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Medical Costs Associated With Type 2 Diabetes Complications and Comorbidities

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Abstract

Objectives—To estimate the direct medical costs associated with type 2 diabetes, its complications, and its comorbidities among US managed care patients.

Study Design—Data were from patient surveys, chart reviews, and health insurance claims for 7109 people with type 2 diabetes from 8 health plans participating in the Translating Research Into Action for Diabetes (TRIAD) study between 1999 and 2002.

Methods—A generalized linear regression model was developed to estimate the association of patients' demographic characteristics, tobacco use status, treatments, related complications, and comorbidities with medical costs.

Results—The mean annualized direct medical cost was $2465 for a white man with type 2 diabetes who had been diagnosed fewer than 15 years earlier, was treated with oral medication or diet alone, and had no complications or comorbidities. We found annualized medical costs to be 10% to 50% higher for women and for patients whose diabetes had been diagnosed 15 or more years earlier, who used tobacco, who were being treated with insulin, or who had several other complications. Coronary heart disease, congestive heart failure, hemiplegia, and amputation were each associated with 70% to 150% higher costs. Costs were approximately 300% higher for end-stage renal disease treated with dialysis and approximately 500% higher for end-stage renal disease with kidney transplantation.

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Conclusions—Most medical costs incurred by patients with type 2 diabetes are related to complications and comorbidities. Our cost estimates can help when determining the most cost-effective interventions to prevent complications and comorbidities.

The worldwide prevalence of type 2 diabetes and the demand for and costs of medical care for treating it have increased over the past decade.[1–4] Simulation models have been developed to estimate the long-term health and economic consequences of diabetes and to help policy makers identify the most cost-effective interventions for preventing and controlling diabetes.[5] The cost data needed for diabetes cost-effectiveness models should be accurate and broadly applicable, come from large samples of patients with type 2 diabetes, and account for variations in costs due to differences in treatments, demographic characteristics, complications, and comorbidities among patients.

Many previous cost studies have estimated the economic cost of diabetes for a country or region as an aggregate, rather than based on individual-level variation.[3,4,6,7] Although others have used data from a single health plan, the resulting estimates might not be widely comparable to those from other settings.[8,9] Most studies that estimated the costs of type 2 diabetes at the individual level did not consider the variation of the costs among patients with different characteristics.[3,4,6] Other studies have used self-reported healthcare costs,[10,11] which might have been inaccurate due to incomplete recall or potential bias from the influence of social desirability. Still others have obtained components of diabetes costs from multiple data sources, each of which might have had its own biases, thus limiting the comparability of the estimates.[12]

The purpose of this study was to use a large and demographically and geographically diverse sample of adults with diabetes in the United States to provide cost data for diabetes simulation models. We described the relationship between direct medical costs and individual patient demographic characteristics, tobacco use status, diabetes treatments, complications, and comorbidities in persons with type 2 diabetes.

METHODS

Study Sample

We analyzed patient surveys, medical records, and administrative data for 7109 patients with type 2 diabetes who participated in the Translating Research Into Action for Diabetes (TRIAD) study between 1999 and 2002.[13] TRIAD was designed to assess how the organization and structure of managed care health plans influence the processes and outcomes of diabetes care. The study involved 10 health plans and 68 provider groups serving approximately 180,000 persons with diabetes across the United States. TRIAD participants—who had to be 18 years or older, community dwelling, English or Spanish speaking, continuously enrolled in the same health plan for at least 18 months, not pregnant, and with more than 1 claim for health services—were sampled from the 10 health plans. We classified patients as having type 2 diabetes if the onset was before 30 years of age without current insulin treatment or if the onset was after 30 years of age with or without current insulin treatment. A total of 11,927 people from the initial sample met these criteria.

Of the 8820 patients whose medical records were abstracted at baseline, 8364 had Charlson Comorbidity Index scores. (The Charlson Comorbidity Index predicts the 10-year mortality for a patient who may have a range of comorbid conditions.) Of the 10 participating health plans, 2 (1255 patients) were excluded due to unavailability of some elements of the health plan administrative data, leaving 7109 patients for our analyses.

TRIAD collected baseline and follow-up data from health plans, provider groups, and diabetes patients. For this analysis, we used patient survey data gathered from the third quarter of 2000 to the first quarter of 2002, and chart review data and administrative data for the 18 months prior to each respondent's survey date.

Data Sources

Direct medical costs from the 18 months prior to each patient's baseline survey were determined from health plan administrative data; costs included inpatient, outpatient, emergency department treatment, pharmacy, and other expenses such as outpatient radiology and laboratory tests. We attempted to minimize price variations due to different labor, nonlabor, and other costs for the same services provided in different health plans. Inpatient costs were calculated based on the patient's final diagnosis using the group weight rate from the Centers for Medicare & Medicaid Services (CMS) for fiscal year (FY) 2002 multiplied by the FY 2000 multiplier ($4328). Outpatient costs represented the estimated costs for procedures based on standardized reimbursement rates developed from the FY 2002 Medicare fee schedules by procedure code. Outpatient pharmaceutical costs were based on average wholesale prices per unit. We used the actual cost in dollars as described above without adjusting it to a single year's cost index because the way health plans reported the data did not allow us to do so. However, we adjusted for the survey interview year in the regression model to attenuate the inflation effect. We also reported the costs in 2010 dollars using the Consumer Price Index for medical services to reflect inflation in treating diabetes over the past decade. Patient copayments and other out-of-pocket costs were not considered in our analyses. Thus, our analyses represent direct medical costs from the perspective of a large health system.

Patient characteristics (eg, age, sex, race and ethnicity, education, income, tobacco use) were determined from patient surveys. Diabetes-related variables, including time since diagnosis of diabetes and methods of treatment, were also determined from patient surveys. Diabetic complications and comorbidities—including retinopathy, nephropathy, neuropathy, hypertension, dyslipidemia, cerebrovascular disease, cardiovascular disease, and peripheral vascular disease—were determined from both patient surveys and medical record reviews. A comorbid condition was considered present if the 18-month medical record or chart review showed that the patient had the condition or if, in the patient survey, the patient recounted being told that in the past 18 months he or she had had the condition. Additional comorbid conditions that are components of the Charlson Comorbidity Index were determined from medical record reviews.[14,15]

Statistical Analyses

We divided 18-month cost figures by 1.5 to standardize them as annual cost amounts. Cost distributions were right skewed; for regression analysis, to account for the skewed distribution we developed a generalized linear model (GLM) with log-link function to estimate the association between costs and patient demographic characteristics, tobacco use status, diabetes treatments, complications, and comorbidities. Health plan indicators and the year of the interview were also included in the calculations to control for health plan fixed effects and cost inflation, respectively. As the GLM with log-link function regression model required original cost data to be log-transformed, coefficients and 95% confidence intervals from the regression model needed to be back-transformed to the ordinal scale using an exponential function to get the cost estimates. We called these back-transformed coefficients cost multipliers in this study.

For this model, the base case was determined to be the 1-year direct medical costs for a white man diagnosed with diabetes for fewer than 15 years, treated with diet or oral agents, and with no complications or comorbidities. Because the costs for treating such a person differed among health plans and we did not know which health plan represented the “true” cost, it was not appropriate to use a cost estimate from any of the health plans as the base-case cost. We decided to use the mean of the estimated base-case costs among all of the health plans. To do this, we included all of the indicators for each health plan in the model and omitted the intercept to get the mean base-case cost in each of the 8 health plans, then computed the mean of the estimated mean costs in the health plans. That provided a modeled mean cost to use as the uniform direct medical cost for a base-case patient.

Because the model had a log-link function, it was a multiplicative model. To determine the relative increase in direct medical costs for a given patient with characteristics other than those of a base-case patient, we multiplied the direct medical costs for a base-case patient by the product of the cost multipliers calculated for each demographic characteristic, tobacco use status, diabetes treatment, complication, or comorbidity that applied to that patient.

All of the independent variables were coded as dichotomous or discrete variables. In the regression analysis, missing values for independent variables were imputed 5 times using a multiple imputation method.[16] We did not impute missing dependent variables. Because the purpose of our model was cost prediction, we used stepwise regression and only variables with regression coefficients significant at the $P \leq .05$ level were kept in the model. For the same group of covariates at different levels, we collapsed the groups that were not statistically significant into 1 level. When several independent variables were highly correlated with each other (correlation coefficient ≥.25), only 1 was included in the model. For example, income and education are highly correlated, so income was deleted from the model. We did not consider interaction effects for our analyses. We used SAS version 9.1.3 (SAS Institute, Cary, North Carolina) and STATA version 10.1 (StataCorp, College Station, Texas) to perform the analyses.

RESULTS

Table 1 shows the unadjusted means and standard deviations of the aggregate costs for treatments, complications, and comorbidities associated with the demographic characteristics of the 7109 patients in the study. Hispanic, non-Hispanic black, and Asian people made up almost half of the sample. More than half of the patients were 60 years or older. Women made up 54% of the sample. Unadjusted costs differed depending on patient demographic and socioeconomic characteristics.

Table 2 shows the unadjusted means and standard deviations of the aggregate costs for treatments, complications, and comorbidities associated with diabetes. One-third of the patients were treated with insulin. The most common comorbidities or complications were hypertension, dyslipidemia, retinopathy, neuropathy, and cardiovascular disease. Other comorbidities, assessed as components of the Charlson Comorbidity Index, were present in 4% to 13% of patients. Unadjusted costs differed depending on time since diagnosis of diabetes, treatment type, complications, and comorbidities. Unadjusted costs also varied substantially across health plans, ranging from $1900 to $2700.

Regression coefficients and cost multipliers associated with tobacco use status and each patient's demographic characteristics, diabetes treatment, complications, and comorbidities are shown in Table 3. Using the model, the mean annualized direct medical cost for a white man diagnosed with type 2 diabetes for fewer than 15 years, treated with oral antidiabetic medication or diet alone, and with no complications or comorbidities was calculated as $2465. Cost multipliers for other characteristics, treatments, complications, and comorbidities were calculated based on differences in costs associated with that characteristic compared with those of the base-case patient. Being Hispanic, non-Hispanic black, Asian, or of other race/ethnicity was associated with a 20% to 30% lower direct medical cost compared with being a non-Hispanic white. Being a woman, having diagnosed diabetes for 15 or more years, using tobacco, and having proliferative diabetic retinopathy, diabetic nephropathy, neuropathy, treated hypertension, dyslipidemia, transient ischemic attack, cerebral vascular accident, angina, or peripheral vascular disease were each associated with direct medical costs 10% to 50% higher than those of the base-case patient. Coronary heart disease, congestive heart failure, hemiplegia, and amputation were each associated with 70% to 150% higher direct medical costs. End-stage renal disease (ESRD) treated with dialysis or kidney transplantation was associated with approximately 300% and 500% higher costs, respectively.

For patients with more than 1 characteristic distinguishing them from the base case, total direct medical costs would likely be many times higher than those for the base-case patient. For example, for a woman who had type 2 diabetes for 15 or more years, with an amputation, hypertension, stroke, and congestive heart failure, direct medical costs would be $24,897, 10.1 times those for the base-case patient. This was calculated as $2465 (the base-case cost) × 10.1 (the product of the multipliers for being female [1.10], diabetes duration ≥15 years [1.20], amputation [2.38], hypertension [1.13], stroke [1.34], and congestive heart failure [2.13].

DISCUSSION

We estimated the association between patient demographic characteristics, tobacco use status, diabetes treatments, complications, and comorbidities and the direct medical costs of type 2 diabetes across 8 managed care organizations in the United States from 1999 to 2002. Costs varied among patients with different characteristics. Being female, having a longer time since diagnosis of diabetes, and having complications and comorbidities were associated with higher costs. The most costly complication was ESRD treated with dialysis or by kidney transplantation. Direct medical costs for patients with ESRD and dialysis or transplantation were approximately 3 to 5 times higher than those for patients with no or early-stage renal complications (microalbuminuria).

Relative to direct medical costs for whites, those for Hispanics, non-Hispanic blacks, and Asians were lower. Since the cost was standardized, the cost difference among race/ethnic groups reflected differences in utilization. However, for the current analysis, we were unable to determine whether these differences were due to different treatments received by different racial and ethnic groups or whether they reflected different needs for healthcare among racial and ethnic minority groups relative to non-Hispanic whites.[17]

Models used for assessing the cost-effectiveness of diabetes interventions often aim to simulate disease progression for a diverse diabetes population and specific diabetic subpopulations, and assign incremental costs to specific diabetes treatment regimens or to the development of diabetes-related complications and comorbidities. Currently available models often do not differentiate among the costs incurred by patients with different characteristics. Our study has several relative strengths in providing the cost data required for such computer simulation models. First, the information on costs came from administrative records, and data on the prevalence of comorbidities and complications were obtained from both patient surveys and chart reviews, thus potentially reducing both recall and social desirability biases compared with studies that used only surveys to gather information.[10,11] Second, cost data related to complications and comorbidities were collected for the same study participants, thus avoiding overlap or discrepancies that can be introduced when using cost components from different data sets. For example, in 1 prior study, different sources of information (eg, literature reviews, acute care discharge databases, government reports, fee schedules) were used to assess different costs, which could introduce inconsistencies to aggregate cost estimates.[12] Third, our study assessed variation in costs associated with different patient characteristics and treatments, which is an advance over prior research that aggregated costs across large patient groups with different complications and comorbidities[10] or did not assess direct medical costs specific to patients with different demographic characteristics or diabetes treatments.[9] Using data specific to so many variables (ie, demographics, tobacco use status, treatments, complications, comorbidities) allowed this study to identify differences in component medical costs better than studies in which these costs were aggregated. Therefore, we likely arrived at a more realistic overall direct medical cost for a diverse diabetic population. Finally, our data were more representative of the wide array of US health systems. They were from health plans across the United States and accounted for the high degree of regional variation in both

disease severity and practice patterns. This is an advance over past studies that used data from single health plans or from more homogeneous populations.[8,11,18]

Despite these strengths, our study is limited in that TRIAD participants were all enrolled in managed care organizations, so their healthcare utilization and costs might not represent those of uninsured patients or those enrolled in fee-for-service health plans. Second, our study sample might inadvertently have included some people with type 1 diabetes, although this number would likely be small. Third, we may have underestimated costs because we reported only direct medical costs to the health plan and did not include patient copayments, deductibles, out-of-pocket costs, direct nonmedical costs, or indirect costs. Fourth, our calculations did not consider the possibility that interactions between multiple complications and comorbidities might increase or decrease cost estimates compared with simply using the multipliers for each individual characteristic. To obtain an idea of the direction of the bias, we chose a subgroup with multiple comorbidities and found that the predicted cost was greater than the actual mean cost; however, the 95% confidence intervals of the 2 costs were wide. Thus, the bias is likely to be comparable to the error of measurement in magnitude. Fifth, we were not able to convert all the cost data into a single-year cost unit because the way in which health plans reported the data did not allow us to do so. In the regression model, we tried controlling for the year in which the patient was interviewed. This allowed us to average costs from different years and smooth some of the cost inflation in the later years. We found that the coefficients were not significantly different from zero, so we subsequently dropped the year indicators from the model. In addition, in constructing the cost variable, we had already considered to some extent the inflation factor: costs were constructed using healthcare utilization multiplied by the standard fee or payment schedule used by CMS in a single year. Sixth, the cost data were almost 10 years old. We addressed this issue by reporting adjusted cost to 2010 dollars using the Consumer Price Index on medical care in addition to the original cost. However, using multipliers instead of absolute differences in cost, our estimated multipliers were relatively independent of the year of data. Finally, due to the small numbers of patients in some complication and comorbidity subgroups and the multicollinearity of a number of the factors, cost estimates for some complications and comorbidities were not included in the model.

SUMMARY

We used rigorous modeling methods to estimate component costs specific to several demographic characteristics, tobacco use status, diabetes treatments, complications, and comorbidities for patients with type 2 diabetes in managed care organizations in the United States from 1999 to 2002. We found that the large proportion of overall direct medical costs for type 2 diabetes is attributable to diabetes complications and comorbidities, and especially to ESRD with dialysis or kidney transplantation treatment. Economic researchers can use these estimates in simulation models to assess the potential cost-effectiveness of interventions intended to prevent or delay type 2 diabetes and its complications.

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Take-Away Points

Because currently available simulation models often do not differentiate costs by patient characteristics, our study has several advantages over previous ones.

- Data on cost and patient characteristics were from both patient surveys and chart reviews.
- Variations in cost associated with different patient characteristics and treatments were assessed in a large and demographically and geographically diverse sample of adults with diabetes.
- Economic researchers can use these estimates in simulation models to assess the potential cost-effectiveness of interventions intended to prevent or delay type 2 diabetes and its complications.

Table 1

Unadjusted Median Annual Direct Medical Costs by Demographic Characteristics of the Study Population (N = 7109)[a]

Demographic Characteristics	Sample Size, n	Unadjusted Mean (SD) Annual Cost, Original $	Unadjusted Mean (SD) Annual Cost, 2010 $
Sex			
Male	3261	5034 (4711, 5358)	7168 (6708, 7630)
Female	3753	5089 (4782, 5395)	7247 (6810, 7682)
Race/ethnicity			
Non-Hispanic white	3108	5847 (5490, 6205)	8326 (7818, 8836)
Hispanic	616	4314 (3808, 4821)	6143 (5423, 6865)
Non-Hispanic black	1257	4935 (4369, 5502)	7027 (6221, 7835)
Asian	1244	3212 (2800, 3624)	4574 (3987, 5161)
Other	452	4989 (4162, 5816)	7104 (5927, 8282)
Age, y			
<35	91	3165 (1322, 5008)	4507 (1883, 7131)
35–44	529	3269 (2877, 3661)	4655 (4097, 5213)
45–54	1489	4444 (4019, 4869)	6328 (5723, 6933)
55–64	1849	4909 (4527, 5292)	6990 (6446, 7536)
>64	3056	5827 (5433, 6221)	8298 (7737, 8859)
Income, $			
<15,000	2055	5924 (5473, 6374)	8436 (7794, 9077)
15,000–39,999	1938	5327 (4857, 5797)	7586 (6916, 8255)
40,000–74,999	1417	4029 (3622, 4437)	5737 (5158, 6318)
>74,999	846	3720 (3299, 4140)	5297 (4698, 5895)
Education			
Less than high school	1788	5394 (4973, 5815)	7681 (7082, 8281)
Completed high school	1968	5341 (4906, 5775)	7606 (6986, 8224)
Some college	1950	4781 (4346, 5217)	6808 (6189, 7429)
Completed college	1196	4423 (3962, 4884)	6298 (5642, 6955)

SD indicates standard deviation.

[a]One-way analysis of variance was used to test whether the unadjusted median costs were the same at different levels within the same group. For the groups, the null hypothesis was rejected at the $P \leq .001$ level, except for sex ($P = .81$) and education ($P = .01$).The sample size may not add up to 7109 in some groups due to missing data.

Table 2

Unadjusted Median Annual Direct Medical Costs by Health-Related Characteristics of the Study Population (N = 7109)[a]

Characteristics	Sample Size, n	Unadjusted Mean (95% CI) Annual Cost, Original $	Unadjusted Mean (95% CI) Annual Cost, 2010 $
Time since diagnosis of diabetes, y			
<5	1929	3902 (3577–4228)	5556 (5094–6021)
5–9	1714	4198 (3852–4544)	5978 (5485–6471)
10–14	1234	4973 (4484–5462)	7082 (6385–7778)
≥15	1739	7217 (6602–7832)	10,277 (9401–11,153)
Diabetes treatments			
Diet only	496	5112 (4029–6195)	7279 (5737–8822)
Oral medications	4535	4139 (3918–4361)	5894 (5579–6210)
Insulin only	1064	7307 (6556–8085)	10,405 (9336–11,513)
Insulin and oral medications	919	7005 (6270–7740)	9975 (8928–11,022)
Retinopathy			
None	2169	4250 (3924–4576)	6052 (5588–6516)
Nonproliferative	938	6230 (5548–6911)	8872 (7900–9841)
Macular edema	119	5636 (4486–6786)	8026 (6388–9663)
Proliferative	174	9003 (7057–10,948)	12,820 (10,049–15,590)
Laser treated	129	7291 (4044–10,539)	10,382 (5759–15,008)
Nephropathy			
None	5784	4573 (4355–4792)	6512 (6202–6824)
Microalbuminuria	309	4446 (3568–5325)	6331 (5081–7583)
Clinical nephropathy	815	6826 (6139–7514)	9720 (8742–10,700)
ESRD but not on dialysis	47	10,332 (2497–18,167)	14,713 (3556–25,870)
ESRD with dialysis	51	28,874 (20,329–37,420)	41,117 (28,948–53,286)
ESRD with transplant	8	21,321 (2000–40,462)	30,361 (2848–57,618)
Neuropathy			
None	3338	3890 (3635–4144)	5539 (5176–5901)
Not painful	1679	5655 (5213–6096)	8053 (7423–8681)
Painful	1782	5771 (5321–6222)	8218 (7577–8860)
Amputation	162	16,010 (11,969–20,050)	22,798 (17,044–28,551)
Hypertension			
None	1514	4012 (3576–4447)	5713 (5092–6333)
Untreated hypertension	798	3979 (3356–4601)	5666 (4779–6552)
Treated hypertension	4521	5693 (5404–5982)	8107 (7695–8518)
Dyslipidemia			
None	4274	4523 (4237–4809)	6441 (6033–6848)
Present	2740	5908 (5556–6260)	8413 (7912–8914)
Smoking			
Nonsmoker	4588	4934 (4646–5222)	7026 (6616–7436)

Characteristics	Sample Size, n	Unadjusted Mean (95% CI) Annual Cost, Original $	Unadjusted Mean (95% CI) Annual Cost, 2010 $
Current smoker	2360	5359 (5008–5709)	7631 (7131–8130)
Cerebrovascular disease			
None	6387	4698 (4481–4914)	6690 (6381–6998)
Transient ischemic attack	120	7179 (5696–8662)	10,223 (8111–12,335)
Cerebral vascular accident	396	8929 (7393–10,645)	12,715 (10,528–15,158)
Hemiplegia	111	10,079 (7477–12,681)	14,352 (10,647–18,058)
Cardiovascular disease			
None	4701	3391 (3204–3578)	4829 (4562–5095)
Angina	82	5396 (3469–7324)	7684 (4940–10,429)
Coronary heart disease	1496	7569 (6933–8206)	10,778 (9873–11,685)
Congestive heart failure	735	10,630 (9613–11,649)	15,137 (13,689–16,588)
Peripheral vascular disease			
None	6027	4485 (4274–4695)	6387 (6086–6686)
Present	987	8600 (7707–9492)	12,246 (10,975–13,517)
Chronic obstructive pulmonary disease [b]			
None	6080	4699 (4472–4926)	6691 (6368–7015)
Present	934	7442 (6682–8202)	10,597 (9515–11,680)
Peptic ulcer disease [b]			
None	6682	4884 (4663–5106)	6955 (6640–7271)
Present	332	8679 (7243–10,115)	12,359 (10,314–14,404)
Liver disease [b]			
None	6761	5038 (4810–5266)	7174 (6849–7499)
Mild	205	5391 (4258–6524)	7677 (6063–9290)
Moderate or severe	48	7354 (5044–9664)	10,472 (7183–13,762)
Collagen vascular disease [b]			
None	6657	4962 (4735–5190)	7066 (6743–7391)
Present	357	6959 (5940–7978)	9910 (8459–11,361)
Cancer [b]			
None	6454	4735 (4524–4947)	6743 (6442–7045)
Present	560	8853 (7539–10,167)	12,607 (10,736–14,478)

CI indicates confidence interval; ESRD, end-stage renal disease.

[a] One-way analysis of variable was used to test whether the unadjusted median costs were the same at different levels within the same group. For the groups, the null hypothesis was rejected at the $P < .001$ level, except for smoking ($P = .08$) and liver disease ($P = .21$). The sample size may not add up to 7109 in some groups due to missing data.

[b] Listed on the Charlson Comorbidity Index of comorbid conditions.

Table 3

Original and Retransformed Regression Coefficients Associated With Demographic Characteristics, Treatments, Diabetes Complications, and Comorbidities

Variable	Original Regression Estimate	Exponential Multiplier[a]	95% Confidence Interval	
			Lower	Upper
Sex				
Female	0.09[b]	1.10	1.02	1.18
Race/ethnicity				
Non-Hispanic white (reference)				
Hispanic	−0.20[c]	0.82	0.73	0.92
Non-Hispanic black	−0.17[b]	0.84	0.75	0.95
Asian	−0.36[c]	0.70	0.60	0.80
Other	−0.20[b]	0.82	0.72	0.93
Time since diagnosis of diabetes				
<15 y (reference)				
≥15 y	0.18[c]	1.20	1.10	1.30
Treatment				
Not using insulin (reference)				
Using insulin	0.23[c]	1.26	1.17	1.36
Nephropathy				
None or microalbuminuria (reference)				
Nephropathy	0.11[d]	1.11	1.01	1.22
End-stage renal disease				
Without dialysis	0.29	1.33	0.78	2.27
With dialysis	1.36[c]	3.91	2.63	5.80
Transplant	1.83[c]	6.26	2.39	16.38
Neuropathy				
None (reference)				
Not painful	0.16[c]	1.18	1.08	1.28
Painful	0.18[c]	1.20	1.10	1.30
Amputation	0.87[c]	2.38	1.81	3.13
Hypertension				
None or untreated (reference)				
Treated	0.12[c]	1.13	1.05	1.22
Dyslipidemia				
None (reference)				
Yes	0.10[b]	1.11	1.04	1.19
Smoking				

Variable	Original Regression Estimate	Exponential Multiplier[a]	95% Confidence Interval	
			Lower	Upper
None (reference)				
Current	0.08[d]	1.08	1.01	1.16
Cerebrovascular disease				
None (reference)				
Transient ischemic attack	0.26[d]	1.30	1.06	1.60
Cerebral vascular accident	0.29[c]	1.34	1.16	1.54
Hemiplegia	0.64[c]	1.89	1.46	2.46
Cardiovascular disease				
None (reference)				
Angina	0.34[b]	1.41	1.12	1.78
Coronary heart disease	0.58[c]	1.79	1.63	1.96
Congestive heart failure	0.76[c]	2.13	1.91	2.37
Peripheral vascular disease				
None (reference)				
Yes	0.16[b]	1.17	1.05	1.30
Components of Charlson Comorbidity Index [e]				
Chronic obstructive pulmonary disease				
Yes	0.25[c]	1.28	1.17	1.40
Collagen vascular disease				
Yes	0.27[c]	1.31	1.15	1.49
Peptic ulcer disease				
Yes	0.31[c]	1.36	1.18	1.56
Cancer				
Yes	0.57[c]	1.77	1.52	2.06
Liver disease				
Mild	0.30[b]	1.35	1.12	1.62
Moderate or severe	0.52[b]	1.68	1.21	2.33
Mean base cost (original $) in health plans [f,g]		2159	1856	2514
Mean base cost (2010 $) in health plans [f,g]		3075	2643	3580

[a] exp (original regression coefficient).

[b] $P < .01$.

[c] $P \leq .001$.

[d] $P \leq .05$.

[e] he other components of the Charlson Comorbidity Index (except AIDS) are related to the comorbidities of diabetes; since those comorbidities are included in the model, they were omitted from the Charlson Comorbidity Index. As can be seen from Table 1, the estimates of the components of

the Charlson Comorbidity Index are based on few observations. Therefore, when available, the costs for these diseases should be obtained from disease-specific studies.

[f] $P \leq .001$ among the health plans.

[g] The base costs for treating a male white patient with diabetes who had diabetes for fewer than 15 years, was not on insulin, and had no comorbidities differed between health plans. Therefore, it was not possible to assign a single value to the base cost.