Tracking diabetes: Prevalence, incidence and risk factors

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Abstract

Objectives

This article examines the prevalence and incidence of diabetes among Canadians aged 18 or older and risk factors associated with developing the condition.

Data sources

The data are from the 1994/95, 1996/97, 1998/99 and 2000/01 National Population Health Survey and the 2000/01 Canadian Community Health Survey, both conducted by Statistics Canada.

Analytical techniques

Descriptive statistics on the prevalence and incidence of self-reported diabetes were computed. Multiple logistic regression was used to identify predictors of incident diabetes. Age-adjusted rates were used to compare diabetic and non-diabetic respondents on a variety of health measures.

Main results

In 2000/01, 4.5% of Canadians aged 18 or older, an estimated 1.1 million, reported having diabetes. The incidence from 1994/95 to 2000/01 was 4.9 new cases per 1,000 person-years at risk. When the possible confounding effects of a number of factors were taken into account, advancing age, family history, sedentary leisure time and excess weight were associated with developing diabetes.

Key words

body mass index, physical activity, longitudinal studies, health surveys

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Diabetes, already one of the most prevalent chronic diseases, is affecting increasing numbers worldwide.[1,2] This increase cannot be attributed to a single cause, but rather, to a combination of demographic, lifestyle and clinical factors. A decline in diabetes mortality over the past two decades has resulted in a large number of people surviving with the disease. Reductions in physical activity and greater caloric intake have contributed to a substantial rise in the prevalence of overweight, a risk factor for diabetes.[3-5] Changes in diagnosis criteria could also influence the number of cases that are identified. In 1998, the cut-point for a diagnosis of diabetes mellitus was lowered from a fasting plasma glucose (FPG) level of 7.8 to 7.0 mmol/L[6] (see *What is diabetes?)*. Finally, growing public and physician awareness could increase testing, and result in detection of more cases.[7]

Studies of diabetes in Canada have generally been based on cross-sectional prevalence data. While useful for public administration purposes, such statistics do not indicate the incidence of new cases over time. With longitudinal data from the National Population Health Survey (NPHS), however, it is possible to estimate the incidence of diabetes since the mid-1990s.

Data sources

National Population Health Survey

This analysis is based on Statistics Canada's National Population Health Survey (NPHS), weighted to represent the population of the 10 provinces. The NPHS, which began in 1994/95, collects information about the health of the Canadian population every two years. It covers household and institutional residents in all provinces and territories, except people on Indian reserves, on Canadian Forces bases, and in some remote areas. The NPHS has a longitudinal and a cross-sectional component.

Cross-sectional sample: The 1994/95 and 1996/97 (cycles 1 and 2) cross-sectional samples are made up of longitudinal respondents and other members of their households, as well as individuals selected as part of supplemental samples, or buy-ins, in some provinces. The 1998/99 (cycle 3) cross-sectional sample is made up mostly of longitudinal respondents and their cohabitants. Although no buy-ins were added to the cycle 3 sample, infants born after 1994 and immigrants who entered Canada after 1994 were randomly selected and added to keep the sample representative. To replace sample lost to attrition, individuals in households that were part of the original sampling frame but whose members did not respond in 1994/95 were contacted and asked to participate.

NPHS data are stored in two files. The General file contains socio-demographic and some health information for each member of participating households. The Health file contains in-depth health information for one randomly selected household member, as well as the information in the General file pertaining to that individual.

In 1994/95, in all selected households, one knowledgeable person provided the socio-demographic and health information about all household members for the General file. As well, one household member, not necessarily the same person, was randomly selected to provide in-depth health information about him- or herself for the Health file.

Among individuals in the longitudinal component in 1996/97 and 1998/99, the person providing in-depth health information about himself or herself for the Health file was the randomly selected person for the household in cycle 1 (1994/95), and was usually the person who provided information on all household members for the General file in cycles 2 and 3. In households added to the 1998/99 cross-sectional sample, the randomly selected respondent was also the person who provided information for the General file.

The 1994/95 provincial, non-institutional sample consisted of 27,263 households, of which 88.7% agreed to participate. After application of a screening rule to keep the sample representative, 20,725 households remained in scope. In 18,342 of these households, the selected person was aged 12 or older. Their response rate to the in-depth health questions was 96.1%, or 17,626 respondents. The response rate at the household level was 82.6% in 1996/97 and 88.2% in 1998/99.

The cross-sectional NPHS data used in this analysis pertain to 16,291, 68,282 and 14,150 respondents aged 18 or older in cycles 1, 2 and 3. Beginning with cycle 4 in 2000/01, the NPHS became strictly longitudinal; the cross-sectional component was taken over by the Canadian Community Health Survey (CCHS).

Longitudinal sample: Of the 17,626 randomly selected respondents in 1994/95, 14,786 were eligible members of the longitudinal panel, along with 468 persons for whom only general information was collected. An additional 2,022 of the 2,383 randomly selected respondents under age 12 were also eligible. Thus, the longitudinal sample is composed of the 17,276 respondents who were selected in cycle 1 and had completed at least the General component of the questionnaire. The longitudinal sample size remained the same (17,276) for all cycles. The response rate for the Health component was 83.6% in cycle 1, 92.8% in cycle 2, 88.9% in cycle 3, and 84.8% in cycle 4.

The 2000/01 cycle 4 longitudinal square master file was used for this analysis. This file contains records for all longitudinal respondents, regardless of whether they provided information for all four cycles (that is, individuals selected for the longitudinal sample for whom information is available on the General file of cycle 1).

The sample used in this analysis pertains to 14,117 respondents aged 18 or older in 1994/95. The diabetes status of 54 respondents could not be determined; they were deleted, leaving 14,063.

More detailed descriptions of the NPHS design, sample and interview procedures can be found in published reports.[8-10]

Canadian Community Health Survey

Data about the prevalence of diabetes in 2000/01 and the association with selected health conditions and health care use are from cycle 1.1 of Statistics Canada's Canadian Community Health Survey (CCHS). The CCHS covers the household population aged 12 or older in all provinces and territories, except persons on Indian reserves, on Canadian Forces bases, and in some remote areas.

The responding sample size for cycle 1.1 was 131,535, and the response rate was 84.7%. The sample used for this article consists of 116,171 respondents aged 18 or older in the 10 provinces. More detail about the design, sample and interview procedures of the CCHS is available in a previously published report.[11]

Using the results of successive waves of the NPHS, this analysis tracks changes from 1994/95 to 2000/01 in the prevalence and incidence of diabetes among Canadian adults and identifies potential risk factors (see *Data sources, Analytical techniques, Definitions* and *Limitations*). A comparison of the diabetic and non-diabetic populations is based on the 2000/01 Canadian Community Health Survey (CCHS).

Prevalence increasing

In 2000/01, an estimated 1.1 million Canadians aged 18 or older reported that they were diabetic (see *Compromised health*). They accounted for 4.5% of the population in that age range, up from 3.4% in 1994/95 (Table 1).

In 1994/95, there had been no difference between men and women in the prevalence of diabetes, but by 2000/01, the rate was significantly higher among men. The proportion of men who had been diagnosed rose from 3.4% to 4.8%, while among women, the increase was from 3.3% to 4.2%. The increase among men was significant at ages 18 to 44 and 45 to 64, but among women, only at ages 45 to 64.

Table 1
Prevalence of diabetes, by sex and age group, household population aged 18 or older, Canada excluding territories, 1994/95 to 2000/01

	1994/95	1996/97	1998/99	2000/01
			%	
Both sexes	3.4	3.5	3.8	4.5*
18-44	0.9	0.9	1.1	1.3*
45-64	4.1	4.9	4.8	6.0*
65-74	11.0	9.9	10.9	12.9
75+	11.4	11.4	12.3	12.5
Men	3.4	3.8	4.3	4.8*
18-44	0.8[E1]	0.8	1.4[E1]	1.2*
45-64	4.5	5.8	5.4	6.7*
65-74	12.5	11.2	12.3	14.7
75+	13.0[E1]	14.6	15.9	14.8
Women	3.3	3.2	3.3	4.2*
18-44	1.1[E1]	1.0	0.7[E1]	1.3
45-64	3.7	4.1	4.3	5.3*
65-74	9.8	8.8	9.7	11.3
75+	10.4	9.2	9.7	10.9

Data sources: 1994/95, 1996/97 and 1998/99 National Population Health Survey, cross-sectional sample, Health file; 2000/01 Canadian Community Health Survey
E1 Coefficent of variation between 16.6% and 25.0%
** Significantly different from 1994/95 ($p < 0.05$)*

What is diabetes?

Diabetes is a chronic disease that has no cure, but can be controlled.[12] There are two major types. Type 1 diabetes occurs most often in children and young adults and is relatively uncommon, accounting for 10% to 15% of cases.[13] It is an autoimmune disease in which the body produces little or no insulin, a hormone needed to convert food into energy. The resulting insulin deficiency is severe, and to survive, a person with type 1 diabetes must regularly inject insulin.

Type 2, which results when the pancreas does not produce enough insulin or when the body does not use the insulin that is produced effectively, accounts for 85% to 90% of cases. It may affect children and adolescents, but usually begins after age 30 and becomes more common with advancing age.

Another form of the disease—gestational diabetes—is a temporary condition that occurs in up to 4% of pregnancies and increases the risk of eventually developing diabetes.

The first symptoms of diabetes are related to high blood sugar levels. As the blood-glucose level rises, glucose passes into the urine. The kidneys excrete additional water to dilute the large amounts of glucose that are being lost. This leads to excessive urination, which in turn, creates abnormal thirst. Because of the severity of insulin deficiency, people with type 1 diabetes almost always lose weight. Most people with type 2 do not lose weight and may not have symptoms for years or decades. Early symptoms of type 2 include recurring skin, gum or bladder infections, slow-to-heal cuts and bruises, itchy skin, vaginal yeast infections, fatigue, blurred vision, frequent urination, and tingling in the hands or feet. Over time, elevated blood sugar levels damage blood vessels, nerves and other internal structures, resulting in serious long-term complications, such as heart attack and stroke. Damage to the blood vessels of the eye can cause vision loss. The kidneys can malfunction, resulting in kidney failure that requires dialysis.

Type 2 diabetes can be detected in blood tests before it has fully developed. The fasting plasma glucose (FPG) test measures blood-glucose levels, usually first thing in the morning after an overnight fast. The oral glucose tolerance test (OGTT) measures blood-glucose levels twice: once after fasting, and again two hours after a sugar-rich drink.

Diabetes is treated by control of blood sugar levels, combined with control of blood pressure and blood lipids. Insulin replacement therapy or an oral hypoglycemic medication is often needed, although many people with type 2 would not need medication if they lost weight and exercised regularly.

Despite the notable upturn at younger ages, diabetes remains a disease of the elderly. In 2000/01, over 12% of seniors were diabetic, compared with 6% of 45- to 64-year-olds and just over 1% of people aged 18 to 44.

A family history is a major risk factor. In 1998/99, 8.5% of people with a diabetic parent and/or sibling reported that they, too, had the disease; the rate among people who did not report first-degree relatives as having diabetes was 2.0% (Table 2).

Diabetes tended to be associated with lifestyle. In 2000/01, rates were high among people who were obese or sedentary. The prevalence was also high among former drinkers and smokers, perhaps reflecting a modification of lifestyle triggered by the diagnosis. There also seems to be some association

Analytical techniques

The unadjusted prevalence of diabetes was computed for 1994/95, 1996/97 and 1998/99 based on the National Population Health Survey (NPHS) and for 2000/01 based on the Canadian Community Health Survey (CCHS).

The diabetes incidence rate is the number of new cases diagnosed in a given period, divided by the total person-time under observation.[14-16] Respondents who were free of "diagnosed diabetes" at the start of each NPHS cycle constitute the population among whom incidence rates were calculated.

Since four cycles of longitudinal NPHS data are available, there are three two-year intervals (1994/95 to 1996/97, 1996/97 to 1998/99, and 1998/99 to 2000/01). Three records were created for each individual on the master file, one record for each two-year interval. The number of respondents free of diabetes at the beginning of each interval constituted the population "at risk" of being diagnosed over the next two years. The sum of respondents at risk at the beginning of each of the three intervals was the population at risk during the entire six years: 33,599.

A respondent was considered to be an incident case if (s)he did not report diabetes in one cycle, but did report having been diagnosed in the next. Interviews for each cycle were conducted approximately two years apart, so the time-at-risk between two adjacent cycles was assumed to be two years for respondents not reporting a diagnosis at either cycle. For respondents who did not report diabetes when they were interviewed at the beginning of one cycle, but did report it at the next interview, the time-at-risk between the two interviews was taken to be one year, based on the assumption that new diagnoses were evenly distributed throughout the interval. The maximum time-at-risk for respondents not diagnosed throughout the survey cycles was six years. Any interval between the cycles for which the existence or non-existence of diabetes was unknown was not used to calculate time-at-risk.

The numerator for the incidence of diabetes was the number of new cases that accumulated over the period; the denominator was the number of person-years contributed by the population at risk (that is, who did not have diabetes) over the follow-up period. Rates were expressed as cases per 1,000 person-years at risk for each two-year interval and for the entire six years.

The selection of independent variables was based on a review of the literature and their availability in the NPHS: sex, age, family history of diabetes, body mass index, physical activity, alcohol use, smoking and education (see *Definitions*). For all independent variables except family history, data from each survey cycle were used. Information on family history was collected only in 1998/99 (see *Limitations*). If respondents stated that they had a family history of diabetes in 1998/99, a family history variable was assigned to their responses for 1994/95 and 1996/97.

Individuals were considered to have a particular characteristic for the full two years between each cycle, even if the value of the characteristic changed from one interview to the next. For example, respondents' answers to the leisure-time physical activity questions in one interview might place them in the "sedentary" category, but answers in the subsequent interview might qualify as "moderately active." Nonetheless, such respondents would be considered "sedentary" for the entire two years between interviews. For each characteristic, an "unknown" category was created so that respondents for whom diabetes information was available could be included in the analysis even if they had not provided data about other characteristics.

Multivariate pooled logistic regression was used to study the association between incident diabetes and the selected risk factors. To ensure an adequate sample size, data for men and women were combined. For the same reason, "missing value" categories were included for some independent variables, but their odds ratios are not shown.

To account for survey design effects, standard errors and coefficients of variation were estimated with the bootstrap re-sampling technique.[17-20] Results at the 0.05 level were considered significant. In instances where multiple means or proportions were tested, the significance levels were adjusted via the Exacted Alpha/L Method.

with socio-economic status, as a relatively large proportion of people with less than secondary graduation were diabetic.

Table 2
Unadjusted prevalence of diabetes, by selected characteristics, household population aged 18 or older, Canada excluding territories, 2000/01

	Sample size	Estimated population		Prevalence of diabetes
		'000	'000	%
Total	116,171	23,300	1,054	4.5
Sex				
Men	53,110	11,430	552	4.8*
Women†	63,061	11,870	502	4.2
Age group				
18-44†	55,279	12,387	155	1.3
45-64	36,758	7,269	436	6.0*
65-74	13,148	2,154	277	12.9*
75+	10,986	1,490	186	12.5*
Family history of diabetes‡				
Yes	...	...	...	8.5*
No†	...	...	...	2.0
Missing	...	...	...	4.2*
Body mass index (BMI)§				
Not overweight (< 25)†	55,768	11,895	295	2.5
Overweight (25.0-29.9)	38,393	7,457	387	5.2*
Obese (≥ 30)	18,447	3,333	352	10.6*
Missing	3,563	615	20	3.2
Leisure time				
Active†	23,181	4,430	140	3.2
Moderately active	26,146	5,044	202	4.0
Sedentary	60,232	12,022	625	5.2*
Missing	6,612	1,799	86	4.8*
Alcohol consumption				
Current drinker	91,252	18,586	635	3.4*
Former drinker	16,638	2,803	272	9.7*
Abstainer†	7,583	1,768	142	8.0*
Missing	698	138	5	3.7
Smoking				
Daily/Occasional	32,886	6,312	204	3.2*
Former smoker	48,094	9,136	535	5.9*
Never smoked†	34,928	7,792	314	4.0
Missing	263	58	1	2.4
Education				
Less than secondary graduation	31,234	5,218	445	8.5*
Secondary graduation/Some postsecondary	31,874	6,757	234	3.5
Postsecondary graduation†	51,830	11,111	361	3.3
Missing	1,233	214	14	6.3*

Data source: 2000/2001 Canadian Community Health Survey; 1998/99 National Population Health Survey, cross-sectional sample, Health file
Note: Because of rounding, detail may not add to totals.
† Reference group
‡ 1998/99 National Population Health Survey
§ Excludes pregnant women.
** Significantly different from reference group (p < 0.05)*
··· Not applicable

Compromised health

According to the results of the 2000/01 Canadian Community Health Survey, people with diabetes tended to have other medical problems, and not surprisingly, made frequent use of health care services, even when the older age profile of the diabetic population was accounted for.

Those who reported that they had been diagnosed with diabetes were more likely than non-diabetics to have high blood pressure, heart disease, urinary incontinence and stroke. Vision problems, too, were more common. Given these high percentages, it is not surprising that over a third of diabetics (37%) rated their health as poor or fair, whereas this was true of 11% of non-diabetics.

As might be expected, diabetics made relatively frequent use of health care services. For instance, 29% reported 10 or more general practitioner contacts in the previous year, compared with 12% of non-diabetics. Diabetics were also more likely to have had at least three contacts with eye doctors and with other specialists in that time. Fully 18% of diabetics had been hospitalized in the past year, compared with 8% of non-diabetics, and a significantly higher proportion had spent more than two weeks in hospital.

Age-adjusted† prevalence of selected health indicators, by diabetes status, household population aged 18 or older, Canada excluding territories, 2000/01

	Diabetic	Non-diabetic
	%	
Chronic conditions		
Heart disease	12*	5
High blood pressure	34*	13
Urinary incontinence	5*	2
Stroke	3*	1
Vision problems		
None	38*	44
Corrected	58*	54
Uncorrected	4*	2
Glaucoma	3*	1
Cataracts	7*	4
Fair/Poor self-perceived health	37*	11
Health care use in past year		
10+ physician contacts	29*	12
3+ eye doctor contacts	13*	6
3+ other medical specialist contacts	21*	9
Hospitalized	18*	8
Hospitalized more than 14 days	3*	1

Data source: 2000/01 Canadian Community Health Survey
† Adjusted to 2000/01 population, both sexes
** Significantly different from non-diabetic (p < 0.05)*

However, many of these characteristics are interrelated. For example, advancing age is associated with increased weight, decreased physical activity, and decreased use of alcohol and tobacco. As well, levels of education tend to be relatively low among elderly people. The potential effects of such confounding relationships should be taken into account to determine associations between diabetes and various risk factors, particularly with regard to new diagnoses.

Definitions

Both the National Population Health Survey (NPHS) and the Canadian Community Health Survey (CCHS) contain questions about chronic conditions. NPHS respondents were asked if they had any "long-term health conditions that have been diagnosed by a health professional." CCHS respondents were asked if they had any "long-term health problems." In addition to diabetes from both surveys, this analysis considers heart disease, high blood pressure, stroke, urinary incontinence, glaucoma and cataracts from the CCHS.

For descriptive analysis, *age* was grouped into four categories: 18 to 44, 45 to 64, 65 to 74, and 75 or older. Age was used as a continuous variable in the adjusted analysis.

In 1998/99, NPHS respondents were asked about the medical history of their immediate family. A *family history of diabetes* was considered to exist if a respondent reported that at least one first-degree relative (biological parent and/or sibling) had the disease. A substantial number (4,005) of respondents did not know their family history. These respondents, who tended to have a higher incidence of diabetes than those without a positive family history (Appendix Table A), were initially excluded. However, additional analysis showed that the independent associations of family history and body mass index with incident diabetes persisted even when these respondents were included and classified as having no family history. Consequently, estimates are shown for this group.

In the NPHS and CCHS, respondents were asked their weight and height. *Body mass index* (BMI) was calculated by dividing weight in kilograms by the square of height in metres. Three categories were defined: not overweight (BMI less than 25), overweight (25 to 29.9) and obese (30 or more). Pregnant women were excluded from the calculations.

Leisure-time physical activity was based on total energy expenditure during leisure time. Information about physical activity at work was not available from either survey. Energy expenditure was based on the frequency and duration of respondents' reported leisure-time activities in the previous three months and the metabolic energy demand of each activity. Activities lasting less than 15 minutes were not counted. Three activity levels were defined: active (3.0 or more kilocalories per kilogram of body weight per day) moderate (1.5 to less than 3.0) and sedentary (less than 1.5).

Respondents to both surveys were asked: "During the past 12 months, how often did you drink alcoholic beverages?" For this analysis, three categories of *alcohol consumption* were established: current (regular and occasional) drinker, former drinker and abstainer.

Respondents to both surveys were asked about their past and current cigarette consumption. Three categories of *smoking* were identified: daily/occasional, former smoker and never smoked.

Education was categorized as less than secondary graduation, secondary graduation/some postsecondary and postsecondary graduation.

As well as the inclusion of cataracts and glaucoma among chronic conditions, the CCHS asked about *vision problems*. This analysis uses three categories of vision problems: none, corrected and uncorrected (including no sight).

CCHS respondents were asked: "In general would you say your health is: excellent, very good, good, fair, poor?" For this analysis, three categories of *self-perceived health* were defined: excellent/very good, good, and fair/poor.

In the CCHS, the use of family doctors or general practitioners was determined by asking: "In the past 12 months how many times have you seen or talked on the telephone about your physical, emotional or mental health with a family doctor or general practitioner?" ... an eye specialist (such as an ophthalmologist or optometrist)?" The same general question also related to consultations with other medical specialists (such as surgeon, allergist, orthopedist, gynecologist or psychiatrist). Frequent use of general practitioner services was defined as 10 or more times in the past year. Frequent use of eye or other medical specialists was defined as three or more times in the past year.

CCHS respondents were asked if they had been an overnight patient in a hospital, nursing home or convalescent home in the past 12 months and for how many nights. In this analysis, heavy users of hospital services were those who had spent more than 14 days in hospital.

Rising incidence

The rate at which new cases of diabetes were diagnosed increased in recent years. Between 1994/95 and 1996/97, the two-year incidence rate was 4.0 cases per 1,000 person-years at risk; between 1998/99 and 2000/01, the rate was 6.7 cases (Table 3). The increase among men from 3.5 to 6.8 cases per 1,000 person-years at risk was statistically significant, but the apparent rise in rates among women from 4.5 to 6.5 cases was not.

From 1994/95 to 2000/01, 353 new cases of diabetes were reported by NPHS respondents, representing about 497,000 new diagnoses. The overall incidence rate for this six-year period was 4.9 cases per 1,000 person-years at risk.

Incidence rose with age from 1.8 new cases per 1,000 person-years at risk for 18- to 44-year-olds to 14.2 cases at age 75 or older (Table 4). Even when adjustments were made for the effects of factors such as family history, weight, physical activity, drinking, smoking and education, the odds of developing diabetes were significantly higher at older ages (Table 5).

Table 3
Two-year incidence of diabetes, by sex, household population aged 18 or older, Canada excluding territories, 1994/95 to 2000/01

	New cases per 1,000 person-years at risk	95% confidence interval
Both sexes		
1994/95 to 1996/97	4.0	3.1, 4.9
1996/97 to 1998/99	4.4	3.3, 5.5
1998/99 to 2000/01	6.7†	5.1, 8.2
Men		
1994/95 to 1996/97	3.5	2.3, 4.7
1996/97 to 1998/99	4.5	2.6, 6.4
1998/99 to 2000/01	6.8†	4.6, 9.0
Women		
1994/95 to 1996/97	4.5	3.1, 5.9
1996/97 to 1998/99	4.3	2.9, 5.7
1998/99 to 2000/01	6.5	4.4, 8.7

Data source: 1994/95, 1996/97, 1998/99, 2000/01 National Population Health Survey, longitudinal sample, Health file
Note: Critical ratio adjusted for multiple comparisons and non-independent samples
† Significantly higher than 1994/95 to 1996/97 (p < 0.05)

Family history

A family history of a disease may indicate a genetic predisposition. It might also increase awareness, which could instigate testing and detection. Among people who had a biological parent and/or sibling with diabetes, the six-year incidence rate was 9.7 new cases per 1,000 person-years at risk, compared with 3.0 cases among people without such a background. A family history, however, may also signal a shared

Table 4
Unadjusted six-year incidence of diabetes, by selected characteristics, household population aged 18 or older, Canada excluding territories, 1994/95 to 2000/01

	New cases per 1,000 person-years at risk	95% confidence interval
Total	4.9	4.3, 5.6
Sex		
Men†	4.8	3.8, 5.8
Women	5.0	4.1, 6.0
Age group		
18-44‡	1.8	1.1, 2.4
45-64	7.0*	5.7, 8.4
65-74	11.6*	8.4, 14.9
75+	14.2*	8.8, 19.7
Family history of diabetes		
Yes	9.7*	7.5, 11.9
No†	3.0*	2.3, 3.6
Missing	5.8*	4.1, 7.4
Body mass index (BMI)§		
Not overweight (< 25)‡	1.9	1.3, 2.5
Overweight (25.0-29.9)	6.1*	4.8, 7.5
Obese (≥ 30)	13.5*	10.6, 16.4
Leisure time		
Active‡	2.7	1.6, 3.9
Moderately active	4.5	3.1, 5.9
Sedentary	5.8*	4.8, 6.8
Alcohol consumption		
Current drinker‡	3.7	3.0, 4.3
Former drinker	10.7*	7.7, 13.8
Abstainer	8.7*	5.2, 12.2
Smoking		
Daily/Occasional	3.4	2.4, 4.4
Former smoker	6.6	5.2, 8.0
Never smoked‡	4.6	3.5, 5.8
Education		
Less than secondary graduation	8.8*	7.0, 10.7
Secondary graduation/Some postsecondary	3.9	3.0, 4.9
Postsecondary graduation‡	3.6	2.5, 4.6

Data source: 1994/95, 1996/97, 1998/99, 2000/01 National Population Health Survey, longitudinal sample, Health file
† Reference group
‡ Reference group at beginning of each two-year interval
§ Excludes pregnant women.
** Significantly different from reference group (p < 0.05)*

home environment that increases the risk of developing a disease. In the case of diabetes, shared behaviour in nutrition, physical activity, smoking and alcohol use could contribute to higher incidence rates.[21-23] Yet even when these factors along with age, sex and education were taken into account, the odds that a person with a diabetic parent or sibling would be diagnosed with the disease were almost three times those of a person without such a family history.

Table 5
Adjusted odds ratios relating selected characteristics to incidence of diabetes between 1994/95 and 2000/01, household population aged 18 or older, Canada excluding territories

	Adjusted odds ratio	95% confidence interval
Sex		
Men	1.11	0.78, 1.56
Women†	1.00	...
Age (in years)‡	1.13*	1.06, 1.21
Family history of diabetes		
Yes	2.75*	1.94, 3.90
No†	1.00	...
Missing	1.56*	1.06, 2.30
Body mass index (BMI)§		
Not overweight (< 25)†	1.00	...
Overweight (25.0-29.9)	1.59*	1.30, 1.94
Obese (≥ 30)	1.77*	1.56, 2.02
Leisure time		
Active†	1.00	...
Moderately active	1.51	0.91, 2.51
Sedentary	1.65*	1.03, 2.64
Alcohol consumption		
Current drinker†	1.00	...
Former drinker	1.97*	1.38, 2.82
Abstainer	1.76*	1.10, 2.81
Smoking		
Daily/Occasional	1.02	0.65, 1.61
Former smoker	1.24	0.85, 1.80
Never smoked†	1.00	...
Education		
Less than secondary graduation	1.14	0.79, 1.65
Secondary graduation/Some postsecondary	1.04	0.71, 1.53
Postsecondary graduation†	1.00	...

Data source: 1994/95, 1996/97, 1998/99, 2000/01 National Population Health Survey, longitudinal sample, Health file
† Reference group
‡ Age-squared was used in model, but data are not shown.
§ Excludes pregnant women.
** Significantly different from reference group (p < 0.05)*
... Not applicable

Weight and exercise

Excess weight is an important risk factor for the development of type 2 diabetes,[24-27] and the risk tends to rise as weight increases.[28] The six-year incidence rate among people who were obese was 13.5 new cases per 1,000 person-years at risk, and among those who were overweight, 6.1 cases. This compared with 1.9 cases among people who were not overweight. The association remained significant when factors such as age, family history and physical activity were considered. The odds that an obese or overweight person would be diagnosed with diabetes were one and a half times those of someone who was not overweight.

Physical activity has been shown to reduce the risk of developing diabetes.[29-39] Over the six years covered by the NPHS, the incidence of the disease was 2.7 new cases per 1,000 person-years at risk for people who were physically active in their leisure time, compared with 5.8 new cases for those with sedentary pursuits. Even though active people are less likely to have excess weight,[40,41] when BMI and the other factors were taken into account, the odds of incident diabetes were significantly higher among people who were sedentary.

Drinking and smoking

The six-year incidence rates of diabetes were highest among former drinkers at 10.7 new cases per 1,000 person-years at risk and abstainers at 8.7 new cases. The rate among current drinkers was just 3.7 cases. People with a family history of diabetes may abstain from alcohol, thus accounting for the higher incidence rate in that group. As well, the high incidence rates among former drinkers and abstainers might be attributable to the age structure of the two groups, since drinking tends to decline at older ages.[42] Yet even when family history, age, and the other factors were considered, the odds of incident diabetes were significantly higher among former drinkers and abstainers than among current drinkers.

Prospective studies have suggested that smoking may be a risk factor for diabetes,[27,43-47] but according to the analysis of the NPHS data, the odds of developing diabetes over the six years did not differ

significantly by smoking status. This is in line with a 1996 report that attempted to control for a wide range of variables and suggested that a causal relationship between smoking and insulin resistance is unlikely.[48]

Education

From 1994/95 to 2000/01, the incidence rate of diabetes for people with less than secondary graduation was 8.8 new cases per 1,000 person-years at risk, considerably above the rate for postsecondary graduates (3.6 cases). But when age, sex, family history, and lifestyle factors were taken into account, the odds of developing diabetes over the period did not differ significantly by education.

Nonetheless, the association between education and diabetes is complex. Similar incidence rates may conceal great differences between education groups in factors that contribute to a diagnosis of diabetes, but that could not be accounted for in this analysis. For example, less-educated people are generally more likely to report chronic diseases,[59] not just diabetes, which could contribute to higher incidence rates. On the other hand, they may not be aware of the means of preventing diabetes and the symptoms associated with it, which could mean fewer diagnoses. Better-educated people, by contrast, tend to be more aware of risk factors and symptoms, which could increase their demand for screening and result in elevated incidence rates. But at the same

Limitations

Diabetes tends to be underdiagnosed,[49,50] as the onset of the disease may occur several years before clinical diagnosis.[13] It has been estimated that as many as one-third of adults with the condition have not been diagnosed.[51] Consequently, some National Population Health Survey (NPHS) and Canadian Community Health Survey (CCHS) respondents who did not report diabetes may actually have had it, so its incidence and prevalence may be underestimated.

On the other hand, no independent source was available to confirm if respondents who reported diabetes (or other chronic conditions) had actually been diagnosed by a health professional. However, a study that compared self-reports of diabetes with hospital and physician claims data suggests that self-reports were fairly accurate.[52]

Reliance on self-reports entails other problems. For instance, self-reported weight and height (used to calculate BMI) may underestimate the prevalence of overweight, particularly among seniors.[53-55] With age, loss of bone mass and height is common, but people tend to report their height as measured in younger years. Similarly, self-reported leisure-time physical activity may bias results toward underestimation of the effect of physical activity on chronic disease incidence and prevalence.[56-58]

In NPHS and CCHS data, type 1 and type 2 diabetes cannot be differentiated. Since the risk factors are not the same, the strength of the relationship between the independent variables and the incidence of diabetes (that is, type 2) may have been diluted.

Although the prevalence of diabetes is high among Aboriginal people,[60-63] the NPHS longitudinal file sample was not large enough to yield precise estimates for this population.

Family history was defined as the presence of diabetes in a biological parent and/or sibling. The number of first-degree relatives with the disease would have been useful,[64-66] but this information is not available. In addition, the question about family history was not asked until the third NPHS cycle, and the responses were applied to individuals who participated in the first cycle. No family history information was available for respondents who had died or moved into residential care by the time of the cycle 3 interview.

The analysis of the association between the independent variables and the incidence of diabetes assumed that the respondent's status in each independent variable category remained stable during each two-year interval. But factors like physical activity or weight might have changed markedly during the interval, so the lack of such information could affect inferences about the importance of some independent variables on the incidence of diabetes.

The cycle 4 NPHS Longitudinal Master File contains records for all longitudinal respondents for whom there was some information in 1994/95. If individuals became non-respondents after the first cycle, they could still contribute to the estimates. In cases where the survey lacks full information on these individuals, there is a potential for bias if those without full responses behave differently from those with full responses for the characteristic being studied.

time, they might be more likely to take preventive measures and make lifestyle changes that would lower the incidence of the disease.

Concluding remarks

In 2000/01, 4.5% of Canadians aged 18 or older—an estimated 1.1 million—had diabetes, and the pace at which new cases were diagnosed seems to have increased.

The analysis of data from the Canadian Community Health Survey reinforces other studies that have shown that that diabetes not only takes a personal toll on those with the disease, but also imposes a substantial burden on physician and hospital services.[67-74]

The analysis of longitudinal data from the National Population Health Survey shows that age, family history, weight and physical activity were the most important predictors of incident diabetes. Age and family history, of course, cannot be modified. However, weight and physical activity can be changed.

The results underscore the importance of public health initiatives aimed at reducing diabetes risk by attaining and maintaining a healthy weight.[6,75] People who gain weight and accumulate fat around the waist, abdomen and upper body tend to have relatively high odds of developing the disease.[76] A recent cohort study found that during a 13-year period, overweight men and women who reported intentional weight loss had about a 25% reduction in the rate of developing diabetes, compared with their counterparts who did not report intentional weight loss.[77]

Higher levels of physical activity may help to prevent type 2 diabetes by increasing sensitivity to insulin and inhibiting progression of the disease in its early stages. And through its influence on weight control, physical activity is important in preventing diabetes.[78,79] Even when weight was accounted for in the NPHS analysis, physical activity was independently associated with a lower risk of developing the disease.

Current patterns of overweight and physical activity suggest that the prevalence of diabetes will rise in the next decade. Despite the benefits of exercise, the majority of Canadians, with and without diabetes, are not active in their leisure time and the proportion of the population who are overweight is rising. Moreover, the number of seniors will increase, so even if incidence rates remain stable, demographic changes may lead to a considerable upturn in the overall prevalence of the disease. ●

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Appendix

Table A
Characteristics of household population aged 18 or older with no diagnosis of diabetes, Canada excluding territories, 1994/95

	Sample size	Estimated population	
		'000	%
Total	13,565	20,398	100.0
Sex			
Men	6,210	10,012	49.1
Women	7,355	10,386	50.9
Age group			
18-44	7,405	11,878	58.2
45-64	3,711	5,679	27.8
65-74	1,434	1,784	8.8
75+	1,015	1,056	5.2
Family history of diabetes			
Yes	2,609	3,791	18.6
No	6,951	10,432	51.1
Missing	4,005	6,175	30.3
Body mass index (BMI)†			
Not overweight (< 25)	6,835	10,432	51.1
Overweight (25.0-29.9)	4,319	6,375	31.3
Obese (≥ 30)	2,260	3,375	16.6
Missing	151	216	1.1
Leisure time			
Active	2,165	3,240	15.9
Moderately active	2,737	4,064	19.9
Sedentary	7,728	11,301	55.4
Missing	935	1,793	8.8
Alcohol consumption			
Current drinker	10,267	15,634	76.6
Former drinker	1,784	2,314	11.3
Abstainer	1,082	1,612	7.9
Missing	432	837	4.1
Smoking			
Daily/Occasional	4,265	6,134	30.1
Former smoker	4,077	5,947	29.2
Never smoked	4,800	7,492	36.7
Missing	423	824	4.0
Education			
Less than secondary graduation	3,888	5,131	25.2
Secondary graduation/Some postsecondary	5,521	8,581	42.1
Postsecondary graduation	4,127	6,639	32.5
Missing	29	46	0.2

Data source: 1994/95, 1996/97, 1998/99, 2000/01 National Population Health Survey, longitudinal sample, Health file
Note: Because of rounding, detail may not add to totals.
† Excludes pregnant women.
F Coefficient of variation greater than 33.3%