes. Currently, the CCDSS does not distinguish between type 1 and type 2 diabetes. However, studies are underway to expand CCDSS methodology for this purpose. For example, a study in British Columbia has been successful in differentiating type 1 and type 2 diabetes within administrative data in persons aged less than 19 years by adapting CCDSS methodology through the application of algorithms that use demographic and drug treatment data.[92]

Looking ahead

Effective national surveillance is vital in order to gain a better understanding of the magnitude, characteristics and public health consequences of type 1 and type 2 diabetes in Canadian children and youth. Type 1 diabetes is not yet preventable. However, healthy weight and regular physical activity remain key to the reduction of type 2 diabetes in this population and contribute directly to the optimal management of both types of diabetes. Since children and youth diagnosed with type 1 and type 2 diabetes will live with the disease for life, effective management is a critical step toward reducing their risk of complications and improving their quality of life.

In that regard, the endorsement of the *Curbing Childhood Obesity: A Federal, Provincial and Territorial Framework for Action to Promote Healthy Weights* by federal, provincial and territorial Ministers of Health in 2010 signalled a commitment from these governments to work together, with partners across and outside the health sector, to take action on promoting healthy weights among children. This framework is comprised of three key strategies: "making childhood overweight and obesity a collective priority for action"; "coordinating efforts on three key policy priorities" (supportive environments, early action and nutritious foods); and "measuring and reporting on collective progress". Currently, actions are being undertaken as part of each strategy by the Ministers of Health, their governments and other sectors, to address childhood obesity and promote healthy weights.

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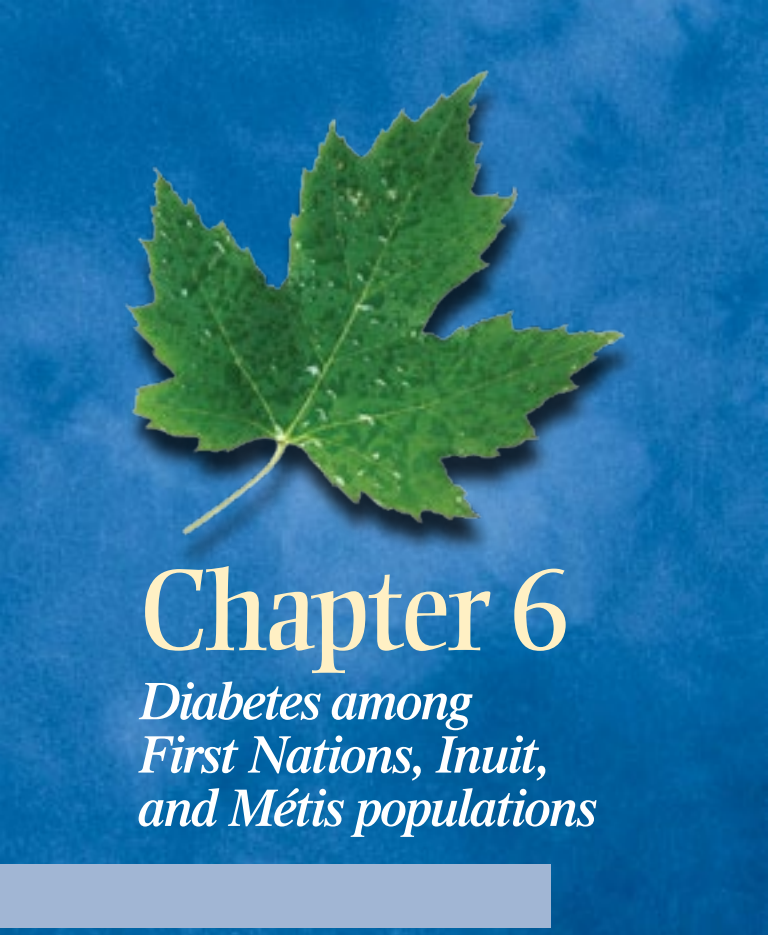


Chapter 6

Diabetes among First Nations, Inuit, and Métis populations

Introduction

Canada's *Constitution Act* of 1982 recognizes three distinct groups of Aboriginal people: First Nations, Inuit and Métis.[1] Each group has a unique history, culture, local languages, and spiritual beliefs.[2;3] Great diversity exists within and between each group. In the 2006 Census of Canada, 1,172,790 people identified themselves as Aboriginal; of them, 59.5% as First Nations (status and non-status Indians[i]), 33.2% as Métis, and 4.3% as Inuit. Together they accounted for 3.8% of the country's total population. These numbers likely underestimate the true population size by at least 80,000 individuals. An estimated 40,115 individuals were not included because enumeration was not completed on 22 First Nations reserves and settlements, in addition to approximately 40,623 individuals who were missed due to incomplete enumeration in participating First Nations communities.[5] The Aboriginal population is younger and growing more rapidly than the general Canadian population. Almost half (47.8%) of Aboriginal individuals were under 25 years of age during the census year, compared to less than a third (31.7%) of the non-Aboriginal population.

i Individuals in Canada registered under the *Indian Act* can be referred to as either Registered Indian or Status Indians.[4] Both terms are used in this report.

While diabetes was rare among the Aboriginal population in North America prior to 1940, the rates increased rapidly after 1950 and have now reached epidemic levels in some communities.[6;7] Higher rates of type 2 diabetes in children and youth and of gestational diabetes in females have also been observed. Moreover, earlier age at onset and high rates of complications amplify the problem within many First Nations and Métis communities.

Diabetes in First Nations, Inuit, and Métis populations shares common trends and similarities. However, due to the considerable degree of diversity that exists within and between each group, presenting aggregated figures of diabetes rates, risk factors and complications for these populations would be misleading in many instances. Moreover, no single data source provides these data at a national level. Consequently, this chapter provides information on diabetes rates, risk factors and complications among First Nations, Inuit and Métis populations in Canada by using findings from a variety of surveys and studies.

Limitations of diabetes surveillance in First Nations, Inuit, and Métis populations

Many data limitations exist for diabetes surveillance for First Nations, Inuit and Métis populations. For example, the inclusion of Aboriginal individuals in national surveys is limited by the geographic coverage of sampling, non-participation, incomplete enumeration of reserves, and exclusion of homeless people.[8;9] Different survey and sampling methods as well as changes in the criteria for diagnosis of diabetes can also interfere with the comparison of survey results between populations and over time. Health administrative data (hospital records, physician billing databases, and provincial/territorial health insurance registries) are often used for diabetes surveillance in the general Canadian population. However, only a limited number of provincial and territorial databases contain Aboriginal identifiers, limiting their use for surveillance for this population. Although the 2006 Aboriginal Peoples Survey (APS) sample is larger, this report used 2009–2010 CCHS data to estimate the prevalence of risk factors among First Nations individuals living off-reserve, Inuit and Métis for comparability reasons and to focus on the most recent data available. The 2008–2010 First Nations Regional Longitudinal Health Survey (RHS) was used to present statistics on First Nations individuals living on-reserve. Box 6-1 provides more detailed information on the national data sources used in this chapter; different years of data, age groups, and geographic areas are used depending on the data source.

Box 6-1. National data sources on the health of First Nations, Inuit, and Métis populations

The most recent national surveys conducted for First Nations, Inuit and Métis populations include the 2008–2010 First Nations Regional Longitudinal Health Survey, which surveyed First Nations individuals living on-reserve, and the 2006 Aboriginal Peoples Survey, which surveyed First Nations living off-reserve, Métis and Inuit individuals. The 2009–2010 CCHS provides information on non-Aboriginal, as well as First Nations individuals living off-reserve, Inuit and Métis populations. For the prevalence of diabetes, these surveys provide information on self-reported diagnosis of diabetes by a health professional. As access to health professionals to diagnose the disease may be difficult in certain remote regions, these surveys may underestimate the true prevalence of diabetes.[10;11]

- First Nations Regional Longitudinal Health Survey (RHS)
  - The RHS is the only First Nations-governed national health survey in Canada; so far, two phases were conducted (2002–2003 and 2008–2010).
  - The survey collects detailed data on the health and well-being of First Nations adults (aged 18 years and older) who live on-reserve and are Registered Indians or recognized by their band as members of their community.
  - Findings from the 2008–2010 RHS (Phase 2), as well as some findings from the 2002–2003 RHS (Phase 1), are included in this report to provide information for First Nations individuals living on-reserve in all provinces and territories, except Nunavut, which has no First Nations communities.[12]
- Aboriginal Peoples Survey (APS)
  - The APS is a post-censal survey conducted by Statistics Canada that runs every five years.
  - The survey examines a variety of issues concerning life for First Nations individuals living off-reserve, Métis and Inuit aged six years and older and living in households. The APS sample was selected from individuals who responded, in the 2006 Census questionnaire, that they:
    - had Aboriginal ancestors; and/or
    - identified themselves as North American Indian and/or Métis and/or Inuit; and/or
    - had treaty or registered Indian status; and/or
    - had Indian Band membership.[13]
  - This report used data from the 2006 APS to report on the prevalence of diabetes among Inuit since the sample size of the CCHS was too small to be reported. For risk factors for which the same question was used in both surveys (e.g. overweight, obesity, and smoking status, but not physical inactivity or vegetable and fruit consumption), APS results are reported in a note under the corresponding table.
- CCHS
  - The CCHS is a cross-sectional survey conducted by Statistics Canada to collect information related to the health status, health care utilization and health determinants of Canadians aged 12 years and older. The CCHS excludes individuals living in institutions, full-time members of the Canadian Armed Forces, individuals living on Indian reserves and on Crown lands, as well as individuals living in certain remote regions of the country.
  - Non-Aboriginal individuals were defined as respondents who answered "No" to the question: "Are you an Aboriginal person, that is, North American Indian, Métis or Inuit?" Among individuals who answered "Yes" to this question, First Nations individuals, Inuit and Métis were defined according to their answer to the follow up question: "Are you… North American Indian? Métis? Inuit?".[14]
  - The CCHS has a smaller sample size for Aboriginal populations than the APS, which specifically surveys these populations. Despite this limitation, this report analyzed data from the 2009–2010 CCHS where possible to provide comparable and more recent information on non-Aboriginal Canadians, as well as First Nations, Inuit and Métis populations.

Diabetes prevalence

In the last two decades, studies of diabetes in these populations across the country have shown that crude prevalence rates range from 2.7% to 19%, with some prevalence estimates reaching up to 30% once age-standardized.[7;8;15-20] The most recent national survey data show that the proportion of the population reporting a diagnosis of diabetes was highest for First Nations individuals living on-reserve (aged 18 years and older: 15.3%), followed by First Nations individuals living off-reserve (aged 12 years and older: 8.7%). The Métis (aged 12 years and older: 5.8%) had a similar prevalence to the non-Aboriginal population (aged 12 years and older: 6.0%). The prevalence of diabetes in the Inuit population remained lower than in these other groups, at 4.3% (aged 15 years and older) (Table 6-1). However, it is important to account for the younger age structure in the First Nations, Inuit and Métis populations when comparing the prevalence of diabetes to that of the non-Aboriginal population. After adjusting for this difference in age structure, the prevalence of diabetes was 17.2% among First Nations individuals living on-reserve, 10.3% among First Nations individuals living off-reserve, and 7.3% among Métis. Although the crude prevalence of diabetes among Inuit has historically been well below the national average, after adjusting for the difference in age structure, the prevalence of diabetes among Inuit was comparable to the general Canadian population.[20]

Table 6-1. Prevalence of self-reported diabetes† among First Nations, Inuit, and Métis individuals aged 12 years and older, Canada, 2006, 2008–2010, 2009–2010

			Prevalence (%) (95% confidence interval)	
	Source	Age	Crude	Age-standardized‡
Non-Aboriginal	2009–2010 CCHS	12+	6.0 (5.8–6.3)	5.0 (4.3–5.7)
First-Nations (on-reserve)	2008–2010 RHS	18+	15.3 (14.2–16.4)	17.2 (16.5–19.0)
First-Nations (off-reserve)	2009–2010 CCHS	12+	8.7 (7.0–10.4)	10.3 (3.4–17.2)
Inuit	2006 APS	15+	4 (3.3–5.6)	NA
Métis	2009–2010 CCHS	12+	5.8 (4.4–7.3)	7.3 (2.2–12.5)

† Gestational diabetes cases excluded from CCHS and RHS data.
‡ Age-standardized to the 1991 Canadian population.
Source: Public Health Agency of Canada (2011), using data from 2009–2010 Canadian Community Health Survey (Statistics Canada); First Nations Information Governance Centre (2011), using data from the 2008–2010 First Nations Regional Longitudinal Health Survey (Phase 2) (First Nations Information Governance Centre); Social and Aboriginal Statistics Division, *Aboriginal Peoples Survey, 2006: Inuit Health and Social Conditions*: Ottawa, ON: Statistics Canada; 2008.

Prevalence by age

As in the general population, the prevalence of diabetes increases with age in First Nations, Inuit and Métis populations, but it is generally diagnosed at a younger age.[19;21;22] Type 2 diabetes is more frequent among Aboriginal children and youth than among their non-Aboriginal counterparts.[23-25]

Prevalence by sex

Aboriginal females experience higher rates of gestational diabetes than non-Aboriginal females.[26-32] Studies have shown prevalence rates of gestational diabetes in the First Nations population that were almost three times higher than in the non-First Nations population.[26;30] Recent Canadian data showed a higher proportion of women diagnosed with gestational diabetes in First Nations (4.8%), Inuit (4.0%) and Métis (2.2%) populations than in the non-Aboriginal population (0.5%).[22]

Studies had suggested that the prevalence of diabetes is higher among Aboriginal females than males, the reverse of the gender pattern observed for diabetes prevalence in the general Canadian population.[6;11;12;33] For example, in the Métis settlements of Northern Alberta, the prevalence of self-reported diabetes among females was significantly different than that reported among males, with a prevalence rate of 7.8% compared to 6.1%, respectively.[34] Another study conducted in Saskatchewan has shown that, between 1980 and 2005, the age-standardized prevalence rates of diabetes among First Nations (both on- and off-reserve) females were higher than among their male counterparts.[17] Some studies, however, found that the difference in prevalence may no longer exist between Aboriginal females and males.[22;35]

Prevalence by region

Administrative health data have been used to examine the prevalence of diagnosed diabetes among First Nations individuals in several regions of Canada. In 2006/07, based on data from the CCDSS, the age-standardized prevalence of diagnosed diabetes among British Columbia First Nations residents (aged one year and older) was 6.7%, compared with 4.8% among other British Columbia residents.[19] In Alberta, between 1995 and 2007, the age- and sex-adjusted prevalence of diabetes was approximately twice as high among status individuals than in the general population,[36] while in Quebec the age-standardized prevalence rate of diagnosed diabetes among James Bay Cree adults (aged 20 years and older) reached 19.1% in 2001/02,[37] compared with 5.1% in the general population.[38]

Prevalence over time

Diabetes is one of the fastest growing diseases among the Aboriginal populations in Canada. While diabetes was not observed in the Aboriginal populations until the second half of the 1900s, today most Aboriginal populations report prevalence rates that exceed or are comparable to the prevalence rates seen in the non-Aboriginal population.[10-12;19] Between 2001/02 and 2006/07, the age-standardized prevalence of diagnosed diabetes in Canadians (aged one year and older) increased by 26.8% (Chapter 1, Prevalence over time), while between 2001 and 2006, the self-reported prevalence of the disease doubled among the Canadian Inuit population, from 2% to 4%.[20] The prevalence in the First Nations population also increased, although data sources give varying estimates of the rise for different study populations and time periods. For example, in British Columbia between 2002/03 and 2006/07, the prevalence of diabetes in the First Nations population increased by about 15.5% (aged one year and older, age-standardized),[19] while during a similar five year period (2001 to 2005) the prevalence of diabetes in First Nations population in Northern Quebec increased by approximately 36.4%, from 11.0% to 15.0% (aged 15 and older, crude rates).[39] As for the Métis population in Canada, the self-reported rate of diabetes among those aged 15 years and older was 5.9% in 2001 and 7.0% in 2006, representing an increase of 19%.[35;40]

Risk factors for diabetes

The rapid increase of diabetes in the First Nations, Inuit and Métis populations has been influenced by a variety of risk factors, including genetic, biological, environmental and lifestyle factors. The rapid socio-cultural, environmental and lifestyle changes seen in First Nations, Inuit and Métis populations in the last half century have had a tremendous impact on their health and have contributed significantly to the higher rates of diabetes and its complications.[6;17;41] Lifestyle factors such as diet, physical inactivity, overweight and obesity, and smoking are key risk factors for type 2 diabetes in First Nations, Inuit and Métis populations, as they are in the general population (Chapter 4).

Genetic risk factors

A genetic risk factor, called the "thrifty gene effect",[42] has been hypothesized to increase diabetes rates in the Aboriginal populations. The theory suggests that as a protective response to regular periods of starvation, individuals of Aboriginal descent are genetically predisposed to conserve calories.[6;42-44] Historically, this thrifty gene was beneficial because Aboriginal individuals lived hunter-gatherer lifestyles, and access to foods was not always constant. However, Aboriginal individuals are now purchasing and consuming processed foods that are higher in calories, saturated fats and simple sugars, which increase their risk of obesity and diabetes.[6;44;45] Specific gene variants of the "thrifty gene" found in Oji-Cree people of north-western Ontario have been associated with the early onset of type 2 diabetes.[43] However, this theory has since been questioned, and the debate concerning the relative importance of

genetic versus other environmental factors associated with diabetes susceptibility continues.[46;47]

Biological risk factors

Unlike the pattern among the non-Aboriginal Canadian population, First Nations females have historically shown higher prevalence of diabetes than First Nations males.[11;33] This is thought to be because First Nations females have higher rates of obesity than First Nations males.[33] As previously noted, Aboriginal females also experience higher rates of gestational diabetes than non-Aboriginal females.[22;26-31] Although gestational diabetes typically resolves after pregnancy, it increases the risk of type 2 diabetes later in life and the risk of obesity among offspring, thereby increasing the risk of diabetes in successive generations.[48] Finally, although impaired glucose tolerance has not been surveyed extensively in the First Nations, Inuit, and Métis populations, some studies suggest that females have higher rates of impaired glucose tolerance than males in the First Nations population,[16;18] increasing their risk of developing diabetes and its complications, particularly cardiovascular disease.[33;49]

Environmental risk factors

Health and social conditions vary significantly between individuals living on-reserve versus off-reserve and in rural versus urban areas. Living in rural or remote areas can lead to reduced opportunities for education and employment, as well as reduced availability of a safe and healthy food supply.[50] All of these factors can have a negative effect on health. Additionally, people living in Aboriginal communities often have less access to health care services due to geographic and language barriers, as well as the cost and limited availability of culturally appropriate services.[48;51] These barriers can affect the distribution of type 2 diabetes in the population and reduce care and treatment available for the prevention of diabetes and its complications.[52]

As a result of changing environments, displacement, hunting and fishing costs or restrictions, and a loss of harvesting capabilities, fewer individuals now consume traditional foods, and physical activity has declined among the Aboriginal populations. Traditional First Nations, Inuit and Métis diets are based on a combination of foods which includes fish, shellfish, marine and land mammals, and game birds, as well as green and root vegetables, fruit and berries – food sources that provide a protective effect from diabetes. A rapid transition to energy-dense foods and away from the traditional hunting, gathering and fishing, combined with lower levels of physical activity, is likely associated with the dramatic increase in the rates of overweight and obesity in the Aboriginal populations in the last several decades.[53]

Lifestyle risk factors

Overweight and obesity

Overweight and obesity are common in First Nations individuals, Inuit and Métis (Table 6-2).[54;55] According to the Canadian BMI guidelines based on self-reported height and weight, estimates suggest that 74.4% of First Nations adults living on-reserve were overweight or obese (2008–2010, aged 18 years and older), as were 62.5% of First Nations individuals living off-reserve, 58.3% of Inuit and 60.8% of Métis (2009–2010, aged 18 years and older). This is a higher proportion than the 51.9% of the non-Aboriginal population who were overweight or obese according to self-reported height and weight (2009–2010, aged 18 years and older). The proportion of the non-Aboriginal population who reported being overweight is similar to the proportion reported by the Aboriginal populations. However, the proportion of respondents who reported being obese was significantly higher among First Nations individuals living on-reserve, First Nations individuals living off-reserve, Métis and Inuit.

Although BMI provides a standard measure of body weight for population comparisons, the BMI standards set by the WHO have been found to overestimate the prevalence of overweight and obesity for the Inuit population. Inuit tend to have different body dimensions than other populations worldwide, such as shorter legs and a shorter stature. A consideration of other proportions, such as a sitting height-to-standing height ratio, could improve the assessment of obesity among Inuit.[56;57]

Table 6-2. Crude prevalence of self-reported overweight and obesity† among First Nations, Inuit, and Métis individuals aged 18 years and older, Canada, 2008–2010, 2009–2010

		Crude prevalence (%) (95% confidence interval)	
	Source	Overweight‡	Obesity§
Non-Aboriginal	2009–2010 CCHS	34.0 (33.4–34.5)	17.9 (17.5–18.3)
First-Nations (on-reserve)	2008–2010 RHS	34.2 (32.9–35.6)	40.2 (38.5–42.0)
First-Nations (off-reserve)	2009–2010 CCHS	34.1 (30.7–37.4)	28.4 (25.1–31.7)
Inuit	2009–2010 CCHS	25.3 (18.5–32.2)	33.0 (23.3–42.8)
Métis	2009–2010 CCHS	35.9 (32.1–39.7)	24.9 (21.2–28.6)

† Overweight based on a BMI greater than or equal to 25.0 kg/m^2 but less than 30.0 kg/m^2; obesity based on a BMI greater than or equal to 30.0 kg/m^2.
‡ 2006 APS estimates: First-Nations (off-reserve) 35.1 (33.7–36.6), Inuit 35.6 (33.7–37.5), Métis 36.2 (34.8–37.6).
§ 2006 APS estimates: First-Nations (off-reserve) 26.1 (24.8–27.4), Inuit 24.0 (22.3–25.6), Métis 26.4 (25.1–27.6).
Source: Public Health Agency of Canada (2011), using data from the 2009–2010 Canadian Community Health Survey (Statistics Canada) and the 2006 Aboriginal Peoples Survey (Statistics Canada); First Nations Information Governance Centre (2011) using data from the 2008–2010 First Nations Regional Longitudinal Health Survey (Phase 2) (First Nations Information Governance Centre).

Physical inactivity

Using 2009–2010 CCHS and 2008–2010 RHS data, the prevalence of physical inactivity during leisure time was estimated among First Nations individuals, Inuit and Métis. However, activities practiced more frequently in Aboriginal populations (such as hunting) were not part of the CCHS pre-determined list of physical activities.

First Nations individuals living on-reserve

Only 26.0% (95% CI: 24.5–27.5%) of First Nations adults aged 18 years and older living on-reserve reported undertaking sufficient physical activity during leisure time. Activities included walking, running, swimming, bicycle riding, fishing, berry picking or food gathering, hunting and trapping. Males were more likely than females to report sufficient physical activity.[12;58]

First Nations individuals living off-reserve

In 2009–2010, 51.8% (95% CI: 48.0–55.5%) of First Nations adults (aged 20 years and older) living off-reserve were physically inactive during leisure time. This is comparable to the 49.7% (95% CI: 49.2–50.3%) of non-Aboriginal adults (aged 20 years and older) who reported being inactive.[11]

Inuit

In 2009–2010, 59.6% (95% CI: 50.5–68.6%) of Inuit adults (aged 20 years and older) reported being physically inactive during their leisure time, a proportion that was higher than the level of inactivity among the non-Aboriginal population (49.7%).[11] In 2004, a Nunavik study reported that 82% of Inuit adults did not meet the recommended levels of physical activity for substantial health benefits. Nearly a quarter (24%) of these adults (aged 18 years and older) reported a main occupation that required very little physical effort. They did not compensate by engaging in a higher level of leisure-time physical activity. More than half (59%) of young Nunavik Inuit (aged 15 to 17 years) were active less than once a week for at least six months of the year; only 14% were at the recommended activity level for this age group.[59]

Métis

In 2009–2010, 46.7% (95% CI: 42.8–50.6%) of Métis adults (aged 20 years and older) reported that they were inactive during their leisure time. This is comparable to the 49.7% of non-Aboriginal adults (aged 20 years and older) who reported being inactive.[11]

Unhealthy eating

Globally, the nutritional habits of indigenous people are changing. Among First Nations, Inuit and Métis populations in Canada, the transition from traditional to non-traditional diets began at different times, is occurring at varying speeds, is affecting different age groups, and is dependent on several factors (e.g. living in an urban or rural area). This transition, combined with the possible "thrifty gene effect", plays a role in increasing the rates of obesity and diabetes in the Aboriginal populations. Today, most First Nations individuals, Inuit and Métis consume more high-sugar, high-fat, store-bought (processed) foods than traditionally gathered foods in their daily diet.[6;60;61] As in the non-Aboriginal population (Chapter 4), a diet high in sugar, fat, or processed foods has contributed to increased overweight, obesity and risk of diabetes. Similarly, daily consumption of vegetables and fruit was used as a proxy for healthy diet; however, when consumed, certain traditional foods can substitute vegetables and fruit to provide essential nutrients.

First Nations individuals living on-reserve

Among First Nations adults living on-reserve, only 30.6% (95% CI: 29.2–32.1%) reported "always" or "almost always" eating a nutritious, balanced diet. More than half of all First Nations adults living on-reserve (51.8%; 95% CI: 50.2–53.4%) reported that they "sometimes" eat a balanced and nutritious diet, while 17.6% (95% CI: 16.4–18.8%) reported that they "rarely" or "never" do. The proportion of adults who reported "always" or "almost always" eating a nutritious and balanced diet was lowest among those aged 18 to 29 years (21.9%; 95% CI: 19.5–24.5%) and highest among those aged 55 years and older (44.4%; 95% CI: 41.9–46.9%).[12] First Nations adults living in communities with fewer than 300 people are more likely to consume traditional foods than those in larger communities.[12;62]

First Nations individuals living off-reserve

Among First Nations adults (aged 20 years and older) living off-reserve, 63.6% (95% CI: 60.1–67.1%) ate less than the recommended five or more servings of vegetables and fruit per day. This is slightly higher than the 56.4% (95% CI: 55.8–57.0%) of non-Aboriginal adults who reported the same.[11]

Inuit

A traditional Inuit diet, including seal, whale, caribou, fish and berries, is rich in omega-3 acids and may offer protection against chronic diseases such as hypertension and diabetes.[59] Consumption of a traditional Inuit diet is believed to play a role in the lower cholesterol levels that have been historically observed in the Inuit population.[63] However, Inuit have also moved away from traditional eating habits over the past two decades towards more commercially produced, processed foods.[20;45;59] A study of Inuit living in Nunavik (Quebec) found that the consumption of non-traditional, imported foods from the south was more common in younger Inuit, whereas the proportion of calories obtained from traditional foods was higher in Inuit adults aged 50 years and older (28.3%) than in adults aged 18 to 29 years (11%).[59] In addition to low consumption of traditional foods, self-reported data also showed low consumption of vegetables and fruit in Inuit adults. In 2009–2010, at the national level, 78.4% (95% CI: 71.7–85.0%) of Inuit aged 20 years and older reported eating less than the recommended number of servings of vegetables and fruit per day.[11]

Métis

Traditionally, Métis consumed a diet based on local wild sea and land mammals, fowl, fish, berries and grains.[64] The decline in use of traditional food-gathering methods, such as hunting, fishing and harvesting, has resulted in a decrease in the consumption of these traditional foods and a decline in the health of many Métis. Consumption of vegetables and fruit on a daily basis was also found to be low in Métis. In 2009–2010, 61.2% (95% CI: 57.3–65.1%) of Métis aged 20 years and older reported eating less than the recommended number of servings of vegetables and fruit per day, comparable to the 56.4% of non-Aboriginal adults who reported the same.[11]

Tobacco smoking

In 2009–2010, the prevalence rates of smoking reported among the First Nations, Inuit and Métis adults aged 18 years and older were double the rates reported among the non-Aboriginal population. Indeed, daily tobacco smoking rates for First Nations individuals living on- and off-reserve, Inuit, and Métis were 2.2 to 2.8 times the rate among non-Aboriginal individuals (Table 6-3).

Table 6-3. Crude prevalence of self-reported daily tobacco smoking among First Nations, Inuit, and Métis individuals aged 18 years and older, Canada, 2008–2010, 2009–2010

	Source‡	Crude prevalence (%) (95% confidence interval)
Non-Aboriginal	2009–2010 CCHS	16.0 (15.6–16.4)
First-Nations (on-reserve)	2008–2010 RHS	43.2 (41.6–44.8)
First-Nations (off-reserve)	2009–2010 CCHS	34.8 (31.1–38.5)
Inuit	2009–2010 CCHS	44.4 (36.4–52.4)
Métis	2009–2010 CCHS	34.6 (31.1–38.0)

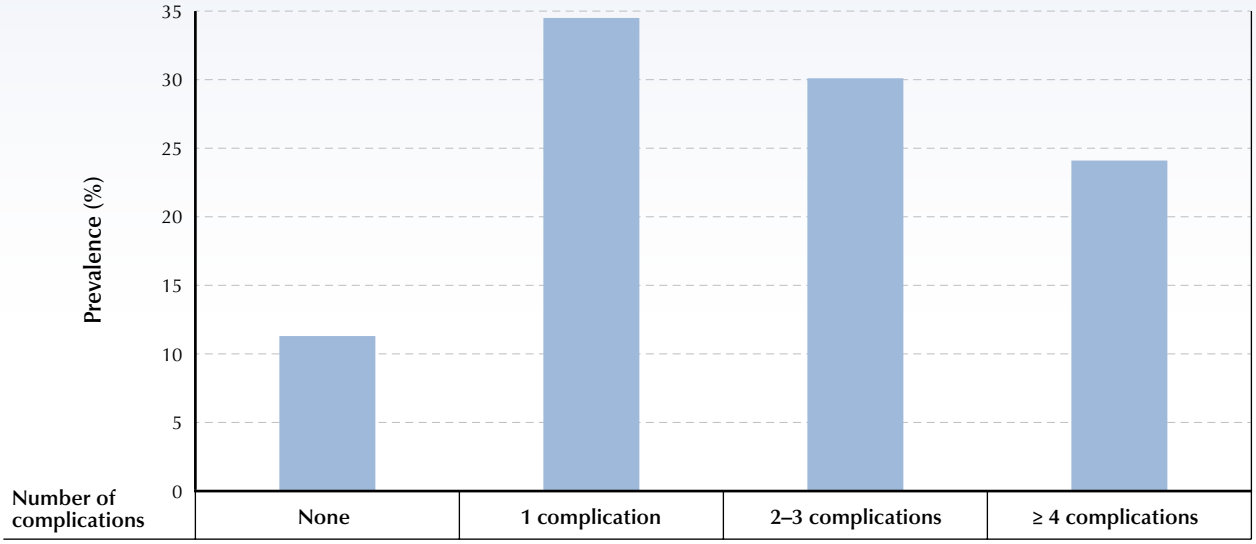
‡ 2006 APS estimates: First-Nations (off-reserve) 34.3 (32.9–35.7), Inuit 60.2 (58.3–62.1), Métis 31.2 (29.9–32.5).
Source: Public Health Agency of Canada (2011), using data from the 2009–2010 Canadian Community Health Survey (Statistics Canada) and the 2006 Aboriginal Peoples Survey (Statistics Canada); First Nations Information Governance Centre (2011), using data from the 2008–2010 First Nations Regional Longitudinal Health Survey (Phase 2) (First Nations Information Governance Centre).

Complications associated with diabetes

First Nations individuals, Inuit and Métis are subject to higher rates of co-morbidities and complications from diabetes than the general Canadian population.[65] Complications of diabetes include cardiovascular disease, lower limb amputation, retinopathy, kidney disease, hypertension, and nervous system disorder (Chapter 2).[33] Complications in the Aboriginal populations are thought to be higher due to an earlier age of diabetes onset, a greater severity of the disease, reduced access to health services due to geographical barriers, and an increased number of risk factors for other chronic diseases.[6;33;65;66] Diabetes mortality rates among First Nations individuals, Inuit and Métis are also higher than for the general Canadian population.[36;67;68] Currently, the rate of complications in First Nations adults living off-reserve, Inuit and Métis has not been studied extensively; available data obtained from the RHS describes the situation of First Nations individuals living on-reserve.

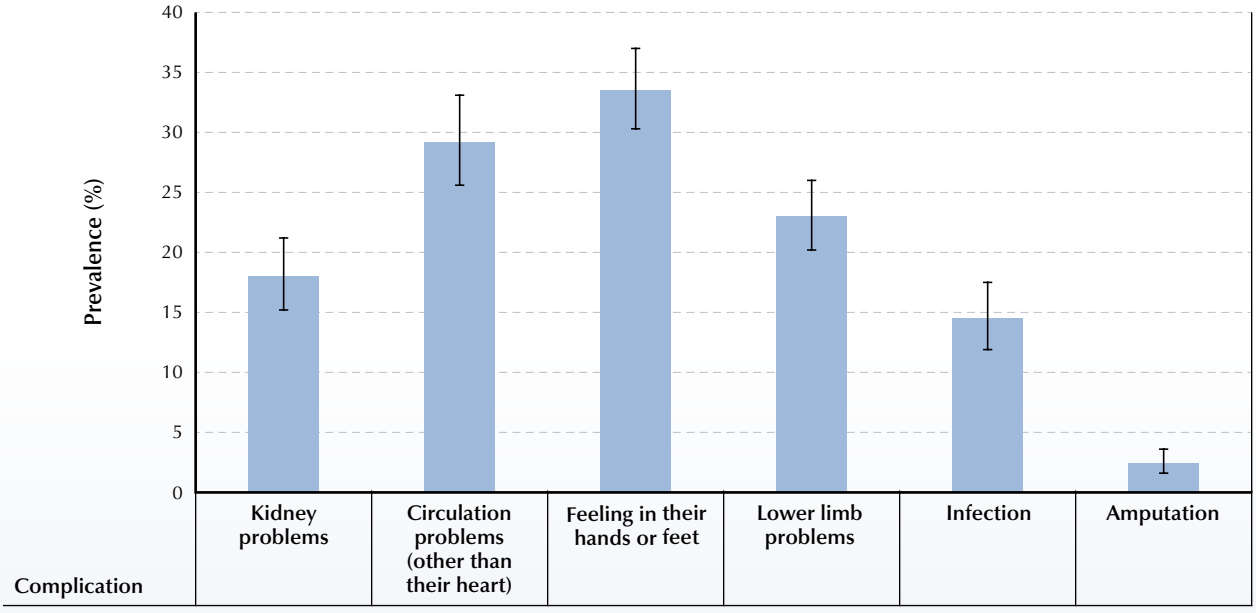
In 2002–2003, 89% of First Nations adults living on-reserve reported one or more adverse health consequences (problems with feeling hands or feet, vision loss, poor circulation, problems with lower limbs, heart problems, impaired kidney function, and/or infection) related to their diabetes, and almost 25% reported four or more (Figure 6-1). More than one-quarter (28.6%) of First Nations adults living on-reserve with diabetes experienced activity limitations as a result of the disease.[62] In 2008–2010, consequences associated with diabetes remained prevalent in First Nations adults living on-reserve, with many reporting complications with their kidneys, blood circulation, and infections (Figure 6-2).

Figure 6-1. Prevalence of adverse complications among First Nations individuals on-reserve aged 18 years and older with self-reported diabetes, by number of complications, Canada, 2002–2003



Source: Public Health Agency of Canada (2011); using findings from the 2002–2003 First Nations Regional Longitudinal Health Survey (Phase 1) (First Nations Information Governance Centre).

Figure 6-2. Prevalence of adverse complications among First Nations individuals on-reserve aged 18 years and older with self-reported diabetes, Canada, 2008–2010



Source: Public Health Agency of Canada (2011); using findings from the 2008–2010 First Nations Regional Longitudinal Health Survey (Phase 2) (First Nations Information Governance Centre).

Health service utilization

Health services for First Nations, Inuit and Métis populations are delivered through various federal, provincial/territorial and Aboriginal-run programs. Despite the high rates of chronic diseases, primary health care utilization is lower among the Aboriginal populations than in the general population.[22;48;69] Lower utilization is partly due to limited geographical access to primary health services for Aboriginal individuals living in Northern or isolated communities. However, rates of hospitalization are higher among some Aboriginal individuals.[44;51] For example, in 2000 in Western Canada (British Columbia, Alberta, Saskatchewan and Manitoba), the age-standardized hospital separation rate for diabetes was seven times higher in the First Nations population living on and off-reserve (780 hospital separations per 100,000 population) than in the general population (110 separations per 100,000 population).[70] The high rates of hospitalization, a measure of more acute serious health events, may be the result of limited access to primary and preventative health care[22;51] and poorer day-to-day management of diabetes.

Direct costs of diabetes for First Nations individuals

Estimating the costs of diabetes is a challenging undertaking (Chapter 3, Economic costs of diabetes). Information is currently unavailable for all First Nations, Inuit and Métis individuals, but two reports – one based on data from Saskatchewan and the other on data from Manitoba – have tried to estimate the costs of care for First Nations individuals with diabetes who are registered under the Indian Act of Canada.[71;72]

In Saskatchewan,[71] registered First Nations individuals with diabetes were more likely to visit a physician, to be hospitalized, or to receive dialysis when compared to the use of services by the general population with diabetes. The health care costs for First Nations individuals with diabetes were more than double those of First Nations individuals without the disease, and 40% higher than the costs for individuals with diabetes in the general population. Using a different methodology for calculating the excess costs of diabetes, the study in Manitoba[72] found that per capita health care costs for First Nations individuals with diabetes were 34% higher than for First Nations individuals without the disease, and 69% higher than for those with diabetes in the general population. However, neither analysis examined outpatient costs such as prescription drugs, devices, or transportation. If the general use of these resources differs from that of the general population, overall cost comparisons may be affected.

The Aboriginal Diabetes Initiative

In response to the high rates of diabetes and its risk factors in Aboriginal populations, the federal government launched the *Aboriginal Diabetes Initiative* (ADI) in 1999, as part of the Canadian Diabetes Strategy, with an initial funding of $58 million over five years. It was expanded in 2005, with a renewed budget of $190 million over five years. In 2010, the federal budget committed $275 million over five years to support the activities of the ADI.

The main objective of the ADI is to reduce type 2 diabetes through the support of health promotion and disease prevention activities and services, delivered by trained community diabetes workers and health service providers. Through the ADI, Health Canada works in partnership with Tribal Councils, First Nations communities and organizations, Inuit communities and groups, and provincial and territorial governments to support prevention, health promotion, screening and care management initiatives that are community-based and culturally appropriate.

Renewed funding (2010–2015) will enable First Nations and Inuit communities to continue to build on past successes in more than 600 First Nations and Inuit communities throughout Canada. The renewed ADI will feature several areas of enhanced focus, including:

- initiatives for children, youth, parents and families;
- diabetes in pre-pregnancy and pregnancy;
- community-led food security plans to improve access to healthy foods, including traditional foods; and
- enhanced training for home and community care nurses on clinical practice guidelines and chronic disease management strategies.

Using local knowledge, First Nations and Inuit communities are encouraged to develop innovative, culturally relevant approaches aimed at increasing community wellness and ultimately reducing the burden of type 2

diabetes. Community activities funded through the ADI vary from one community to another, and may include walking clubs, weight-loss groups, diabetes workshops, fitness classes, community kitchens, community gardens and healthy school food policies. The ADI also supports traditional activities, such as traditional food harvesting and preparation, canoeing, drumming, dancing, and traditional games.

Looking ahead

The rapid socio-cultural changes in the lives of First Nations individuals, Inuit and Métis in the last half century have had a tremendous impact on their health. In its report, the Subcommittee on Population Health of the Standing Senate Committee on Social Affairs, Science and Technology highlighted that: *"population level factors which determine the health and well being for any collectivity have their origins in upstream historic, cultural, social, economic and political forces affecting the lives of Aboriginal Peoples living in Canada."*[52] The management of lifestyle risk factors, such as physical inactivity, unhealthy eating, and overweight and obesity, plays a key role in preventing diabetes and reducing complications. Community-based programs that reflect the distinct heritages, languages, cultural practices and spiritual beliefs of First Nations, Inuit and Métis populations are important for primary prevention, care and management of diabetes in these populations.

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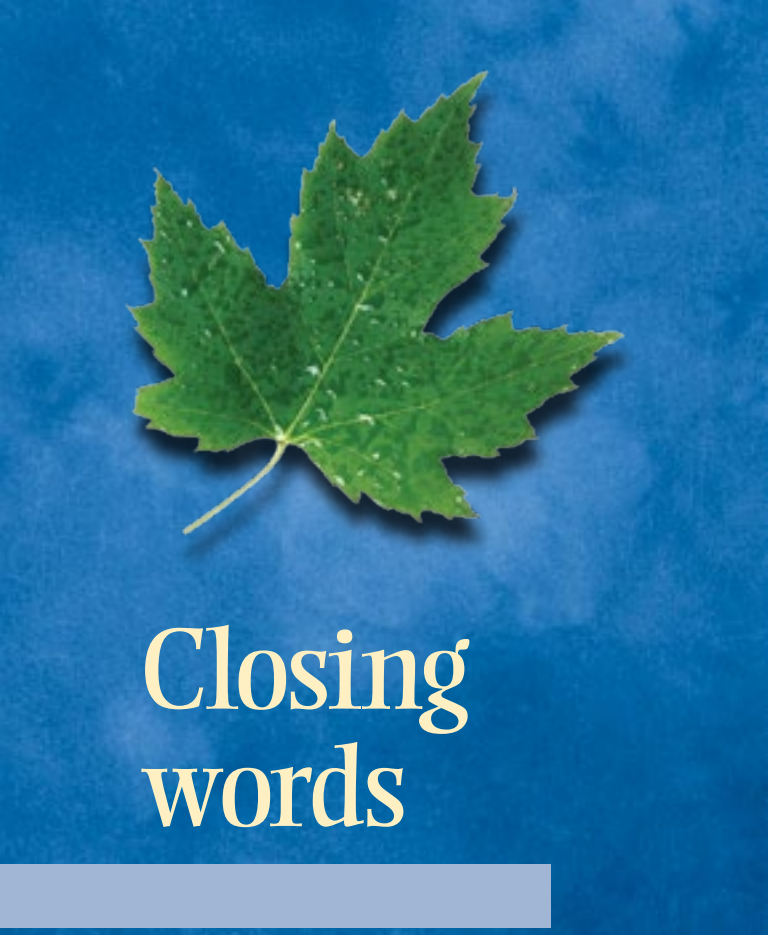

Closing words

The number of Canadians with diabetes is growing at an alarming rate. In 2008/09, one in every 15 Canadians was living with diabetes. In addition, according to recent Canadian data, there may be up to 20% of individuals with diabetes whose disease has not yet been diagnosed. From 1998/99 to 2008/09, the age-standardized prevalence of diagnosed diabetes increased by 70%. Although the incidence rate has only slightly increased during the same period, the highest relative increase of newly diagnosed cases was seen in the 30 to 44 year age group. If the current incidence and mortality trends continue, it is estimated that there will be 3.8 million Canadians with diabetes in 2018/19.

There were 200,000 Canadians newly diagnosed with diabetes in 2008/09, with nearly half between the ages of 45 to 64 years old. Obesity is a major contributor to the development of diabetes in this age group, with nearly half (47.5%) of those with diabetes reporting obesity, compared to only 19.1% among those without diabetes. Since increasing age is also a major factor for type 2 diabetes, the aging of the "baby boom" cohort has begun and will continue to have an impact on the incidence and prevalence of diabetes in Canada.

The incidence of diabetes has not increased sufficiently over the last decade to account for the distinct rise observed in prevalence, which is a clear indication that the increase in prevalence is mainly due to the longer duration of the disease among those diagnosed with diabetes. While this is likely due to improved care and treatment, it may also indicate earlier detection of those with undiagnosed diabetes or earlier age of onset of

diabetes. However, the implication of this is that the longer an individual lives with diabetes, the higher the risk of developing long-term debilitating complications, such as end-stage renal disease, vision loss, or lower limb amputation. Moreover, the impact of diabetes extends beyond those living with the disease and their family; it also has a major impact on the Canadian health care system. The economic costs associated with treating and managing diabetes are expected to increase greatly in the coming years as a result of both the increased prevalence of diabetes and the ongoing rise in health care costs.

Although some aspects of the current situation may appear gloomy, scaling up prevention can curb the rising human and economic costs associated with diabetes. Attaining and maintaining a healthy weight and being physically active are the cornerstone interventions for both diabetes prevention and optimal management. The current overweight and obesity epidemic must be tackled, particularly in children, youth and young adult populations. Canadians must also become more active. Physical activity not only helps individuals manage weight, but it also independently increases sensitivity to insulin. An important national childhood obesity initiative is currently underway. This collaborative approach, agreed to by the Federal, Provincial, and Territorial Ministers of Health, is seeking to make childhood obesity a national priority through the implementation of *Curbing Childhood Obesity: A Federal, Provincial and Territorial Framework for Action to Promote Healthy Weights*.

Although the care and management of individuals with diabetes has improved in the last decade, there is still room for further improvement. Appropriate glycemic control along with increased screening and more aggressive treatment of complications and risk factors for cardiovascular disease (such as hypertension, hyperlipidemia, and tobacco smoking) require ongoing attention.

Although very important, individual-level interventions will not be sufficient for success. The adoption of healthier lifestyles is complex and is influenced by larger socio-economic factors. For example, heavy marketing of unhealthy food and beverage choices and car-driven urban design are both recognized as having important influences on the current eating and physical activity patterns of the population. Public policies promoting healthy foods and environments conducive to physical activity must be put into practice.

Furthermore, as shown in this report, diabetes is not distributed equally accross Canada. A geographical distribution of diabetes in Canada has shown higher rates in the east, particularly in Newfoundland and Labrador, Nova Scotia, and Ontario, and lower rates in the west and north, particularly in Alberta and Nunavut. After adjusting for age, First Nations populations are particularly affected, with rates two to three times higher than the rest of the population. Similarly, immigrants of non-European descent are experiencing higher prevalence rates. Finally, two other populations require special attention: children and youth, and females of child-bearing age. The rising overweight and obesity rates in children and youth as well as the increasing rates of diabetes are particularly worrisome since the early onset of the disease means an increased risk of related complications and lifelong consequences. In addition, besides the well-known short-term impacts of gestational diabetes on the mother and the foetus, it has also been shown to increase the risk of overweight, obesity and diabetes in the child later in life. Although important national initiatives such as the *Aboriginal Diabetes Initiative* and the Federal/Provincial/Territorial framework on *Curbing Childhood Obesity* already exist, efforts targeting these populations should continue.

In conclusion, this report highlights some positive news, such as the relatively stable incidence rate over the last decade and the improved longevity of those with diabetes. However, it also demonstrates the important increase in the number of people living with diabetes and the associated impact on the health system. The report also highlights the major effect of obesity in the development of diabetes in younger adults, which may usher in a new wave of diabetes in Canada.

List of acronyms

ACHORD	Alliance for Canadian Health Outcomes Research in Diabetes
ADI	Aboriginal Diabetes Initiative
APS	Aboriginal Peoples Survey
BMI	Body mass index
CAD	Canadian dollar
CCDSS	Canadian Chronic Disease Surveillance System
CCHS	Canadian Community Health Survey
CDS	Canadian Diabetes Strategy
CGM	Continuous glucose monitoring
CHMS	Canadian Health Measures Survey
CI	Confidence interval
CNIB	Canadian National Institute for the Blind (now called CNIB)
COPD	Chronic obstructive pulmonary disease
CSII	Continuous subcutaneous insulin infusion
CTUMS	Canadian Tobacco Use Monitoring Survey
DKA	Diabetic ketoacidosis
EBIC	Economic Burden of Illness in Canada
FPG	Fasting plasma glucose
HALE	Health-adjusted life expectancy
HbA1c	Glycated haemoglobin
HDL	High-density lipoprotein
HHNS	Hyperglycemic hyperosmolar nonketotic syndrome
HRQOL	Health-related quality of life
IDDM	Insulin-dependent diabetes mellitus
IFG	Impaired fasting glucose
IGT	Impaired glucose tolerance
LE	Life expectancy
MDI	Multiple daily injections
NGO	Non-government organizations
OGTT	Oral glucose tolerance test
OR	Odds ratio
RHS	First Nations Regional Longitudinal Health Survey
WHO	World Health Organization

Glossary

A

Aboriginal: Descendants of the first inhabitants of North America. Indians (First Nations), Métis and Inuit are the three groups of Aboriginal people recognized in the Canadian Constitution.

Age-standardized: Rates are adjusted for changes in the age structure of the population over time, or for differences in age structure across different populations (for example, by provinces, territories, or ethnicity).

Asymptomatic: When an individual has a disease or condition but does not experience or present with any symptoms.

B

Bipolar disorder: A mood disorder sometimes called manic-depressive illness or manic-depression that is characterized by altering episodes of depression and mania.

Body mass index (BMI): A measure of human body size and proportion. It is defined as the weight in kilograms divided by the square of height in meters (see Obesity). Various levels of BMI are used as guidelines for healthy targets.

C

Cardiovascular disease: All diseases of the circulatory system including congenital and acquired diseases such as acute myocardial infarction (heart attack), ischemic heart disease, valvular heart disease, peripheral vascular disease, arrhythmias, hypertension, and stroke.

Cataracts: A gradual clouding of the natural lens of the eye that prevents light from reaching the retina.

Canadian Chronic Disease Surveillance System (CCDSS): A national surveillance system that uses population-based administrative data from provinces/territories to provide comparative information for assessing the scope, use of health services and health outcomes of chronic diseases in Canada.

Celiac disease: A disease of the small intestine. It is caused by an immunological (allergic) reaction to gluten in the diet that inflames and destroys the inner lining of the small intestine.

Chronic obstructive pulmonary disease (COPD): A disorder where the bronchial airflow is persistently obstructed.

Co-morbidity: When two disorders or illnesses occur in the same person, simultaneously or sequentially, they are described as co-morbid. Co-morbidity also implies interactions between the illnesses that affect the course and prognosis of both.

Confidence interval (CI): An interval provided around an estimate to indicate its reliability. In this report, the 95% confidence intervals show an estimated range of values which is likely to include the true rate 19 times out of 20.

Congenital malformation: A physical defect present in a newborn, irrespective of whether the defect is caused by a genetic factor or by prenatal events that are not genetic.

Costs due to premature mortality: The economic burden of premature mortality refers to the foregone future economic production that otherwise could have been realized by society had death not occurred prematurely.

D

Diabetes mellitus: A chronic disease that occurs when the body is unable to sufficiently produce or properly use insulin. Diabetes mellitus occurs in several forms – type 1, type 2 and gestational are the most common.

Diabetic ketoacidosis (DKA): Often referred to as diabetic coma, DKA results from high levels of blood sugar due to a relative lack of insulin.

Diabetic nephropathy: Results when high blood sugar levels damage the blood vessels that filter blood in the kidneys.

Diabetic retinopathy: Results when high blood sugar levels damage the tiny blood vessels in the retina of the eye.

Dialysis: A procedure that is a substitute for many of the normal duties of the kidneys, such as filtering waste products from the blood.

Diagnosed diabetes: The Canadian Chronic Disease Surveillance System summarized data about Canadian residents who have used the Canadian health care system. If there was sufficient evidence of use attributed to diabetes, it was assumed that a person had diagnosed diabetes. The minimum requirement was at least one hospitalization or two physician claims, with a diabetes specific code(s), over a two-year period. Cases of gestational diabetes are excluded.

Direct costs: Direct costs refer to the value of those goods and services for which a payment was made or resources were used in the treatment, care, or rehabilitation related to illness or injury. Direct costs are comprised of expenditures for hospital care, physician care, and medication, as well as expenditures for care in other institutions and additional direct health expenditures (such as other professionals, other health spending, capital, and public health and administration).

Depression: A mood disorder characterized by sadness, inactivity, difficulty with thinking and concentration, significant increase or decrease in appetite and time spent sleeping, feelings of dejection and hopelessness, and, sometimes, suicidal thoughts or an attempt to commit suicide.

E

Ethnicity: Ethnicity in the 2009–2010 CCHS was based on the question, "People living in Canada come from many different cultural and racial backgrounds. Are you: 1. White?" 2. Chinese?" 3. South Asian (e.g., East Indian, Pakistani, Sri Lankan)?" 4. Black?" 5. Filipino?" 6. Latin American?" 7. Southeast Asian (e.g., Cambodian, Indonesian, Laotian, Vietnamese, etc.)?" 8. Arab?" 9. West Asian (e.g., Afghan, Iranian)?" 10. Japanese?" 11. Korean?" 12. Other – specify."

F

Fasting plasma glucose (FPG): A test that measures blood glucose after a fast of eight hours minimum. See also oral glucose tolerance test.

G

Gestational diabetes: Occurs when elevated blood sugar levels develop during pregnancy, but normally ends following childbirth.

Gingivitis: An inflammatory condition of the gums surrounding the teeth.

Glaucoma: An eye problem that develops when the increased pressure within the eye starts destroying the nerves within the retina. Without early treatment, glaucoma can cause vision loss and blindness.

Glucagon: A medication for treating severe hypoglycemic reactions.

H

HbA1c levels: Glycohemoglobin – often referred to as HbA1c or A1c – is a hemoglobin molecule bound with glucose. HbA1c levels are determined by a blood test that determines the proportion of glycohemoglobin in the blood. Typically, approximately 4% to 6% of hemoglobin in the blood has glucose bound to it, but individuals with diabetes usually have higher blood levels of glycohemoglobin.

Health literacy: A person's ability to find, understand and use written information to promote, maintain and improve their health.

Hospital separation: The number of in-patients who leave hospital through discharge or death.

Hyperglycemia: Elevated blood sugar levels.

Hypertension: High blood pressure is generally defined as a systolic blood pressure equal to or greater than 140 mmHg and/or a diastolic blood pressure equal to or greater than 90 mmHg. In people with diabetes, however, hypertension is defined as a systolic blood pressure equal to or greater than 130 mmHg and/or a diastolic blood pressure equal to or greater than 80 mmHg.

Hypoglycemia: Blood sugar levels lower than normal. Occurs when excess insulin in the blood leads to low blood sugar levels.

I

Incidence: The number of newly diagnosed cases during a given period in a specified population.

Incidence rate: The rate of individuals newly diagnosed with a disease among those at risk during a specified time period.

Indirect costs: Indirect costs refer to the value of economic output lost as a result of illness, injury or premature death. Indirect costs are comprised of short-term and long-term disability (morbidity costs), and premature death (mortality). They are measured in terms of the value of decreased productivity attributable to restricted activity days due to morbidity, and lost years due to premature mortality.

Insulin: A hormone secreted by beta cells in the pancreas that enables the cells of the body to absorb sugar from the bloodstream and use it as an energy source.

Insulin pump: A programmable medical device worn outside the body 24 hours a day that aims to mimic the natural insulin delivery of the pancreas. It continuously infuses insulin based on the individual's corporal needs over the course of a 24-hour cycle.

L

Laser photocoagulation: A technique to seal off bleeding blood vessels. Tissue is coagulated using a laser which produces light in the visible green wavelength that is selectively absorbed by the pigment in red blood cells.

Life expectancy: A summary measure of the health status of a population. It is defined as the average number of years an individual of a given age is expected to live if current mortality rates continue to apply.

M

Mania: A mood disorder characterized by symptoms such as inappropriate elation, increased irritability, severe insomnia, grandiose notions, increased speed and/or volume of speech, disconnected and racing thoughts, increased sexual desire, markedly increased energy and activity level, poor judgment, and inappropriate social behaviour.

Morbidity: Any departure, subjective or objective, from a state of physiological or psychological wellbeing.

Morbidity costs due to long term disability: The economic burden of long-term disability refers to lost economic production due to restricted activity days caused by long-term disability. Long-term disability refers to periods of restricted activity lasting six months or greater.

Morbidity costs due to short term disability: The economic burden of short-term disability refers to the lost economic production due to restricted activity days caused by short-term disability. Short term disability refers to periods of restricted activity of less than six months.

Mortality rate: An estimate of the proportion of a population that dies during a specified period.

Mortality data: Mortality or death data are collected by the provincial or territorial registrar of vital statistics for residents of that province or territory at the time of death and sent to Statistics Canada for final editing. The death registration covers all deaths of Canadians occurring in Canada and to some extent in the United States. Deaths occurring in countries other than Canada and the United States are not included.

N

Neuropathy: A group of nerve diseases that affect the peripheral nerves. Can cause numbness, and sometimes pain and weakness, in the hands, arms, feet, and legs.

O

Obesity: A relative term for excessive accumulation of fat in the body; defined in several ways. This report uses the World Health Organization definition: individuals are considered obese if they have a Body Mass Index (BMI) equal to or greater than 30 kg/m^2 (see Body Mass Index, Waist-to-hip ratio).

Obesogenic: That promotes high-energy diets and sedentary lifestyles, that increases risk factors associated with obesity.

Oral glucose tolerance test (OGTT): A test that measures blood glucose after a fast of eight hours minimum and two hours after administration of 75 grams of glucose. See also Fasting plasma glucose (FPG).

Osteoarthritis: A common form of arthritis that causes pain, stiffness and swelling around one or more joints that lasts longer than two weeks. It can involve any joint, but usually occurs in hands and in weight-bearing joints such as the hips, knees, feet and spine.

Overweight: Individuals are considered overweight if they have a Body Mass Index (BMI) equal to or greater than 25 kg/m^2.

P

Periodontitis: The destruction of the ligament, bone, and soft tissues that support the teeth.

Physical inactivity: A relative term, which refers to the lack of exercise, the definition of which varies among researchers.

Population attributable risk (PAR): The proportion of the deaths or disease cases that may be preventable in the whole population if a cause of mortality or a risk factor were totally eliminated.

Pre-diabetes: A state in which affected persons have fasting blood sugar levels or a response to a fasting glucose tolerance test that is higher than normal, but not high enough for a diagnosis of diabetes.

Prevalence: The number of individuals affected by a disease or a risk factor at a given point in time.

Prevalence rate: The proportion of individuals that are affected by a disease or a risk factor at a given point in time.

S

Sleep apnea: A sleep-related breathing disorder. The word *apnea* means "no breathing", and *sleep apnea* refers to pauses in breathing that occur during sleep. On average, these pauses last for ten to 30 seconds, until the brain reacts to overcome the problem.

Standard population: A population structure that is used to provide a constant age distribution, so that the rates of different study populations can be adjusted for comparison (see Age-standardized rates).

T

Thyroid disease: An over- or under-functioning of the thyroid gland. The thyroid gland is an essential organ for producing thyroid hormones, which maintain body metabolism.

Type 1 diabetes: An autoimmune disease in which the body's immune system attacks and destroys the insulin-producing cells of the pancreas.

Type 2 diabetes: A metabolic disorder that occurs when the pancreas does not produce enough insulin and/or when the body does not properly use the insulin it makes.

W

Waist-to-hip ratio: The ratio of waist circumference to hip circumference. It is used as a measurement of obesity (see Obesity).

Comments and requests

To obtain hard copies or to submit comments about this report, please contact:

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