

The Economic Cost of Diabetes in Canada, 1998

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OBJECTIVE — In Canada, diabetes poses a significant health problem, and current estimates of its economic burden have not incorporated the total cost of the disease. The objective of this study was to quantify the direct medical- and mortality-related productivity cost of diabetes in Canada for 1998.

RESEARCH DESIGN AND METHODS — Direct medical costs included hospital services, physician services, and medicines consumed by people with diabetes. These costs were based on a top-down costing methodology that allocated 1998 total medical expenditures to diabetes. The prevalence of diagnosed and undiagnosed diabetes and the relative risk of complications in people with diabetes were used to estimate the proportion of medical services that were consumed by people with diabetes. Mortality-related productivity losses were calculated using the human capital approach.

RESULTS — After varying the assumptions in a sensitivity analysis, the total economic burden (in U.S. dollars) of diabetes and its chronic complications in Canada for 1998 was likely to be between \$4.76 and \$5.23 billion. In those people just with diagnosed diabetes, the direct medical costs associated with diabetes care, before considering any complications, were \$573 million. Of the costs associated with the complications of diabetes, cardiovascular disease was by far the greatest, at \$637 million.

CONCLUSIONS — Cardiovascular disease was the major contributor to the direct costs of diabetes. The preventive management of diabetes should receive priority attention, and the prevention of cardiovascular disease in the patient with diabetes should become an imperative.

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Diabetes is a growing health problem in Canada, as in the rest of the world. The prevalence is expected to increase by 35% over the next 25 years (1). Despite the existence in Canada of a national health system, to date, no accu-

rate nationwide statistics on diabetes in Canada have been published. Health Canada, a federal agency, estimated that 1.2–1.4 million Canadians aged ≥ 12 years actually have diabetes (2). This represents 4.9–5.8% of the population aged

≥ 12 years, and this estimate includes the 35–44% of the diabetic population that are undiagnosed (3).

It has been estimated by others that the total cost (in U.S. dollars) of diabetes in Canada may be as high as \$9 billion annually (2); however, this estimate was based on applying the results of a 1992 U.S. study (4) to the Canadian population based on a percent of the total population. Other attempts to determine the burden of diabetes in Canada have not included all relevant costs (5). This analysis was therefore conducted to identify and quantify the direct medical and indirect mortality costs of diabetes in Canada for 1998.

RESEARCH DESIGN AND METHODS

Overview

This analysis evaluated the total cost of diabetes, including both the direct medical costs for individuals with diabetes and the cost of mortality-related productivity losses due to the disease. This analysis was done from the societal perspective, which includes costs borne by the Provincial Health Care systems and the patients. Direct medical costs included all hospital services, physicians' services, and prescription medicines that were consumed by people with type 1 or type 2 diabetes and that were attributable to their disease. This analysis used a top-down costing methodology that allocated to diabetes that portion of 1998 total medical expenditures (across all diseases in Canada) that were attributable to diabetes, based on estimates of the proportion of the total of these services that were consumed by individuals with diabetes. The value of productivity loss attributable to diabetes was estimated using the human capital approach. The indirect morbidity cost of diabetes was not estimated because of lack of sufficient data on disability and work loss due specifically to diabetes. Canadian dollars were converted to U.S. dollars, using an exchange rate of 1.483 as of 1 May 1998 (6).

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Abbreviations: ADA, American Diabetes Association; MDC, major diagnostic category.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—Prevalence of diabetes in Canada by sex and age

	Proportion of undiagnosed diabetes†	Prevalence* (estimated number of cases)			
		Age 0–34 years	Age 35–64 years	Age 65+ years	Total
Diagnosed diabetes					
Male	—	0.47% (36,293)	5.57% (331,767)	16.61% (268,412)	4.36% (636,471)
Female	—	0.63% (47,333)	5.08% (304,257)	14.01% (307,986)	4.47% (659,577)
Total	—	0.55% (83,626)	5.32% (636,024)	15.09% (576,398)	4.41% (1,296,048)
Diagnosed and undiagnosed diabetes					
Male	35%	55,835	510,411	412,941	979,187
Female	35%	72,820	468,088	473,824	1,014,733
Total	35%	128,655	978,499	886,766	1,993,920

*Using updated prevalence estimates from published reports from Manitoba (11,12); †using the 1997 ADA fasting plasma glucose diagnostic criteria (3).

Direct medical costs

The direct medical costs were calculated based on the proportion of total 1998 health expenditures by service (hospital services, physician services, and medications) that could be allocated to diabetes (7). This allocation procedure was based on a methodology developed by the American Diabetes Association (ADA) (4,8) that was modified to fit the data available in Canada.

The first step was to allocate total health care expenditures in 1998 to each ICD-9 major diagnostic category (MDC), based on the proportions in the burden of illness study previously reported (5,7). This allocation of health care expenditures assumes that although total expenditures on each service have changed from year to year, the proportion of overall expenditures related to each MDC has remained relatively constant over the 5-year period (1993–1998).

The second step was to allocate the expenditures for each MDC to the individual ICD-9 diagnoses related to diabetes or its complications (4). This included ICD-9 250.0 for diabetes without complications and an additional 109 ICD-9 diagnoses for the chronic complications related to diabetes. For hospital services, the proportion of total bed days that could be allocated to each ICD-9 diagnosis was calculated from data provided by Statistics Canada (9) (bed days by ICD-9 ÷ bed days by MDC). For physicians' services, the proportion of office visits attributable to each ICD-9 diagnosis was calculated using data from a survey of office visits in the IMS Health Disease and Therapeutic Index for 1998 (10) (office

visits by ICD-9 ÷ office visits by MDC). For medications, the proportion of prescriptions given for each ICD-9 diagnosis was calculated from data available from IMS (11) (prescriptions by ICD-9 ÷ prescriptions by MDC). These proportions of medical services consumed for each ICD-9 diagnosis were applied to the total expenditures for each respective MDC diagnosis to arrive at a cost associated with each ICD-9 diagnosis.

The third step in the allocation process specified the proportion of health care resources within each ICD-9 diagnosis that was consumed by people with diabetes. For services that were attached to a diabetes-specific diagnosis (ICD-9 250.0), the entire cost of that service was attributed to diabetes. However, for complications and general medical conditions for which people with diabetes represent only a fraction of the resources consumed, the allocation was a function of the prevalence of diabetes and the relative risk of the diagnosis between those having and those not having diabetes. This proportion (the etiologic fraction) was calculated according to the following formula:

$$E_i = \sum_j P_j \times (R_{ij} - 1) / [P_j \times (R_{ij} - 1) + 1]$$

for each complication (i.e., neurological, peripheral vascular, cardiovascular, renal, and ophthalmic disease) and other diabetes-related complications (e.g., bacteremia, fungal infections, osteomyelitis, impotence, and cellulitis) (7). P_j was taken from published reports of the diabetes period prevalence, based on physi-

cian-diagnosed disease in Manitoba from 1991 to 1993 (12,13), updated to point prevalence data for 1998. The prevalence has been estimated both before and after the inclusion of undiagnosed diabetes, which was calculated as 35% of the total population with diabetes (Table 1) (3). The estimate for the undiagnosed population by Harris et al. (3) represents perhaps the most sophisticated data available in North America, and it was used because no hard data on this point are currently available in Canada.

Productivity costs

Total mortality costs, by MDC, were estimated using the human capital approach to estimate the present value of lost productivity caused by premature mortality (5). Similar to the methods used for the direct medical costs, total mortality costs were allocated to specific ICD-9 codes using age- and sex-specific mortality rates (14), and then the ICD-9-specific productivity loss was multiplied by the etiologic fraction to ascertain that amount attributable to diabetes and its fatal complications (cardiovascular disease, cerebrovascular disease, and renal complications). The indirect morbidity cost of diabetes was not estimated because of the lack of sufficient data on disability and work loss due specifically to diabetes.

Sensitivity analysis

As noted above, the estimates of the prevalence of diabetes in Canada that were used in this analysis were based on administrative data collected in Manitoba. Because these data, based on physician-diagnosed diabetes only and excluding

Table 2—Economic burden of diabetes, Canada, 1998: direct medical and productivity costs due to premature death from diabetes

	Diagnosed diabetes only			Diagnosed and undiagnosed diabetes		
	Direct medical costs	Mortality costs	Total costs	Direct medical costs	Mortality costs	Total costs
Diabetes	573	455	1,028	573	455	1,028
Chronic complications	921	619	1,540	1,233	822	2,055
Neurological disease*	148	63	211	202	86	288
Peripheral vascular disease	63	n/a	63	87	n/a	87
Cardiovascular disease	637	545	1,182	843	721	1,563
Renal disease	49	11	61	69	16	84
Ophthalmic disease	6	n/a	6	9	n/a	9
Other chronic complications	17	n/a	17	24	n/a	24
General medical conditions	1,133	n/a	1,133	1,672	n/a	1,672
Total	2,627	1,074	3,701	3,478	1,277	4,756

Data are millions of U.S. dollars. *Mortality costs for neurological disease included deaths due to cerebrovascular disease only.

aboriginal and nursing home patients, were certain to underestimate the prevalence of diabetes, a sensitivity analysis was conducted by increasing the age- and sex-specific prevalence by an arbitrary 10%.

RESULTS— Expenditures for all diseases across Canada for hospital care (\$18 billion), physician care (\$7.8 billion), and drugs (\$7.6 billion) were estimated at over \$33 billion (all figures are in U.S. dollars) (6). The Canadian etiologic fractions were as follows: cardiovascular (17.4%), neurological (9.7%), peripheral vascular (13.6%), renal (8.8%), ophthalmic (10.4%), other complications (6.9%), and general medical conditions (4.2%).

The direct medical cost of care for Canadians with diagnosed diabetes in 1998 was approximately \$2.6 billion (Table 2), or ~7.8% of total medical expenditures in Canada during that year. Of this, 50% was associated with hospital care, 19% with physician care, and 31% with medications (Table 3).

Direct medical costs associated with acute and chronic diabetes care, excluding complications, were \$573 million, or only ~22% of the total cost of care for people with diabetes (\$2.627 billion). When the undiagnosed population was included, the direct medical costs and the costs of complications increased to \$3.478 billion (Table 2).

The costs for acute and chronic diabetes care, excluding complications, were not affected by undiagnosed disease because the undiagnosed would not be expected to have direct diabetes-associated medical costs. Chronic complications in people with diagnosed diabetes cost the Canadian health care system \$921 million

(35% of the total direct medical costs). Neurological disease accounted for \$148 million (5.7%), peripheral vascular disease \$63 million (2.4%), cardiovascular disease \$637 million (24.3%), renal disease \$49 million (1.9%), ophthalmic disease \$6 million (0.2%), and other chronic complications \$17 million (0.6%). When the undiagnosed population was included, the direct medical costs of all chronic complications combined increased to \$1.233 billion. Interestingly, the direct medical costs associated with cardiovascular disease complications in patients with diabetes were ~11% greater than the direct medical costs associated with acute and chronic diabetes care (\$637 vs. \$573 million).

Productivity costs associated with premature mortality (mortality costs) in those having diabetes was \$1.074 billion. Of this, \$455 million was due to diabetes mortality and \$619 million was due to deaths associated with chronic complications. Of the chronic complications costs,

\$63 million was due to neurological disease (cerebrovascular disease), \$545 million to cardiovascular disease, and \$11 million to renal complications. When the undiagnosed population was included, these costs increased to \$1.277 billion, of which deaths due to cardiovascular disease accounted for the largest proportion (56%) (Table 2).

The total cost of diabetes and its chronic complications for 1998 was approximately \$3.7 billion, but when people with undiagnosed diabetes were accounted for, this estimate increased to \$4.756 billion. After varying the prevalence of diabetes in the sensitivity analysis, the total economic burden of diabetes in Canada for 1998 was likely to be between \$4.756 and \$5.23 billion.

CONCLUSIONS— Previous reports of the burden of illness of diabetes in Canada were either based on estimates from the U.S. or did not include the cost of chronic complications attributable to di-

Table 3—Hospital, physician, and medication costs for diagnosed diabetes, Canada, 1998

	Hospital costs	Physician costs	Medication costs
Diabetes	231	84	257
Chronic complications	482	129	310
Neurological disease	139	4	5
Peripheral vascular disease	49	6	8
Cardiovascular disease	261	101	275
Renal disease	25	13	11
Ophthalmic disease	2	0.7	4
Other chronic complications	6	5	6
General medical conditions	606	291	237
Total	1,319	504	804

Data are millions of U.S. dollars.

Table 4—Direct medical costs in Canada versus the U.S., excluding the undiagnosed

	U.S.	Canada
Diabetes costs: total (acute/chronic care costs excluding complications)	17.4	21.8
Chronic complications	26.8	35.0
Neurological disease	3.4	5.6
Peripheral vascular disease	2	2.4
Cardiovascular disease	17.2	24.2
Renal disease	2.4	1.9
Ophthalmic disease	0.2	0.23
General medical conditions	55.8	43.1

Data are % of total diabetes costs.

abetes. This study, based on the epidemiology of diabetes as determined by an administrative database in Manitoba as well as from nationally collected cost data, has estimated the cost of diabetes in non-aboriginal populations in Canada. Proportional allocation of direct medical cost to various diabetic complications seen in this study are remarkably similar when compared with the U.S. study (4) (Table 4). The comparison shows that, in Canada, the cost of cardiovascular complications exceeds the cost of direct acute and chronic diabetes management, whereas those costs are equivalent in the U.S. Cardiovascular costs are higher in Canada, as are the diabetes direct costs.

Some difficulties arise in trying to account for the cost of undiagnosed diabetes. For this reason, the calculations of both the diagnosed and the undiagnosed populations have been presented. Although it has been estimated that up to 35% of all people with diabetes have undiagnosed disease, there is no proof that these rates apply in Canada. Clearly, a large group with undiagnosed disease will have a significant impact on the overall burden of diabetes. But it might be claimed that the undiagnosed population will not have as great an effect in each type of complication. For example, it is doubtful that advanced diabetic retinopathy would be seen in equal numbers in undiagnosed people or that advanced renal failure would occur before the diagnosis of diabetes. But cardiovascular disease has clearly been shown to afflict the undiagnosed and, indeed, those with impaired glucose tolerance and those with a fasting blood glucose as low as 5.5 mmol/l to a significant degree (15,16).

Several additional limitations of this study must be recognized. First, the prob-

lem of coding of the diagnosis of diabetes, mentioned above, is unresolved. Capture-recapture techniques have been used to assess the completeness of capture of diagnosed diabetes in administrative databases (12,13). Studies using this methodology have suggested that the ascertainment rate was >95%. Second, the specific ICD-9-CM codes used in the analysis may not accurately represent the chronic complications experienced by people with diabetes in Canada in 1998. However, this same allocation was used in the ADA analysis and thus allows for intercountry comparisons. Third, the human capital approach for productivity costs is almost unanimously used, although several researchers question its validity and favor the friction cost method (17). This method would have produced smaller estimates of lost productivity; however, lack of available data prohibited us from investigating this method further. Fourth, it should be noted that the costs of treatment of diabetes and its complications are largely dependent on the practice patterns prevalent several years ago, and they do not necessarily represent current practice. It will be many years before we can assess the impact of current treatment practices. Fifth, hospitalization costs for any disease and its complications are currently in a state of flux. The average duration of hospitalization has dramatically fallen in the last 3 years for some illnesses such as surgery for coronary bypass grafts. However, our data were based on 1998 statistics, at which time many of the dramatic reductions had been put in place. Last, our estimates may be underestimates of the true burden of diabetes in Canada. Long-term care hospitals were included in our estimates of hospitalization costs (accounting for 6.9% of all hos-

pital expenditures); however, nursing home care and home health care were not included. Additionally, the study conducted by the ADA showed that indirect morbidity costs were more than twice as high as mortality costs, and they were not included in our analysis. Moreover, the estimates for disease prevalence were based on detailed Manitoba studies, which relied on administrative data and may not be applicable to all other jurisdictions. However, it was found that when these estimates were applied to the general population, the overall number of Canadians with diabetes was very similar to that derived by Health Canada (1.30 vs. 1.2–1.4 million) (2). As noted earlier, the aboriginal population was not included in this report. However, it is recognized that the prevalence of diabetes and its complications among aboriginals may well be double the incidence in the Caucasian population of Canada, potentially causing us to underestimate the true burden.

An additional major cost has not been reviewed in the assessment of the total cost of diabetes. Patients currently test their blood glucose levels more than eight times a week, the number being higher for insulin-requiring patients and lower for oral agent- and diet-controlled patients. The costs of this aspect of care are now borne principally by the patients themselves and not by provincial health care, although in each province, different systems exist for partial reimbursement by the health care system and by private insurance. The total cost of the testing in Canada in 1998 is estimated to be over \$115 million (18), based on the evidence that the average person with diabetes in Canada is testing his or her blood glucose level 8.6 times a week, and that cost is about \$0.6 a strip. This cost has not been included in our analysis.

The total cost of this disease in Canada in 1998 was almost \$5 billion. The direct and more immediate cost, which is now the responsibility of the provinces, was over \$3.478 billion. However, the more striking findings included the fact that cardiovascular disease (including peripheral vascular disease) accounted for ~35% of the total burden of diabetes. Current wisdom has always considered that renal complications, including dialysis and transplantation, were some of the most costly aspects of health care delivery for people with diabetes, since fully 35% of dialysis patients currently have renal

failure caused by diabetes. However, even these costs pale in comparison to the costs of cardiovascular disease.

This study serves to emphasize that the cost of preventive treatment is insignificant compared with the downstream costs of failure to adequately treat the disease. It is important to consider the total costs associated with the disease when health care resource allocation decisions are being made. Optimal therapy must be delivered as soon as feasible because the cost of therapy to prevent complications is justified by its significant cost effectiveness (19). Optimal therapy should include reduction of glucose to as near normal levels as possible, the addition of antihypertensive therapy to optimal levels, and the lowering of lipids and elevation of HDL levels to goal levels as identified by published guidelines (20). The preventive management of diabetes should receive priority attention, and the prevention of cardiovascular disease in the patient with diabetes should become an imperative.

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