

# Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995–2005: a population-based study

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## Summary

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See Editorial page 716

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**Background** The prevalence of diabetes has been increasing greatly, but WHO's predicted 39% rise in the global rate of diabetes from 2000 to 2030 might be an underestimate. We aimed to assess diabetes trends in Ontario, Canada.

**Methods** Using population-based data, including a validated diabetes database from the province of Ontario, Canada, we examined trends in diabetes prevalence and mortality from 1995 to 2005, and incidence from 1997 to 2003, in adults aged 20 years or older.

**Findings** Age-adjusted and sex-adjusted diabetes prevalence increased by 69%, from 5.2% in a population of 7 908 562 in 1995 to 8.8% of 9 276 945 in 2005. Prevalence increased by 27% from 6.9% in a population of 8 457 720 in 2000 to 8.8% of 9 276 945 in 2005. Although prevalence rates have remained higher in people aged 50 years or older (7.1% of 3 675 554) than in those aged 20–49 years (3.5% of 5 601 391), rates increased to a greater extent in the younger population (94% vs 63%,  $p < 0.0001$ ). A 31% increase occurred in yearly incidence over 6 years, from 6.6 per 1000 in 1997 to 8.2 per 1000 in 2003. The adjusted mortality rate in people with diabetes fell by 25% from 1995 to 2005.

**Interpretation** The prevalence of diabetes in Ontario, Canada increased substantially during the past 10 years, and by 2005 already exceeded the global rate that was predicted for 2030. This increase in prevalence is attributable to both rising incidence and declining mortality. Effective public-health interventions aimed at diabetes prevention are needed, as well as improved resources to manage the greater number of people living longer with the disease.

## Introduction

The number of people with diabetes has increased substantially during the past 20 years,<sup>1–3</sup> making it one of the most costly and burdensome chronic diseases of our time. Diabetes is one of the leading causes of

blindness and the most common cause of end-stage renal disease in developed countries.<sup>4,5</sup> It is also an important cause of cardiovascular complications.<sup>6</sup> Furthermore, the treatment is complex and costly, with direct health-care costs of diabetes ranging from 2.5% to 15% of health budgets.<sup>7</sup>

According to the latest WHO report,<sup>7</sup> the number of people worldwide with diabetes increased from 30 million to 171 million between 1985 and 2000; an estimated 4.6% of adults aged 20 years or older are now affected.<sup>3</sup> Prevalence rates are generally higher in developed countries than in developing ones (6.3% vs 4.1%), but developing nations have seen the greatest rise, with about a 25% increase in diabetes rates since 1995.<sup>2,3</sup>

This increase in diabetes has been mainly attributed to a rise in new cases of type 2 diabetes,<sup>8</sup> which in turn is driven by increasing obesity rates<sup>9–14</sup> and ageing of the population.<sup>15</sup> The increased migration of susceptible populations, accompanied by shifts in lifestyle, has also added to the diabetes burden in developed countries.<sup>16–18</sup> Additionally, improved survival in people with diabetes might have also contributed to the increasing prevalence of the disease.<sup>19,20</sup>

Rates of diabetes are expected to continue to increase. WHO has predicted that the global diabetes prevalence in adults will reach 6.4% by 2030,<sup>3</sup> representing a 60% increase since 1995,<sup>2</sup> and a 39% rise from 2000 to 2030.<sup>3</sup> However, these projections are likely to be underestimates, since they were based on an unwarranted<sup>10–14</sup> assumption that obesity rates would remain constant.<sup>3</sup>

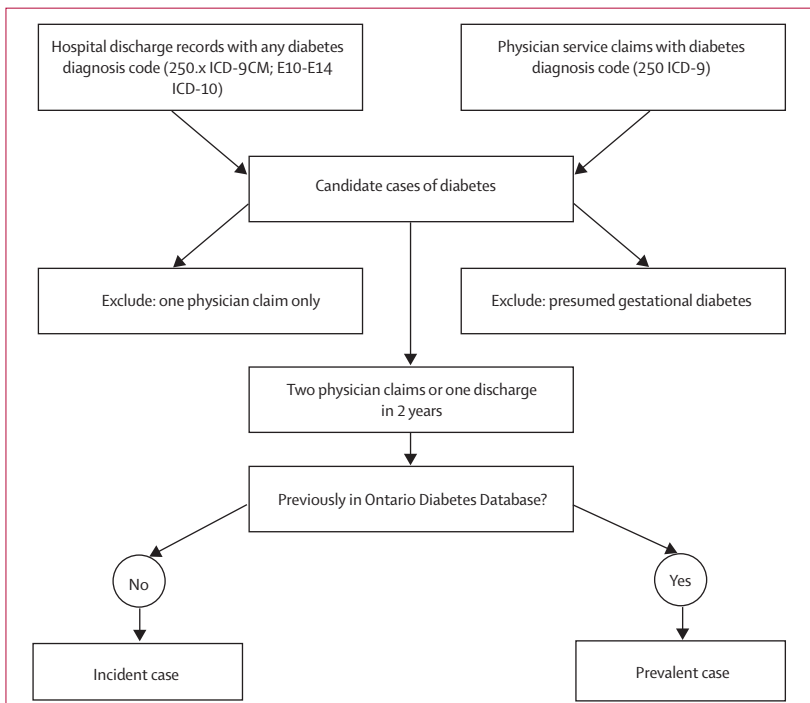


Figure 1: Algorithm for identification of diabetes cases in the Ontario Diabetes Database

	Overall			Women			Men		
	All Ages*	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years
<b>1995†</b>									
People with diabetes (n)	388 433	92 777	295 656	187 306	43 472	143 834	201 127	49 305	151 822
Population (n)	7 908 562	5 107 531	2 801 031	4 066 297	2 556 057	1 510 240	3 842 265	2 551 474	1 290 791
Adjusted prevalence rate (%)	5.2‡,§	1.8	10.6	4.6	1.7	9.5	5.2	1.9	11.8
<b>2000†</b>									
People with diabetes (n)	580 731	139 272	441 459	280 071	67 809	212 262	300 660	71 463	229 197
Population (n)	8 457 720	5 270 953	3 186 767	4 341 264	2 634 169	1 707 095	4 116 456	2 636 784	1 479 672
Adjusted prevalence rate (%)	6.9‡,§	2.6	13.9	6.5	2.6	12.4	7.3	2.7	15.5
<b>2005†</b>									
People with diabetes (n)	827 419	197 378	630 041	400 361	98 904	301 457	427 058	98 474	328 584
Population (n)	9 276 945	5 601 391	3 675 554	4 750 578	2 792 820	1 957 758	4 526 367	2 808 571	1 717 796
Adjusted prevalence rate (%)	8.8‡,§	3.5¶	17.1¶	8.4	3.5	15.4	9.4	3.5	19.1

\*Significant interactions existed between age and year and age, sex, and year ( $p < 0.0001$  for each). †By March 31 of year shown. ‡Prevalence rates are age-adjusted and sex-adjusted with 2001 census data. § $p < 0.0001$  for comparison of prevalence between years, adjusted for age-group, sex, and interaction terms. ¶ $p < 0.0001$  for comparison of 2005 prevalence between age groups. || $p < 0.0001$  for comparison of 2005 prevalence between sexes.

**Table 1: Diabetes prevalence by age-group and sex in 1995, 2000, and 2005**

Using a validated diabetes registry derived from hospital records and physician claims,<sup>21</sup> we describe trends in diabetes prevalence, incidence, and mortality in Ontario, Canada, from 1995 to 2005. We aimed to determine whether diabetes prevalence rates rose beyond predicted levels during that period, and to examine the contribution of changes in incidence and mortality to changes in prevalence.

## Methods

### Data sources and study population

Data were obtained from anonymised, administrative health-care databases that included records for all individuals eligible for coverage under the government-funded Ontario health plan. As in other Canadian provinces, this health plan is available to all residents; therefore, almost all Ontarians are represented by these datasets. With a population of 12 million, Ontario is the largest and most ethnically diverse Canadian province, and contains both rural and urban areas. Patient records are linked across datasets with a unique patient identifier. Data were available from April 1, 1991, until March 31, 2005. Ethics approval was obtained from the institutional review board at Sunnybrook Health Sciences Centre, Toronto, ON, Canada.

### Procedures

The Ontario diabetes database is a validated registry of Ontario residents with diagnosed diabetes, which was generated with administrative data.<sup>21</sup> To generate the database, hospital discharge abstracts from the Canadian Institute for Health Information were used to identify patients admitted with diabetes as one of their diagnoses (International Classification of Diseases Clinical

Modification diagnostic code 250 (ICD-9CM) before 2002 or ICD-10 code E10–E14 after 2002), and physicians' service claims were used to identify visits for diabetes (code 250). Any individuals having at least one hospital admission or two physicians' claims bearing a diabetes diagnosis within 2 years were included in the database. Using this algorithm (figure 1), the database has been validated and shown to have a high sensitivity (86%) and specificity (97%) for identification of individuals with diabetes recorded in primary-care records.<sup>21</sup> Records with an obstetric event within 5 months were excluded to avoid capturing cases of gestational diabetes; however, women with subsequent diabetes claims were included in the database. Individuals entered in the database remain there until they die or cease having Ontario health coverage. Adults aged 20 years or older were included.

For diabetes prevalence, we calculated the number of people recorded in the Ontario Diabetes Database on a yearly basis from fiscal years 1995 (April 1, 1994, to March 31, 1995) to 2005 (ending March 31, 2005). We presented data using the point prevalence and incidence at the end of the fiscal periods. To confidently identify an incident case, a minimum diabetes-free observation period of 5 years was set as a requirement. For example, a person meeting criteria in 1997 must have had no diabetes records during the previous 5 years to be included as an incident case. As a result, the incidence of diabetes before 1997 was not estimated, because a 5-year prediagnosis period was not available. Incidence was calculated up to March 31, 2003, as this was the last year for which complete incidence data were available. For people meeting the case definition, the incidence date was defined as the first record with a diabetes diagnosis.

	Overall			Women			Men		
	All ages*	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years
<b>1995–2000†</b>									
People with diabetes	49.5%	50.1	49.3	49.5	56.0	47.6	49.5	44.9	51.0
Population	6.9%	3.2	13.8	6.8	3.1	13.0	7.1	3.3	14.6
Prevalence rate‡	33.0%	45.5	31.2	40.1	51.4	30.6	39.5	40.3	31.7
<b>2000–2005‡ (%)</b>									
People with diabetes	42.5%	41.7	42.7	42.9	45.9	42.0	42.0	37.8	43.4
Population	9.7%	6.3	15.3	9.4	6.0	14.7	10.0	6.5	16.1
Prevalence rate‡	26.7%	33.4	23.7	30.6	37.6	23.8	29.2	29.4	23.5
<b>Change 1995–2005‡ (%)</b>									
People with diabetes	113.0%	112.7	113.1	113.7	127.5	109.6	112.3	99.7	116.4
Population	17.3%	9.7	31.2	16.8	9.3	29.6	17.8	10.1	33.1
Prevalence rate‡	68.6%	94.0§	62.4§	83.0	108.2¶	61.7	80.2	81.4¶	62.6

\*Prevalence rates are age-adjusted and sex-adjusted with 2001 census data. †April 1–March 31. ‡Percentage change in rates were calculated with differences between rates relative to the baseline rate, before rounding the rates as presented in table 1. §p<0.0001 for comparison between years, stratified by age-group (χ<sup>2</sup>, Breslow-Day test); ¶p<0.0001 for comparison between years, stratified by sex, in 20–49 age-group (χ<sup>2</sup>, Breslow-Day test).

**Table 2: Changes in diabetes prevalence by age-group and sex from 1995 to 2000, 2000 to 2005, and 1995 to 2005**

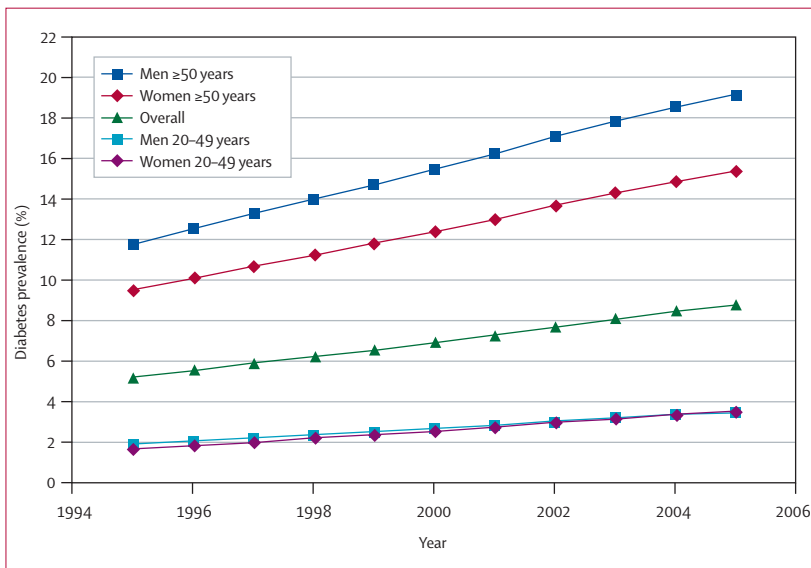
The yearly number of deaths in people with diabetes in the Ontario Diabetes Database from fiscal years 1995 to 2005 was recorded from the Registered Persons Database, which contains demographic and residential information for all Ontarians eligible for coverage. All deaths were included, whether or not diabetes was listed as a cause of death, since diabetes is listed as a cause in only 12.5% of deaths in people with diabetes, even though in many cases diabetes might have been a contributing factor.<sup>22</sup> Deaths recorded in the database were based on probabilistic linkage of death-certificate information and might therefore have missed some events. Accordingly, deaths that occurred in hospital were also recorded and,

where discrepancies in dates of death existed between the two sources, the hospital date was used.

**Statistical analysis**

To adjust for differences in population distribution over time, direct age and sex standardisation was undertaken for diabetes prevalence, incidence, and mortality with 2001 Canadian census data. We calculated diabetes prevalence rates yearly from fiscal year 1995 to 2005 using data for everyone in the Ontario diabetes database who were alive at year end as the numerator, and census population counts as of July 1 of the previous year as the denominator (or estimated population measures provided by Statistics Canada<sup>23</sup> for years for which no census was available). The Canadian census represents most citizens, excluding a small number of First Nation reserve residents for whom enumeration was incomplete.<sup>24</sup> We calculated incidence of diabetes in a similar way as for prevalence rates, using new cases of diabetes for a particular year as the numerator. Yearly death rates were calculated with the number of deaths for each year as the numerator and the number of people in the Ontario diabetes database that year as the denominator.

We used logistic regression to test for trends in diabetes prevalence, incidence, and mortality over time using year as an ordinal variable, and for examining the effect of age and sex on rates. Multivariable logistic regression models included fiscal year, age-group (20–34 years, 35–49 years, 50–64 years, 65–74 years, and >75 years), and sex. χ<sup>2</sup> analyses were used to compare diabetes prevalence rates in 2005 between sexes and age-groups and to compare rates in 1995–2005 within sexes and age-groups. The Cochran-Mantel-Haenszel and Breslow-Day tests were used to compare prevalence changes from 1995 to 2005 between age and sex strata. Similar analyses were done for incidence rates in 2003, and for changes



**Figure 2: Yearly diabetes prevalence rates, by sex and age-group, (fiscal years 1995–2005)**  
Overall prevalence rates are age-adjusted and sex-adjusted with 2001 census data. Yearly rates are based on prevalence by March 31 of each year.

	Overall			Women			Men		
	All ages*	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years	All ages	Age 20–49 years	Age ≥50 years
<b>1997†</b>									
Number with new diabetes	51 100	16 144	34 956	24 480	7 649	16 831	26 620	8 495	18 125
Population	8 108 471	5 185 179	2 923 292	4 176 243	2 600 057	1 576 186	3 932 228	2 585 122	1 347 106
Incidence rate per 1000	6.6‡,§	3.1	12.0	5.9	2.9	10.7	6.8	3.3	13.5
<b>2003†</b>									
Number with new diabetes	73 852	24 574	49 278	35 337	11 803	23 534	38 515	12 771	25 744
Population	8 969 282	5 500 634	3 468 648	4 591 283	2 740 761	1 850 522	4 377 999	2 759 873	1 618 126
Incidence rate per 1000	8.2‡,§	4.5¶	14.2¶	7.7	4.3	12.7	8.86	4.6	15.9
<b>Change from 1997 to 2003 (%)</b>									
Number with new diabetes	44.5	52.2	41.0	44.35	54.31	39.83	44.68	50.34	42.04
In population	10.6	6.1	18.7	9.9	5.4	17.4	11.3	6.8	20.1
In incidence rate	30.7	43.5	18.8	31.3	46.4	19.1	30.0	40.8	18.2

\*A significant interaction was found between age group and year ( $p < 0.0001$ ); †by March 31 of that year. ‡Incidence rates are age-adjusted and sex-adjusted with 2001 census data; § $p < 0.0001$  for comparison between years, adjusted for age group, sex, and interaction term; ¶ $p < 0.0001$  for comparison of 2003 incidence between age groups. || $p < 0.0001$  for comparison between years, stratified by age-group ( $\chi^2$ , Breslow-Day test);  $p < 0.0001$  for comparison of 2003 incidence between sexes.

**Table 3: Diabetes incidence by sex and age-group, 1997 and 2003**

between 1997 and 2003. We calculated percentage changes in prevalence, incidence, and mortality rates between years (eg, from 1995 to 2005) by dividing the difference between the two rates by the earlier rate, and multiplying by 100. For percentage changes in numbers of people and deaths, we divided the difference in numbers between the 2 years by the earlier number and multiplied by 100. All analyses were done with SAS version 8.0.

### Role of the funding and data sources

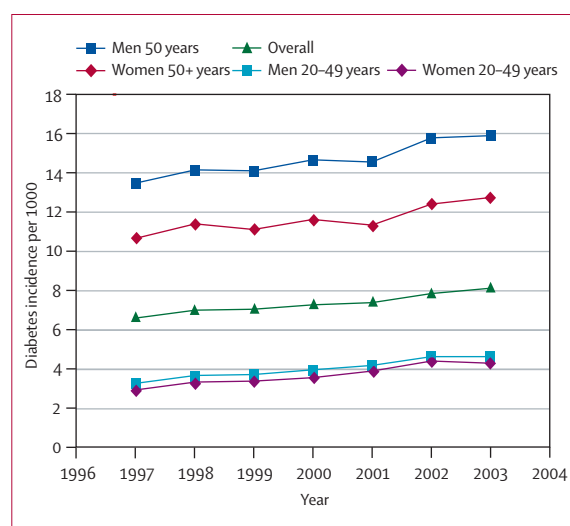
The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

The opinions, results, and conclusions reported in this paper are those of the authors, are independent from the funding sources, and no endorsement from Ontario's Ministry of Health and Long-Term Care is intended or should be inferred.

### Results

An 81.6% increase (from 4.9% to 8.9%) in the crude prevalence of diabetes in Ontario adults took place between March 31, 1995, and March 31, 2005, ( $p < 0.0001$  for trend by year). Ageing of the population accounted for only a small proportion of this increase, since the age-adjusted and sex-adjusted prevalence increased by 68.6%, from just over 5% in 1995 to nearly 9% by 2005 (tables 1 and 2). Prevalence increased by a third during the first 5 years, and by another quarter from 2000 to 2005 (table 2). In addition to this increase in the prevalence rate, the number of people with diabetes increased by 113%, from 388 433 to 827 419 during that time, whereas the population grew by only 17%.

A two-way interaction existed between age-group and year, and a three-way interaction between age, sex, and year. Therefore, we also analysed data stratified by age-group (20–49 years and ≥50 years), and by sex within age-groups. Diabetes prevalence remained higher in people aged 50 years or older than in those aged 20–49 years ( $p < 0.0001$ ) (table 1). However, in a stratified analysis, the prevalence of diabetes increased about 31% more in young people than in older people ( $p < 0.0001$ ) between 1995 and 2005 (table 2). As a result, the number of people with diabetes doubled in both age-groups, despite a 20% greater increase in the population of those over 50 years than in younger people (table 2).



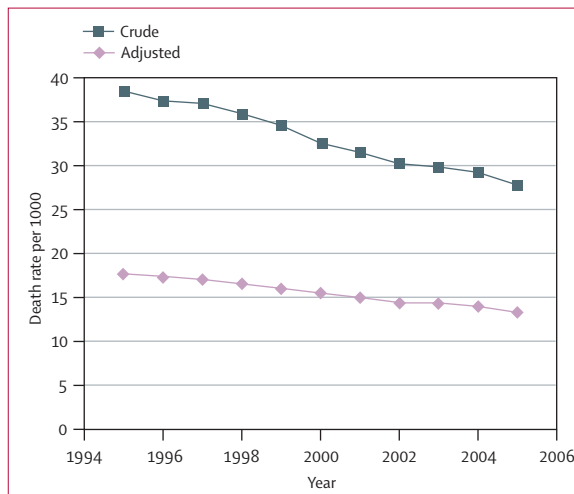
**Figure 3: Yearly diabetes incidence rates per 1000 by sex and age-group, (fiscal years 1997–2003)**

Overall incidence rates are age-adjusted and sex-adjusted with census data. Yearly rates are based on incident cases by March 31 of each year.

	Age-group					All ages	
	20–34 years	35–49 years	50–64 years	65–74 years	>75 years	Crude*	Adjusted†
<b>1995‡</b>							
Deaths	72	394	2196	4454	7825	14941	
People with diabetes	21686	71091	124202	102906	68548	388433	
Death rate per 1000	3.3	5.5	17.7	43.3	114.2	38.5§	17.6
<b>2000‡</b>							
Deaths	79	508	2564	5103	10647	18901	
People with diabetes	29555	109717	186686	144625	110148	580731	
Death rate per 1000	2.7	4.6	13.7	35.3	96.7	32.6§	15.4
<b>2005‡</b>							
Deaths	74	584	3032	5252	14034	22976	
People with diabetes	38404	158974	273367	189128	167546	827419	
Death rate per 1000	1.9	3.7	11.1	27.8	83.8	27.8§	13.3
<b>Change from 1995 to 2005 (%)</b>							
Deaths	2.8	48.2	38.1	17.9	79.3	53.8	
People with diabetes	77.1	123.6	120.1	83.8	144.4	113.0	
Death rate	-42.0	-33.7	-37.3	-35.8	-26.6	-27.8	-24.8

\*Significant interaction between age-group and year ( $p=0.0002$ ). †Age-adjusted and sex-adjusted with census data. ‡By March 31st of that year. § $p<0.0001$  for comparison between years, adjusted for age-group, sex, and interaction term.

**Table 4: Death rates per 1000 in prevalent diabetes cases by age-group in 1995, 2000, and 2005**



**Figure 4: Yearly crude and age-adjusted and sex-adjusted death rates per 1000 in prevalent diabetes cases, (fiscal years 1995–2005)**  
Adjusted death rates are direct age-standardised and sex-standardised with census data. Yearly rates are based on deaths by March 31 of each year.

As shown in figure 2, diabetes prevalence increased linearly from 1995 to 2005, with an average increase of 6.2% a year. The overall prevalence remained higher in men than in women (9.4% vs 8.4% in 2005,  $p<0.0001$ ). However, the greatest rise in diabetes occurred in young women (108.2%) compared with an 81.4% increase in young men ( $p<0.0001$ ), whereas the increases in men and women aged over 50 years were similar (62% and 63%, respectively).

The age-adjusted and sex-adjusted rates of new cases of diabetes increased between 1997 and 2003 ( $p<0.0001$ )

(table 3). A two-way interaction existed between age-group and year; we therefore analysed data stratified by age-group. As with prevalence, incidence rates were higher in older people than in younger people ( $p<0.0001$ ). However, increase in incidence was greater in the younger age-group than in the older age-group ( $p<0.0001$ ). Rates also remained higher in men than in women ( $p<0.0001$ ), and both sexes had similar increases in incidence over time (table 3 and figure 3).

The age-adjusted and sex-adjusted death rate in people with diabetes fell by about a quarter between 1995 and 2005 ( $p<0.0001$ ) (table 4 and figure 4). Death rates fell in all age-groups, but did so to a greater extent in the younger age-group than in the older age-group ( $p=0.0002$  for interaction between year and age-group). By 2005, crude death rates were slightly higher in men than in women (28.5 vs 27.0 per 1000,  $p<0.0001$ ), but similar falls over 10 years occurred in both sexes (26.9% in men and 28.6% in women).

### Discussion

We have shown that the prevalence of diabetes increased steadily from 1995 to 2005, by an average of 6.2% a year. By 2005, the age-adjusted and sex-adjusted adult prevalence of diabetes in Ontario, Canada reached 8.8%, representing a 69% increase since 1995. This rise has already exceeded the 60% global increase and the 65% Canadian increase that were projected to occur in the 35 years from 1995 to 2030.<sup>2,3</sup> WHO predicted that a global increase in diabetes prevalence rates of 39% would take place between 2000 and 2030; however, in Ontario, a 27% increase has taken place after only 5 years. In view of this linear growth in prevalence, more than 10% of the adult population of

Ontario will be diagnosed with diabetes before 2010. If similar trends are occurring throughout developed countries, then the size of the emerging diabetes epidemic is far greater than anticipated.

The strengths of our study relate to the use of population-based data for a large geographically and ethnically diverse jurisdiction. Comprehensive health-care data were linked with a unique identifier, and people with diagnosed diabetes were identified with a validated algorithm. Our findings do, however, have some limitations. First, the use of administrative data confers potential for misclassification. Second, we were unable to differentiate between type 1 and type 2 diabetes; however, more than 90% of diabetes cases are estimated to be type 2 diabetes.<sup>8</sup> Third, our database identifies only diagnosed diabetes, which underestimates the true prevalence of diabetes. Additionally, the rise in prevalence could be argued to be partly due to an increased number of diagnosed cases because of changes in diagnostic criteria in 1998,<sup>25</sup> but rates rose linearly from 1995 to 2005. Moreover, a spike in diabetes incidence shortly after 1998 would have been expected if the lower diagnostic threshold were a major contributor; however such a spike was not noted in our study. Finally, we were unable to assess the independent effects of ethnicity and socioeconomic status on diabetes rates. Understanding of these factors would be important to better target prevention strategies, and further studies are needed.

The increase in diabetes prevalence is attributable to a combination of increasing incidence and falling mortality. During the 6 years between 1997 and 2003, we recorded a 31% rise in yearly diabetes incidence, such that in 2003, the rate of new cases of diabetes was 8.2 per 1000 people. Rising obesity rates during this period might have contributed to this increase, since obesity in Canadians has increased by an estimated 20–30% during the past decade.<sup>11,12</sup> We also showed a significant 25% reduction in standardised mortality in people with diabetes between 1995 and 2005. Active screening might lead to both an increase in incidence and a decrease in mortality because more people with early diabetes would be diagnosed; however, no organised screening initiatives have been mounted in Ontario during the past decade. Nonetheless, the publication of new diabetes screening guidelines<sup>25,26</sup> and enhanced public awareness might have contributed to a decrease in undiagnosed cases.

Declining mortality rates in people with diabetes have been documented in other studies, but changes have been modest compared with our findings. In the USA, mortality in people with diabetes fell by 13.8% from 1970 to 1994.<sup>20</sup> Investigators from Denmark<sup>19</sup> and the USA<sup>27</sup> have examined trends in diabetes prevalence, incidence, and mortality up to 1999 and 2001, respectively. By contrast with our study, these studies reported only small reductions in mortality of 2–5% over 7 years. Therefore, rising incidence seemed to be the main contributor to increasing diabetes prevalence in those

populations. Important differences exist between those studies and ours. First, the US study<sup>27</sup> included only older people with Medicare health insurance. Such a population might be less healthy than Ontario adults. Second, the population-based Danish study<sup>19</sup> was limited to people with drug-treated diabetes, who might have had more advanced disease than those in our population.

Ontario might have a higher diabetes rate than other areas in developed countries because of its high rate of immigration from regions with more susceptible populations, such as south Asia.<sup>16,17,28</sup> Based on 2001 census data,<sup>17</sup> 25% of Ontarians are immigrants, and an estimated 23% who immigrated between 1996 and 2001 are of south Asian origin. Moreover, a 51% increase in immigrants from south Asia has taken place in Ontario between 1995 and 2001.<sup>11</sup> Therefore, this immigration pattern might have also contributed to the rising rates of diabetes.

In accord with other studies,<sup>1,29</sup> we showed that most cases of diabetes were in older individuals. However, rates of diabetes grew most rapidly in the population under 50 years and in particular, in young women. This pattern might be due to a greater rise in obesity in younger than in older adults.<sup>10,12</sup> The greatest effect of diabetes in developed countries might thus be emerging in young individuals. Although the yearly cost of caring for elderly people with diabetes might be higher than caring for younger people with diabetes, the lifetime health burden and cost will be greater still for young people because they have longer to live with the disease.

Our data are important to enable policymakers to adequately prepare for the increasing burden of diabetes on health-care resources. Rising rates of obesity could be a cause of this striking growth<sup>11,12</sup> and, accordingly, effective public-health interventions to manage and prevent obesity are sorely needed. Future research should also focus on identification of high-risk sociodemographic groups for whom specific interventions might be required.

#### Contributors

L Lipscombe and J Hux designed the study and wrote the manuscript. L Lipscombe analysed the data. Both authors have seen and approved the final version.

#### Conflict of interest statement

We declare that we have no conflict of interest.

#### Acknowledgments

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#### References

- 1 Gregg EW, Cadwell BL, Cheng YJ, et al. Trends in the prevalence and ratio of diagnosed to undiagnosed diabetes according to obesity levels in the US. *Diabetes Care* 2004; **27**: 2806–12.
- 2 King H, Aubert RE, Herman WH. Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 1998; **21**: 1414–31.
- 3 Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27**: 1047–53 (webappendix <http://care.diabetesjournals.org/cgi/content/full/27/5/9047/DC1> [accessed May 9, 2006]).

- 4 Atkins RC. The epidemiology of chronic kidney disease. *Kidney Int Suppl* 2005; **94**: 14–18.
- 5 Congdon NG, Friedman DS, Lietman T. Important causes of visual impairment in the world today. *JAMA* 2003; **290**: 2057–60.
- 6 Tavani A, Bertuzzi M, Gallus S, Negri E, La Vecchia C. Diabetes mellitus as a contributor to the risk of acute myocardial infarction. *J Clin Epidemiol* 2002; **55**: 1082–87.
- 7 WHO. Global Strategy on diet, physical activity and health: diabetes. Jan 1, 2006. <http://www.who.int/dietphysicalactivity/publications/facts/diabetes/en/index.html> (accessed April 28, 2006).
- 8 American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2005; **28** (suppl 1): 537–42.
- 9 Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA* 2002; **288**: 1723–27.
- 10 Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA* 2006; **295**: 1549–55.
- 11 Katzmarzyk PT, Mason C. Prevalence of class I, II and III obesity in Canada. *CMAJ* 2006; **174**: 156–57.
- 12 Statistics Canada. Health Status: Health indicators. 2006. <http://www.census.gov/population/www/socdemo/foreign.html> (accessed Oct 3, 2006).
- 13 Rennie KL, Jebb SA. Prevalence of obesity in Great Britain. *Obes Rev* 2005; **6**: 11–12.
- 14 Luo J, Hu FB. Time trends of obesity in pre-school children in China from 1989 to 1997. *Int J Obes Relat Metab Disord* 2002; **26**: 553–58.
- 15 Zimmet P, Alberti KG, Shaw J. Global and societal implications of the diabetes epidemic. *Nature* 2001; **414**: 782–87.
- 16 Anand SS, Yusuf S, Vuksan V, et al. Differences in risk factors, atherosclerosis, and cardiovascular disease between ethnic groups in Canada: the Study of Health Assessment and Risk in Ethnic groups (SHARE). *Lancet* 2000 July 22; **356**: 279–84.
- 17 Statistics Canada. Immigration and citizenship. 2002. <http://www12.statcan.ca/english/census01/products/standard/themes/RetrieveProductTable.cfm?Temporal=2001&PID=62124&APATH=3&GID=431515&METH=1&PTYPE=55440&THEME=43&FOCUS=0&AID=0&PLACENAME=0&PROVINCE=0&SEARCH=0&GC=99&GK=NA&VID=0&FL=0&RL=0&FREE=0> (accessed Oct 2, 2006).
- 18 US Census Bureau. The foreign-born population in the United States, March 1999: current population reports. 2003. <http://www.census.gov/population/www/socdemo/foreign.html> (accessed Oct 3, 2006).
- 19 Stovring H, Andersen M, Beck-Nielsen H, Green A, Vach W. Rising prevalence of diabetes: evidence from a Danish pharmacoepidemiological database. *Lancet* 2003; **362**: 537–38.
- 20 Thomas RJ, Palumbo PJ, Melton LJ, et al. Trends in the mortality burden associated with diabetes mellitus: a population-based study in Rochester, Minn, 1970–1994. *Arch Intern Med* 2003; **163**: 445–51.
- 21 Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario: determination of prevalence and incidence using a validated administrative data algorithm. *Diabetes Care* 2002; **25**: 512–16.
- 22 Manuel DG, Schultz SE. Health-related quality of life and health-adjusted life expectancy of people with diabetes in Ontario, Canada, 1996–1997. *Diabetes Care* 2004; **27**: 407–14.
- 23 Statistics Canada. Annual Demographic Statistics, 2005. Ottawa Statistics Canada, Demography Division, March 2006. <http://statcan.ca/bsolc/english/bsolc?catno=91-213-XpB#formatdisp> (accessed April 6, 2006).
- 24 Statistics Canada. 2001 community profiles. 2002. [http://www12.statcan.ca/english/census01/Products/Reference/tech\\_rep/coverage/data\\_quality.cfm#3.1](http://www12.statcan.ca/english/census01/Products/Reference/tech_rep/coverage/data_quality.cfm#3.1) (accessed Oct 5, 2006).
- 25 Meltzer S, Leiter L, Daneman D, et al. 1998 clinical practice guidelines for the management of diabetes in Canada: Canadian Diabetes Association. *CMAJ* 1998; **159** (suppl 8): 1–29.
- 26 American Diabetes Association. Screening for type 2 diabetes. *Diabetes Care* 2004; **27** (suppl 1): 11–14.
- 27 McBean AM, Li S, Gilbertson DT, Collins AJ. Differences in diabetes prevalence, incidence, and mortality among the elderly of four racial/ethnic groups: whites, blacks, Hispanics, and Asians. *Diabetes Care* 2004; **27**: 2317–24.
- 28 Ramachandran A, Snehalatha C, Kapur A, et al. High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. *Diabetologia* 2001; **44**: 1094–101.
- 29 Dunstan DW, Zimmet PZ, Welborn TA, et al. The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle Study. *Diabetes Care* 2002; **25**: 829–34.