Change in Medical Spending Attributable to Diabetes: National Data From 1987 to 2011

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OBJECTIVE

Diabetes care has changed substantially in the past 2 decades. We examined the change in medical spending and use related to diabetes between 1987 and 2011.

RESEARCH DESIGN AND METHODS

Using the 1987 National Medical Expenditure Survey and the Medical Expenditure Panel Surveys in 2000–2001 and 2010–2011, we compared per person medical expenditures and uses among adults ≥18 years of age with or without diabetes at the three time points. Types of medical services included inpatient care, emergency room (ER) visits, outpatient visits, prescription drugs, and others. We also examined the changes in unit cost, defined by the expenditure per encounter for medical services.

RESULTS

The excess medical spending attributed to diabetes was $2,588 (95% CI, $2,265 to $3,104), $4,205 ($3,746 to $4,920), and $5,378 ($5,129 to $5,688) per person, respectively, in 1987, 2000–2001, and 2010–2011. Of the $2,790 increase, prescription medication accounted for 55%; inpatient visits accounted for 24%; outpatient visits accounted for 15%; and ER visits and other medical spending accounted for 6%. The growth in prescription medication spending was due to the increase in both the volume of use and unit cost, whereas the increase in outpatient expenditure was almost entirely driven by more visits. In contrast, the increase in inpatient and ER expenditures was caused by the rise of unit costs.

CONCLUSIONS

In the past 2 decades, managing diabetes has become more expensive, mostly due to the higher spending on drugs. Further studies are needed to assess the cost-effectiveness of increased spending on drugs.

In the past 2 decades, the number of Americans in whom diabetes has been diagnosed more than doubled (1). Along with the growth in the prevalence of diabetes, the complexity of diabetes care has also substantially increased (2). This is, in part, due to the translation into clinical practice of findings in landmark trials such as the UK Prospective Diabetes Study (3) and the Diabetes Control and Complications Trial (4). Those studies, conducted between the late 1980s and early 1990s, established the microvascular benefits of tight glycemic control and the macrovascular benefits of tight blood pressure and lipid control for adults with diabetes (4,5). After the publication of those studies, increasingly aggressive approaches were gradually adopted in diabetic management (6,7). Considerable development and diffusion of

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new pharmacological products and medical procedures followed. Patients now receive a more complicated management regimen to reduce the risk of macrovascular and microvascular complications.

Not surprisingly, these changes have led to significant ramifications for the pattern of medical use and spending and thus warrant an examination of the change in diabetes-related costs over time. Previous studies have documented a considerable increase in the use of oral medications (8) and the number of prescription medications used among diabetes patients in managed care and ambulatory care settings (9,10). However, any changes in the use of and spending on hospitalizations, outpatient visits, and other medical services related to diabetes care remain unclear. Few studies have comprehensively quantified the change in the use of all these medical components in the U.S. Moreover, no study has used national-level data to examine the trend of the financial burden of diabetes from the patients' or payers' perspectives.

In this study, we assembled data on inpatient, outpatient, and emergency room (ER) visits, as well as prescription medication use, reported in two national data sets, to examine how medical spending and use attributable to diabetes have changed between 1987 and 2011. These nationally representative data provide a comprehensive assessment of the cost impact related to the changes in diabetes care.

RESEARCH DESIGN AND METHODS

Data

We used data from the 1987 National Medical Expenditure Survey (NMES) and data from the 2000–2001 and 2010–2011 Medical Expenditure Panel Survey (MEPS). NMES, the predecessor of MEPS, was conducted among 22,538 individuals only in 1987. MEPS is a set of national surveys of families and individuals, their medical providers, and employers in the U.S. It samples data on an average of 39,000 individuals per year to estimate the use of medical resources in the U.S. population. We used the most recent 2-year data, from 2010 to 2011 along with prior 2-year data collected a decade earlier (2000–2001). Both the NMES and MEPS use the same method to collect information on health care use, expenditures, sources of payment, health status, the status of health insurance coverage, and demographic and socioeconomic characteristics of the civilian, noninstitutionalized population of the U.S. Because of the change in the charge-to-cost ratio over time, we adjusted medical expenditures reported in the NMES following the data providers' guide (11) to make it comparable to the MEPS. Medical use and expenditures were collected from both household respondents and their medical providers.

Measurements

We identified diabetes cases by respondents' self-reported physician's diagnosis. In the 2010–2011 MEPS, the question concerning diabetes diagnosis was asked only among persons $\geq$18 years of age. Therefore, we included diabetes patients $\geq$18 years of age in the study sample to ensure consistency over study periods. In both the NMES and MEPS, medical expenditures were reported as the total payment for health care services by all payers (including insurance, survey respondents, and other sources). Expenditures were measured in the following five categories: inpatient, outpatient, ER visits, prescription medications, and "other medical services." The other medical services include medical equipment such as testing supplies, dental care, home health care, vision aids, and other miscellaneous items or services. Total medical spending was calculated as the sum of the spending on the five components. All spending was adjusted for inflation and expressed in 2012 dollars.

Medical use was measured in the following five categories: the numbers of outpatient visits, including office visits and hospital-based outpatient visits; ER visits; hospital admissions; nights of hospital stay; and prescription medication purchases (i.e., the total number of encounters with medication purchases, including initial purchases and refills). Medical spending per encounter with each medical service (e.g., spending per encounter of outpatient visit) was calculated by dividing medical spending by the quantities of the medical service used (e.g., the number of outpatient visits over a year).

Statistical Analyses

We used a two-part model to estimate the medical spending attributable to diabetes. The model accounted for the large number of observations with no expenditures (i.e., zero costs) in the data. The two-part model included a logit model to estimate the probability of an individual having any positive medical spending, and the second part, for positive medical spending, was a generalized linear model with a log-link for annual medical spending. We performed a modified Park test (12) and determined that a γ-variance function was an appropriate variance specification for the generalized linear model. Medical uses were estimated using a zero-inflated negative binomial model. The model included a logit regression for predicting the probability of having zero use and a negative binomial count regression to fit the positive count data. We conducted a Vuong specification test and determined that a negative binomial distribution was a better fit than a Poisson distribution to model the count data (13). In all regression models, we included the following key explanatory variables: diabetes status, time period indicators, and their interaction terms. To account for the secular change in population demographics and socioeconomic position of people with or without diabetes, we also included the following covariates: age and age squared, and the interactions between diabetes diagnosis and age and between diabetes diagnosis and age squared, sex, race/ethnicity, BMI, residential regions, marital status, insurance coverage, educational attainment, and annual income. We also adjusted for other self-reported chronic medical conditions including high cholesterol, arthritis, current smoking, asthma, hypertension, and any current cancer. In this way, our analysis accounts for the secular change in the population-level patient characteristics; therefore, the estimated costs of diabetes are directly comparable across time periods. Because diabetes is a primary risk factor for cardiovascular diseases (CVDs), we did not include CVD to prevent potential underestimation of the effect of diabetes on medical spending (14,15). In a sensitivity analysis, we included CVD in the regression to obtain the lower-bound estimate of the spending attributable to diabetes.

The excess medical expenditures and uses attributed to diabetes were estimated by comparing the means of those

outcomes that were predicted based on the above regression models by diabetes status. It represents the increased medical spending or use for diabetes patients, compared with what would have been spent or occurred if those patients with diabetes did not have diabetes. The SEs were estimated using 1,000 iterations of bootstrapping. In examining the spending growth, we presented both absolute and relative changes, and we emphasized absolute changes because, first, it provides a better measurement of the contribution of each medical component to the increase in total spending, and, second, compared with relative changes, absolute changes are less sensitive to the estimation errors of baseline spending, especially when the values of the spending are small. All statistical analyses were conducted using Stata, version 13 (StataCorp, College Station, TX).

RESULTS

Table 1 shows the characteristics of adults with and without diabetes in the U.S. during 1987, 2000–2001, and 2010–2011. Diabetes patients were, on average, older; less likely to be a non-Hispanic white or a smoker; more likely to have hypertension, CVD, and stroke; and more likely to be covered by health insurance than persons without diabetes. Despite those differences, similar trends were observed in people with and without diabetes between 1987 and 2011, as follows: the mean age for both groups slightly increased; the proportion of minorities for both groups increased; the prevalence of current smokers for both groups decreased; and the prevalence of hypertension for both groups increased. However, diverging trends exist. Adults without diabetes experienced a significant increase in the prevalence of CVD, whereas, among adults with diabetes, the prevalence of CVD remained unchanged. Additionally, adults with diabetes bore a greater increase in their (unadjusted) annual medical spending.

Table 2 shows that, after adjusting for observed differences, the estimated excess medical spending attributed to diabetes increased from $2,588 (95% CI $2,265 to $3,104) per person in 1987 to $4,205 (95% CI $3,746 to $4,920, $P < 0.001$) per person in 2000–2001, and to $5,378 (95% CI $5,129 to $5,688, $P < 0.001$) per person in 2010–2011. The increase was observed across all components of medical spending, with the greatest absolute increase in the spending on prescription medications ($1,528 increase), followed by inpatient visits ($680 increase) and outpatient visits ($430 increase). The absolute change in the spending on ER and other medical services use was relatively small. In relative terms, the spending on ER visits grew more than five times, faster than that of prescription medication and other medical components. Among the total absolute increase ($2,790), prescription medication accounts for 55%; inpatient visits account for 24%; outpatient visits account for 15%; and spending on ER visits and other medical services account for 6%. Among the total annual diabetes-attributable medical spending, the spending on inpatient and outpatient visits dropped from 40% and 23% to 31% and 19%, respectively, between 1987 and 2011, whereas spending on prescription medication increased from 27% to 41%. Accounting for CVDs, the estimated annual medical spending attributable to diabetes decreased by 14–17%, depending on the study period.

Table 1—Characteristics and crude medical spending of U.S. adults ≥18 years of age with and without diagnosed diabetes between 1987 and 2011

	Year 1987		Year 2000–2001		Year 2010–2011	
	Without diabetes	With diabetes	Without diabetes	With diabetes	Without diabetes	With diabetes
Sample, *n*	20,958	1,502	38,222	2,875	43,747	4,787
Mean age, years	42.9	58.9*	44.3†	59.8*	45.2†	60.3*
Female, %	52.3	57.7*	52.1	51.4†	51.9	49.9
White, %	80.5	76.3*	73.6†	66.7*†	67.6†	62.6*‡
Black, %	9.9	15.3*	11.0	17.0*	11.0	16.1*
Hispanic, %	6.5	6.0	11.1†	12.5†§	14.5†	14.5
Other race/ethnicity, %	3.1	2.4	4.3‡	3.8	6.9†	6.8†
Current smoker, %	28.2	22.1*	21.2†	16.9*†	16.8†	14.5*‡
Hypertension, %	21.9	62.3*	20.0†	62.5*	28.2†	77.5*†
Had CVD, %	6.2	31.7*	9.2†	31.6*	11.9†	33.1*
Had stroke, %	1.6	10.7*	2.0†	9.4*	2.7†	12.1*‡
Covered by Medicare, %	15.3	46.4*	16.4‡	48.0*	17.3	46.1*
Covered by Medicaid, %	5.0	11.1*	7.5†	14.2*‡	10.3†	16.5*
Covered by private insurance, %	77.7	72.8*	74.5†	62.4*†	66.9†	55.2*†
Had no insurance, %	13.8	7.1*	13.0	6.8*	15.6†	8.8*†
Crude total spending, $ (in 2012 dollars)	2,447	7,229*	3,749†	11,226*†	4,754†	11,880*

The sources of data are the 1987 NMES, and the 2000–2001 and 2010–2011 data from the MEPS. Hypertension is defined as self-reported diagnosis and/or use of antihypertensive medications. CVDs are identified based on self-reports of coronary heart disease, angina or angina pectoris, acute heart attack or myocardial infarction, and other unspecified heart diseases. Stroke is identified based on self-reports of stroke and transient ischemic attack. *Significantly different when comparing people with diabetes with people without diabetes at $P < 0.01$ level. †Significantly different compared with previous time point at $P < 0.01$ level. ‡Significantly different compared with previous time point at $P < 0.05$ level. §Significantly different when comparing people with diabetes with people without diabetes at $P < 0.05$ level.

Table 2—Estimated medical spending attributable to diabetes, per year per person, 1987, 2000–2001, and 2010–2011

	Year 1987			Year 2000–2001			Year 2010–2011		
	Without diabetes	With diabetes	Difference	Without diabetes	With diabetes	Difference	Without diabetes	With diabetes	Difference
Total	4,418	7,006	2,588* (100)	6,463	10,668	4,205*† (100)	7,986	13,364	5,378*† (100)
Inpatient	1,549	2,586	1,037* (40)	2,123	3,602	1,479*† (35)	2,401	4,118	1,717* (32)
ER	34	53	19* (1)	104	161	57*‡ (1)	216	337	120*‡ (2)
Outpatient	1,403	1,987	583* (23)	2,010	2,858	848*† (20)	2,395	3,408	1,013* (19)
Prescription medications	594	1,285	690* (27)	1,437	3,007	1,570*† (37)	1,969	4,187	2,218*† (41)
Others	838	1,096	258* (10)	790	1,040	251* (6)	1,004	1,314	310*‡ (6)

Data are reported in 2012 dollars (% of each expenditure component among the total difference between persons with and without diabetes). The sources of data for the authors' analysis are the 1987 NMES, and the 2000–2001 and 2010–2011 data from the MEPS. The estimated medical expenditures were predicted values of spending per person per year based on regression analyses, in which the observed differences of demographics, socioeconomic status, and major health conditions were adjusted for. *Significantly greater than zero at $P < 0.01$ level. †Significantly different compared with previous time point at $P < 0.01$ level. ‡Significantly different compared with previous time point at $P < 0.05$ level.

Table 3 shows that the trend of medical use diverged by the type of medical service. The use of prescription medication, measured by the number of total encounters of medication purchases, continuously grew by 51% between 1987 and 2011, whereas the use of other medical services either declined or remained relatively unchanged. The number of inpatient and ER visits declined both in adults with and without diabetes; yet, diabetes patients had a greater decrease. As a result, the frequency of inpatient and ER visits attributable to diabetes declined by 29% and 19%, respectively. The length of hospital stays attributable to diabetes decreased by half. Outpatient visits attributable to diabetes remained unchanged after a slight increase between 1987 and 2001.

The unit costs rose universally in all five measures of medical care in adults with and without diabetes. For each hospital admission, diabetes patients spent significantly more than persons without diabetes. The gap increased from $1,028 to $1,605 per hospital admission between 1987 and 2001, and dropped slightly to $1,360 per hospital admission in 2011. Diabetes patients also had higher spending per ER visit and per purchase of prescription medications. However, the spending per night of hospital stay and per outpatient visit was not significantly different by diabetes status. In diabetes patients, the greatest absolute growth of unit cost was observed in inpatient visits, followed by ER visits,

Table 3—Medical service use and cost per unit of medical use attributable to diabetes, 1987–2011

	Year 1987			Year 2000–2001			Year 2010–2011		
	Without diabetes	With diabetes	Difference	Without diabetes	With diabetes	Difference	Without diabetes	With diabetes	Difference
Mean frequency, per person per year									
Outpatient visit	5.41	7.59	2.18*	7.95	11.11	3.16*†	7.08	10.04	2.96*
ER visit	0.28	0.40	0.12*	0.24	0.34	0.10*‡	0.22	0.31	0.10*‡
Hospital admission	0.21	0.36	0.16*	0.17	0.31	0.13*†	0.14	0.25	0.11*†
Nights of hospital stay	1.65	3.14	1.49*	1.01	1.95	0.94*†	0.74	1.45	0.71*†
Prescription medication purchase§	12.93	25.47	12.53*	18.18	34.66	16.48*†	19.35	37.93	18.58*†
Unit cost, $ per encounter									
Outpatient visit	231	233	NS	223	236	NS	275	275	NS
ER visit	125	102	NS	461	483	22‡	986	1,052	66‡
Hospital admission	6,743	7,772	1,029*	10,762	12,367	1,605*‡	13,285	14,645	1,360*‡
Nights of hospital stay	819	898	NS	1,755	1,908	NS	2,376	2,446	NS
Prescription medication purchase§	44	44	NS	71	83	12*‡	76	125	49*‡

The sources of data for the authors' analysis are the 1987 NMES, and the 2000–2001 and 2010–2011 data from the MEPS. NS, not significantly different than zero. *Significantly greater than zero at $P < 0.01$ level. †Significantly different compared with previous time point at $P < 0.01$ level. ‡Significantly different compared with previous time point at $P < 0.05$ level. §The number of prescription medication purchases was defined as the sum of the numbers of purchases of all individual medications, including initial purchases and refills. The unit cost of each prescription medication purchase was defined as the average spending per each encounter. The difference in unit cost by diabetes status measures the increased spending for diabetes patients at each prescription medication encounter.

prescription drugs, and outpatient services. In relative terms, ER visits experienced the most rapid growth (930%), followed by prescription medications (182%), hospital admissions (88%) and stays (172%), and outpatient visits (18%).

CONCLUSIONS

Diabetes care in the U.S. has changed substantially since the publication of landmark studies (2,16) 2 decades ago. Our study is one of the first studies to assess how those changes have affected patient-level medical uses and expenditures using nationally representative data. Our analyses reveal a doubling of the medical spending attributable to diabetes per person between 1987 and 2011. Over half of the spending increase was due to the growth in prescription medication spending, resulting from the increase in both use and price in prescription medications. The increase in outpatient expenditure was almost entirely driven by more outpatient visits. In contrast, the increase in inpatient and ER expenditures was caused by the rise in unit cost, as the number of hospital admissions, nights of hospital stay, and ER visits decreased modestly or remained unchanged.

Our results resemble the findings from previous studies with respect to the growing economic burden of diabetes in the U.S. (17–21), though discrepancies exist. A series of American Diabetes Association (ADA) studies from 1997 to 2012 suggested that the per capita medical cost attributable to diabetes changed from $11,759 (in 2012 dollars) in 1997 to $7,888 in 2012 (17–20). Because of the changes in the data used and the refinements in the analytical methods in those studies, it remains unclear whether the per capita medical spending was comparable over time. Because we applied the same analytical framework to national data sets that were collected using the same methods, our estimates account for many population-level changes over time and thus are directly comparable. Our estimated absolute values of the per capita medical spending also appear to be lower than the ADA estimates. This could be due to differences in estimation methods and data sources. The population etiological fractions method adopted by the ADA studies has been shown to produce somewhat higher estimates than those produced from the individual-based regression method used in the current study, probably due to the underestimation of the individual-level differences by diabetes status in the etiological fraction method (14). In addition, the ADA studies include national nursing home and home health care data, which are not included in the MEPS or NMES. The spending on those cases was shown to account for ~10% of the total medical spending attributable to diabetes (20).

Our results suggest that prescription medication spending has been the primary driver of the growth in per capita diabetes spending. A growing trend of increased spending on prescription medication has also been observed among people without diabetes and general populations in the U.S. and other developed countries (22). However, the increase in prescription medication spending related to diabetes care has well outpaced that of prescription medication spending in the general population (22). From 1999 to 2011, national data suggest that growth in the use and price of prescription medications in the general population is 2.6% and 3.6% per year, respectively; and the growth has decelerated in recent years (22). Our analysis suggests that the growth rates in the use and prices of prescription medications for diabetes patients are considerably higher. The higher rate of growth is likely, in part, due to the growing emphasis on achieving glycemic targets, the use of newer medications, and the use of multidrug treatment strategies in modern diabetes care practice (23,24). In addition, the growth of medication spending is fueled by the rising prices per drug, particularly the drugs that are newly introduced in the market. For example, the prices for newer drug classes such as glitazones, dipeptidyl peptidase-4 inhibitors, and incretins have been 8 to 10 times those of sulfonylureas and 5 to 7 times those of metformin (9).

The increase in excess medical spending on inpatient and ER visits had been entirely driven by the rise in the unit cost, rather than the volume, of medical use. Taking inpatient care as an example, despite the decline in the number of hospital admissions and length of stay among diabetes patients, the average excess inpatient spending due to diabetes increased by $632 (or 65%) between 1987 and 2011. This is merely because, during the same time interval, the unit cost per hospital admission and the unit cost per night of hospital stay for diabetes patients increased by 88% and 273%, respectively. However, it should be noted that after 2001 the increased unit cost attributable to diabetes appeared to slightly decrease, suggesting that the gap of hospitalization costs between diabetes and nondiabetes patients slightly decreased. The growing trend of inpatient costs is consistent with the findings of previous studies (25,26), which had linked the rapid growth in the price of hospitalization to the higher cost of medical devices and supplies. Because of the higher rates of hospitalizations and higher costs per hospitalization, the price growth may have a greater financial impact on diabetes patients and potentially cause them to miss episodes of needed care because of cost.

In absolute terms, the spending growth was ubiquitous in all medical components. However, the contributions of different components have substantially changed. The proportion of prescription medication spending among the total medical spending attributable to diabetes continuously increased, whereas that of inpatient and ER services declined. As a result, prescription medication has now exceeded inpatient services and accounts for the largest component of spending associated with diabetes. Previous studies (23) have suggested that more intensive use of medications improves the control of vascular disease risk factors and thus may reduce inpatient costs. While we did not observe a compensatory reduction in inpatient or ER spending associated with higher drug costs, a declining or plateauing trend for hospital admissions, inpatient stays, and ER visits was observed in this study. This appears to be consistent with the encouraging steady nationwide improvement in diabetes complications (27,28). In turn, it may signify the progress of complication prevention through more aggressive pharmacological treatments, advances in diabetes management care, health system performance, and health promotion efforts for the U.S. diabetes population (29,30).

However, it is also possible that the declining or plateauing trend in the use of inpatient service was driven by other

forces. Because this modest decline or plateau was accompanied by a considerable rise in the unit cost of hospitalization during the same period, the reduced use of services may also, in part, reflect circumstances in which diabetes patients forego needed episodes of inpatient or outpatient care because they cannot afford the costs. In addition, since similar trends have also been observed in adults without diabetes, the declining use might merely reflect a national trend that exists in the broad spectrum of medical care.

Our study has several notable limitations. It is possible that the changing health status of the population with diabetes affected our estimates. For example, changing diagnostic thresholds in 1997 and 2003 and enhanced detection during the past 2 decades could have led to the identification of a "diabetic" population that is characterized by lesser degrees of hyperglycemia and better general health. At the same time, this could have been counteracted by decreasing mortality rates, keeping people alive longer with more morbidity. Unfortunately, clinical biomarkers are not available in the data, which prevented us from further examining the effects of the changes. Second, as with other medical spending survey data, respondents in the MEPS and NMES tend to under-report ER and office visits (by 19–30%) (31). It may have led to an underestimation of the spending on the two medical services, and therefore of the total medical spending. However, it is unlikely that it would affect the trend since the underreporting has been found to be consistent across times and surveys (31). Third, the number of prescription medication encounters collected in the MEPS and NMES reflects the quantity of medication purchases, but does not measure the dosage of medication prescribed or the length of supply, which might provide a better description of medication use. Fourth, the medical costs of type 1 and type 2 diabetes are different; however, neither the MEPS nor the NMES allows us to distinguish the types of diabetes. Finally, both the MEPS and NMES surveys are limited to the civilian noninstitutionalized population, and thus the spending for institutional care, such as nursing home care, was not included.

Between 1987 and 2011, medical spending increased both in persons with and in persons without diabetes; and the increase was substantially greater among persons with diabetes. As a result, the medical spending associated with diabetes nearly doubled. The growth was primarily driven by the spending in prescription medications. Further studies are needed to assess the cost-effectiveness of increased spending on drugs. Despite the modest decline in the use of inpatient, ER, and other medical services, the excess medical spending on those services that is attributable to diabetes continued to grow due to a substantial increase in the price of those services.

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Author Contributions. X.Z. contributed to the study concept and design and helped to acquire, analyze, and interpret the data; perform the statistical analysis; write the first draft of the manuscript; and perform critical revision of the manuscript for important intellectual content. P.Z. contributed to the study concept and design and helped to analyze and interpret the data, write the first draft of the manuscript, perform critical revision of the manuscript for important intellectual content, and provide administrative, technical, and material support. H.S.K., B.H.B., and R.L. helped to analyze and interpret the data and to perform critical revision of the manuscript for important intellectual content. E.W.G. helped to analyze and interpret the data, critically revise the manuscript for important intellectual content, and provide administrative, technical, and material support. X.Z. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
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References

1. Centers for Disease Prevention and Control. Percentage of civilian, noninstitutionalized population with diagnosed diabetes, by age, United States, 1980–2010 [article online], 2011. Available from http://www.cdc.gov/diabetes/statistics/prev/national/figbyage.htm. Accessed 12 June 2013
2. Grant RW, Pirraglia PA, Meigs JB, Singer DE. Trends in complexity of diabetes care in the United States from 1991 to 2000. Arch Intern Med 2004;164:1134–1139
3. United Kingdom Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 1998;352:837–853
4. Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med 1993;329:977–986
5. United Kingdom Prospective Diabetes Study Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. BMJ 1998;317:703–713
6. Fowler M. Microvascular and macrovascular complications of diabetes. Clin Diabetes 2008; 26:77–82
7. American Diabetes Association. Standards of medical care in diabetes—2013. Diabetes Care 2013;36(Suppl. 1):S11–S66
8. Wysowski DK, Armstrong G, Governale L. Rapid increase in the use of oral antidiabetic drugs in the United States, 1990-2001. Diabetes Care 2003;26:1852–1855
9. Alexander GC, Sehgal NL, Moloney RM, Stafford RS. National trends in treatment of type 2 diabetes mellitus, 1994-2007. Arch Intern Med 2008;168:2088–2094
10. Turner LW, Nartey D, Stafford RS, Singh S, Alexander GC. Ambulatory treatment of type 2 diabetes in the U.S., 1997-2012. Diabetes Care 2014;37:985–992
11. Zuvekas SH, Cohen JW. A guide to comparing health care expenditures in the 1996 MEPS to the 1987 NMES. Inquiry 2002;39:76–86
12. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? J Health Econ 2001;20:461–494
13. Greene W. Accounting for excess zeros and sample selection in poisson and negative binomial regression modelsa: NYU Working Paper No. EC-94-10 [article online], 1994. Available from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1293115##. Accessed 1 June 2013
14. Honeycutt AA, Segel JE, Hoerger TJ, Finkelstein EA. Comparing cost-of-illness estimates from alternative approaches: an application to diabetes. Health Serv Res 2009;44:303–320
15. Lee DW, Meyer JW, Clouse J. Implications of controlling for comorbid conditions in cost-of-illness estimates: a case study of osteoarthritis from a managed care system perspective. Value Health 2001;4:329–334
16. Deeb CL. Diabetes technology during the past 30 years: a lot of changes and mostly for the better. Diabetes Spectrum 2008;21:78–83
17. American Diabetes Association. Economic consequences of diabetes mellitus in the U.S. in 1997. Diabetes Care 1998;21:296–309
18. Hogan P, Dall T, Nikolov P; American Diabetes Association. Economic costs of diabetes in the US in 2002. Diabetes Care 2003;26:917–932
19. American Diabetes Association. Economic costs of diabetes in the U.S. In 2007. Diabetes Care 2008;31:596–615
20. American Diabetes Association. Economic costs of diabetes in the U.S. in 2012. Diabetes Care 2013;36:1033–1046
21. Roehrig CS, Rousseau DM. The growth in cost per case explains far more of US health spending increases than rising disease prevalence. Health Aff (Millwood) 2011;30:1657–1663
22. Henry J. Kaiser Family Foundation. Prescription drug trends fact sheet—May 2010 update [Internet], 2010. Menlo Park, CA: Henry J. Kaiser Family Foundation. Available from http://kff.org/health-costs/fact-sheet/prescription-drug-trends-fact-sheet-may-2010/. Accessed 5 June 2013
23. Stephens JM, Botteman MF, Hay JW. Economic impact of antidiabetic medications and glycemic

control on managed care organizations: a review of the literature. J Manag Care Pharm 2006;12:130–142
24. Cohen FJ, Neslusan CA, Conklin JE, Song X. Recent antihyperglycemic prescribing trends for US privately insured patients with type 2 diabetes. Diabetes Care 2003;26:1847–1851
25. Lemieux J, Mulligan T. Trends in inpatient hospital prices, 2008 to 2010. Am J Manag Care 2013;19:e106–e113
26. Maeda JL, Raetzman SO, Friedman BS. What hospital inpatient services contributed the most to the 2001-2006 growth in the cost per case? Health Serv Res 2012;47:1814–1835
27. Gregg EW, Li Y, Wang J, et al. Changes in diabetes-related complications in the United States, 1990-2010. N Engl J Med 2014;370:1514–1523
28. Wang J, Geiss LS, Cheng YJ, et al. Long-term and recent progress in blood pressure levels among U.S. adults with diagnosed diabetes, 1988-2008. Diabetes Care 2011;34:1579–1581
29. Ali MK, Bullard KM, Saaddine JB, Cowie CC, Imperatore G, Gregg EW. Achievement of goals in U.S. diabetes care, 1999-2010. N Engl J Med 2013;368:1613–1624
30. Hoerger TJ, Segel JE, Gregg EW, Saaddine JB. Is glycemic control improving in U.S. adults? Diabetes Care 2008;31:81–86
31. Zuvekas SH, Olin GL. Validating household reports of health care use in the Medical Expenditure Panel Survey. Health Serv Res 2009;44:1679–1700