Health Care Use and Costs in the Decade After Identification of Type 1 and Type 2 Diabetes

A population-based study

JEFFREY A. JOHNSON, PHD[1,2,3]
SHERI L. POHAR, PHD[1]
SUMIT R. MAJUMDAR, MD, MPH[1,2,3]

OBJECTIVE — To analyze trends in health care costs in the decade after identification of diabetes, contrasting type 1 and 2 diabetes.

RESEARCH DESIGN AND METHODS — The Canadian National Diabetes Surveillance System criteria were applied to administrative databases to identify incident diabetes cases in 1992. Cases were categorized as type 1 or type 2 diabetes based on patterns of drug use. Per capita health care costs (in 2001 Canadian dollars) for five resource categories were estimated according to the type of diabetes, for the year before identification (1991) and 10 years after (1992–2001) identification of the cases.

RESULTS — We identified 156 type 1 and 3,469 type 2 incident cases of diabetes, from a population base of ~950,000. The mean (±SD) age of case subjects at index was 61.2 ± 16.7 years, and 54% of subjects were male. Overall annual per capita health expenditures rose considerably in the year after identification of diabetes but then stabilized at a lower level for the next 9 years, ranging from $3,800 to $4,400. From 1992 to 2001, diabetic individuals used $137.1 million in health care resources, most of which (96%) was attributable to type 2 diabetes. The average 10-year cost per individual with diabetes was $37,820 ($33,684 per type 1 and $38,006 per type 2 diabetes case; adjusted $P = 0.45$).

CONCLUSIONS — Total health expenditures for diabetes are driven by the much larger prevalence of type 2 compared with type 1 diabetes. Policymakers need to acknowledge and allocate resources for diabetes prevention and management accordingly.

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It is generally recognized that the costs of treating chronic medical conditions are rising for health care systems because of an aging population and the increasing prevalence of such conditions. Attempts to quantify the cost of these chronic medical conditions have often relied on models, synthesizing estimates using data from various sources, or surveys of relatively small samples of diseased individuals. Diabetes, for example, has been the focus of a large body of literature (1), with cost estimates usually based on modeled values (2,3).

Diabetes, however, is a difficult condition to study because it includes both type 1 and type 2 diabetes, two very different conditions in terms of pathophysiology and epidemiology (4). Furthermore, most cost-of-diabetes estimates have been derived from prevalence cohorts or cross-sectional analyses (1). Few studies have followed the health care costs of an incident cohort with diabetes over time, an approach where the natural history of the disease can be more accurately captured (1,5–7).

Estimating the progressive costs of diabetes is important for resource allocation, health policy, and perhaps even allocation of research funding. Accurate costing is important, given that a substantial portion of costs are not attributable directly to the condition itself but to accumulated complications and comorbidities (1–3,8–10). The purpose of this study was to analyze trends in actual health care use and estimated costs in the year before and 10 years after identification of diabetes in an incident cohort of individuals with diabetes and to contrast the cost of care for people identified with type 1 and 2 diabetes.

RESEARCH DESIGN AND METHODS

— Ethical approval for this study was obtained from the Health Research Ethics Board of the University of Alberta. The Canadian National Diabetes Surveillance System (NDSS) criteria (4) were applied to Saskatchewan Health's administrative databases to identify incident cases of diabetes in 1992. Using the NDSS case definition, individuals are considered to have diabetes if they have two physician visits with a diagnosis of diabetes (ICD code 250) on 2 different days within any 730-day period or one hospitalization with a discharge diagnosis of diabetes (4).

Individuals were then categorized as having type 1 or type 2 diabetes based on patterns of drug use during the 11-year study period. Individuals who had insulin dispensed within 6 months of their index date and no oral agents at any point during the follow-up period were classified as having type 1 diabetes; all others were considered to have type 2 diabetes.

Estimation of health care costs

Health care services (i.e., prescriptions, physician visits, hospitalizations, day sur-

From the [1]Institute of Health Economics, Edmonton, Canada; the [2]Department of Public Health Sciences, School of Public Health, University of Alberta, Edmonton, Canada; and the [3]Division of General Internal Medicine, University of Alberta, Edmonton, Canada.

Address correspondence and reprint requests to Jeffrey A. Johnson, PhD, Institute of Health Economics, 1200-10405 Jasper Ave., Edmonton, Alberta, Canada T5J 3N4. E-mail: jeff.johnson@ualberta.ca.

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Abbreviations: NDSS, Canadian National Diabetes Surveillance System.

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

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Table 1—*Demographic characteristics of 1992 incident cohort* (n = *3,625*)

	Type 1 diabetes	Type 2 diabetes	Total
n	156 (4.3)	3,469 (95.7)	3,625
Age (years)	49.5 ± 22.1	61.7 ± 16.2*	61.2 ± 16.7
Follow-up (years)	6.5 ± 3.6	7.7 ± 2.9*	7.7 ± 3.0
Sex (male)	92 (59.0)	1,854 (53.4)	1,946 (53.7)
Residence (rural)	76 (48.7)	1,619 (46.7)	1,695 (48.6)
Data source for NDSS case definition (hospital file)	24 (15.4)	402 (11.6)	426 (11.7)
Deaths, 1991–2001	48 (30.8)	1,066 (30.7)	1,114 (30.7)

Data are mean ± SD or *n* (%). *$P < 0.001$.

geries, and dialysis) in each calendar year were identified from services recorded in the databases. The prescription database contains out-of-hospital medication claims for all beneficiaries eligible for provincial drug plan benefits. Annual prescription costs were obtained directly from each claim record and inflated to year 2001 dollars using the Consumer Price Index (11).

Annual physician costs were also obtained directly from service claim records in Saskatchewan Health's databases. Physician visits included visits to general practitioners, specialists, and physicians out of the province, as well as visits to other practitioners who provided insured services, such as optometrists.

The databases contained the number of hospitalizations and day surgeries each year. The cost per hospitalization in 2001 Canadian dollars was determined by multiplying the resource intensity weight (12), calculated by the Canadian Institute of Health Information, by the funding per weighted case for the 2001–2002 fiscal year ($3,369.77) (12,13). The diagnoses most responsible for hospitalizations were identified from claims records. The cost per day surgery was estimated by multiplying the day procedure group weight by the same funding per weighted case.

Fee-for-service billing codes were used to identify individuals who received dialysis. Annual dialysis costs were calculated by multiplying the proportion of each calendar year on either hemodialysis or peritoneal dialysis by an estimated annual cost of each dialysis modality (14). These latter cost estimates were based on a prospective observational study of patients who attended dialysis clinics in a neighboring province (14) and amounted to $52,719 per year of hemodialysis and $37,431 per year of peritoneal dialysis, in 2001 Canadian dollars.

Analysis

Per capita health care costs (in year 2001 Canadian dollars) for each resource category were calculated according to type of diabetes and type 1 and type 2 diabetes combined for the year before index (1991) and 10 years after identification of diabetes (1992–2001). Per capita health care costs for the five resource categories combined were also determined. These estimates were based on the number of active cases in each follow-up year. The cumulative and average costs for the entire decade of follow-up were determined based on the entire cohort. We compared the average per capita cumulative cost of care for type 1 and type 2 diabetes after adjusting for age, sex, and comorbidities using ANCOVA models. Analyses were performed using SPSS (version 13.0; SPSS, Chicago, IL).

RESULTS

— Using the NDSS criteria, 3,625 incident diabetes cases were identified for the 1992 calendar year. Individuals with type 1 ($n = 156$) and type 2 ($n = 3,469$) diabetes were similar in demographic characteristics, with the exception of age at index (Table 1). The average duration of follow-up was longer in the type 2 diabetic group, but overall mortality was similar.

Hospitalizations accounted for the largest proportion of total per capita costs each year (Table 2). In the incident year (1992), per capita hospital costs were several times higher than the year prior to diagnosis (1991), particularly for individuals with type 1 diabetes, where costs rose from $738 in 1991 to $5,212 in 1992. Hospital costs decreased over the 10 years of follow-up for both type 1 and type 2 diabetes but were often higher in type 2 than type 1 diabetes (Table 2). From 1991 to 2001, cardiovascular disease was most frequently the reason for hospitalization. In the index year (1992), however, diabetes (ICD codes 250.0, 250.1, 250.2, 250.7, and 250.9) was the diagnosis responsible for more hospitalizations than

Table 2—*Per capita costs according to resource category and type of diabetes*

	Prescriptions			Physicians			Hospitalizations
	Type 1 diabetes	Type 2 diabetes	Total	Type 1 diabetes	Type 2 diabetes	Total	Type 1 diabetes
1991	586 ± 784	424 ± 640	431 ± 648	311 ± 502	491 ± 762	484 ± 753	738 ± 2,924
1992	851 ± 875	564 ± 709	577 ± 719	1,047 ± 1,392	867 ± 1,029	875 ± 1,047	5,212 ± 11,510
1993	632 ± 902	540 ± 657	544 ± 669	613 ± 831	649 ± 889	647 ± 886	3,739 ± 10,288
1994	582 ± 594	541 ± 660	543 ± 658	515 ± 1,019	580 ± 863	578 ± 869	2,308 ± 7,104
1995	696 ± 772	575 ± 685	579 ± 688	538 ± 865	580 ± 873	578 ± 873	2,104 ± 5,869
1996	637 ± 577	642 ± 751	642 ± 745	528 ± 1617	589 ± 822	586 ± 864	1,825 ± 6,765
1997	738 ± 756	753 ± 876	752 ± 871	568 ± 1,273	595 ± 827	594 ± 847	1,357 ± 4,347
1998	787 ± 906	823 ± 898	821 ± 898	578 ± 1,266	620 ± 912	618 ± 926	2,281 ± 12,200
1999	898 ± 1,089	922 ± 1,014	921 ± 1,017	639 ± 1,288	646 ± 910	646 ± 926	2,023 ± 7,417
2000	1,024 ± 1,256	1,039 ± 1,076	1,038 ± 1,083	702 ± 1,481	661 ± 1,014	662 ± 1,034	2,341 ± 7,045
2001	1,126 ± 1,297	1,171 ± 1,190	1,169 ± 1,194	598 ± 1,207	718 ± 1,045	714 ± 1,051	1,386 ± 4,972

was cardiovascular disease (14.2 vs. 13.7%).

In the years after identification of diabetes, prescription costs initially decreased but then steadily increased for individuals with type 2 diabetes; costs more than doubled from $564 in 1992 to $1,171 in 2001. For type 1 diabetes, prescription costs increased ~32% from $851 in 1992 to $1,126 in 2001. Physician costs did not increase to the same extent as prescription costs during the 10 years after index. An initial spike in physician costs was observed in the 1st year after identification, but annual per capita physician costs grew relatively slowly from 1993 to 2001 (Table 2).

The largest increase in costs during the 10 years after identification of diabetes was seen for dialysis. From 1991 to 1994, there were no costs for dialysis for individuals with type 1 diabetes. By 2001, however, the per capita dialysis cost for type 1 diabetes had reached $1,098, which was almost five times the per capita cost for type 2 diabetes ($227) in the same year (Table 2). After 1996, dialysis costs in the type 1 diabetes cohort by far exceeded those of the type 2 diabetes cohort. Overall, ~31.5% of dialysis costs were for peritoneal dialysis and 68.5% were for hemodialysis.

Total per capita costs were substantially higher in the year after index than in any other year (Fig. 1). Per capita costs for type 1 diabetes were relatively constant for 3–6 years after index but began to rise in the last 4 years of follow-up with the increased onset of dialysis. For type 2 diabetes, total per capita costs increased from a low of $3,880 3 years after index to $4,441 10 years thereafter.

Over the 10 years of follow-up, ~$137.1 million in health care resources were used by 3,625 individuals with diabetes. The average cost per individual with diabetes was $37,820. The difference in average individual 10-year cumulative costs between type 1 ($33, 684) and type 2 ($38,006) diabetes was not statistically significant (adjusted $P = 0.45$). The vast majority of the total expenditures ($131.8 million or 96% of costs) were for the provision of care to individuals with type 2 diabetes (Fig. 2).

CONCLUSIONS — We analyzed five categories of health care costs in an incident cohort with diabetes over an 11-year period, including the year before and the decade after identification of diabetes. Total health care costs increased markedly in the incident year but then stabilized at a lower level, with only minor increases over the ensuing decade. Trends in overall per capita costs were similar in type 1 and type 2 diabetes, with the exception of dialysis, where costs increased more dramatically for type 1 diabetes, resulting in slightly higher per capita costs in later years of our follow-up.

Interestingly, only a very small proportion (4%) of the total $137 million spent over the decade after onset of diabetes was for individuals with type 1 diabetes. Type 2 diabetes accounted for >96% of total costs (i.e., the same proportion of their population distribution). As the number of type 2 diabetes cases will likely continue to outweigh the number of type 1 diabetes cases, type 2 diabetes is clearly the driver of the public health burden for diabetes (15).

We had anticipated that overall per capita health care costs for individuals with diabetes would increase over the 10 years after identification of diabetes, as a result of disease progression, accumulation of comorbidities, and deterioration of health status. This, however, was not the case. After a large increase in costs in the incident year, costs were relatively stable, despite increases in prescription, day surgery, and dialysis costs. Decreased hospital costs over the study period, which offset cost increases in the other categories, may reflect changes in hospitalization rates, length of stay, case mix, and service intensity (12,16,17). It is also possible that decreased hospital costs in the later years of follow-up reflect a survival bias in which healthier individuals survived to the end of the follow-up period.

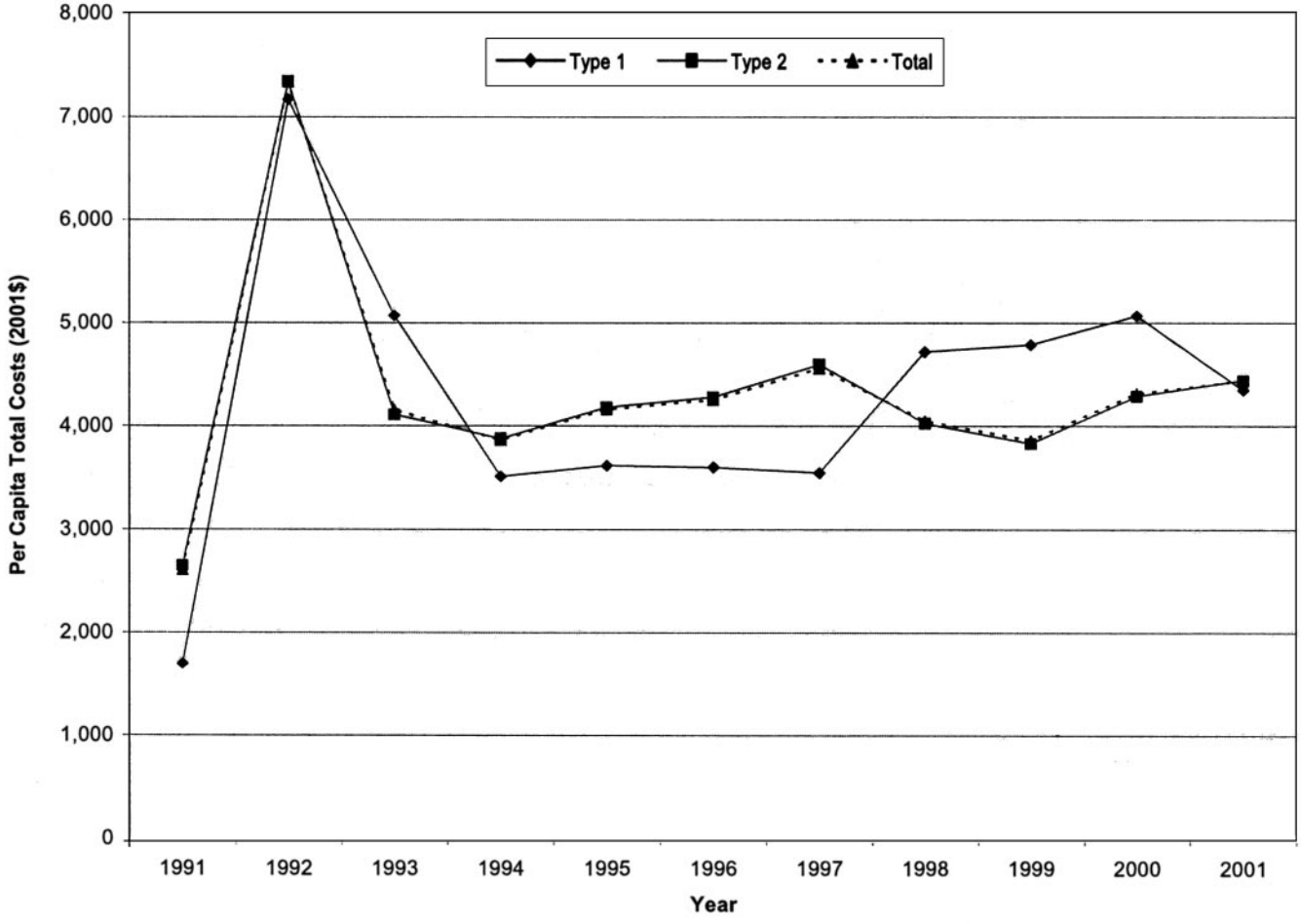
Prescription medications were the second largest cost category after hospitalizations during most years of follow-up. Medication costs increased considerably from 1991 to 2001 for both type 1 and type 2 diabetes. This trend could be the result of *1*) increased use of medications overall, *2*) increased use of more expensive disease treatment options for cardiovascular risk reduction, and *3*) use of newer, more expensive antidiabetic agents in the later years of follow-up (18). Increasing prescription costs should not be viewed entirely as problematic, however, given that proven effective treatments in this population are reportedly underused (19,20).

Other studies have explored costs before and after diagnosis of diabetes. Brown and colleagues, for example, estimated the incremental medical costs for people with type 2 diabetes for 8 years before (6) and after (5) diagnosis by using

Table 2—*Continued*

Hospitalizations		Day surgeries			Dialysis		
Type 2 diabetes	Total	Type 1 diabetes	Type 2 diabetes	Total	Type 1 diabetes	Type 2 diabetes	Total
1,648 ± 6,693	1,609 ± 6,578	61 ± 250	73 ± 277	72 ± 276	0 ± 0	14 ± 665	14 ± 651
5,788 ± 41,262	5,763 ± 40,435	58 ± 200	101 ± 398	99 ± 391	0 ± 0	23 ± 787	22 ± 770
2,767 ± 8,721	2,809 ± 8,795	87 ± 317	109 ± 398	108 ± 395	0 ± 0	46 ± 1,325	44 ± 1,296
2,547 ± 13,230	2,538 ± 13,050	107 ± 353	124 ± 441	124 ± 438	0 ± 0	87 ± 2,167	83 ± 2,126
2,835 ± 20,453	2,808 ± 20,100	188 ± 651	119 ± 407	121 ± 418	90 ± 989	74 ± 1,671	74 ± 1,650
2,864 ± 25,422	2,826 ± 24,986	144 ± 433	138 ± 457	138 ± 456	467 ± 4,959	44 ± 1,421	60 ± 1,687
3,066 ± 31,745	3,005 ± 31,183	104 ± 361	142 ± 361	140 ± 496	780 ± 5,816	40 ± 1,269	67 ± 1,665
2,351 ± 11,279	2,348 ± 11,310	125 ± 453	180 ± 624	178 ± 619	949 ± 6,533	52 ± 1,560	83 ± 1,960
2,001 ± 5,894	2,002 ± 5,952	127 ± 418	166 ± 525	164 ± 522	1,102 ± 5,905	93 ± 1,920	129 ± 2,189
2,279 ± 8,336	2,281 ± 8,293	136 ± 583	151 ± 464	150 ± 469	866 ± 8,127	159 ± 2,640	184 ± 3,005
2,163 ± 7,110	2,136 ± 7,048	142 ± 411	163 ± 552	162 ± 547	1,098 ± 9,944	227 ± 3,108	257 ± 3,566

Data are mean ± SD. For case subjects who remained active in each year of the study.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Type 1	1696 ± 3390	7168 ± 12666	5071 ± 10941	3513 ± 8156	3617 ± 7445	3600 ± 13233	3547 ± 11451	4720 ± 19036	4788 ± 12983	5069 ± 14834	4349 ± 14970
Type 2	2650 ± 7345	7343 ± 41454	4110 ± 9672	3880 ± 14008	4182 ± 20965	4277 ± 25720	4596 ± 31963	4026 ± 12075	3828 ± 7511	4288 ± 10348	4441 ± 9338
Total	2609 ± 7222	7335 ± 40636	4152 ± 9731	3866 ± 13832	4160 ± 20620	4252 ± 25369	4558 ± 31460	4050 ± 12377	3861 ± 7765	4315 ± 10534	4438 ± 9582

Figure 1—*Per capita overall costs according to type of diabetes, for case subjects who remained active in each year of the study. Values in table are mean ± SD.*

health records from one HMO in the U.S. In the estimation of costs of care after diagnosis, however, these authors used a cumulative incidence cohort approach rather than a closed incident cohort identified in a single year because of the relatively small sample size available in the HMO. This limited their evaluation of cumulative costs and reduced confidence in the costs in the longer term after diagnosis. Regardless of differences between studies and between Canadian and U.S. health care systems, results of both studies indicate relatively large increases in total health care costs in the year that diabetes is diagnosed (attributable to increased hospital expenditures) and substantial increases in prescription expenditures in the years after the diagnosis (5).

Several limitations should be noted when interpreting these data. First, although there is good evidence of validity of the NDSS criteria for identifying diabetes cases, some cases may have been missed (21). In addition, we could not examine the Registered Indian population because prescription data were not available. Because ~10% of Saskatchewan's population with diabetes are Registered Indians, it is unlikely that overall trends would be affected drastically by inclusion of their data, although the relative proportion of type 2 diabetes and costs would be even more than 96%.

Resource use and cost comparisons between cohorts in this study were limited to five categories of direct costs. We were unable to capture resource use and costs for diabetes educators, dietitians, and podiatrists, as well as the auxiliary costs of transplants and laboratory services after 1993, because these are managed under regional health budgets. Before 1993, funding of laboratory services was reflected in fee-for-service physician billings, but these were no longer included after this year. We were also unable to capture other expenditures such as emergency department services or directly capture dialysis costs, although we are confident that the prospective costing data we used to estimate the latter is both valid and accurate (14). It should also be noted that day surgery and hospital costs were not obtained directly from Saskatchewan Health records but were estimated by applying costs from external

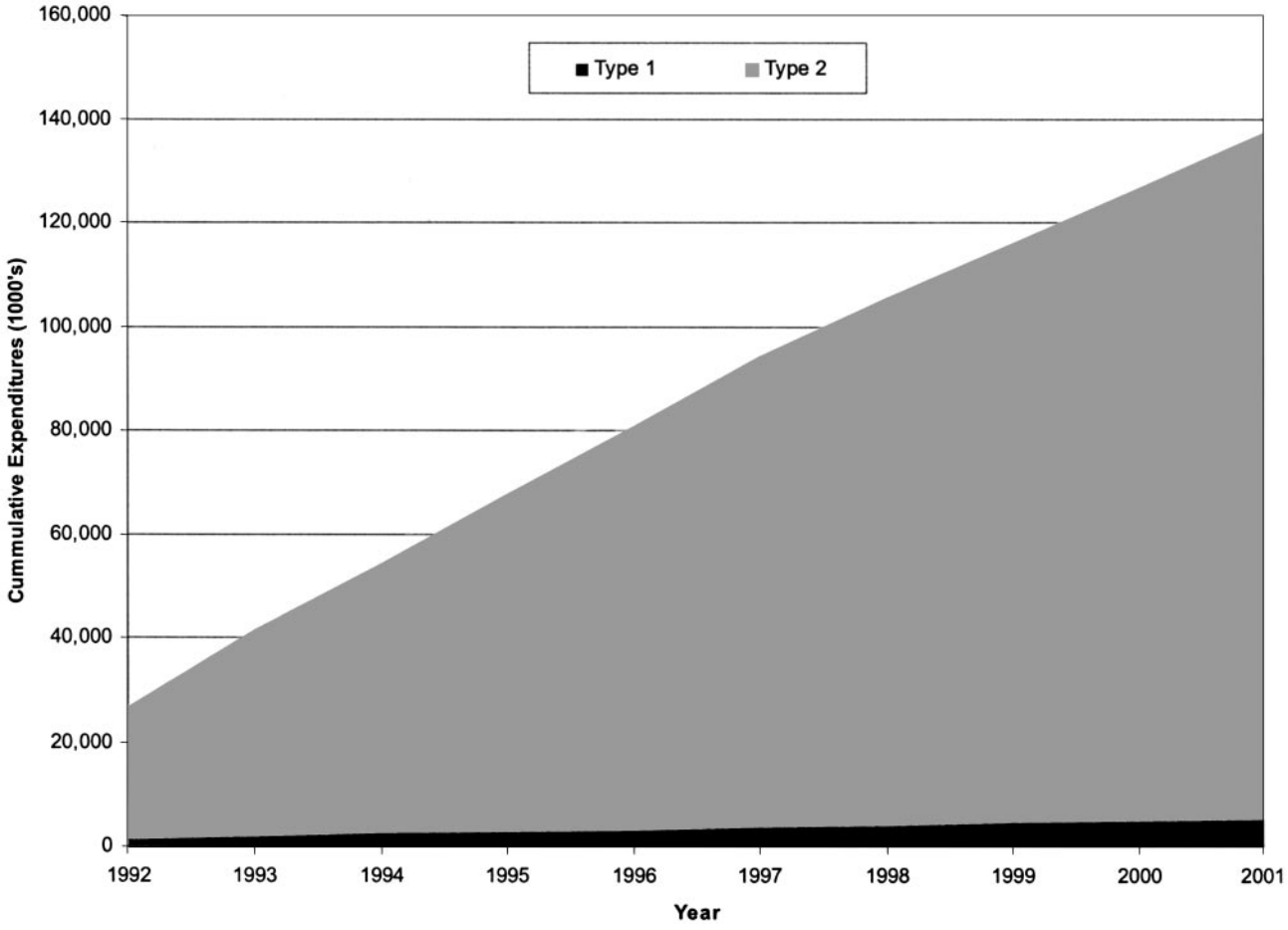


Figure 2—*Cumulative health care costs according to type of diabetes.*

sources to records obtained directly from Saskatchewan Health. Furthermore, the same estimation approach was used for all subjects, so there was no bias in the comparison between type 1 and type 2 diabetic patients.

The algorithm used in this study to distinguish between type 1 and type 2 diabetes has not been previously validated. Using our algorithm, it is possible that some individuals with late-onset type 1 diabetes would be misclassified as having type 2 diabetes. We chose not to use age at index as a criterion for classification and depended only on treatment patterns. The proportion of incident cases categorized as type 1 diabetes was, however, similar to the proportion observed in U.S. population-based data from 1990 to 1992 (22,23), where ~4.9% of incident cases were categorized as type 1 diabetes. Although some potential for misclassification existed, we believe it would be trivial.

Last, the time period of data used to eliminate prevalent cases of diabetes from the analysis was relatively short. It is conceivable that some prevalent diabetes cases would appear to be incident in 1992 because they may not have met the NDSS criteria in 1989 or 1990. This would explain, in part, the older-than-expected average age at index of individuals with type 1 diabetes and why two case subjects with type 2 diabetes received dialysis before identification of the disease. Further, as a chronic medical condition, even 10 years of follow-up might be considered a limited time horizon for the estimation of costs of care for diabetes. Nevertheless, to our knowledge, this study represents the largest cohort with the longest follow-up of health care use and costs published to date.

Information on the relative burden of health conditions, in epidemiologic or economic terms, is of interest to health policymakers when making decisions regarding the allocation of resources for the management of prevalent and expected cases and to justify health promotion and disease prevention programs. It has also been suggested that public health should be the first consideration in allocation of research funding (24). If this were the case, research funding for type 2 diabetes should far outweigh funding available for type 1 diabetes.

In summary, although we had anticipated that per capita costs associated with caring for individuals with diabetes would increase as the disease progressed over the decade after diagnosis, decreasing hospitalization costs kept total per capita costs relatively stable. Total health care expenditures for diabetes are driven by the much larger prevalence of type 2 compared with type 1 diabetes and highlight the relative public health burden of both conditions.

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References

1. Ettaro L, Songer TJ, Zhang P, Engelgau MM: Cost-of-illness studies in diabetes mellitus. *Pharmacoeconomics* 22:149–164,2004
2. Hogan P, Dall T, Nikolov P: Economic costs of diabetes in the U.S. in 2002. *Diabetes Care* 26:917–932, 2003
3. Dawson KG, Gomes D, Gerstein H, Blanchard JF, Kahler KH: The economic cost of diabetes in Canada, 1998. *Diabetes Care* 25:1303–1307, 2002
4. Health Canada: *Responding to the Challenge of Diabetes in Canada: First Report of the National Diabetes Surveillence System (NDSS)*. Ottawa., Canada, Health Canada, 2003
5. Brown JB, Nichols GA, Glauber HS, Bakst AW: Type 2 diabetes: incremental medical care costs during the first 8 years after diagnosis. *Diabetes Care* 22:1116–1124, 1999
6. Nichols GA, Glauber HS, Brown JB: Type 2 diabetes: incremental medical care costs during the 8 years preceding diagnosis. *Diabetes Care* 23:1654–1659, 2000
7. Olsen BS, Sjolie A, Hougaard P, Johannesen J, Borch-Johnsen K, Marinelli K, Thorsteinsson B, Pramming S, Mortensen HB: A 6-year nationwide cohort study of glycaemic control in young people with type 1 diabetes: risk markers for the development of retinopathy, nephropathy and neuropathy: Danish Study Group of Diabetes in Childhood. *J Diabetes Complications* 14:295–300, 2000
8. Bjork S: The cost of diabetes and diabetes care. *Diabetes Res Clin Pract* 54 (Suppl. 1):S13–S18, 2001
9. Caro JJ, Ward AJ, O'Brien JA: Lifetime costs of complications resulting from type 2 diabetes in the U.S. *Diabetes Care* 25: 476–481, 2002
10. Simpson SH, Corabian P, Jacobs P, Johnson JA: The cost of major comorbidity in people with diabetes mellitus. *CMAJ* 168: 1661–1667, 2003
11. Statistics Canada: Consumer price index (CPI), 2001 basket content, annual [article online], 2006. Available from www.statscan.ca. Accessed 20 September 2006
12. Pohar SL, Simpson SH, Majumdar SR, Jacobs P, Ohinmaa A, Osei W, Stang M, Downey W, Johnson JA: *Epidemiologic and Cost Trends in Diabetes in Saskatchewan, 1991 to 2001*. Edmonton, Canada, Alliance for Canadian Health Outcomes Research in Diabetes, 2006 (Institute of Health Economics Working Paper 05-06)
13. Johnson JA, Simpson SH, Jacobs P, Downey W, Beck P, Osei W: *Cost of Health Care for People With Diabetes Mellitus in Saskatchewan 1991 to 1996*. Edmonton, Alliance for Canadian Health Outcomes Research in Diabetes, 2002 (Institute of Health Economics Working Paper 02-02)
14. Lee H, Manns B, Taub K, Ghali WA, Dean S, Johnson D, Donaldson C: Cost analysis of ongoing care of patients with end-stage renal disease: the impact of dialysis modality and dialysis access. *Am J Kidney Dis* 40:611–622, 2002
15. Engelgau MM, Geiss LS, Saaddine JB, Boyle JP, Benjamin SM, Gregg EW, Tierney EF, Rios-Burrows N, Mokdad AH, Ford ES, Imperatore G, Narayan KM: The evolving diabetes burden in the United States. *Ann Intern Med* 140:945–950, 2004
16. Pohar SL, Majumdar SR, Jacobs P, Johnson JA: *Healthcare Utilization and Direct Healthcare Costs of Diabetes in Urban and Rural Saskatchewan, 1991–2001*. Edmonton, Canada, Alliance for Canadian Health Outcomes Research in Diabetes, 2006 (Institute of Health Economics Working Paper WP 06-01)
17. Liu L, Hader J, Brossart B, White R, Lewis S: Impact of rural hospital closures in Saskatchewan, Canada. *Soc Sci Med* 52: 1793–1804, 2001
18. Morgan SG, Bassett KL, Wright JM, Evans RG, Barer ML, Caetano PA, Black CD: "Breakthrough" drugs and growth in expenditure on prescription drugs in Canada. *BMJ* 331:815–816, 2005
19. Klinke JA, Johnson JA, Guirguis LM, Toth EL, Lee TK, Lewanczuk RZ, Majumdar SR: Underuse of aspirin in type 2 diabetes mellitus: prevalence and correlates of therapy in rural Canada. *Clin Ther* 26:439–446, 2004
20. Brown LC, Johnson JA, Majumdar SR, Tsuyuki RT, McAlister FA: Evidence of suboptimal management of cardiovascular risk in patients with type 2 diabetes mellitus and symptomatic atherosclerosis. *CMAJ* 171:1189–1192, 2004
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* 25: 512–516, 2002
22. LaPorte RE, Matsushima M, Chang YF: Prevalence and incidence of insulin-dependent diabetes [article online], 1995. Available from http://diabetes.niddk.nih.gov/dm/pubs/america/pdf/chapter3.pdf. Accessed 13 December 2005
23. Kenny SJ, Aubert RE, Geiss LS: Prevalence and incidence of non-insulin dependent diabetes [article online], 1995. Available from diabetes.niddk.nih.gov/dm/pubs/america/pdf/chapter4.pdf. Accessed 13 December 2005
24. Gross CP, Anderson GF, Powe NR: The relation between funding by the National Institutes of Health and the burden of disease. *N Engl J Med* 340:1881–1887, 1999