Economic Costs of Diabetes in the US in 2002

American Diabetes Association

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I. Abstract

A. Objective

Diabetes Mellitus is the sixth leading cause of death in the United States. Diabetes also contributes to higher rates of morbidity – people with diabetes are at higher risk for heart disease, blindness, kidney failure, extremity amputations and other chronic conditions. The objectives of this study were (1) to estimate the direct medical and indirect costs attributable to diabetes and (2) to calculate the total and per capita medical expenditures for people with and without diabetes.

B. Research Design and Methods

Medical expenditures were estimated for the U.S. population with and without diabetes in 2002 by sex, age, race / ethnicity, type of medical condition and healthcare setting. Healthcare utilization and total healthcare expenditures attributable to diabetes were estimated using etiological fractions, calculated based on national healthcare survey data. The value of lost productivity attributable to diabetes was also estimated based on estimates of lost work days, restricted activity days, prevalence of permanent disability and mortality attributable to diabetes.

C. Results

Direct medical and indirect expenditures attributable to diabetes in 2002 were estimated at $132 billion. Direct medical expenditures alone totaled $ 91.2 billion and comprised $23.2 billion for diabetes care, $ 24.6 billion for chronic complications attributable to diabetes and $ 44.1 for excess prevalence of general medical conditions. Inpatient days (43.9%), nursing home care (15.1%) and office visits (10.9%) constituted the major expenditure groups by service settings. In addition, 51.8% of direct medical expenditures were incurred by people more than 65 years old. Attributable indirect expenditures resulting from lost work days, restricted activity days, mortality and permanent disability due to diabetes, totaled $ 39.8 billion. U.S. health expenditures for the healthcare components included in the study totaled $865 billion, of which $160 billion are incurred by people with diabetes. Per capita medical expenditures totaled $13,243 for people with diabetes and $2,560 for people without diabetes. Adjusting for differences in age, sex and race / ethnicity between the population with and without diabetes, people with diabetes have medical expenditures that are approximately 2.4 times higher than expenditures that would be incurred by the same group in the absence of diabetes.

D. Conclusions

The estimated $132 billion cost likely underestimates the true burden of diabetes because it omits intangibles, such as pain and suffering, care provided by non-paid care givers and several areas of healthcare spending where people with diabetes probably use services at higher rates than people without diabetes (e.g. dental care, optometry care, and the use of licensed dieticians). In addition, the cost estimate excludes undiagnosed cases of diabetes.

Healthcare spending in 2002 for people with diabetes is more than double what spending would be without diabetes. Diabetes imposes a substantial cost burden to society and, in particular, to those individuals with diabetes and their families. Eliminating or reducing the health problems caused by diabetes through factors such as better access to preventive care, more widespread diagnosis, more intensive disease management, and the advent of new medical technologies could significantly improve the quality of life for people with diabetes and their families while at the same time potentially reducing national expenditures for healthcare services and increasing productivity in the U.S. economy.

Diabetes mellitus cost the U.S. an estimated $132 billion in 2002 in medical expenditures and lost productivity. Across the components of the healthcare system included in this study, per capita direct medical expenditures for the approximately 12.1 million people diagnosed with diabetes in the U.S. are more than double the expenditures of otherwise similar people without diabetes. A total of $92 billion in direct medical expenditures are attributable to diabetes. Diabetes is associated with higher rates of lost work time, disability and premature mortality. The resulting economic loss to the U.S. economy in 2002 alone is estimated at $40 billion. This cost estimate documents the extraordinary national economic burden of diabetes. Even so, such estimates do not account for the losses attributable to pain and suffering incurred by people with diabetes, as well as to families and friends of those with diabetes.

The prevalence of diabetes increases with age and is higher among certain racial and ethnic minority populations. The growth, aging, and increasing racial and ethnic diversity of the U.S. population portends a substantial increase in the size of the population with diabetes. If diabetes prevalence rates remained constant over time, controlling for age, sex, race, and ethnicity, then based on Census Bureau population projections (1) the number of people diagnosed with diabetes could increase to approximately 14.5 million by 2010 and to 17.4 million by 2020. The projected increase in the number of people with diabetes suggests that the annual cost in 2002 dollars of diabetes could rise to an estimated $156 billion by 2010 and to $192 billion by 2020. The actual cost in future years could be higher if the cost of health care outpaces the overall cost of living, and if current trends in obesity in the U.S. continue, with the resulting contribution to increased incidence of type 2 diabetes.

This national cost estimate represents an increase from estimates reported in earlier studies, reflecting the growing prevalence of diabetes in the U.S. and the increasing cost of healthcare services. Comparison of national cost estimates across studies is complicated by differences in the cost components included in each study, the continuing growth and aging of the U.S. population, and changes over time in the cost of healthcare services. The previous American Diabetes Association cost–of-diabetes study estimated the national cost of diabetes at $98 billion in 1997 (2).

Documenting the national economic impact of diabetes can inform priority setting in health care research and delivery, including prevention, diagnosis, and treatment of diabetes.

This study uses prevalence-based cost-of-illness methods similar to the approach used by ADA (2, 3) unless specifically noted. Following is an overview of the research design and methods used for this study; a discussion of important findings; and a summary of the implications of these findings, limitations of the study, and suggestions for future research.

II. Research Design and Methods

The approach used to estimate the cost of diabetes follows—to the extent possible—that used in previous studies of the cost of diabetes and, in particular, ADA's previous cost estimate (2). This approach has found acceptance in the general cost-of-disease literature. Deviations from the approach used previously by ADA (2) are noted, and occur in some instances when the exact approach used in the earlier study could not be determined or when new data sources and analytical tools enable improvements to past approaches. Below is a summary of the approach used to estimate (1) the size of the population with diabetes, (2) healthcare utilization and total healthcare expenditures attributable to diabetes, and (3) the value of lost productivity attributable to diabetes.

A. Estimating the Size of the Population with Diabetes

This national cost estimate is based on an estimate of 12.1 million people in the U.S. in 2002 who have been diagnosed with diabetes mellitus. This estimate of the magnitude of the diabetic population represents an increase of one million (9%) from year 2000 estimates, and an increase of 1.8 million (17%) from year 1997 estimates.[1] It is based on self-reported prevalence of diabetes only; therefore, it does not account for the considerable number of people with diabetes who are unaware that they have the disease or do not report it. Indeed, as many as one-third of people with diabetes are unaware that they have the disease.[2] Further, this estimate excludes women with gestational diabetes.

This cost estimate is based on prevalence rates derived from the combined 1998, 1999 and 2000 files of the National Health Interview Survey (NHIS). Combining three years' worth of NHIS files created larger samples with which to estimate separate prevalence rates for each of 12 age groups by sex and by four race/ethnicity designations.[3,4] As

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[1] Based on results from the 2000 Census, it appears that, during the period 1990 to 2000, the U.S. population grew faster than projected by the Census Bureau. The actual U.S. population in 2000, based on the 2000 Census, exceeded by approximately 6.8 million individuals (or 2.4% of the total population) the Census Bureau's pre-2000 projections of the U.S. population in 2000. One implication is that pre-year 2000 estimates of the number of people with diabetes in the U.S were biased downward because the sample weights used in surveys such as the National Health Interview Survey were based on Census Bureau population estimates.

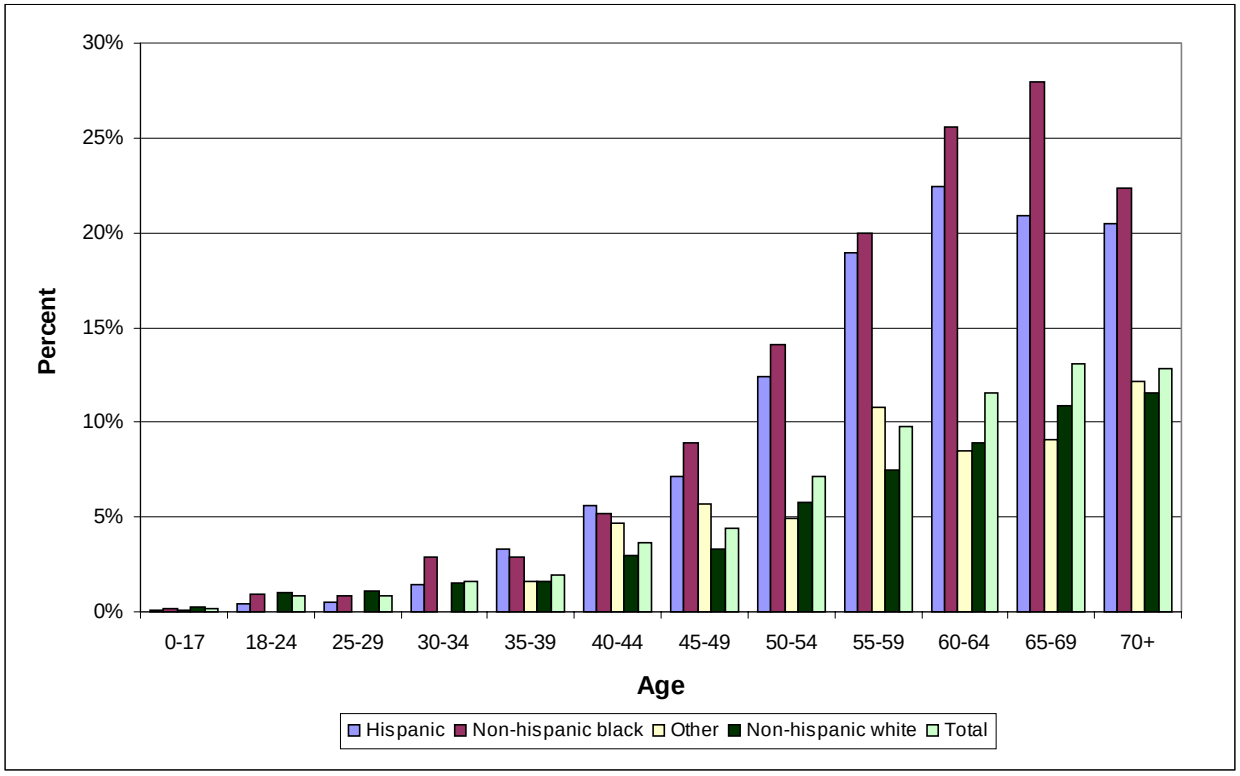
[2] Source: *Basic Diabetes Information*, http://www.diabetes.org as of October 2002.

[3] The 12 age categories are 0-17, 18-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, and 70 and above. The four race/ethnicity categories are Hispanic, non-Hispanic white, non-Hispanic black, and non-Hispanic other.

shown in ***Figures 1*** and ***2***, diabetes prevalence rates increase with age. Prevalence rates vary substantially by race and ethnicity. They are higher for Hispanics and non-Hispanic blacks compared to non-Hispanic whites. Furthermore, the rates for other populations (i.e., Asian Americans, American Indians, Pacific Islanders, etc.) are similar to those of non-Hispanic whites among females, but are lower than the rates for non-Hispanic whites among males.

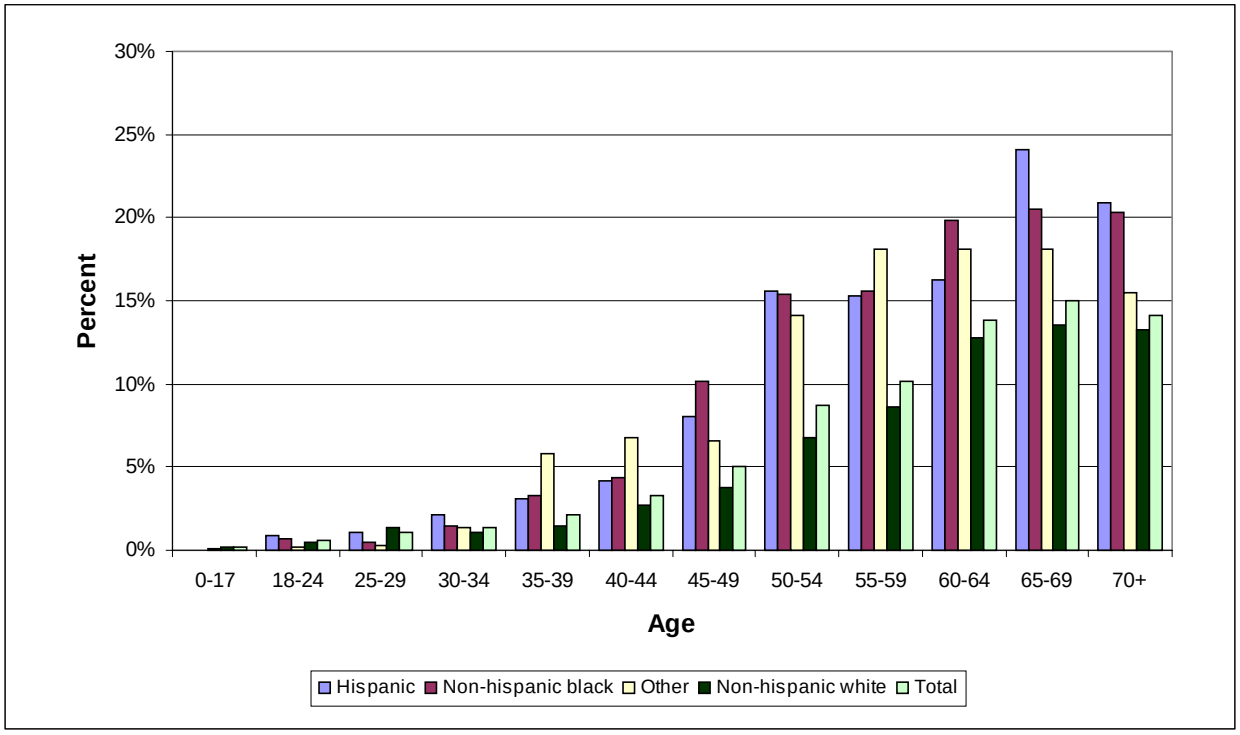
Applying these prevalence rates to the size of the U.S. population in each demographic group, as determined by the 2000 Census and projected to 2002 using Census Bureau estimates, produced the estimate of 12.1 million people diagnosed with diabetes.

Figure 1. Proportion of Female Population with Confirmed Diabetes: 2002



[4] The NHIS collects data on approximately 43,000 households of more than 106,000 people annually. The combined files for 1998 to 2000 create a sample of more than 320,000 people. People with diabetes are identified using the survey question that asks whether the survey participant has been told by a doctor that he or she has diabetes (other than gestational diabetes). Responses to the question are coded as "yes", "no", "borderline", and "no response." People responding "yes" are coded as having diabetes. People responding "borderline" are not counted as having diabetes in this analysis.

Figure 2. Proportion of Male Population with Confirmed Diabetes: 2002



If diabetes prevalence rates within a demographic group remained constant over time then, based on Census Bureau population projections (1), the size of the population with diabetes will grow to approximately 14.5 million by 2010, and to 17.4 million by 2020 (***Table 1***). While the U.S. population is projected to increase by approximately 17% between 2002 and 2020, the size of the population diagnosed with diabetes is projected to increase by 44% due, in large part, to the increase in the size of the elderly population and the increasing racial and ethnic diversity of the U.S. population. Changing demographics will contribute to an increase in the overall prevalence rate for diagnosed cases of diabetes from 4.2% in 2002 to a projected 5.2% in 2020.

The number of Hispanics and other minority populations diagnosed with diabetes is projected to double between 2002 and 2020, while the number of non-Hispanic blacks and non-Hispanic whites diagnosed with diabetes is projected to increase by 50% and 27%, respectively.

While there is no projected increase in the total number of people under age 45 diagnosed with diabetes between 2002 and 2020, the projected increases for the age 45-64 and age 65 and over populations are 48% and 56%, respectively.

Table 1. Projections of the U.S. Population Diagnosed with Diabetes (in millions)

U.S. Population	2002	2010	2020	% Increase 2002 to 2020
Total population [a/]	**288**	**307**	**335**	**17%**
Diagnosed with diabetes	**12.1**	**14.5**	**17.4**	**44%**
Overall diabetes prevalence rate	**4.2%**	**4.7%**	**5.2%**	**24%**
Race/ethnicity				
Hispanic	1.4	2.0	2.9	107%
Non-Hispanic white	8.1	9.1	10.3	27%
Non-Hispanic black	2.0	2.5	3.0	50%
Non-Hispanic other	0.6	0.9	1.2	100%
Sex				
Male	5.8	7.1	8.6	48%
Female	6.3	7.4	8.8	40%
Age				
<45	2.1	2.0	2.1	0%
45-64	5.2	7.0	7.7	48%
65+	4.8	5.5	7.5	56%

a/ Census Bureau (1) population projections adjusted using calibration factors that align Census Bureau projections for the year 2000 with actual Census 2000 counts.

B. Health Resource Utilization Attributable to Diabetes

In addition to receiving healthcare services for medical conditions directly related to diabetes, people with diabetes are at greater risk for neurological disease, peripheral vascular disease, cardiovascular disease, renal disease, endocrine/metabolic complications, ophthalmic disease and other chronic complications compared to those without diabetes. A portion of healthcare utilization associated with these medical conditions is attributable to diabetes.

The general principle for estimating the cost of diabetes in this analysis is straightforward. Healthcare use attributable to diabetes is determined by a comparison of the healthcare utilization patterns of individuals with and without diabetes, controlling for differences between the two populations in demographic characteristics that are potentially correlated with the use of healthcare services (e.g., age, sex, and race/ethnicity).

Three limitations of the source data, however, increase the complexity of the analysis design and calculations. These limitations are: (1) no single source of data, (2) small sample sizes for some items of interest, and (3) underreporting of diabetes as a

comorbidity. The implications of these limitations and how we have addressed these limitations are summarized below.

- **No single source of data**. Because no single data source is representative of the U.S. population and contains all of the information necessary to estimate the healthcare cost of diabetes, it is necessary to draw upon multiple data sources. Among some of these sources are differences in definitions for identifying people with diabetes and differences in levels of detail to categorize types of patient visits. One source of complete data required to estimate direct medical expenditures attributable to diabetes is claims from Group Health of Puget Sound (GHPS). This data source contains a diabetic flag in a disease registry, but the GHPS sample might not be representative of healthcare utilization patterns and costs for the entire U.S. population. The Medical Expenditure Panel Survey (MEPS) is closest to a single, nationally-representative source of data in that it (1) identifies people with diabetes-related conditions, (2) measures healthcare utilization, and (3) provides cost information. However, MEPS is limited by small sample size.

- **Small sample size**. Disaggregating the U.S. population by age, sex, race and ethnicity requires relatively large sample sizes to obtain reliable estimates of differences in utilization patterns by diabetes status when analyzing specific medical conditions associated with diabetes. The number of identified people with diabetes who participated in the most recent MEPS survey is insufficient to obtain reliable estimates of healthcare use for some chronic complications associated with diabetes and in some healthcare settings. The use of alternative data sources, such as the National Ambulatory Medical Care Survey (NAMCS), increases sample size, but suffers from the third major limitation—underreporting of diabetes as a comorbidity.

- **Underreporting of diabetes as a comorbidity**. The literature reports that there is significant under-reporting of diabetes as a comorbidity in healthcare databases. Unless the attending physician lists diabetes as a comorbidity on the patient's medical record, the healthcare services provided to that patient are not linked to diabetes. Sources such as GHPS and MEPS allow one to identify whether a person has been diagnosed with diabetes but, as discussed above, suffer from questions about their representativeness (in the case of GHPS) or have insufficient sample size.

These data limitations are addressed as follows. First, the study uses an eclectic approach that combines findings from empirical analysis of multiple data sources with findings reported in the literature. Second, for several national surveys completed annually, multiple years' worth of data are pooled to increase sample size. Third, similar to previous studies, this study uses an attributable risk methodology to estimate utilization of healthcare services that can be attributed to diabetes.

The attributable risk methodology estimates the odds of having a particular medical condition by diabetes status, then combines these odds with estimates of the proportion

of the population with diabetes to calculate an etiological fraction. The etiological fraction represents an estimate of the proportion of healthcare services for a particular medical condition that is attributable to diabetes. The etiological fraction is calculated based on the following equation,

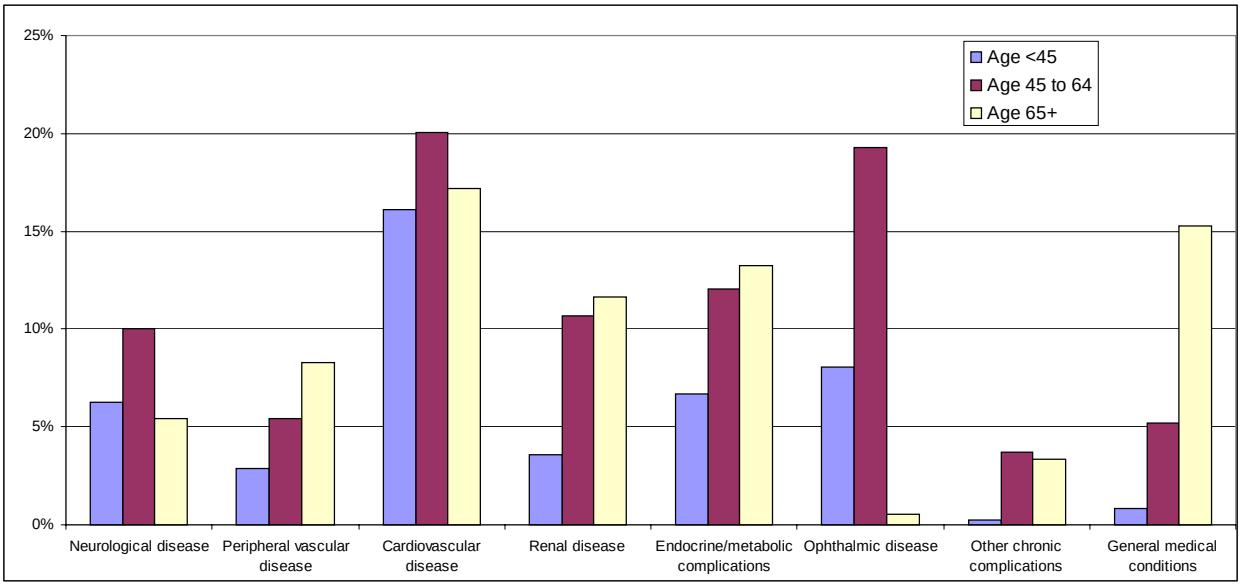
$$E_i = \frac{P \times (R_i - 1)}{P \times (R_i - 1) + 1},$$

where E_i is the fraction of healthcare utilization for medical condition "*i*" that is attributable to diabetes, P represents the diabetes prevalence rate, and R_i is the relative risk of disease i (i.e., the odds ratio) for people with diabetes compared to people without diabetes.

Combining odds ratios estimated using MEPS with diabetes prevalence rates estimated using the NHIS creates separate etiological fractions for the medical conditions listed in ***Figure 3*** for each demographic group modeled. This figure combines etiological fractions across the 12 age groups and by race/ethnicity and sex to present etiological fractions for the population under age 45, age 45 to 64, and age 65 and over. The etiological fractions vary substantially by age to reflect the changing prevalence of diabetes and differences in the prevalence of specific medical conditions by age. For example, for the population under age 45, age 45 to 64, and age 65 and over, the proportion of all healthcare utilization associated with neurological disease that is attributable to diabetes is 6%, 10% and 5%, respectively. The medical condition with the highest etiological fractions is cardiovascular disease, where the proportions of all healthcare visits attributable to diabetes for the under age 45, age 45 to 64, and age 65 and over are 16%, 20% and 17%, respectively.

Although not reported here, the etiological fractions vary substantially by race and ethnicity, with the fractions generally higher for Hispanics and non-whites compared to non-Hispanic whites. This finding is consistent with past research that shows ethnic disparities in both diabetes prevalence rates and the rates of diabetic complications (see, for example, Karter et al. (4)).

Figure 3. Etiological Fractions



Note: Etiological fractions reported here adjust for race/ethnicity, sex, and finer age groupings.

Table 2 summarizes the data sources used to analyze each component of the cost analysis, and summarizes the unit cost estimates. Sources of healthcare use data include the 1998-2000 files of the National Ambulatory Medical Care Survey (NAMCS); the 1998-2000 files of the National Hospital Ambulatory Medical Care Survey (NHAMCS); the 1999 National Inpatient Sample (NIS); the 1999 National Nursing Home Survey (NNHS); and the 1998 and 2000 files of the National Home and Hospice Care Survey (NHHCS).

For each of these files, the primary diagnosis is used to classify the healthcare visit (or inpatient day) into one of nine medical condition classifications: (a) diabetes without complications; (b) one of the seven chronic medical conditions above (i.e., neurological disease, peripheral vascular disease, cardiovascular disease, renal disease, endocrine/metabolic complications, ophthalmic disease and other chronic complications) ; or (c) neither (a) nor (b), in which case the visit is classified as a "general medical condition."[5]

Healthcare utilization rates for each of the nine conditions in each health delivery setting are estimated by patient age, sex, and race/ethnicity. Combining these utilization rates with etiological fractions and estimates of population size for each

[5] See table in appendix for a list of diagnosis codes used to categorize visits and hospital inpatient days by medical condition.

demographic group produces national estimates of healthcare use attributable to diabetes for each medical condition.

Table 2: Source of Health Resource Utilization and Price Estimates

	Cost Component	Source of Utilization Data	Source of Price Data	Unit price (2002 $)
Institutional care	Hospital day	1999 NIS	1998 MEPS	$2,385
	Nursing home day	1999 NNHS	Kiplinger (5)	169
Outpatient care	Office-based physician encounter	1998-2000 NAMCS	1998 MEPS	160
	Emergency department visit	1998-2000 NHAMCS	1998 MEPS	452
	Ambulance service	1998-2000 NHAMCS	AAA	247 [a/]
	Hospital outpatient & free-standing ambulatory surgical center visit	1998-2000 NHAMCS	1998 MEPS	561
	Outpatient medication	1998-2000 NAMCS, 1998-2000 NHAMCS	1998 MEPS	47
	Home health visit	1998, 2000 NHHCS, 1998-2000 NHIS	1998 MEPS	89
	Hospice care day	1998, 2000 NHHCS	Hospice Association of America (6)	107
Indirect costs	Lost work day	1998-2000 NHIS	BLS	168 [b/]
	Restricted activity day	1998-2000 NHIS	BLS	67 [b/]
	Premature mortality (lost lifetime earnings)	Social Security Administration (7)	BLS	116,928 [b/]
	Permanent disability (lost annual earnings)	2002 Social Security Administration Data (8)	BLS	42,462 [c/]
Supplies	Insulin use (supplies include: glucose monitoring supplies, insulin delivery supplies, and insulin) and average annual cost of use	1998-2000 NHIS, 2002 The Source™ Prescription Audit (SPA), LifeClinic (9), LifeClinic (10), Fertig (11), Frost & Sullivan (12)	2002 Red Book (13), 2002 The Source™ Prescription Audit (SPA), Scott-Levin 2002 AllegroMedical (14) 2002 MiniMed (15)	1,778 [c/]
	Use of oral agents and average annual cost of use	1998-2000 NHIS, Luna (16), 2002 The Source™ Prescription Audit (SPA), CDC (17), NIDDKD (18)	2002 Red Book (13)	666 [c/]

[a/] American Ambulance Association estimate of the national average cost for a basic life support transport, adjusted to 2002 dollars.

[b/] Actual estimate varies by age group and sex.

[c/] Estimated annual cost per user.

The 1998 MEPS is the primary source for most estimates of the per-unit price of healthcare services. Price estimates are based on actual payment for services, not charges. Price estimates from other sources are used when such information is readily available for more recent years or when price estimates from the MEPS appear unreliable (e.g., because of small sample sizes in the MEPS). All price estimates for healthcare services are adjusted to 2002 dollars using the medical component of the consumer price index (CPI). The unit prices represent averages across all patients irrespective of diabetes status or reason for visit.[6] To the extent that the unit price is higher when diabetes is a comorbidity, or that inpatient days and outpatient visits tend to be more expensive for the medical complications associated with diabetes, the average unit cost might under-represent the true unit cost for services attributable to diabetes.

Estimates of the average annual cost of supplies for people using insulin and oral agents were calculated using cost data from The Source™ Prescription Audit (SPA)[7], the 2002 Red Book (13), and from pharmaceutical companies, and suppliers of devices used by people taking insulin. Based on prevalence rates computed using the combined 1998-2000 files of NHIS and estimates of the population in 2002, the estimated number of people using oral agents for diabetes and the estimated number of people using insulin are 7.5 million and 3.9 million, respectively. The percentage of people using insulin and oral agents varies substantially by age, reflecting the increasing proportion of cases involving type 2 diabetes among the population with diabetes in older age brackets. Not all people with diabetes use either insulin or oral agents, especially among the younger age brackets.

C. Productivity Foregone

People with diabetes are at greater risk of temporary incapacity (defined as lost work days and bed days), permanent disability, and premature mortality. The pecuniary value of lost productivity is calculated based on the average earnings of the person whose productivity is foregone. Bureau of Labor Statistics (BLS) estimates of year 2001 annual earnings by age and sex for the civilian, non-institutional population are used to estimate the average cost per day of missing work, the average cost per year of permanent disability, and the loss of expected lifetime earnings resulting from premature mortality (19, 20). Earnings estimates for 2001 are inflated to 2002 dollars using the overall CPI.

Lost Work Days and Bed Days

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[6] Neonatal inpatient stays were omitted from the calculation of average cost per day.

[7] Scott-Levin maintains The Source™ Prescription Audit (SPA), which tracks national sales of all prescription drugs dispensed by retail pharmacies.

The economic impact of temporary incapacity due to diabetes can be measured by both work days lost and number of bed days as both capture physical limitation due to diabetes that results in lost productivity. This data is obtained from the NHIS in which respondents report work days lost and bed days during the previous year due to illness. Lost work days are defined as days in which a person misses work at a job or business because of diabetes or diabetes-related-injury (excluding maternity leave). Bed days are defined as days in which a person is kept in bed more than half of the day because of diabetes or diabetes-related injury (including days while an overnight patient at a hospital). Lost work days are subtracted from bed days to prevent over-counting if a person has both a lost work day and a bed day.

An estimate of work days lost due to diabetes is found by comparing average days lost by diabetes status, for each age group and by sex. Controlling for age, men with diabetes have 3.1 more lost work days and 7.9 more bed days per year, on average, compared to men without diabetes. Women with diabetes had 0.6 more lost work days and 8.1 more bed days, on average, compared to women without diabetes. These estimates likely underestimate lost work days, however, to the extent that men and women with diabetes are less likely to be in the labor force compared to men and women without diabetes.

The pecuniary value of a work day is defined as average earnings for the person incurring the lost work day. Average earnings differ by age group and sex, but the average earnings for people with diabetes who are between the ages of 18 and 64 is estimated at $168 per day. Following the approach used by Yassin, Beckles and Messonnier (21), the cost per bed day is defined as 40% of the cost of a lost work day.

Disability

People with diabetes are at greater risk for amputations, loss of vision, and other physical problems that can limit their earning potential or preclude them from gainful employment. Ideally, estimating lost earnings would entail comparing the average earnings of all people with diabetes to the average earnings of people without diabetes, controlling for differences in demographic characteristics and other factors that affect earnings potential but that are unrelated to diabetes. A comparison of gross average earnings would capture both differences in labor force participation patterns, and the possibility that an individual with diabetes will be in a lower-paying job. Unfortunately, there are no recent data that provide reliable information with which to estimate average earnings by diabetes status while controlling for demographic and other factors affecting earnings potential.

Consequently, following the approach previously used by the ADA (2), data from the Social Security Administration are used to estimate the prevalence of total number of permanently disabled workers attributable to diabetes. The Social Security Disability Insurance (SSDI) program provides benefits to disabled workers, their spouses, or

children (whether or not they are disabled), retired workers and retired workers' dependent family members, and survivors of deceased workers. Individuals age 18 to 64 who receive SSDI benefits are included in the estimate of lost productivity attributed to diabetes-related disability.[8]

As of January 2002, there were an estimated 122,000 people age 18 to 64 receiving SSDI benefits where diabetes is listed as the primary basis of disability, and another 109,000 people age 18 to 64 receiving SSDI benefits where diabetes is listed as the secondary basis of disability. This study attributes to diabetes 100% of the cases where diabetes is the primary basis of disability, and 50% of the cases where diabetes is the secondary basis of disability. The number of cases where diabetes is a contributing factor to the disability, but where diabetes is not listed as the primary or secondary diagnosis, was unavailable. Also, the number of unemployed people with diabetes who are not receiving SSDI but who would be employed in the absence of diabetes is unknown. An estimated 176,475 person-years of permanent disability in 2002 are attributable to diabetes. Each case of permanent disability results in average lost earnings of $42,462 per year. The national cost estimate excludes the cost to family and friends caring for a person with permanent disabilities attributable to diabetes.

Mortality

Data from the 1998 Multiple Cause of Death File (22) were used to determine the total number of deaths attributable to diabetes. The file reports causes of death, along with economic, geographic and demographic information, for deaths of all U.S. citizens occurring within the U.S.

Mortality-related productivity costs are the estimated value of lost future earnings from paid market and unpaid household labor resulting from premature death due to diabetes or diabetes-related diseases.[9] Estimates of the present value of lifetime future earnings are based on human capital methodology, which assumes earnings reflect the contribution workers make to the value of goods and services and that the present value of expected future earnings is an estimate of the value of human capital (23). The

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[8] The Social Security Administration Office of Research, Evaluation and Statistics compiles information on the total number of people with disabilities by specified condition. Therefore, using information on number of disabled workers as a percentage of the total number of beneficiaries from Table 1 in the Annual Statistical Report on the Social Security Disability Insurance Program, 2000, we adjusted the SSA data to reflect number of disabled workers by specified condition.

[9] The estimated loss in annual earnings is based on estimates of the proportion of the population in the labor force, estimates of annual mean earnings from the BLS, and estimates of the mean value of housekeeping services. The estimated value of lost housekeeping services is estimated at 40% of annual earnings for individuals not in the labor force, and 20% of annual earnings for individuals in the labor force.

mortality-related productivity loss estimate incorporates both the number and timing of premature deaths attributable to diabetes.

Using 2001 earnings estimates from the Bureau of Labor Statistics, we updated the present value of future earnings (PVFE) estimates from Haddix et al. (24). The PVFE for 2002, including unpaid household work, was estimated assuming a 4% real discount rate. The average PFVE estimate for all diabetes-attributed mortality cases is $116,928, although the actual cost estimate differs by age and sex.

III.Results

A. Health Resource Utilization Attributable to Diabetes

From estimates of per capita healthcare utilization and the size of the population, by demographic group, this study estimates total healthcare utilization for each demographic group. Applying the etiological fractions for the corresponding demographic groups results in estimates of health resource utilization attributable to diabetes.

Table 3 shows estimated healthcare utilization by type of service aggregated into three broad age groups. The attributable healthcare utilization due to diabetes is greatest for the population age 65 and over, despite this population having slightly fewer people with diabetes compared to the population age 45 to 64. For instance, office-based physician encounters attributable to diabetes for people over age 65 is more than double the office-based physician encounters for people between 45 and 64 years. Utilization of emergency department, home health, and hospice care services is also substantially higher for the over age 65 population compared to the population age 45 to 64 and the population under age 45.

Table 3: Healthcare Utilization Attributable to Diabetes in the U.S., by Age and Type of Service, 2002 (in thousands)

Type of Service	<45 years	45-64 years	≥ 65 years	Total
Institutional Care				
Hospital inpatient days	2,183	5,802	8,927	16,912
Nursing home days	15,141	32,805	34,406	82,352
Outpatient Care				
Office-based physician encounters	11,555	16,718	34,365	62,638
Emergency department encounters	334	971	3,478	4,782
Hospital outpatient & free-standing ambulatory surgical center encounters	46	2,399	3,467	5,912
Home health visits	1,493	5,899	36,820	44,212
Hospice care days	48	430	4,616	5,094

Tables 4 through 6 provide information on healthcare utilization attributable to diabetes by medical condition and type of service. ***Table 4*** shows total utilization of services by type of medical condition attributable to diabetes, ***Table 5*** shows each medical

condition's proportion of total utilization attributable to diabetes, and ***Table 6*** shows the proportion of total U.S. utilization attributable to diabetes. Examination of these three tables reveals the following trends.

- Most of the healthcare utilization attributable to diabetes is for the treatment of general medical conditions, i.e., visits or inpatient days where the primary diagnosis is neither diabetes nor one of the seven chronic complications analyzed. For example, 63% of hospital inpatient days attributable to diabetes fall under the category of general medical conditions.

- Of the seven chronic complications analyzed, cardiovascular disease accounts for the largest proportion of healthcare utilization attributable to diabetes. For example, in 2002, an estimated 4 million hospital inpatient days are attributable to diabetes where the primary diagnosis is related to cardiovascular disease. This constitutes 24% of total hospital days attributable to diabetes and 19% of total U.S. inpatient days when the primary diagnosis is related to cardiovascular disease.

- Diabetes accounts for a sizable increase in the use of healthcare services. An estimated 18% of home health visits in the U.S. are attributable to diabetes. Approximately 15% of nursing home services and 14% of hospice care services in the U.S. are attributable to diabetes.

Table 4: U.S. Healthcare Utilization Attributable to Diabetes by Medical Condition (in thousands)

Service	Diabetes	Chronic Complications							General medical conditions	Total
		Neurological	Peripheral vascular	Cardio-vascular	Renal	Metabolic	Ophthalmic	Other		
Institutional Care										
Inpatient days	856	460	313	4,084	410	16	5	89	10,680	**16,912**
Nursing home days	25,296	7,948	941	12,628	2,600	107	9	161	32,663	**82,352**
Outpatient Care										
Physician office visits	9,930	652	336	13,064	980	1,171	1,502	175	34,826	**62,638**
Emergency visits	309	65	31	690	166	4	19	41	3,456	**4,782**
Hospital outpatient visits	1,357	47	49	1,367	111	93	109	16	2,763	**5,912**
Home health visits	16,924	1,077	1,000	6,973	803	33	77	103	17,221	**44,212**
Hospice care days	121	39	9	698	52	1	0	0	4,175	**5,094**

Table 5: Share of Total U.S. Healthcare Utilization Attributable to Diabetes by Medical Condition (%)

Service	Diabetes	Chronic Complications							General medical conditions	Total
		Neurological	Peripheral vascular	Cardio-vascular	Renal	Metabolic	Ophthalmic	Other		
Institutional Care										
Inpatient days	5	3	2	24	2	0	0	1	63	**100**
Nursing home days	31	10	1	15	3	0	0	0	40	**100**
Outpatient Care										
Physician office visits	16	1	1	21	2	2	2	0	56	**100**
Emergency visits	6	1	1	14	3	0	0	1	72	**100**
Hospital outpatient visits	23	1	1	23	2	2	2	0	47	**100**
Home health visits	38	2	2	16	2	0	0	0	39	**100**
Hospice care days	2	1	0	14	1	0	0	0	82	**100**

Table 6: Proportion of Total U.S. Healthcare Utilization Attributable to Diabetes for Various Conditions (%)

Service [a/]	Diabetes	Chronic Complications							General medical conditions	Total
		Neurological	Peripheral vascular	Cardio-vascular	Renal	Metabolic	Ophthalmic	Other		
Institutional Care										
Inpatient days	100	7	8	19	10	13	8	3	8	**9**
Nursing home days	100	15	12	19	20	13	0	4	9	**15**
Outpatient Care										
Physician office visits	100	8	6	20	8	14	6	2	5	**7**
Emergency visits	100	7	7	20	7	13	17	1	4	**4**
Hospital outpatient visits	100	9	8	22	8	14	12	1	4	**7**
Home health visits	100	7	9	19	12	7	9	3	11	**18**
Hospice care days	100	5	9	19	10	11	0	0	13	**14**

a/ Differences across service types in the proportion of total healthcare utilization attributable to diabetes occur because the etiological fraction for a particular medical condition differs by demographic group, and the demographic characteristics of patients receiving services differ by type of service.

B. Healthcare Expenditures Attributable to Diabetes

Healthcare expenditures attributable to diabetes are those costs incurred by the population with diabetes above what would be expected if this population did not have diabetes. Of the estimated $91.8 billion in healthcare expenditures attributable to diabetes, $48 billion (52%) is for services provided to people age 65 or older. An estimated $31.6 billion (34%) is for services provided to people age 45 to 64, while the remaining $12.6 billion (14%) is for services provided to people under age 45 (***Table 7*****).** Home and hospice care expenditures attributable to diabetes are incurred primarily by the population age 65 and older.

Table 7: Healthcare Expenditures Attributable to Diabetes in the U.S., by Age and Type of Service, 2002 (in millions of dollars)

Type of Service	<45 years	45-64 years	≥ 65 years	Total
Institutional Care				
Hospital inpatient days	5,207	13,838	21,293	40,337
Nursing home days	2,552	5,528	5,798	13,878
Outpatient Care				
Office-based physician encounters	1,851	2,678	5,505	10,033
Emergency department encounters	151	439	1,572	2,162
Hospital outpatient & free-standing ambulatory surgical center encounters	26	1,345	1,944	3,315
Home health visits	133	524	3,273	3,930
Hospice care days	5	46	492	543
Other Expenditures				
Ambulance services	28	40	77	146
Outpatient medication	756	1,991	2,769	5,516
Oral agents	533	2,318	2,157	5,009
Insulin and delivery supplies	1,355	2,891	2,745	6,991
Total	12,596	31,640	47,626	91,861

Table 8 shows estimates of attributable healthcare expenditures by medical condition and type of service. Expenditures for health care events with a primary diagnosis of uncomplicated diabetes and diabetes-related supplies are estimated to be $23.2 billion for 2002, which accounts for 25% of all healthcare attributable expenditures. At over $44 billion (or 48% of total attributable expenditures), general medical conditions

comprise the largest component of expenditures attributable to diabetes. Together, the seven chronic conditions associated with diabetes account for the remaining 27% of attributable expenditures, with cardiovascular disease being the single largest contributor.

Table 8: Healthcare Expenditures Attributable to Diabetes,

by Medical Condition and Type of Service, 2002 (in millions of dollars)

Medical Condition	Inpatient Days	Office Visits	Outpatient Visits	ED Visits	Nursing Home Days	Home Health Visits	Hospice Care Days	Other [a/]	Total
Diabetes [a/]	2,043	1,591	761	140	4,263	1,504	13	12,916	23,231
Neurological symptoms	1,096	104	26	29	1,339	96	4	52	2,748
Peripheral vascular disease	746	54	27	14	159	89	1	31	1,121
Cardiovascular disease	9,740	2,093	767	312	2,128	620	74	1,892	17,626
Renal complications	977	157	62	75	438	71	6	92	1,879
Endocrine / metabolic complications	38	188	52	2	18	3	0	126	426
Ophthalmic complications	11	241	61	9	2	7	0	92	422
Other complications	212	28	9	19	27	9	0	14	318
General medical conditions	25,473	5,578	1,549	1,562	5,504	1,531	445	2,447	44,091
Total	40,337	10,033	3,315	2,162	13,878	3,930	543	17,662	91,861

a/ Includes ambulance services, outpatient medications, oral agents, insulin and supplies

Total U.S. expenditures for healthcare services analyzed in this study are estimated at $865 billion (***Table 9***), which is 58% of total U.S. healthcare expenditures of approximately $1.5 trillion in 2002 (25).[10] Cost components not included in this analysis include such things as school-based and public health clinics, dental care, optometry

[10] CMMS estimated national healthcare expenditures of $1.3 trillion in the year 2000, which is adjusted to 2002 using CMMS's projection of 8% increase in annual cost of healthcare services in the U.S. resulting from rising medical costs and increased use of services.

care and vision products (with the exception of ophthalmology services which are included), research, over-the counter medicines, and other areas. [11]

This analysis focuses on those areas where healthcare utilization patterns have been shown to differ by diabetes status. Therefore, it is unknown what portion of the remaining 42% of U.S. healthcare costs can be attributed to diabetes. Components of the healthcare system not analyzed in this study, but where healthcare utilization patterns might differ by diabetes status include dentistry, optometry, and licensed dieticians. It is known, for example, that people with diabetes are at higher risk for periodontal disease than the general population, but this data is not incorporated here. Thus, it is likely that this estimate of healthcare costs attributable to diabetes underestimates the true amount.

Of the healthcare components analyzed, more than one in ten dollars spent in the U.S. on healthcare services is attributable to diabetes. Expenditures attributable to diabetes are greatest for hospital inpatient stays ($40.3 billion), followed by nursing home care ($13.9 billion), and visits to physicians' offices ($10 billion). The cost of oral agents to lower blood sugar, insulin, and insulin-related supplies totaled approximately $12 billion. Diabetes is responsible for a substantial proportion of total U.S. expenditures for certain healthcare services -- e.g., 18% of home health expenditures, 15% of nursing home expenditures, and 14% of hospice care expenditures.

The estimated cost to provide healthcare services to people with diabetes exceeds $160 billion in 2002 (for those components of the healthcare system included in this study). This includes costs attributable to diabetes as well as non-diabetes-related costs. Although people with diagnosed diabetes comprise only slightly more than 4% of the U.S. population, of the components of the healthcare system included in this study almost one of every five dollars spent on healthcare in the U.S. is for a person with diabetes.

Because the prevalence of type 2 diabetes increases with age, the population with diabetes tends to be older compared to the population without diabetes. Consequently, people with diabetes incur a substantial proportion of long-term care services. For example, more than one in four dollars spent for nursing home, home health, and hospice care is spent to provide services to someone with diabetes.

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[11] National expenditures for healthcare areas not analyzed in this study include the following. The Centers for Medicare and Medicaid Services estimates expenditures in 2000 to be $60 billion for dental care; $44 billion for government public health activities; and $44 billion for investment (i.e., research and construction). Martin, Whittle and Levit (31) estimate expenditures in 1998 to be $16 billon for vision products and other medical durables (e.g., hearing aides, medical equipment rentals, etc.) and $122 billion for over-the-counter medicine and sundries.

Table 9: Total Healthcare Expenditures by Diabetes Status: 2002

(in Millions of Dollars and % of U.S. Total)

Cost Component	Population with diabetes: Attributable to diabetes: Dollars	Population with diabetes: Attributable to diabetes: % of U.S. total	Population with diabetes: Incurred by people with diabetes: Dollars	Population with diabetes: Incurred by people with diabetes: % of U.S. total	Population without diabetes	U.S. Total
Hospital inpatient	$40,337	9%	$76,245	18%	$354,970	$431,216
Nursing home	13,878	15	25,860	28	67,915	93,775
Physician's office	10,033	7	18,433	13	118,484	136,917
Hospital outpatient	3,315	7	5,911	12	42,330	48,240
Emergency	2,162	4	4,424	9	44,952	49,375
Outpatient medication	5,516	9	9,636	15	55,074	64,710
Home health	3,930	18	6,230	28	15,873	22,103
Hospice care	543	14	1,020	26	2,960	3,981
Ambulance services	146	5	281	10	2,433	2,714
Insulin and delivery supplies	6,991	100	6,991	100	NA	6,991
Oral agents	5,009	100	5,009	100	NA	5,009
Total Healthcare Costs	**91,861**	**11**	**160,041**	**19**	**704,991**	**865,032**

Dividing healthcare expenditures by the size of the population with and without diabetes creates estimates of per capita expenditures (***Table 10***). On average, people with diabetes incurred approximately $13,243 in healthcare expenditures in 2002 across the healthcare components included in this study. People without diabetes incurred approximately $2,560 in expenditures, for a ratio of approximately 5 to 1. This comparison is slightly higher than ratios estimated by ADA (2) and Rubin et al. (26) who found a four-fold difference in average annual healthcare expenditures for people with diabetes compared to others. However, this ratio somewhat overstates the impact of diabetes on per capita costs because the demographic composition of the population with diabetes differs substantially from the demographic composition of the population without diabetes. The population with diabetes tends to be older, on average, than the population without diabetes.

We derived an age-adjusted annual per capita expenditure of $5,642 to control for differences in demographics of the population with diabetes compared to the non-diabetes population, we age-adjusted yielding a ratio of approximately 2.4 to 1 of healthcare expenditures among people with and without diabetes. This ratio prevails, roughly, across cost components, ranging from a high of 2.7 to 1 for home health services to a low of 2 to 1 for emergency services.

Table 10: Annual Per Capita Healthcare Expenditures by Diabetes Status: 2002

Cost Component	With diabetes	Unadjusted		Adjusted [a/]	
		Without diabetes	Ratio with to without diabetes	Without diabetes	Ratio with to without diabetes
Hospital inpatient	$6,309	$1,289	4.9	$2,971	2.1
Nursing home	2,140	247	8.7	991	2.2
Physician's office	1,525	430	3.5	695	2.2
Hospital outpatient	489	154	3.2	215	2.3
Emergency	366	163	2.2	187	2.0
Home health	516	58	8.9	190	2.7
Hospice	84	11	7.9	39	2.1
Ambulance services	23	9	2.6	11	2.1
Outpatient medication	797	202	3.9	341	2.3
Insulin & delivery supplies	579	NA	NA	NA	NA
Oral agents	414	NA	NA	NA	NA
Total Healthcare Costs	**13,243**	**2,560**	**5.2**	**5,642**	**2.4**

a/ Adjusted to reflect demographic composition of the population with diabetes.

C. Indirect Costs Attributable to Diabetes

At an annual cost of $7.5 billion, more than 176,000 cases of permanent disability in 2002 are attributable to diabetes (***Table 11***).[12] Disability cases where diabetes is the primary cause accounts for more than two-thirds of total cases attributed to diabetes. Cases where cardiovascular disease is listed as the primary cause of disability accounts for 7% of all cases attributed to diabetes.

[12] This cost estimate represents a sizeable decrease from the cost of disability in ADA (2), which used the present value of lost lifetime earnings to estimate the cost of disability. We use average annual lost earnings, estimated at $42,462 per case, to represent the productivity loss associated with the disability.

Table 11: Mortality Costs Attributable to Diabetes, 2002

Cause of Permanent Disability	Attributed Disability Cases	% of Total Attributed Cases	Value of Lost Productivity ($Billions)
Diabetes	121,893	69%	$5.2
Cardiovascular disease	12,110	7	0.5
Renal disease	3,887	2	0.2
Other diagnoses	38,584	22	1.6
Total	**176,475**	**100**	**7.5**

The estimated number of deaths attributable to diabetes is derived from instances where the primary cause of death is diabetes, renal disease, cerebrovascular disease, or cardiovascular disease. The etiological fractions used to estimate healthcare utilization attributable to diabetes are applied to the estimates of the number of deaths—by age, sex, race / ethnicity and primary cause of death—to estimate deaths attributable to diabetes. Estimated lost years of life are based on comparing timing of premature death to life expectancy (27).

In 2002, an estimated 186,000 deaths are attributable to diabetes (***Table 12***). An estimated 19% of all deaths for which cardiovascular disease is listed as the primary cause of death are attributed to diabetes, and this accounts for 108,000 (58%) of all deaths attributable to diabetes.

This finding is consistent with the major findings of a study by DeStefano and Newman (28), which finds that coronary heart disease is the leading cause of mortality among people with diabetes. DeStefano and Newman find that for younger people (i.e., men under age 45 and women under age 55), people with diabetes had a thirteenfold greater risk of coronary heat disease mortality compared to people without diabetes when controlling for other coronary heart disease risk factors. The Center for Disease Control reports that adults with diabetes have heart death rates that are 2 to 4 times higher than adults without diabetes (29). An estimated 2,000 deaths with renal disease as the primary cause are attributed to diabetes. Geiss et al. (30) find that age-adjusted renal mortality rates for people with diabetes are more than 2.5 times the rates for people without diabetes.

Table 12: Mortality Costs Attributable to Diabetes, 2002

Primary Cause of Death	Deaths Attributed to Diabetes (thousands)	% of Total U.S. Deaths	Total Lost Years (thousands)	Value of lost productivity (Millions of Dollars)
Diabetes	72	100%	1,080	$10,622
Renal Disease	2	6	31	273
Cerebrovascular Disease	4	12	54	305
Cardiovascular Disease	108	19	1,357	10,358
Grand Total	**186**	**NA** [a/]	**2,522**	**21,558**

a/ Grand Total comprises mortality for reasons other than diabetes, renal disease, cerebrovascular disease and cardiovascular disease.

D. National Cost of Diabetes

Combining estimates of healthcare expenditures and productivity losses attributable to diabetes yields an estimate of the national cost of diabetes (***Table 13***). In 2002, the estimated cost of diabetes is approximately $132 billion, of which approximately $92 billion (70%) is additional healthcare expenditures and $40 billion (30%) is lost productivity due to disability and early mortality. Institutional care (i.e., hospital inpatient care and nursing home care) is the largest component of healthcare costs and comprises 41% of the national cost of diabetes. Outpatient care, at $20 billion in 2002, comprises 15% of the national cost of diabetes. At $17.5 billion, the cost of outpatient medication and supplies comprises 13% of the national cost of diabetes.

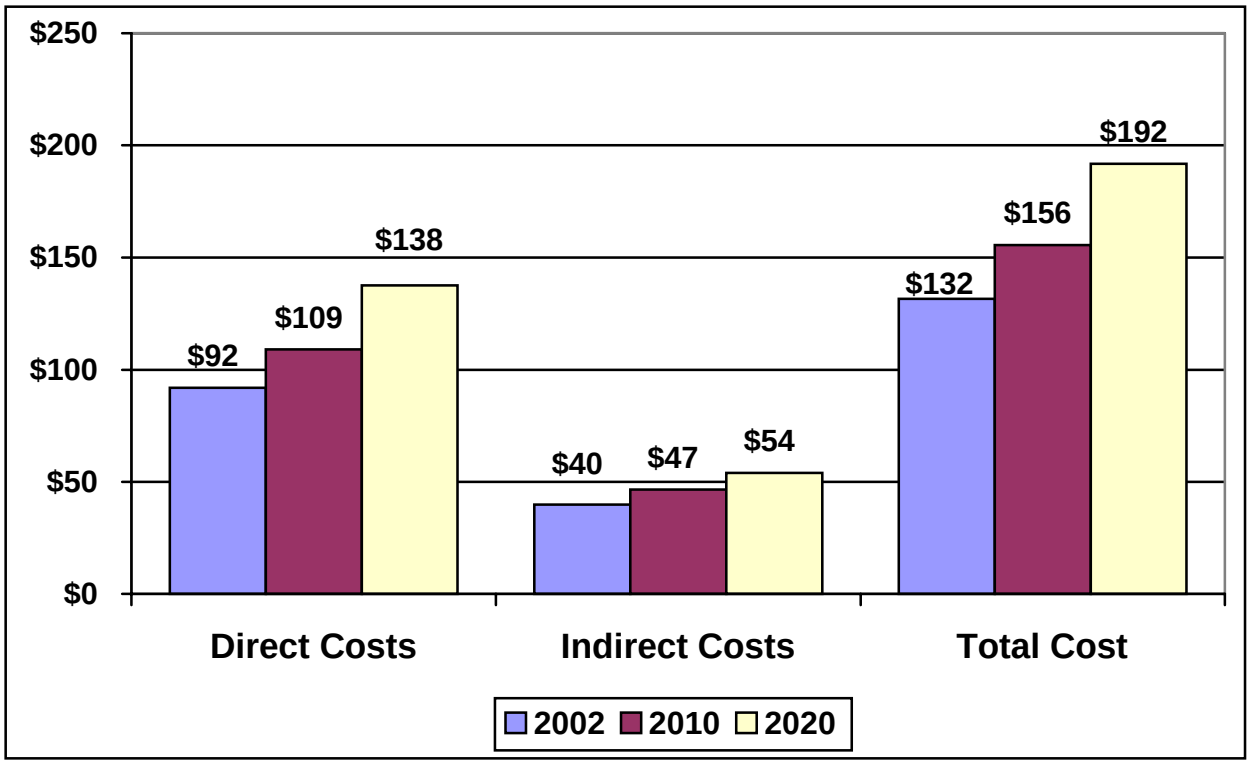
Table 13: Total Cost of Diabetes: 2002

Cost Component	Total Cost Attributable to Diabetes (in Millions of Dollars)	Components' Proportion of Total Cost (%) a/
Healthcare Expenditures	**$91,861**	**70%**
Institutional Care	**54,215**	**41**
Hospital inpatient care	40,337	31
Nursing home care	13,878	11
Outpatient Care	**20,130**	**15**
Physician office-based care	10,033	8
Emergency care	2,162	2
Ambulance services	146	0
Hospital outpatient care	3,315	3
Home healthcare	3,930	3
Hospice care	543	0
Outpatient Medication & Supplies	**17,516**	**13**
Outpatient medication	5,516	4
Insulin and delivery supplies	6,991	5
Oral agents	5,009	4
Indirect Costs Due to Lost Productivity	**39,810**	**30**
Lost work days	4,503	3
Restricted activity days	6,256	5
Mortality	21,558	16
Permanent Disability	7,494	6
Total Cost	**131,672**	**100**

a/ Cost component percentages do not necessarily sum to category totals due to rounding.

As the U.S. population grows in size, ages, and becomes more racially and ethnically diverse, the size of the population diagnosed with diabetes will grow, even if current patterns in diabetes prevalence remain unchanged. Using current diabetes prevalence rates applied to Census Bureau population projections, the national cost of diabetes could grow to $156 billion by 2010 (in 2002 dollars) and to $192 billion by 2020 (***Figure 4***). Direct medical costs could increase from $92 billion in 2002 to $138 billion in 2020, while indirect costs from lost productivity could increase from $40 billion in 2002 to $54 billion in 2020. The actual future cost of diabetes is likely to be substantially higher than these projected amounts if the prevalence of diabetes continues to grow—especially for type 2 diabetes, which is correlated with the growing problem of obesity in the U.S.—even after controlling for changing demographics.

Figure 4: Projected Impact of Changing Demographics on the National Cost of Diabetes: 2002 to 2020 (in 2002 dollars)



Note: Assumes no change in diabetes prevalence rates within a population defined by age, sex, race, and ethnicity.

IV. Conclusions

Healthcare spending in 2002 for people with diabetes is more than double what spending would be without diabetes. This costs the U.S. economy an estimated $92 billion in higher healthcare expenditures. Lost productivity attributed to diabetes resulting from lost work days, lost home services, permanent disability, and premature mortality is estimated at $40 billion. Compared to people without diabetes, people without diabetes and their families bear a disproportionate share of healthcare expenditures.

This cost estimate is conservative and very likely understates the true burden of diabetes, for the following reasons.

- This estimate omits the cost of intangibles such as pain and suffering, the cost of care provided by informal caregivers, and administrative costs of insurers.

- The cost components included in this analysis account for only 58% of the estimated $1.5 trillion in U.S. healthcare expenditures in 2002. For example, over-the-counter medications and sundries, which Martin, Whittle and Levit (31) estimate at $122 billion in 1998, are omitted from the cost estimate. While the areas of healthcare expenditures analyzed are those where healthcare utilization patterns have been shown to differ by diabetes status, there are several areas omitted from the analysis where people with diabetes probably use services at higher rates than people without diabetes—e.g., dental care, optometry care, and the use of licensed dieticians.

- The average price per health service used could differ by diabetes status. If health care used classified as "general medical conditions" (e.g., pneumonia) are more severe for people with than without diabetes, then the cost estimate would be too low. The study controls for differences in healthcare use attributable to diabetes—e.g., the number of hospital inpatient days—but does not control for differences in mix of healthcare professionals seen (e.g., if people with diabetes are more likely to see a specialist instead of a primary care physician).

- In this study, people with undiagnosed diabetes are categorized with the non-diabetic population. To the extent that such individuals have higher expected use of healthcare services compared to the non-diabetic population, then including the undiagnosed with the non-diabetic population results in underestimating the cost attributable to diabetes.

Future research might investigate the cost of diabetes in these areas omitted from the present analysis.

The estimated national cost of diabetes was calculated using prevalence-based cost-of-illness methods with data from 1998 through 2002. For some components of the cost estimate (e.g., the cost of supplies), multiple data sources were analyzed and the results compared to ensure robust results. One change from the approach used in ADA's 1998 study was to combine multiple years of national health use databases to increase sample size and allow for finer disaggregation of the U.S. population—both of which would improve the accuracy of the findings, because the prevalence of diabetes and the use of healthcare services varies substantially by age group, sex, and race/ethnicity. Greater disaggregation also allows for more accurate projections of the national cost of diabetes in future years as the U.S. population grows, ages, and becomes more racially and ethnically diverse. However, if lifestyle trends in the U.S. (such as the growing problem of obesity) increase diabetes prevalence rates, future costs could grow in excess of those extrapolated based on current prevalence rates.

Although this study includes the same cost components at ADA's 1998 study (2), the change in estimated diabetes-attributed costs between 1997 and 2002 for some cost components reflects a refinement in the cost estimates as opposed to an actual change in true costs. As discussed previously, the 1998 study estimated disability-related costs at $32.5 billion in 1997, compared to the current study, which estimates disability-related costs at $7.5 billion. Much of the decrease in attributed costs is the result of using foregone expected *annual* expenditures instead of foregone expected *lifetime* earnings to estimate the pecuniary cost of lost productivity, which may have been an inadvertent overstatement in the previous report. This large decrease in attributed costs is offset by substantially higher cost estimates for certain healthcare components such as nursing home care, home health care, and physician office-based care. One factor contributing to the large increase in attributed cost for nursing home care is the higher estimated cost per day in nursing homes ($169 per day used in this study versus $79 per day [$97 per day in 2002 dollars] used in the 1998 study). This study estimates a much higher cost of home health services, with an estimated 18% of total U.S. home healthcare services costs attributed to diabetes compared to an estimated 0.2% of the total U.S. cost of home health services attributed to diabetes in the 1998 study.[13]

Eliminating or reducing the health problems caused by diabetes through factors such as better access to preventive care, more widespread diagnosis, more intensive disease management, and the advent of new medical technologies could significantly improve the quality of life for people with diabetes and their families while at the same time potentially reducing national expenditures for healthcare services and increasing productivity in the U.S. economy.

[13] Martin, Whittle and Levit (31) estimate national expenditures of approximately $30 billion for home health care in 1997, compared to the estimate of $19 billion in ADA (2).

In conclusion, the cost of diabetes, both direct medical expenditures and the costs of foregone productivity, is estimated to be $132 billion in 2002. This represents a substantial cost burden to society and, in particular, to those individuals with diabetes and their families. Nevertheless, this estimate is conservative and probably underestimates the true cost of the disease.

Acknowledgments

Support for this study was provided by the American Diabetes Association, the National Institute of Diabetes and Digestive and Kidney Diseases, and the American Diabetes Association Industry Advisory Council.

V. Appendix

Chronic complications of diabetes	ICD-9 MEPS codes
Neurological symptoms	
Myasthetic syndromes in diseases classified elsewhere (amyotrophy)	358.1
Other specified idiopathic peripheral neuropathy	356.8
Mononeuritis of upper and lower limbs	354, 355
Arthropathy associated w/neurological disorders (Charcot's arthropathy)	713.5
Peripheral autonomic neuropathy	337.1
Polyneuropathy in diabetes	357.2
Neuralgia, neuritis, and radiculitis, unspecified	729.2
Diabetes with neurological complications	250.6
Occlusion of cerebral arteries	434
Hemorrhagic stroke	430-432
Late effects of cerebrovascular disease	438
Occlusion of stenosis of pre-cerebral arteries	433
Other and ill-defined cerebrovascular disease	437
Acute, but ill-defined, cerebrovascular disease	436
TIAs	435
Peripheral vascular disease	
Atherosclerosis	440
Embolism and thrombosis, structure of artery	444, 447.1
Other peripheral vascular disease	443
Other disorders of circulatory system	459
Phlebitis and thrombophlebitis, portal vein throbosis and thrombolism and venous thrombolism	451,452
Other venous embolism and thrombolism	453
Varicose veins of lower extremities	454
Gangrene and amputations	785.4, 885-887, 895-897
Chronic ulcer of skin	707
Cardiovascular disease	
Aotic and other aneurysms	441, 442
Hypotension	458
Angina	413
Conduction disorders and cardiac dysrhythmias	426-427
ASCVD	429.2
Cardiomegaly	429.3
Cardiomyopathy	425
Other acute and subacute forms of ischemic heart disease	411
Heart failure	428
Diabetes w/peripheral circulatory disorders	250.7
Myocardial degeneration	429.1
Myocardial infarction	410, 412
Other chronic ischemic heart disease	414
Hypertension	401-405
Renal Complications	

Infections of kidney	590
Other disorders of bladder	596
Cystitis	595
Renal sclerosis, unspecified	587
Glomerulonephritis, nephrotic syndrome, nephritis, and nephropathy	580-583
Proteinuria	791.0
Renal failure and its sequelae	584, 586, 588
Other disorders of kidney and ureter	593
Urinary tract infection	599.0
Diabetes and renal complications	250.4
Chronic renal failure (ESRD)	585
Endocrine/metabolic complications	
Dwarfism-obesity syndrome	259.4
Glycogenosis and galactosemia	271.0, 271.1
Disorders of iron metabolism	275.0
Hypercholesterolemia	272.0
Hyperchylomicronemia	272.3
Hyperkalemia	276.7
Hypertriglyceridemia	272.1
Macroglobulinemia	273.3
Lancereaux's disease	261
Lipidoses	272.7
Other specified endocrine disorders	259.8
Other and unspecified hyperlipidemia	272.4
Mixed hyperlipidemia	272.2
Renal glycosuria	271.4
Ophthalmic complications	
Other retinal disorders	362
Vascular disorders of the iris and ciliary body	364.0, 364.4
Disorders of the optic nerve and visual pathways	377
Diabetes with ophthalmic complications	250.5
Cataract	366
Glaucoma	365
Visual disturbance, low vision, blindness	368-369
Other complications	
Bacteremia, bacterial infection, Coxsackie virus	079.2, 790.7
Candidiasis of skin and nails	112.3
Chronic osteomyelitis of the foot	730.17
Other and unspecified noninfectious gastroenteritis and colitis	558.9
Impotence of organic origin	607.84
Infective otitis externa	380.1
Degenerative skin disorders	709.3
Candidiasis of vulva and vagina	112.1
Cellulitis	681, 682
Diabetes with other specified manifestations	250.8
Diabetes with unspecified complication	250.9
Other bone involvement in disease classified elsewhere	731.8

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