Economic Costs of Diabetes in the U.S. in 2002

AMERICAN DIABETES ASSOCIATION

OBJECTIVE — Diabetes is the fifth leading cause of death by disease in the U.S. 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 productivity-related costs attributable to diabetes and 2) to calculate and compare the total and per capita medical expenditures for people with and without diabetes.

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 health care setting. Health care use and total health care expenditures attributable to diabetes were estimated using etiological fractions, calculated based on national health care survey data. The value of lost productivity attributable to diabetes was also estimated based on estimates of lost workdays, restricted activity days, prevalence of permanent disability, and mortality attributable to diabetes.

RESULTS — Direct medical and indirect expenditures attributable to diabetes in 2002 were estimated at $132 billion. Direct medical expenditures alone totaled $91.8 billion and comprised $23.2 billion for diabetes care, $24.6 billion for chronic complications attributable to diabetes, and $44.1 billion 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 >65 years old. Attributable indirect expenditures resulting from lost workdays, restricted activity days, mortality, and permanent disability due to diabetes totaled $39.8 billion. U.S. health expenditures for the health care components included in the study totaled $865 billion, of which $160 billion was incurred by people with diabetes. Per capita medical expenditures totaled $13,243 for people with diabetes and $2,560 for people without diabetes. When adjusting for differences in age, sex, and race/ethnicity between the population with and without diabetes, people with diabetes had medical expenditures that were ~2.4 times higher than expenditures that would be incurred by the same group in the absence of diabetes.

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 nonpaid caregivers, and several areas of health care 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 dietitians). In addition, the cost estimate excludes undiagnosed cases of diabetes. Health care 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 health care services and increasing productivity in the U.S. economy.

Diabetes Care 26:917–932, 2003

● ●

D iabetes cost the U.S. an estimated $132 billion in 2002 in medical expenditures and lost productivity. Across the components of the health care system included in this study, per capita direct medical expenditures for the ~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 to be $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 ~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, or if the growing problem of obesity increases the prevalence 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 health care services. Comparison of national cost estimates across studies is complicated by differ-

ences 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 health care services. The previous American Diabetes Association (ADA) study on the cost of diabetes estimated the national cost of diabetes in 1997 to be $98 billion (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.

Unless specifically noted, this study uses prevalence-based cost-of-illness methods similar to the approach used by ADA (2,3). The 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.

RESEARCH DESIGN AND METHODS — The approach used to estimate the cost of diabetes follows, to the extent possible, the approach 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) health care use and total health care expenditures attributable to diabetes, and 3) the value of lost productivity attributable to diabetes.

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. This estimate of the magnitude of the diabetic population represents an increase of 1 million (9%) from year 2000 estimates and an increase of 1.8 million (17%) from year 1997 estimates. Based on results from the 2000 Census, it appears that during the period of 1990–2000, 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 the Census Bureau's pre-2000 projections of the U.S. population in 2000 by ~6.8 million individuals [or 2.4% of the total population]. One implication is that pre-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 (NHIS) were based on Census Bureau population estimates.) 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, the ADA estimates that as many as one-third of people with diabetes are unaware that they have the disease. 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 NHIS. Combining 3 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. (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 years. The four race/ethnicity categories are Hispanic, non-Hispanic white, non-Hispanic black, and non-Hispanic other.)

The NHIS collects data on ~43,000 households of more than 106,000 people annually. The combined files for 1998–2000 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.

As shown in Figs. 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 than for 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 higher 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.

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 ~14.5 million by 2010 and to 17.4 million by 2020 (Table 1). Whereas the U.S. population is projected to increase by ~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 demographic characteristics 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, whereas the number of non-Hispanic blacks and non-Hispanic whites diagnosed with diabetes is projected to increase by 50 and 27%, respectively.

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

Health resource use attributable to diabetes

In addition to receiving health care 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 with individuals without diabetes. A portion of health care use associated with these medical conditions is attributable to diabetes.

The general principle for estimating the cost of diabetes in this analysis is
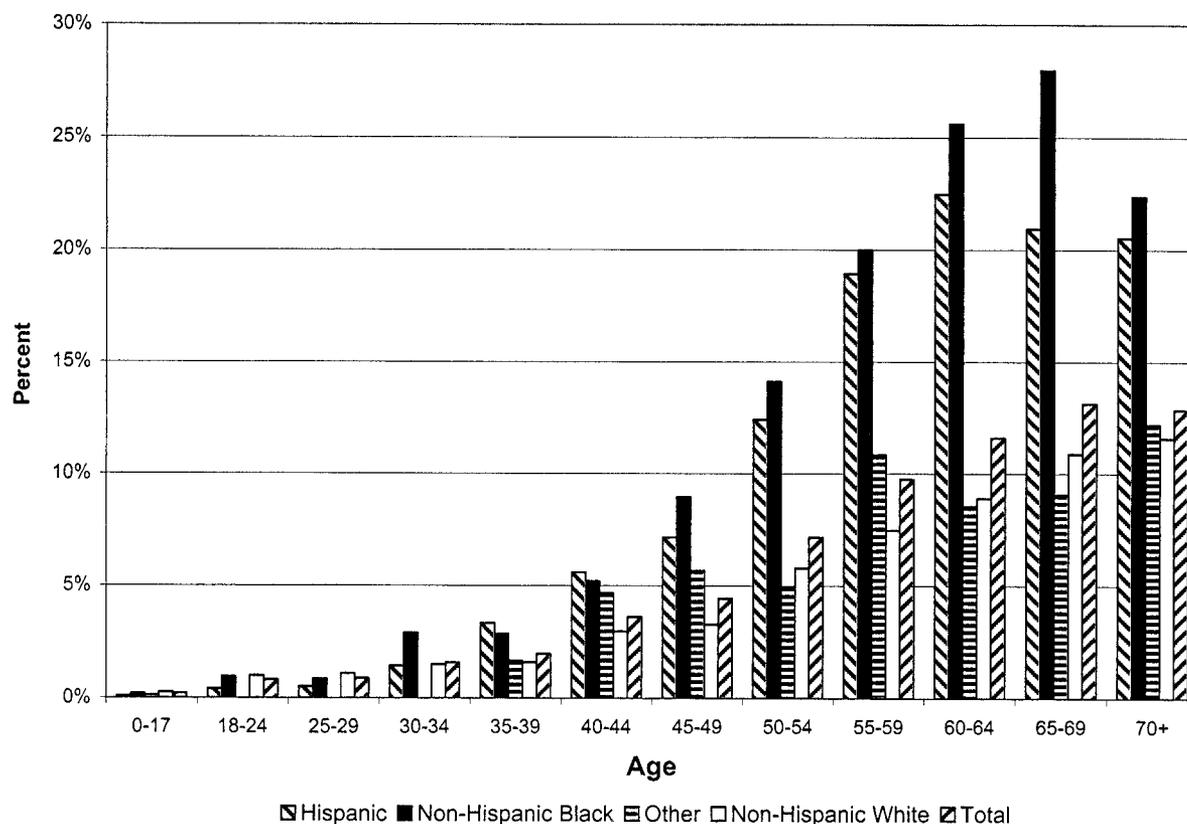
Figure 1—*Proportion of female population with confirmed diabetes in 2002.*

straightforward. Health care use attributable to diabetes is determined by a comparison of the health care use 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 health care 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*) absence of a single data source for all estimates, *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 representative of the U.S. population contains all of the information necessary to estimate the health care cost of diabetes, it is necessary to draw upon multiple data sources. Among some of these sources are differences in definitions for identi-

fying 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 health care use 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 health care use, and *3*) provides cost information. However, MEPS is limited by the small sample size.

- Small sample sizes for some items of interests. Disaggregating the U.S. population by age, sex, race, and ethnicity requires relatively large sample sizes to obtain reliable estimates of differences in use 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 is insufficient to obtain reliable estimates of health care use for some chronic complications associated with diabetes and in some health care settings. The use of alternative data sources, such as the National Ambulatory Medical Care Survey, increases sample size but is hindered by the third major limitation—underreporting of diabetes as a comorbidity.

- Underreporting of diabetes as a comorbidity. The literature reports that there is significant underreporting of diabetes as a comorbidity in health care databases. Unless the attending physician lists diabetes as a comorbidity on the patient's medical record, the health care 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, their representativeness is often questioned (in the case of GHPS) or they have insufficient sample size.
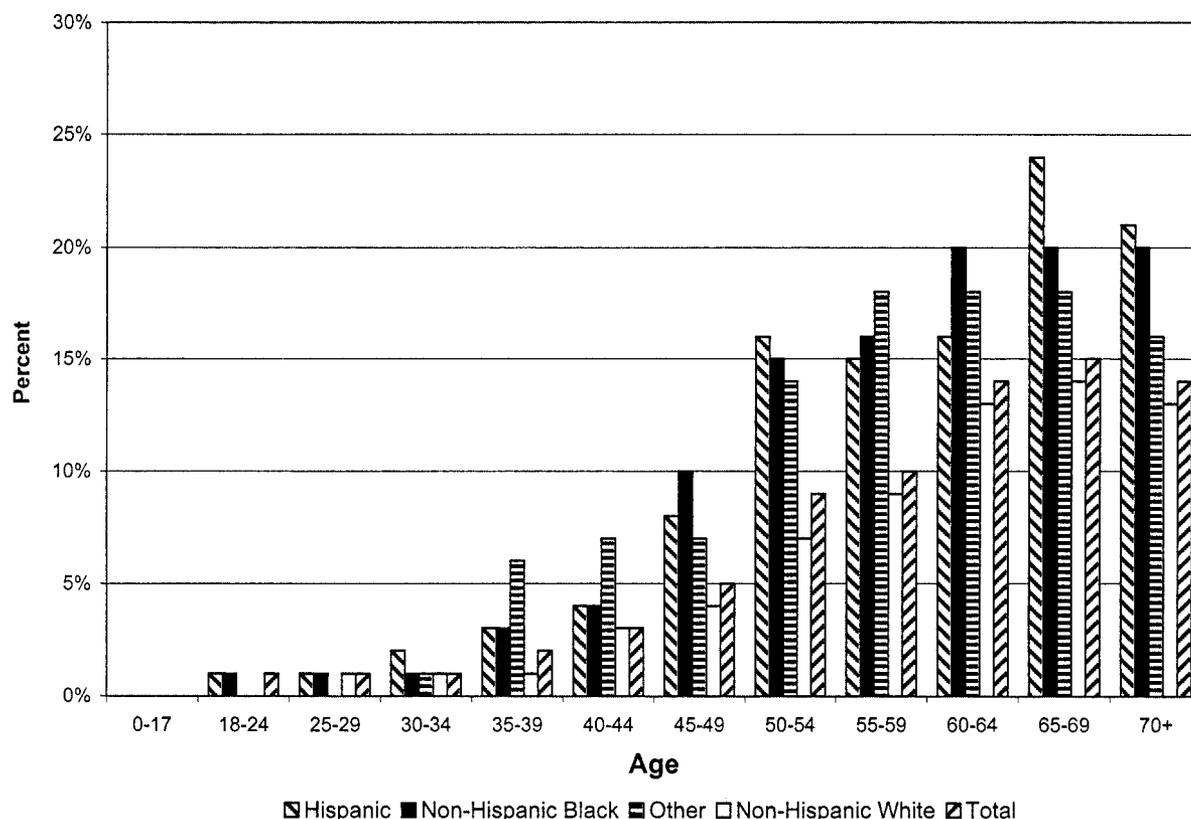
Figure 2—*Proportion of male population with confirmed diabetes in 2002.*

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 use of health care 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 health care services for a particular medical condition that is attributable to diabetes. The etiological fraction is calculated based on the following:

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

where E_i is the fraction of health care use 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 with people without diabetes.

Combining odds ratios estimated using the MEPS with diabetes prevalence rates estimated using the NHIS creates

Table 1—*Projections of the U.S. population diagnosed with diabetes (in millions)*

	2002	2010	2020	% Increase from 2002 to 2020
Total population	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				
M	5.8	7.1	8.6	48
F	6.3	7.4	8.8	40
Age (years)				
<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

Census Bureau (1) population projections adjusted using calibration factors that align Census Bureau projections for the year 2000 with actual Census 2000 counts.
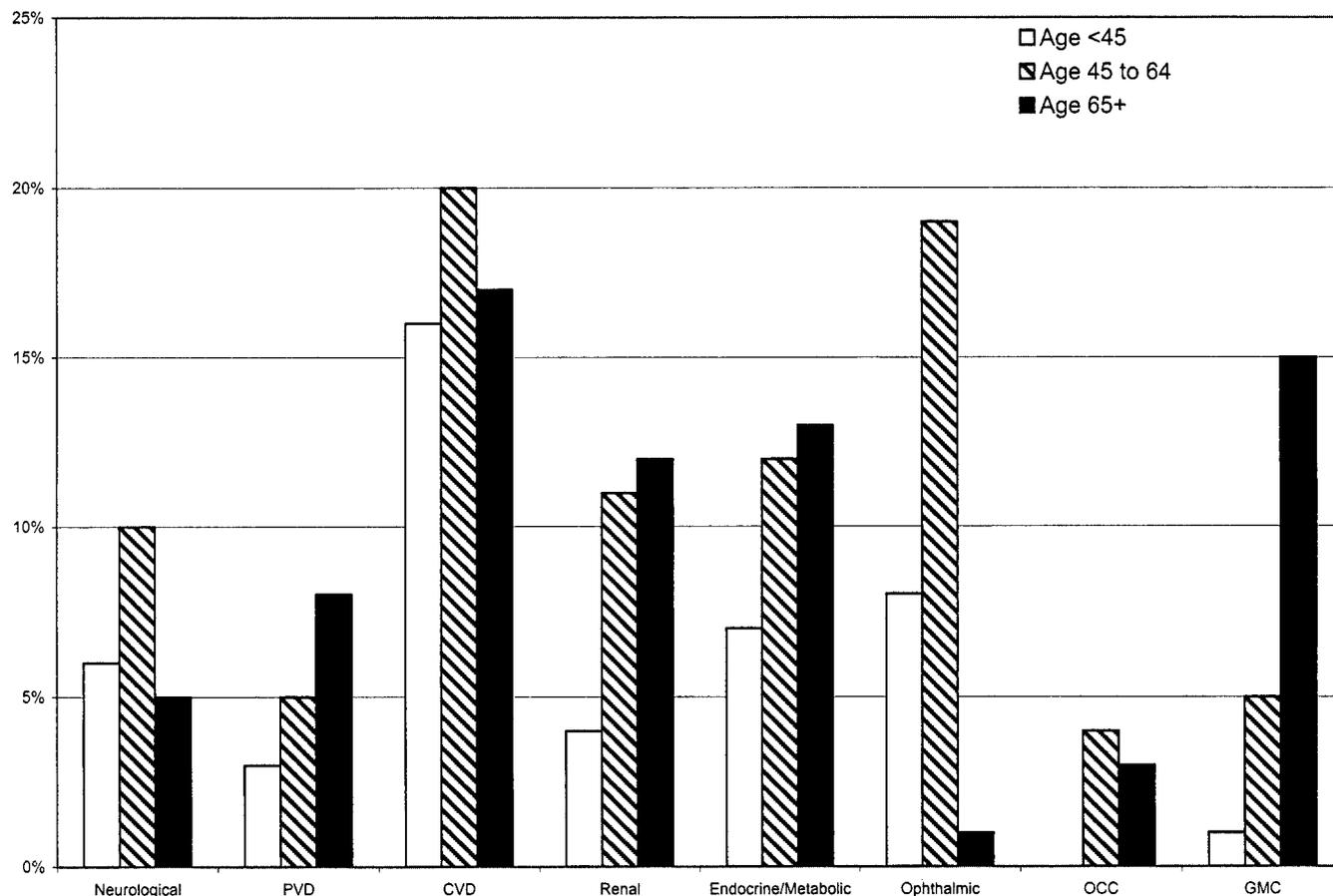
Figure 3—*Etiological fractions, adjusted for race/ethnicity, sex, and finer age-groupings. CVD, cardiovascular disease; GMC, general medical conditions; PVD, peripheral vascular disease; OCC, other chronic complications.*

separate etiological fractions for the medical conditions listed in Fig. 3 for each demographic group modeled. This figure combines etiological fractions across the 12 age-groups by race/ethnicity and sex to present etiological fractions for the population aged <45, 45–64, and ≥65 years. 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 populations aged <45, 45–64, and ≥65 years, the proportions of all health care use associated with neurological disease that is attributable to diabetes are 6, 10, and 5%, respectively. The medical condition with the highest etiological fractions is cardiovascular disease, where the proportions of all health care visits attributable to diabetes for individuals aged <45, 45–64, and ≥65 years 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 with 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 (4).

Table 2 summarizes the data sources used to analyze each component of the cost analysis and summarizes the unit cost estimates. Sources of health care use data include the 1998–2000 files of the National Ambulatory Medical Care Survey, the 1998–2000 files of the National Hospital Ambulatory Medical Care Survey, the 1999 National Inpatient Sample, the 1999 National Nursing Home Survey, and the 1998 and 2000 files of the National Home and Hospice Care Survey.

For each of these files, the primary diagnosis is used to classify the health care visit (or inpatient day) into one of nine medical condition classifications: 1) diabetes without complications, 2) one of 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 3) neither 1) nor 2), in which case the visit is classified as a "general medical condition." (See the APPENDIX for a list of diagnosis codes used to categorize visits and hospital inpatient days by medical condition.)

Health care use rates for each of the nine conditions in each health delivery setting are estimated by patient age, sex, and race/ethnicity. Combining these use rates with etiological fractions and estimates of population size for each demographic group produces national estimates of health care use attributable to diabetes for each medical condition.

The 1998 MEPS is the primary source for most estimates of the per-unit price of health care services. Price estimates are based on actual payment for services, not charges. Price estimates from other

Table 2—*Source of health resource use and price estimates*

Cost component	Source of use data	Source of price data	Unit price (2002 dollars)
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*
Hospital outpatient and 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 workday	1998–2000 NHIS	BLS	168†
Restricted activity day	1998–2000 NHIS	BLS	67†
Premature mortality (lost lifetime earnings)	Social Security Administration (7)	BLS	116,928†
Permanent disability (lost annual earnings)	2002 Social Security Administration Data (8)	BLS	42,462‡
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, LifeClinic (9, 10), Fertig et al. (11), Frost and Sullivan (12)	2002 *Red Book* (13), 2002 The Source Prescription Audit, Scott-Levin, 2002 AllegroMedical et al. (14), 2002 *MiniMed* (15)	1,778‡
Use of oral agents and average annual cost of use	1998–2000 NHIS, Luna and Feinglos (16), 2002 The Source Prescription Audit, CDC (17), NIDDK (18)	2002 *Red Book* (13)	666‡

*American Ambulance Association (AAA) estimate of the national average cost for a basic life support transport, adjusted to 2002 dollars; †actual estimate varies by age-group and sex; ‡estimated annual cost per user. CDC, Centers for Disease Control and Prevention; NAMCS, National Ambulatory Medical Care Survey; NHAMCS, National Hospital Ambulatory Medical Care Survey; NHHCS, National Home and Hospital Care Survey; NIS, National Inpatient Sample; NIDDK, National Institute of Diabetes and Digestive and Kidney Diseases; NNHS, National Nursing Home Survey.

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 health care services are adjusted to 2002 dollars using the medical component of the consumer price index. The unit prices represent averages across all patients irrespective of diabetes status or reason for visit (neonatal inpatient stays were omitted from the calculation of average cost per day). 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 underrepresent 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, the 2002 *Red Book* (13), 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 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.

Productivity foregone
People with diabetes are at greater risk of temporary incapacity (defined as lost workdays and bed days), permanent disability, and premature mortality. The pe-

cuniary 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 noninstitutional 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 consumer price index.

Lost workdays and bed days

The economic impact of temporary incapacity due to diabetes can be measured by both workdays lost and number of bed days, because both capture physical limitation due to diabetes that results in lost productivity. These data are obtained from the NHIS, in which respondents report workdays lost and bed days during the previous year due to illness. Lost workdays 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 workdays are subtracted from bed days to prevent overcounting if a person has both a lost workday and a bed day.

An estimate of workdays 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 workdays and 7.9 more bed days per year, on average, than men without diabetes. Women with diabetes had 0.6 more lost workdays and 8.1 more bed days, on average, than women without diabetes. However, these estimates likely underestimate lost workdays to the extent that men and women with diabetes are less likely to be in the labor force than men and women without diabetes.

The pecuniary value of a workday is defined as average earnings for the person incurring the lost workday. 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 et al. (21), the cost per bed day is defined as 40% of the cost of a lost workday.

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 earning 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 earning 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 and their spouses or children (whether or not they are disabled), retired workers and their dependent family members, and survivors of deceased workers. Individuals aged 18–64 years who receive SSDI benefits are included in the estimate of lost productivity attributed to diabetes-related disability. 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 the 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 Social Security Administration data to reflect the number of disabled workers by specified condition.

As of January 2002, there were an estimated 122,000 people aged 18–64 years receiving SSDI benefits where diabetes is listed as the primary basis of disability and another 109,000 people aged 18–64 years 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 an 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. 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 for individuals not in the labor force is 40% of average earnings for people of similar age and sex who are in the work force and 20% of annual earnings for individuals in the labor force. Estimates of the present value of lifetime future earnings are based on human capital methodology, which assumes that 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 mortality-related productivity loss estimate incorporates both the number and timing of premature deaths attributable to diabetes.

Table 3—*Health care use attributable to diabetes in the U.S., by age and type of service, 2002 (in thousands)*

	Age (years)			
Type of service	<45	45–64	≥65	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 and 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

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 PVFE estimate for all diabetes-attributed mortality cases is $116,928, although the actual cost estimate differs by age and sex.

RESULTS

Health resource use attributable to diabetes

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

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

Tables 4–6 provide information on health care use attributable to diabetes by medical condition and type of service. Table 4 shows total use of services by type of medical condition attributable to diabetes, Table 5 shows each medical condition's proportion of total use attributable to diabetes, and Table 6 shows the proportion of total U.S. use attributable to diabetes. Examination of these three tables reveals the following trends:

- Most of the health care use 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 health care use attributable to diabetes. For example, in 2002, an estimated 4 million hospital inpatient days were 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 was related to cardiovascular disease.
- Diabetes accounts for a sizable increase in the use of health care 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.

Health care expenditures attributable to diabetes

Health care expenditures attributable to diabetes are those costs incurred by the population with diabetes above what

Table 4—*U.S. health care use attributable to diabetes by medical condition (in thousands)*

		Chronic complications							General medical conditions	Total
Service	Diabetes	Neurological	Peripheral vascular	Cardiovascular	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. health care use attributable to diabetes by medical condition*

		Chronic complications							General medical conditions	Total
Service	Diabetes	Neurological	Peripheral vascular	Cardiovascular	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

Data are %.

would be expected if this population did not have diabetes. Of the estimated $91.8 billion in health care expenditures attributable to diabetes, $47.6 billion (52%) is for services provided to people ≥65 years of age. An estimated $31.6 billion (34%) is for services provided to people age 45–64 years, whereas the remaining $12.6 billion (14%) is for services provided to people under age 45 years (Table 7). Home and hospice care expenditures attributable to diabetes are incurred primarily by the population ≥65 years of age.

Table 8 shows estimates of attributable health care 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 health care 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.

Total U.S. expenditures for health care services analyzed in this study are estimated at $865 billion (Table 9), which is 58% of the total U.S. health care expenditures of approximately $1.5 trillion in 2002 (25). (Centers for Medicare and Medicaid Services [CMMS] estimated national health care expenditures of $1.3 trillion in the year 2000, which is adjusted to 2002 using CMMS's projection of an 8% increase in annual cost of health care services in the U.S. resulting from rising medical costs and an increased use of services.) Cost components not included in this analysis include such things as school-based and public health clinics, dental care, podiatric care, optometry care and vision products (with the exception of ophthalmology services, which are included), research, over-the-counter medicines, and other areas. CMMS 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 et al. (26) estimate expenditures in 1998 to be $16 billion 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.

This analysis focuses on those areas where health care use patterns have been shown to differ by diabetes status. Therefore, it is unknown what portion of the remaining 42% of U.S. health care costs can be attributed to diabetes. Compo-

Table 6—*Proportion of total U.S. health care use attributable to diabetes for various conditions*

		Chronic complications							General medical conditions	Total
Service*	Diabetes	Neurological	Peripheral vascular	Cardiovascular	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

Data are %. *Differences across service types in the proportion of total health care use 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.

Table 7—*Health care expenditures attributable to diabetes in the U.S., by age and type of service, 2002 (in millions of dollars)*

| Type of service | Age (years) | | | Total |
	<45	45–64	≥65	
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 and 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

nents of the health care system not analyzed in this study, but where health care use patterns might differ by diabetes status include dentistry, podiatry, optometry, and licensed dietitians. It is known, for example, that people with diabetes are at higher risk for periodontal disease than the general population, but these data are not incorporated here. Thus, it is likely that this estimate of health care costs attributable to diabetes underestimates the true amount.

Of the health care components analyzed, more than $1 in $10 spent on health care services in the U.S. 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 physician offices ($10 billion). The cost of oral agents to lower blood glucose, insulin, and insulin-related supplies totaled approximately $12 billion. Diabetes is responsible for a substantial proportion of total U.S. expenditures for certain health care services, e.g., 18% of home health expenditures, 15% of nursing home expenditures, and 14% of hospice care expenditures.

The estimated cost to provide health care services to people with diabetes exceeded $160 billion in 2002 (for those components of the health care 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 health care system included in this study, almost $1 of every $5 spent on health care 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 with the population without diabetes. Consequently, people with diabetes incur a substantial proportion of long-term care services. For example, more than $1 in $4 spent for nursing home, home health, and

Table 8—*Health care expenditures attributable to diabetes, by medical condition and type of service, 2002 (in millions of dollars)*

Medical condition	Inpatient days	Office visits	Outpatient visits	Emergency visits	Nursing home days	Home health visits	Hospice care days	Other	Total
Diabetes	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

Includes ambulance services, outpatient medications, oral agents, insulin, and supplies.

Table 9—*Total health care expenditures by diabetes status, 2002 (in millions of dollars and % of U.S. total)*

| | Population with diabetes | | | | | |
| | Attributable to diabetes | | Incurred by people with diabetes | | | |
Cost component	Millions of dollars	% of U.S. total	Millions of dollars	% of U.S. total	Population without diabetes	U.S. total
Hospital inpatient	40,337	9	76,245	18	354,970 (millions of dollars)	431,216 (millions of dollars)
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 health care costs	91,861	11	160,041	19	704,991	865,032

hospice care is spent to provide services to someone with diabetes.

Dividing health care 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 health care expenditures in 2002 across the health care components included in this study. People without diabetes incurred approximately $2,560 in expenditures, for a ratio of ~5 to 1. This comparison is slightly higher than ratios estimated by ADA (2) and Rubin et al. (27), who found a four-fold difference in average annual health care expenditures for people with diabetes compared with 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 demographic characteristics of the population with diabetes compared with the nondiabetic population, yielding a ratio of ~2.4-to-1 for health care 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.

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 10—*Annual per capita health care expenditures by diabetes status, 2002*

| | | Unadjusted | | Adjusted* | |
Cost component	With diabetes	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 health care costs	$13,243	$2,560	5.2	$5,642	2.4

*Adjusted to reflect demographic composition of the population with diabetes.

Table 11—*Morbidity costs attributable to diabetes, 2002*

Cause of permanent disability	Attributed disability cases	% of total attributed cases	Value of lost productivity (billions of dollars)
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

(Table 11). This cost estimate represents a sizeable decrease from the cost of disability in the 1998 report (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. Disability cases where diabetes is listed as 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.

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 health care use 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 (28).

In 2002, an estimated 186,000 deaths were 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 (29), 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 years and women under age 55 years), people with diabetes had a 13-fold greater risk of coronary heat disease mortality

than people without diabetes when controlling for other coronary heart disease risk factors. The Centers for Disease Control and Prevention reports that adults with diabetes have heart death rates that are two to four times higher than those of adults without diabetes (30). An estimated 2,000 deaths with renal disease as the primary cause are attributed to diabetes. Geiss et al. (31) found that age-adjusted renal mortality rates for people with diabetes are more than 2.5 times the rates for people without diabetes.

National cost of diabetes
Combining estimates of health care 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 was approximately $132 billion, of which approximately $92 billion (70%) was additional health care expenditures and $40 billion (30%) was lost productivity due to disability and early mortality. Institutional care (i.e., hospital inpatient care and nursing home care) was the largest component of health care costs and comprised 41% of the national cost of diabetes. Outpatient care, at $20 billion in

2002, comprised 15% of the national cost of diabetes. At $17.5 billion, the cost of outpatient medication and supplies comprised 13% of the national cost of diabetes.

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 (Fig. 4). Direct medical costs could increase from $92 billion in 2002 to $138 billion in 2020, whereas 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 demographic characteristics.

CONCLUSIONS — Health care 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 health care expenditures. Lost productivity attributed to diabetes resulting from lost workdays, lost home services, permanent disability, and premature mortality is estimated at $40 billion. Compared to people without diabetes, people with diabetes and their families bear a disproportionate share of health care expenditures.

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*	2,522	21,558

*Grand total comprises mortality for reasons other than diabetes, renal disease, cerebrovascular disease, and cardiovascular disease.

Table 13—*Total cost of diabetes, 2002*

Cost component	Total cost attributable to diabetes (millions of dollars)	Components' proportion of total cost (%)*
Health care 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 and 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

*Cost component percentages do not necessarily sum to category totals because of rounding.

This cost estimate is conservative and 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. health care expenditures in 2002. For example, over-the-counter medications and sundries, which Martin et al. (26) estimate at $122 billion in 1998, are omitted from the cost estimate. Whereas the areas of health care expenditures analyzed are those where health care use 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 dietitians.
- The average price per health service used could differ by diabetes status. If health care conditions classified as "general medical conditions" (e.g., pneumonia) are more severe for people

with diabetes than without diabetes, then the cost estimate would be too low. The study controls for differences in health care use attributable to diabetes, e.g., the number of hospital inpatient days, but does not control for differences in mix of health care 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 nondiabetic population. If per capita use of health care services is greater for people with undiagnosed diabetes than for people without diabetes, the health care costs attributable to diabetes will be underestimated.

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 were 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 health care 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.

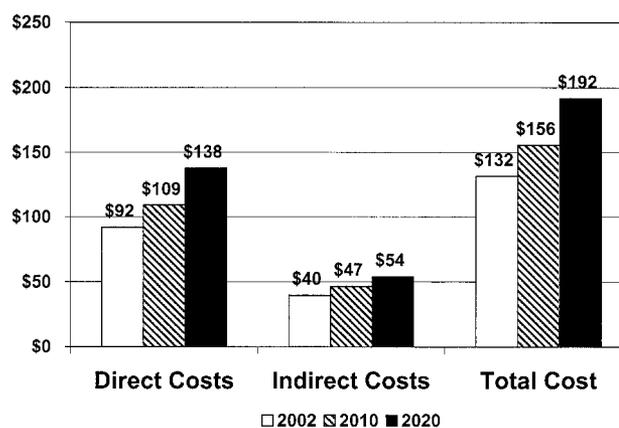Although this study includes the same cost components of ADA's 1998

Figure 4—*Projected impact of changing demographic characteristics on the national cost of diabetes: 2002–2020 (in 2002 billions of dollars).*

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 with 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 health care 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 vs. $79 per day [$97 per day in 2002 dollars] used in the 1998 study). This study estimates a much higher cost of home health care services, with an estimated 18% of total U.S. home health care services costs attributed to diabetes compared with an estimated 0.2% of the total U.S. cost of home health care services attributed to diabetes in the 1998 study. Martin et al. (26) estimated national expenditures of approximately $30 billion for home health care in 1997, compared with the estimate of $19 billion in the 1998 report (2).

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 health care services and increasing productivity in the U.S. economy.

In conclusion, the cost of diabetes, both direct medical expenditures and the costs of foregone productivity, is estimated to have been $132 billion in 2002. This represents a substantial cost burden to society and, in particular, to those in-

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
Transient ischemic attack	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 thrombosis, 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	
Aortic and other aneurysms	441, 442
Hypotension	458
Angina	413
Conduction disorders and cardiac dysrhythmias	426–427
Atherosclerotic cardiovascular disease	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, nephropathy	580–583
Proteinuria	791.0

Continued on following page

Appendix continued

Chronic complications of diabetes	ICD-9 MEPS codes
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 (end-stage renal disease)	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

ICD-9, *International Classification of Diseases, Ninth Revision.*

dividuals with diabetes and their families. Nevertheless, this estimate is conservative and probably underestimates the true cost of the disease.

References
1. U.S. Bureau of the Census: *Population Projections.* Available from http://www.census.gov/population/www/projections/popproj.html. Accessed October 2002
2. American Diabetes Association: Economic consequences of diabetes mellitus in the U.S. in 1997. *Diabetes Care* 21:296–309, 1998
3. American Diabetes Association: *Direct and Indirect Costs of Diabetes in the United States in 1992.* Alexandria, VA, American Diabetes Association, 1993
4. Karter AJ, Ferrara A, Liu JY, Moffet HH, Ackerson LM, Selby JV: Ethnic disparities in diabetic complications in an insured population. *JAMA* 287:2519–2527, 2002
5. Kiplinger. *Retirement Report.* Available from http://www.kiplinger.com/retreport/archives/2000/September/living2.htm. Accessed October 2002
6. Hospice Association of America: *Hospice Facts and Statistics.* Available from http://www.nahc.org/Consumer/hpcfacts.pdf. Accessed October 2002
7. Social Security Administration: *Annual Statistical Report on the Social Security Disability Insurance Program, 2000.* The Office of Policy, Social Security. Available from http://www.ssa.gov/statistics/di_asr/2000/index.html. Accessed October 2002
8. Social Security Administration: *Persons Receiving SSDI Benefits on the Basis of Disability, by Specified Disease, 2000.* Washington, DC, The Office of Policy, Social Security, 2000
9. LifeClinic: *Insulin Delivery.* Available from http://www.lifeclinic.com/focus/diabetes/supply_syringes.asp. Accessed October 2002
10. LifeClinic. *Insulin.* Available from http://www.lifeclinic.com/focus/diabetes/supply_insulin.asp. Accessed October 2002
11. Fertig BJ, Simmons DA, Martin DB: Therapy for diabetes. In *Diabetes in America.* 2nd ed. Harris MI, Cowie CC, Stern MP, Boyko EJ, Reiber GE, Bennett PH, Eds. Washington, DC, U.S. Govt. Printing Office, 1995 (NIH publ. no. 95-1468), p. 519–540
12. Frost & Sullivan: *U.S. Diabetes Delivery Systems Markets.* New York, Frost & Sullivan, 2001
13. *Red Book: Drug Topics.* Montvale, NJ, Medical Economics Company, 2002
14. AllegroMedical: *Needles & Syringes.* Available from http://www.allegromedical.com/Home/Subcategory.asp?C=520&S=3631. Accessed October 2002
15. MiniMed. *Test Strips.* Available from http://www.minimedstore.com/test-strips.html. Accessed October 2002
16. Luna B, Feinglos MN: Oral agents in the management of type 2 diabetes mellitus. *Am Fam Physician* 63:1747–1756, 2001
17. Centers for Disease Control and Prevention: *Diabetes Surveillance 1997.* Atlanta, GA, U.S. Department of Health and Human Services, 1997
18. National Institute of Diabetes and Digestive and Kidney Diseases: *Diabetes in America.* 2nd ed. Harris MI, Cowie CC, Stern MP, Boyko EJ, Reiber GE, Bennett PH, Eds. Washington, DC, U.S. Govt. Printing Office, 1995 (NIH publ. no. 95-1468)

19. U.S. Census Bureau: *Detailed Income Tabulations from the CPS: Earnings by Sex and Age, 2001*. Available from http://www.census.gov/hhes/income/dinctabs.html. Accessed October 2002
20. U.S. Bureau of Labor Statistics: *Household Data: Employment Status of the Civilian Noninstitutional Population by Age, Sex, and Race, 2001*. Available from ftp://ftp.bls.gov/pub/special.requests/lf/aat3.txt. Accessed October 2002
21. Yassin AS, Beckles GL, Messonnier ML: Disability and its economic impact among adults with diabetes. *J Occup Environ Med* 44:136–142, 2002
22. Centers for Disease Control and Prevention: *Public Use Data File Documentation: Multiple Cause of Death for ICD-9 1998 Data*. Atlanta, GA, U.S. Department of Health and Human Services, 2000
23. Becker G: *Human Capital*. New York, National Bureau of Economic Research, 1975
24. Haddix AC, Teutsch SM, Shaffer PA, Dunet DO: *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation*. New York, Oxford University Press, 1996
25. Centers for Medicare and Medicaid Services: *Chart Services, Chapter 1: U.S. Health Care System*. Available from http://cms.hhs.gov/charts/series/sec1.pdf. Accessed October 2002
26. Martin AB, Whittle LS, Levit KR: Trends in state health care expenditures and funding: 1980–1999. *Health Care Financ Rev* 22:111–140, 2001
27. Rubin RJ, Altman WM, Mendelson DN: Health care expenditures for people with diabetes mellitus, 1992. *J Clin Endocrinol Metab* 78:809A–809F, 1994
28. Centers for Disease Control and Prevention: *Life Expectancy Tables*. Available from http://www.cdc.gov/nchs/fastats/pdf/47_13t3.pdf. Accessed October 2002
29. DeStefano F, Newman J: Comparison of coronary heart disease mortality risk between black and white people with diabetes. *Ethn Dis* 3:145–151, 1993
30. Centers for Disease Control and Prevention: *National Diabetes Fact Sheet*. Available from http://www.cdc.gov/diabetes/pubs/estimates.htm. Accessed October 2002
31. Geiss LS, Herman WH, Teutsch SM: Diabetes and Renal Mortality in the United States. *Am J Public Health* 75:1325–1326, 1985