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# Distinguishing the Economic Costs Associated with Type 1 and Type 2 Diabetes

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## Abstract

The objective was to estimate the economic costs of diagnosed type 1 (T1DM) and type 2 (T2DM) diabetes mellitus in the United States in 2007. Medical claims were analyzed to estimate the proportion of diagnosed diabetes cases and excess medical costs by diabetes type. Indirect costs associated with T1DM and T2DM were estimated by using findings from the literature on diagnosed diabetes, as well as differences in health per case of T1DM and T2DM. This study builds on the Cost of Diabetes Model developed for the American Diabetes Association to estimate the economic burden of diagnosed diabetes. T1DM accounts for an estimated 5.7% (1.0 million) of the 17.5 million people with diagnosed diabetes. Approximately $14.9 billion (8.6%) of the economic burden of diagnosed diabetes is associated with T1DM, including medical costs of $10.5 billion and indirect costs of $4.4 billion. Costs associated with T2DM are $159.5 billion, including medical costs of $105.7 billion and indirect costs of $53.8 billion. The economic burden per case of diabetes is greater for T1DM than for T2DM, and the difference increases with age. The prevalence of T2DM is significantly greater than the prevalence of T1DM, so T2DM is responsible for most of the economic burden of diabetes. Estimates for T1DM are sensitive to the criteria used to identify people with diabetes using claims data; estimates for T2DM are relatively stable. Improved coding of diabetes type in medical claims and identification of diabetes type in survey data could lead to more precise estimates of the economic burden by diabetes type. (*Population Health Management* 2009;12:103–110)

## Introduction

The annual economic burden associated with diagnosed diabetes in the United States is estimated to be $174 billion.[1] Approximately 90%–95% of diagnosed cases are type 2 diabetes (T2DM), the form of diabetes that is largely preventable.[2] Type 1 diabetes (T1DM) comprises the remaining 5%–10%, but because onset of T1DM tends to occur at a much younger age, patients with T1DM have higher prevalence of complications than do T2DM patients of a similar age.

Challenges to identifying diabetes type in medical claims data have contributed to a paucity of large sample studies to compare use of health care services and medical costs by diabetes type.[3–5] Because T1DM constitutes a relatively small proportion of total cases, this type of diabetes often is overlooked in studies. Understanding the differences in health care use patterns and major cost drivers by diabetes type can be useful in tailoring diabetes management programs and other preventive interventions to the unique needs of people with T1DM and T2DM. Also, the differences in costs incurred by diabetes type have different implications for payers whose diabetes cases are disproportionately T1DM (eg, Medicaid) or T2DM (eg, Medicare).

The indirect costs of diabetes include increased absenteeism (missed work days), "presenteeism" (reduced productivity while at work), long-term disability (that prevents working), and early mortality.[6–13] The lack of information specifying diabetes type in survey data has contributed to a dearth of information about indirect costs by diabetes type. Distinguishing between the indirect costs per case by diabetes type provides information that can be used to help employers understand the business case for health promotion activities designed to help prevent chronic problems like T2DM.

## Research Design and Methods

The data and methods used to estimate the national economic burden of diagnosed diabetes are described elsewhere.[1]

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The focus of this article is the data and methods used to estimate the proportion of diagnosed diabetes costs attributed to T1DM and T2DM, respectively. First, to obtain national prevalence estimates by diabetes type, we estimate the proportion of diagnosed T1DM cases for each demographic group (by age and sex). Second, we estimate patterns of health care use by diabetes type and demographic group. Finally, we use these estimates of health care use patterns to model productivity loss per case by diabetes type. Information from the major components of this study—diabetes prevalence by

Table 1. Summary of Data Sources Used

| *Source* | *Description* | *Use* |
|---|---|---|
| 2004–2006 National Health Interview Survey (NHIS) | Stratified random sample of noninstitutionalized households surveyed annually by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC) | • Calculate national prevalence rates for diagnosed diabetes by age group, sex, and race/ethnicity<br>• Calculate work days absent, inability to work because of permanent disability, and rates of insulin and oral agent use for people with diagnosed diabetes |
| The 2003–2005 Medical Expenditure Panel Survey (MEPS) | Stratified random subset of the NHIS households surveyed; this file contains more detailed information on health care use and associated costs | • Calculate average medical cost per health care event (eg, per visit) or per annum usage (eg, home health care, podiatric care, medical supplies) |
| 2004–2005 Nationwide Inpatient Sample (NIS) | This file contains discharge records for approximately 8 million hospital stays each year from over 1000 hospitals located in 37 states; produced by the Agency for Healthcare Research and Quality | • Calculate national inpatient days and hospital costs by patient demographic and complication category |
| 2003–2005 National Ambulatory Medical Care Survey (NAMCS) | National sample of visits to non-federally employed office-based physicians who are primarily engaged in direct patient care; produced annually by NCHS, CDC | • Calculate national physician office visits by patient demographic and complication category |
| 2003–2005 National Hospital Ambulatory Medical Care Survey (NHAMCS) | National sample of visits to emergency and outpatient departments of noninstitutional general and short-stay hospitals; produced annually by NCHS, CDC | • Calculate national emergency and outpatient visits by patient demographic and complication category |
| 2000 National Home and Hospice Care Survey (NHHCS) | Survey of home and hospice care agencies; produced by NCHS, CDC | • Calculate diabetes-associated national hospice visits by patient demographic |
| 2004 National Nursing Home Survey (NNHS) | Survey of nursing homes; produced by NCHS, CDC | • Calculate total resident days in nursing facilities and the prevalence of T1DM and T2DM among the population in long-term care |
| 2006 Ingenix MCURE database | Annual medical claims for approximately 16.2 million insured persons younger than age 65 in 2006 (approximately 650,000 with a diagnosis of diabetes) | • Calculate the proportion of diagnosed diabetes cases that are T1DM and how patterns of health care use differ by diabetes status (no diabetes diagnosis, likely T1DM, or likely T2DM) |
| 2006 Medicare 5% Sample File | Annual medical claims for approximately 1.8 million people age 65 and older (approximately 350,000 with a diagnosis of diabetes) | • Calculate the proportion of diagnosed diabetes cases that are T1DM and how patterns of health care use differ by diabetes status |
| California's 2001 MediCal (Medicaid) 20% File. | Medical claims for approximately 1.3 million people who were insured under MediCal for at least 9 continuous months, of which 33,000 have a diagnosis of diabetes. | • Calculate the proportion of diagnosed diabetes cases that are T1DM and how patterns of health care use differ by diabetes status |

type, health care use patterns, and lost productivity—are estimated and combined by patient age (0–17, 18–34, 35–44, 45–54, 55–59, 60–64, 65–69, and 70 older) and sex. The data sources and approach used are described in the following sections.

### Data sources

This study builds on a Cost of Diabetes Model that combines information from the peer-reviewed literature, government statistics, and original analyses. Table 1 summarizes the data sources used; additional information on these sources and their use is provided later. The diabetes prevalence and cost estimates reflect population estimates from the United States Census Bureau for 2007.

### Prevalence of T1DM and T2DM

The recent study of the national economic burden of diagnosed diabetes estimated the number of people in the United States with diagnosed diabetes in 2007 by age, sex, and race/ethnicity based on nationally representative data sources. To determine the portion of these cases that are T1DM, we use medical data from 3 sources: the Managed Care Utilization Rate Estimates (MCURE) database, the Medicare 5% Sample File, and the MediCal 20% File. Although we capture the uninsured population in our national prevalence of diagnosed diabetes, we have identified no data source to estimate the proportion of T1DM cases in this population and assume the proportion of cases with T1DM is similar to that of the commercially insured population, controlling for age and sex.

After reviewing methods of type classification with medical claims used in previous studies, we adopt the following criteria to categorize patients as likely T1DM, or likely T2DM.[3–5] For the MCURE, Medicare 5% Sample, and MediCal files, we analyze the ICD-9-CM codes in the annual medical claims for each patient. Patients with at least 1 claim with a code of 250.xx are assumed to have diabetes. For these patients, we then use the following criteria to define diabetes type:

(1) if a patient has a diagnosis of diabetic ketoacidosis (250.1x), then the patient is categorized as T1DM (1.1% of cases); else
(2) if a patient has an insulin resistance diagnosis (277.7x), then the patient is categorized as T2DM (1.5% of cases); else
(3) if all diabetes diagnoses during 2006 are 250.x1 or 250.x3, then the patient is categorized as T1DM (3.7% of cases); else
(4) if all diabetes diagnoses during 2006 are 250.x0 or 250.x2, then the patient is categorized as T2DM (81.9% of cases); else
(5) if a patient has both T1DM and T2DM/unspecified diagnoses and no diagnosis of ketoacidosis or insulin resistance (11.9 % of cases), then additional assumptions must be made to categorize a patient's diabetes type. As there are almost 3 times as many people in this category as are in cases (1) and (3), the prevalence of T1DM is sensitive to the assumptions used to categorize these patients. We explore alternate criteria based on the proportion of a patient's diabetes diagnoses that indicate T1DM.
   a. The approach used in this study recognizes that T2DM prevalence increases more rapidly with age than does T1DM prevalence. Consequently, all else being equal, older patients with diagnosis codes for both T1DM and T2DM are more likely than are younger patients to have T2DM. For the 88% of patients we can classify as T1DM or T2DM with some degree of certainty by applying criteria (1) through (4) above, we estimate the proportion that are T1DM. We assume that the same proportion of patients with mixed T1DM/T2DM diagnoses have T1DM as do patients classified with a greater degree of certainty. To calculate this proportion with T1DM, we categorize all patients younger than age 18 years as T1DM and patients age 55 and older as T2DM. Patients ages 18–34 are categorized as T1DM if more than 55% of their diagnoses indicate T1DM; those ages 35–44 are categorized as T1DM if more than 80% of their diagnoses indicate T1DM, and those ages 45–54 are categorized as T1DM if more than 90% of their diagnoses indicate T1DM.
   b. An alternate approach categorizes a patient as T1DM if more than half of the diabetes diagnoses indicate T1DM. Otherwise, the patient is assumed to have T2DM.

Patients with claims data indicating both T1DM and T2DM tend to be high users of health care services—making this population important for the analysis. Having multiple claims with a diabetes diagnosis, however, increases the likelihood that at least 1 diagnosis will incorrectly identify diabetes type. Approach (a) produces a prevalence rate that stabilizes after age 35 and produces a median age of T1DM onset that is consistent with published findings. Approach (b) produces a national T1DM prevalence rate that continues to increase rapidly with age. The estimates presented use approach (a), although we report prevalence and cost using approach (b) as a sensitivity analysis. Estimates of per capita health care use by diabetes type are relatively unaffected by the use of approach (a) or (b), so the impact on total diabetes costs of using approach (a) over approach (b) is primarily the different estimates produced of the proportion of cases that are T1DM.

### Health care resource use associated with T1DM and T2DM

Diabetes is associated with increased risk of neurological symptoms, peripheral vascular disease, cardiovascular disease, renal complications, endocrine complications, ophthalmic complications, as well as a number of other complications.[1,14–19] People with diabetes tend to have longer hospital stays and increased numbers of encounters per capita for health problems that are not identified as complications of diabetes. In our previous paper, we estimated the total national utilization of medical services in the physician office, outpatient, emergency department, and inpatient settings, as well as the amount of utilization associated with diagnosed diabetes.[1] Primary diagnosis codes were used to categorize each of these estimates by complication group.

To determine the proportion of these costs that are associated with T1DM, we examine the difference in health care use patterns between the T1DM population and the T2DM

population, compared with the population without diagnosed diabetes. We use the MCURE database to examine the population younger than age 65, and the Medicare 5% sample to examine the population age 65 and older. For each age group, sex, delivery setting, and diabetes type (T), we define the rate ratio (RR) for each complication group (C) as the ratio of the mean number of events for people with the given diabetes type to the mean number of events for people without diagnosed diabetes. Etiological fractions ($\varepsilon$) are calculated using diabetes prevalence rates (P) and the above rate ratios, providing estimates of the proportion of health care use associated with T1DM and T2DM in each health care delivery setting by age group and sex[20]:

$$\varepsilon_{C,T} = \frac{(RR_{C,T} - 1) \times P_T}{1 + \sum_{t = T1DM,\, T2DM} (RR_{C,t} - 1) \times P_t}$$

We then calculate the proportion of diagnosed diabetes health care use and cost attributed to T1DM, as:

$$\text{Proportion}_{C,T} = \frac{\varepsilon_{C,T}}{\varepsilon_{C,T1DM} + \varepsilon_{C,T2DM}}.$$

This proportion is applied to the cost estimates for diagnosed diabetes produced in our previous study.

Using the National Nursing Home Survey, we can identify residents with T1DM and T2DM based on admission diagnosis. We compare the diabetes prevalence rate in nursing homes to the prevalence rate among the general population to calculate the excess number of nursing home residents associated with diabetes.

The MCURE database used has medical claims data for only a portion of patients, as many employers use different insurers to manage pharmacy benefits than are used to manage other health care use. Consequently, we base our estimates of the proportion of T1DM patients who use insulin and who use oral agents on published benchmarks.[21] From the insulin and oral agent use estimates for diagnosed diabetes, we subtract the estimates of use associated with T1DM to infer the portion of T2DM patients who use insulin and oral agents. Estimates of the proportion of retail prescription costs by diabetes type are linked to differences by type in number of outpatient, office, and emergency visits.

Estimates of the cost of diabetic supplies were developed using the Medicare Expenditure Panel Survey (MEPS). While MEPS does not identify diabetes type, analysis suggests that insulin use is highly correlated with the use of diabetic supplies. Consequently, differences in prevalence of insulin use by diabetes type are used to calculate the proportion of diabetic supplies associated with T1DM.

Ambulance costs are linked to emergency visits associated with each diabetes type. For all other categories of medical costs (eg, hospice, home health, podiatric care, other equipment and supplies), costs associated with diagnosed diabetes are divided between T1DM and T2DM based on the relative prevalence of T1DM and T2DM by age and sex.

### *Productivity loss associated with T1DM and T2DM*

Estimates of diabetes-attributed absenteeism, presenteeism, and reduced productivity among those in the workforce have been calculated previously.[1] However, these estimates are based on surveys that lack information about diabetes type. Determining the proportion of productivity loss associated with T1DM requires estimates of how productivity loss per T1DM case differs, on average, from a T2DM case. Our analysis of health care utilization shows that per capita use of medical services is higher for T1DM than for T2DM. We estimate total days spent receiving health care services associated with diabetes by age and sex, and use the proportion of these days associated with each diabetes type to estimate the proportion of diabetes-attributed lost productivity associated with T1DM and T2DM. To estimate total days spent receiving care, we assume that each office and outpatient visit is equivalent to half a day, and each emergency visit and inpatient day is equivalent to a full day. For sensitivity analysis, we report cost estimates assuming that T1DM and T2DM cases have similar rates of associated productivity loss, so the proportion of productivity loss associated with T1DM is equal to the proportion of diabetes cases that are T1DM. Accounting for differences in health yields productivity loss estimates that are 6.9% higher for T1DM (and 0.4% lower for T2DM) than estimates based solely on the relative prevalence of T1DM and T2DM.

Analysis of the National Health Interview Survey (NHIS) reveals that diabetes is associated with increased receipt of Supplemental Security Income (SSI), an indication of employment-preventing long-term disability.[1] Unfortunately, the NHIS does not contain information on diabetes type, nor is diabetes type reported by the Social Security Administration for those who qualify for SSI. To estimate the proportion of diabetes-attributed long-term disability costs associated with T1DM, we use the proportion of hospital inpatient days associated with T1DM to take into consideration differences by diabetes type in the prevalence and severity of chronic conditions. Compared with the allocation of disability costs based on the relative prevalence of T1DM and T2DM, the overall impact of using this approach is to increase the estimates of T1DM productivity loss from long-term disability by approximately 22% and lower estimates for T2DM by 2%.

Our earlier work suggests that there were 284,000 premature deaths attributed to diabetes in 2007, of which the primary cause of death was diabetes for 77,000 persons, renal failure for 25,000, cerebrovascular disease for 59,000, and cardiovascular disease for 123,000.[1,8,22,23] Two studies report that, controlling for demographic and other risk factors, the risk of mortality due to cardiovascular disease is similar for both T1DM and T2DM.[22,23] However, because T1DM is associated with higher use of health care resources for renal complications, cardiovascular disease, and other complications, we assume T1DM is more likely to be associated with the increased mortality rates resulting from these complications. To estimate the proportion of these 284,000 premature deaths associated with T1DM, we use the proportion of diabetes-attributed emergency visits associated with T1DM by complication category (ie, diabetes, renal failure, cerebrovascular disease, cardiovascular disease). This approach produces estimates of T1DM productivity loss from mortality that are approximately 8% higher (and estimates for T2DM that are 0.7% lower), compared with the allocation of mortality costs based simply on the relative prevalence of the 2 diabetes types.

Earlier work combining Bureau of Labor Statistics data on earnings and labor force participation with life expectancy

Table 2. Rate Ratios for Annual Health Care Use (for population ages 45–64 Years)

| | *Physician Office Visits* | | *Outpatient Visits* | | *Emergency Visits* | | *Hospital Inpatient Days* | |
|---|---|---|---|---|---|---|---|---|
| *Complication Groups* | *T1DM* | *T2DM* | *T1DM* | *T2DM* | *T1DM* | *T2DM* | *T1DM* | *T2DM* |
| Neurological symptoms | 7.9 | 4.9 | 6.2 | 4.1 | 5.4 | 3.7 | 6.0 | 5.3 |
| Peripheral vascular disease | 3.5 | 2.9 | 5.6 | 4.3 | 4.0 | 2.5 | 10.9 | 5.8 |
| Cardiovascular disease | 1.7 | 2.0 | 1.9 | 2.1 | 3.1 | 3.0 | 7.1 | 6.1 |
| Renal complications | 4.1 | 2.9 | 4.0 | 2.9 | 3.1 | 2.8 | 15.3 | 6.7 |
| Endocrine complications | 1.3 | 1.4 | 1.3 | 1.4 | 14.7 | 8.3 | 23.0 | 9.8 |
| Ophthalmic complications | 5.7 | 3.6 | 6.2 | 4.0 | 2.3 | 2.3 | 7.4 | 7.2 |
| Other diabetes complications | 4.1 | 3.1 | 6.6 | 4.4 | 2.8 | 2.7 | 12.9 | 10.3 |
| All other medical conditions | 1.4 | 1.4 | 1.4 | 1.4 | 1.6 | 1.7 | 2.6 | 1.9 |
| Total | 2.1 | 1.9 | 2.2 | 2.1 | 1.8 | 1.9 | 3.7 | 2.7 |

Rate ratio of 1.0 means that people with diagnosed diabetes of the specified type have the same rate of health care use as the population with no diagnosis of diabetes. The diagnosis codes used to define the complication groups are documented elsewhere.[1]

data from the Centers for Disease Control and Prevention, suggests that the present value of lost productivity associated with premature mortality ranges from $14,000 (for females ages 70–74) to $1.25 million (for males younger than age 18).[1] We use age-sex specific lost lifetime productivity estimates to calculate the productivity loss associated with T1DM and T2DM premature mortality. We use a 3% discount rate, and for each 1% increase in the discount rate the national estimated lost productivity resulting from diabetes-attributed premature mortality declines by 6%–7%.

## Results

In 2007, of the estimated 17.5 million people with diagnosed diabetes in the United States, approximately 1.0 million (5.7%) have T1DM and 16.5 million (94.3%) have T2DM. Our resulting overall percent T1DM of 5.7% is within the 5%–10% range found by others. The national prevalence rates suggest that the median age of diagnosis is approximately 24 years for T1DM and 57 for T2DM.

We find that the percent of diabetes cases that are T1DM varies by age, sex, and payer mix. The estimated percent with T1DM is 79.0% for the population younger than age 18, 26.2% for ages 18–34, 8.5% for ages 35–44, 4.6% for ages 45–54, 3.5% for ages 55–59, 3.6% for ages 60–64, 2.4% for ages 65–69, and 2.5% for ages 70 and older. The proportion of cases that are T1DM among children is similar to the estimate (81%) reported by the SEARCH for Diabetes in Youth Study, a study of 6379 youth and adolescents with diabetes.[24] Analysis of the MediCal file found that only 43% of youth with a diabetes diagnosis had an ICD-9 code indicating T1DM—an estimate significantly below the 79% and 81% estimates above. This low estimate for youth from the MediCal data likely reflects data limitations, and for our analysis we assume that 79% of children with diabetes in the Medicaid population have T1DM. No recent estimates of T1DM among adults were found, but a 1995 study estimates that 0.3% of adults ages 30 to 74 have T1DM (compared to our estimate of 0.4% of all adults).[25]

For most complication categories and age groups, per capita use of health care services is higher for people with T1DM relative to people with T2DM. Using the population age range of 45 to 64 for illustration, people with T1DM have 7.9 times as many physician office visits for neurological symptoms, on average, compared with people without diabetes (Table 2). This is nearly twice the ratio (4.9) for a person with T2DM.

The national economic burden of diagnosed diabetes was estimated at $174 billion in 2007, including $116 billion in the form of higher medical costs and $58 billion in reduced national productivity (Table 2). Approximately $159.5 billion (91.4%) is attributed to T2DM; the remaining $14.9 billion (8.6%) is associated with T1DM. Although T1DM constitutes only 5.7% of diagnosed cases and the skew of T1DM is toward younger populations, T1DM accounts for 9.1% ($10.5 billion) of excess medical costs associated with diagnosed diabetes, and 7.5% ($4.4 billion) of excess productivity costs.

While the average diabetes-associated medical cost per year increases with age, the average cost of productivity loss *decreases* with age so that the average total cost per case of T2DM per year is relatively constant, at $9200 to $9700 across 3 aggregate age groups (Table 3). However, for T1DM, the average medical cost per case increases rapidly with age—from $4044 for people younger than age 44 to $35,365 for the population age 65 and older. The high cost per case for T1DM among those age 65 and older is attributed to the high use of costly nursing and residential facilities, as well as the increased incidence of inpatients stays. Whereas T1DM is responsible for about 9% of medical costs associated with diabetes, T1DM is responsible for 59% of nursing/residential facility costs associated with diabetes due to the greatly increased prevalence of T1DM among the nursing home population as compared to the noninstitutionalized population.

We conducted sensitivity analysis on 2 key assumptions. First, for the approximately 12% of patients who have diagnoses indicating both T1DM and T2DM/unspecified, we classify patients as likely T1DM if more than 50% of the diabetes diagnoses indicate T1DM (regardless of patient age).

Table 3. Economic Burden of Diagnosed Diabetes in 2007 (millions of dollars)

| | *Total Costs Attributed to Diabetes* | | | *Total Costs Incurred by Population* | | | | |
|---|---|---|---|---|---|---|---|---|
| *Cost Component** | *All Diagnosed Diabetes* | *Type 1* | *Type 2* | *All Diagnosed Diabetes* | *Type 1* | *Type 2* | *No Diagnosis of Diabetes* | *US Total* |
| Total* | 174,418 | 14,926 | 159,492 | | | | | |
| Medical Costs | 116,258 | 10,548 | 105,710 | 205,092 | 13,960 | 191,133 | 846,412 | 1,051,504 |
| Institutional care | 65,831 | 7,769 | 58,062 | 115,499 | 9,478 | 106,020 | 389,593 | 505,092 |
| Hospital inpatient | 58,344 | 3,322 | 55,022 | 96,974 | 4,738 | 92,236 | 332,902 | 429,875 |
| Nursing/residential facility | 7,487 | 4,447 | 3,040 | 18,525 | 4,740 | 13,784 | 56,692 | 75,216 |
| Outpatient care | 22,743 | 1,237 | 21,505 | 46,743 | 2,342 | 44,401 | 312,356 | 359,099 |
| Physician's office | 9,897 | 544 | 9,353 | 21,739 | 1,065 | 20,674 | 132,984 | 154,723 |
| Emergency department | 3,870 | 234 | 3,636 | 8,065 | 489 | 7,576 | 73,381 | 81,446 |
| Ambulance services | 103 | 4 | 100 | 370 | 13 | 358 | 1,726 | 2,096 |
| Hospital outpatient | 2,985 | 279 | 2,705 | 6,770 | 491 | 6,279 | 60,054 | 66,824 |
| Home health† | 5,586 | 167 | 5,419 | 9,391 | 272 | 9,119 | 31,149 | 40,540 |
| Hospice† | 28 | 1 | 27 | — | — | — | — | 12,033 |
| Podiatry† | 273 | 8 | 265 | 408 | 13 | 395 | 1,028 | 1,437 |
| Outpatient medications and supplies | 27,684 | 1,541 | 26,143 | 42,851 | 2,139 | 40,712 | 144,463 | 187,314 |
| Insulin | 3,733 | 528 | 3,205 | 3,733 | 528 | 3,205 | 0 | 3,733 |
| Diabetic supplies | 1,783 | 128 | 1,654 | 1,783 | 128 | 1,654 | 0 | 1,783 |
| Oral agents | 8,586 | 266 | 8,320 | 8,586 | 266 | 8,320 | 0 | 8,586 |
| Retail prescriptions | 12,692 | 584 | 12,108 | 26,035 | 1,113 | 24,921 | 127,562 | 153,597 |
| Other equipment and supplies† | 890 | 35 | 855 | 2,714 | 103 | 2,611 | 16,901 | 19,615 |
| Nonmedical costs | 58,160 | 4,378 | 53,782 | — | — | — | — | — |
| Absenteeism | 2,597 | 127 | 2,470 | — | — | — | — | — |
| Presenteeism | 19,955 | 1,240 | 18,715 | — | — | — | — | — |
| Inability to work from disability | 7,949 | 674 | 7,276 | — | — | — | — | — |
| Premature mortality | 26,902 | 2,298 | 24,604 | — | — | — | — | — |
| Reduced productivity for those not in labor force | 757 | 39 | 718 | — | — | — | — | — |
| Medical costs per person with diabetes | 6,649 | 10,495 | 6,414 | — | — | — | — | — |
| Age 0 to 44 | 3,808 | 4,044 | 3,755 | — | — | — | — | — |
| Age 45 to 64 | 5,094 | 8,169 | 4,966 | — | — | — | — | — |
| Age 65 and older | 9,713 | 35,365 | 9,061 | — | — | — | — | — |
| Total costs per person with diabetes | 9,975 | 14,856 | 9,677 | — | — | — | — | — |
| Age 0 to 44* | 9,099 | 8,649 | 9,202 | — | — | — | — | — |
| Age 45 to 64* | 9,868 | 13,881 | 9,701 | — | — | — | — | — |
| Age 65 and older* | 10,473 | 36,349 | 9,815 | — | — | — | — | — |

Numbers do not necessarily sum to totals because of rounding. Proportion of diagnosed diabetes costs associated with T1DM estimated based on differences in health care use patterns (*) or relative prevalence of T1DM versus T2DM (†). "–" = not available.

This alternate approach yields 1.4 million T1DM cases (8.2% of diagnosed diabetes cases) and $19.5 million in attributed costs (11.2% of all diabetes attributed costs). Compared to the approach used, this alternate approach results in a higher T1DM prevalence rate among the elderly and a lower T1DM prevalence rate among children and young adults. Second, using relative prevalence of T1DM and T2DM to estimate the proportion of diabetes-attributed productivity loss associated with T1DM lowers estimates of the indirect costs associated with T1DM by $398 million (9%) and raises the estimated indirect cost associated with T2DM by $398 million (0.7%).

## Conclusions

This study suggests that the average economic burden per person with diabetes is larger for T1DM than for T2DM. However, because 94.3% of diagnosed diabetes cases are T2DM, the national economic burden is much greater for

T2DM, suggesting that effective measures to prevent, delay, or manage T2DM have the potential to substantially reduce the overall burden of diabetes.

On a per person basis, costs among the population younger than age 45 are similar for T1DM and T2DM. Although annual medical cost per person increases with age, the medical costs increase at a much faster rate for those who have T1DM. Medical costs for those age 65 and older with T1DM are 8.7 times higher than costs for T1DM patients younger than age 45; medical costs for T2DM are 2.4 times higher for those age 65 and older compared to the population younger than age 45.

The large increase in annual cost per person for T1DM is driven by an increased utilization of institutional care. We find that of the estimated 165,000 T1DM patients age 65 and over, approximately 62,600 live in year-round nursing home facilities (not including residential care facilities), and another 47,600 will spend some portion of the year (about 4 months on average) in a nursing facility. One possible explanation for this finding is that, on average, older people with T1DM have had diabetes for a longer time period than their peers with T2DM and, as reported by the National Institutes of Health, the risk of complication increases with diabetes duration.[26]

The overall cost of diagnosed diabetes could be conservative. Because of data limitations, the medical cost estimates exclude over-the-counter medications, optometry and dental costs, expenditures for preventive services (eg, disease management programs), and administrative costs for government and commercial insurers. The nonmedical cost estimates exclude the cost of informal care, fringe benefits, and personnel costs incurred when a person is absent from work, costs associated with underemployment and early retirement due to poor health, and the costs of absenteeism and presenteeism incurred when a family member or friend has diabetes (ie, only absenteeism and presenteeism associated with one's own diabetes are included).

Other limitations of this study include the following:

1. Analyzing medical claims to identify diabetes type can lead to misidentification of individual cases of T1DM and T2DM. T1DM comprises a relatively small portion of the total population with diagnosed diabetes, and thus prevalence estimates for the T1DM population are sensitive to underlying assumptions, while estimates for T2DM are relatively stable.
2. The primary databases used to analyze health care use differences by diabetes type—MCURE for the commercially insured population and the Medicare 5% Sample for the Medicare population—cover approximately 77% of diagnosed cases. The remaining 23% of cases occur among Medicaid and uninsured populations. The etiological fractions assume that the rate ratios are independent of insurance type, although the national estimates of total health care use to which the etiological fractions are applied do take into consideration the impact of insurance status and payer type.
3. Insufficient data exist to analyze differences in health care utilization by diabetes type for home health, hospice, podiatry, and other equipment and supplies. Our use of relative prevalence of disease type to estimate the proportion of the diagnosed diabetes costs associated with T1DM likely underestimates the burden of T1DM for these cost components.
4. Survey data to estimate the indirect costs of diagnosed diabetes lack information on diabetes type. Consequently, we use differences in health care utilization to estimate differences between T1DM and T2DM in per capita productivity loss.

Suggested areas for future research include:

1. Refining the criteria to identify patients by diabetes type using medical claims data;
2. Modeling the lifetime costs associated with T1DM and T2DM; and
3. Analyzing whether children with T2DM are more likely to experience future rates of complication and economic cost similar to older patients with T2DM, or similar to older patients with T1DM.

These estimates highlight the extensive economic burden associated with diabetes. The total cost to society, however, is higher than the estimate provided here when the impact of diabetes on reduced quality of life is considered.

There are approximately 16 times as many people with T2DM as with T1DM; therefore, policies targeting the prevention and management of T2DM have the greatest potential to lower the overall economic impact of diagnosed diabetes. Among the T1DM population, medical costs increase substantially with age (and duration of diabetes), highlighting the importance of diabetes management directed toward the prevention of costly complications.

## Disclosures

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