RESEARCH

# Total and Component Health Care Costs in a Non-Medicare HMO Population of Patients With and Without Type 2 Diabetes and With and Without Macrovascular Disease

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## ABSTRACT

BACKGROUND: Type 2 diabetes (T2DM) is one of the most prevalent and costly chronic conditions in the United States. Macrovascular disease (MVD) remains a common and costly comorbidity in T2DM. Understanding the impact of MVD on total health care costs in patients with T2DM is of great importance to managed care organizations (MCOs).

OBJECTIVE: To examine from the perspective of an MCO the impact of MVD on health care costs in patients with T2DM and in a matched comparison group of patients without diabetes.

METHODS: This study involved retrospective analysis of administrative claims (eligibility, pharmacy, and medical) using data from a commercial health maintenance organization population of approximately 700,000 members in an East Coast health plan. Patients were included in this study if they (a) had 2 or more claims for T2DM (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] codes 250.X0 or 250.X2), or (b) had a prescription drug claim for insulin and a diagnosis of T2DM, or (c) had at least 1 pharmacy claim for an oral glycemic-modifying agent during the 12-month period from January 1, 2003, through December 31, 2003. Patients with 2 or more medical claims for type 1 diabetes (ICD-9-CM codes 250.X1 or 250.X3) were excluded from the study. A random group of comparison patients without diabetes (ICD-9 code 250.xx) were matched on age group and sex. Study patients in these 2 groups were subdivided into 4 groups based on the presence of medical claims with diagnosis codes for MVD (acute myocardial infarction, other ischemic heart disease, coronary artery bypass surgery, percutaneous transluminal angioplasty, congestive heart failure, cerebrovascular accident, peripheral vascular disease, cerebrovascular disease, and peripheral vascular disease). Direct medical costs were aggregated for 12 months after the index date for patients in all 4 groups. Bootstrapping technique was used to compare the health care costs between patients with T2DM and those without diabetes, stratified by MVD status.

RESULTS: A total of 9,059 patients with T2DM were identified and were matched by age group and sex to a random group of patients without diabetes. MVD was present in 26.9% (n=2,441) of patients with T2DM versus 11.3% (n=1,027) of patients without diabetes. Patients with MVD and T2DM were, on average, a year younger than patients with MVD but without diabetes (54.55 vs. 55.55 years, $P$ <0.001). Patients with T2DM but without MVD were nearly the same age as patients with neither diabetes nor MVD (50.44 vs. 50.59 years, $P$=0.092). The T2DM patients with MVD had average 12-month costs more than 3 times the costs for patients with T2DM but without medical claims with diagnosis codes for MVD—$10,450 versus $3,385, respectively. Pharmacy costs accounted for 29.0% and inpatient hospital costs accounted for 43.9% of total medical costs in T2DM patients with MVD versus 55.0% and 17.3%, respectively, in T2DM patients without MVD. Patients with MVD diagnoses and T2DM had total average medical costs that were 1.7 times the total medical costs for MVD patients without T2DM—$10,450 versus $6,090, respectively.

CONCLUSIONS: The results of this analysis suggest that MVD may triple the total medical care costs in patients with T2DM. These economic consequences would appear to support the importance of interventions intended to prevent macrovascular events in patients with T2DM.

KEYWORDS: Macrovascular disease, Type 2 diabetes, Health care costs, Managed care, HMO

*J Manag Care Pharm.* 2006;12(7):546-54

Diabetes has been classified as a global epidemic. The World Health Organization estimated that more than 177 million individuals live with diabetes, and approximately 4 million deaths each year are related to complications from the disease.[1] Globally, the total number of people with diabetes is projected to rise from 171 million in 2000 to 366 million by 2030,[2] largely due to the prevalence of type 2 diabetes (T2DM), which accounts for 95% of all diabetic cases. In the United States, there were approximately 12.1 million cases in 2002,[3] and forecasters predict that this number will increase to approximately 14.5 million by 2010 and 17.4 million by 2020.[4] Over the past decade, the age at diagnosis of T2DM has decreased by an average of 6 years, from 52 to 46 years.[5]

The American Diabetes Association (ADA) estimated the direct costs of diabetes to be $91.8 billion in 2002; associated health care costs and demands of diabetes are increasing along with its prevalence.[6-9] T2DM is associated with many microvascular and macrovascular complications. Macrovascular disease (MVD) includes coronary disease, cerebrovascular disease, and peripheral vascular disease. Cardiovascular disease (CVD) is the major cause of morbidity and mortality in subjects with T2DM,[10,11] accounting for approximately 65% of deaths in patients with T2DM in 1999.[3] Several studies have shown that CVD is a major driver of costs in patients with diabetes.[6,12-20] The excess costs of T2DM could start as early as 8 years before diagnosis, and CVD is responsible for a significant portion of the prediagnostic costs.[21] When CVD is present in patients with

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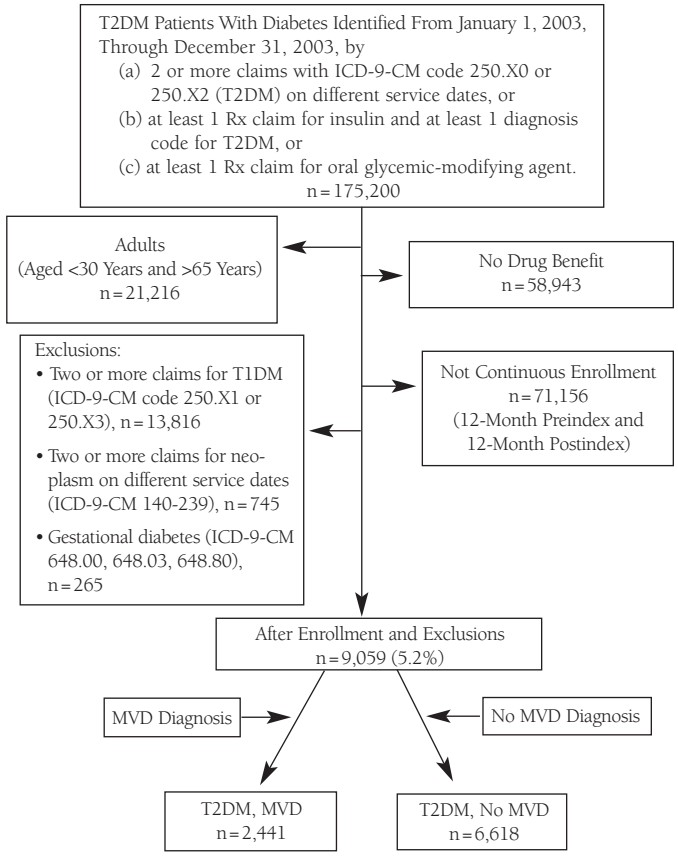
T2DM, more costs occur earlier in life as well as earlier in the course of T2DM.[17] However, few data are available in the typically younger, commercially insured population.

Although there are national estimates for aggregate expenditures for CVD and diabetes, there are few published studies estimating the average cost of treatment per patient per year (PPPY) for MVD. Glauber and Brown reported that CVD accounted for at least 24% of total medical care costs among patients with diabetes, compared with 12% of costs for patients without diabetes.[15] While that study included members of a health maintenance organization (HMO) diabetes registry, it did not differentiate between patients with type 1 and type 2 diabetes. Nichols and Brown reported the annual cost of CVD in patients with and without T2DM among members of an HMO diabetes registry.[17] However, nearly half of their study sample was aged 65 years and older. With the increase in T2DM in younger age groups, it is important to quantify the medical costs of T2DM and MVD in this "working age" population.

Given the prevalence of T2DM in the United States, and its impact on health care and budgets, policy makers need up-to-date information about treatment outcomes and costs. Interest in prevention and treatment of MVD in T2DM is increasing. ADA has called for renewed efforts at intensive treatment so that the most serious complications of this disease can be prevented or mitigated.[22] In this article, we detail the economic impact of MVD in a younger, commercially insured patient population with T2DM and in a comparison patient group without diabetes, matched by age and sex.

Using a case-control methodology, the analyses allowed for an examination of the direct medical costs associated with T2DM and T2DM with comorbid MVD compared with a "healthy" nondiabetic cohort. Quantification of the medical costs may prove useful in the determination of cost drivers and promotion of preventive health care services within a managed care population. The study therefore provides data that may help managed care decision makers and employers gain a better understanding of the economic impact of T2DM, both alone and accompanied by comorbid MVD.

**FIGURE 1** Sample Selection Criteria




*ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; MVD = macrovascular disease; Rx = prescription; T1DM = type 1 diabetes mellitus; T2DM = type 2 diabetes mellitus.*

## Methods

### Data

This retrospective analysis was based on a deidentified administrative claims database containing medical and demographic information on approximately 700,000 members enrolled in an East Coast commercial HMO health plan. The database contains paid facility, professional service, and community and mail-service pharmacy claims for inpatient and outpatient care for all enrollees (and their spouses and dependants). Monthly eligibility data were also available for all enrollees. All patient identifiers in the database have been fully encrypted, and the database is fully compliant with the Health Insurance Portability and Accountability Act of 1996.[23] Since study subjects cannot be identified, either directly or through linked identifiers, Institutional Review Board review was not sought for this study.[24]

### Patient Selection

Study patients were identified during the period January 1, 2003, through December 31, 2003. The index date was the first identified claim for T2DM during the subject identification period. Patients between the ages of 30 and 65 years as of January 1, 2003, who were commercially insured with a pharmacy benefit, were included in this study if they met the following criteria: (1) had at least 2 or more claims for T2DM (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] of 250.X0 or 250.X2) in the primary or secondary position on physician or hospital claims with different dates of service, or (2) had at least 1 pharmacy claim for insulin and a diagnosis of T2DM (ICD-9-CM of 250.X0 or 250.X2), or (3) had at least 1 pharmacy claim for an oral glycemic-modifying agent (Figure 1). All patients were

**TABLE 1** ICD-9-CM Codes for Macrovascular Disease and Comorbidities

| Comorbidity or Complication | ICD-9-CM and CPT Codes |
|---|---|
| Macrovascular disease | 410.xx (acute myocardial infarction); 411.xx-414.xx (other ischemic heart disease); 36.10-36.16 and 36.19 (coronary artery bypass surgery); 36.01 and 36.05 (percutaneous transluminal angioplasty); 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0, 428.1, 428.9, and 398.91 (congestive heart failure); 431.xx, 433.xx, 434.xx, and 436.xx (cerebrovascular accident); 250.7, 440.xx-442.xx, 443.9, and 447.1 (peripheral vascular disease) |
| Nephropathy | 583.81, 580.9x, 581.81, 581.9x, 582.9x, 583.xx, 588.8x, 593.9x |
| Neuropathy | 358.01, 354.xx-355.xx, 713.5x, 337.1x, 357.2x |
| Retinopathy | 362.0x, 362.1x, 362.2, 362.41, 363.31, 369.xx, 366.41, 365.44 |
| Obesity | 278.xx |
| Hyperlipidemia | 272.x |
| Other metabolic diseases | 251.0x-251.3x, 270.3x, 276.xx |

*CPT = Current Procedural Terminology; ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; MVD = macrovascular disease; T2DM = type 2 diabetes mellitus.*

required to have at least 12 months of continuous enrollment prior to the index date and at least 12 months of continuous enrollment following the index date. MVD was identified using ICD-9-CM codes in any position on office visits, emergency room visits, and hospital claims, for cases and controls. The diagnosis codes used for identifying MVD are listed in Table 1.

Exclusion criteria for patients included (1) 2 or more claims for type 1 diabetes (ICD-9-CM codes 250.X1 or 250.X3); (2) 2 or more claims with a diagnosis of neoplasm (ICD-9-CM codes 140-239) on different dates of service (at least 2 claims were required to ensure that patients with rule-out diagnosis [i.e., those thought to have neoplasms but found not to have neoplasms upon further examination] were not captured); and (3) a diagnosis of gestational diabetes (ICD-9-CM codes 648.00, 648.03, or 648.80). Patients with neoplasms typically are heavy users of the health care system and incur high direct medical costs. These patients were excluded because this allowed us to ensure that the costs in both T2DM and comparison groups were not driven by the presence of a high proportion of patients with neoplasms.

## Control Group Selection

A random sample was drawn from the same overall patient population to serve as the control group. Sex- and age-matched groups (30-35 years, 36-40 years, 41-45 years, 46-50 years, 51-55 years, 56-60 years, and 61-65 years) of enrollees who used services but did not have any diabetes claims (ICD-9-CM code 250.xx) during the study period were selected on a 1:1 basis. Matched controls were continuously eligible for medical and pharmacy benefits and required to have at least 1 facility or medical claim during the study year. We matched patients on age and sex because these variables often influence treatment patterns.[25] We were unable to match on other patient characteristics such as race/ethnicity, income level, region, etc., since this information was not available in the database.

## Comorbidity

Patient comorbidities were identified using ICD-9 codes from medical claims. The comorbidities were selected to represent the conditions expected to be the most common and costly. The comorbidities identified among the 4 groups included nephropathy, neuropathy, retinopathy, obesity, hyperlipidemia, and other metabolic diseases. These comorbid conditions were considered to exist for a patient if there was at least 1 claim with a corresponding ICD-9 code at any time during the study period. Table 1 lists the ICD-9 codes used to identify these conditions.

## Cost Calculations

The direct medical costs included inpatient, outpatient, ancillary, and pharmacy costs for each member. Costs were defined from the perspective of the health plan and included total payments made by the health plan to health care providers for inpatient, outpatient, physician, prescription drug services, and other ancillary services (e.g., laboratory tests, procedures). Patient copayments and deductibles were not included in the total direct medical costs. Costs were reported as PPPY costs in 2004 U.S. dollars. The medical care component of the consumer price index was used to adjust the costs to 2004 dollars.

Costs relating to claims for the following primary diagnoses were excluded from the computation of direct costs: (1) injury and poisoning (ICD-9-CM codes 800–999.99); (2) complications of pregnancy, childbirth, and the puerperium (ICD-9-CM codes 630-679.99); (3) potential health hazard related to personal and family history of malignant neoplasm (ICD-9-CM codes V10-V10.99); and (4) persons encountering health care services relating to pregnancy (ICD-9-CM codes V22-V24.99), procreative management (ICD-9-CM codes V26-V26.99), outcome of delivery (ICD-9-CM codes V27-V27.99), and antenatal screening (ICD-9-CM codes V28-V28.99).

Mean annual medical costs were computed for patients with and without T2DM, stratified by MVD status for 12 months after the index date. The goal for the cost analysis was to compare costs for 4 groups of patients: (1) patients with T2DM and MVD, (2) patients with T2DM but without MVD, (3) patients without diabetes but with MVD, and (4) patients without diabetes and MVD.

**TABLE 2** *Age and Sex Distribution in 2 Cohorts With T2DM and Without Diabetes*

| Characteristic | T2DM Group | | | Control Group Without Diabetes* | | |
|---|---|---|---|---|---|---|
| | No. Male | No. Female | No. Total (%) | No. Male | No. Female | No. Total (%) |
| N | 4,953 | 4,106 | 9,059 | 4,953 | 4,106 | 9,059 |
| Age group (years)† | | | | | | |
| 30-35 | 254 | 216 | 470 (5.2) | 254 | 216 | 470 (5.2) |
| 36-40 | 354 | 347 | 701 (7.7) | 354 | 347 | 701 (7.7) |
| 41-45 | 475 | 591 | 1,066 (11.8) | 475 | 591 | 1,066 (11.8) |
| 46-50 | 635 | 874 | 1,509 (16.7) | 635 | 874 | 1,509 (16.7) |
| 51-55 | 959 | 1,150 | 2,109 (23.3) | 959 | 1,150 | 2,109 (23.3) |
| 56-60 | 870 | 1,090 | 1,960 (21.6) | 870 | 1,090 | 1,960 (21.6) |
| 61-65 | 559 | 685 | 1,244 (13.7) | 559 | 685 | 1,244 (13.7) |
| Baseline age ± SD† | 51.7 ± 7.9 | 51.1 ± 8.6 | 51.7 ± 8.6 | 51.4 ± 8.2 | 50.8 ± 8.7 | 51.1 ± 8.5 |
| % women† | | | 45.3 | | | 45.3 |

*Note: Data are means ± SD or % for administrative claims with dates of service from January 1, 2003, through December 31, 2003.*

** A random group of control patients without diabetes (ICD-9-CM code 250.xx).*

*† Age group and sex were not significantly different (chi-square analysis) between the cohorts with T2DM and without diabetes.*

*ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; T2DM = type 2 diabetes mellitus.*

### Statistical Analysis

Descriptive statistics were used to describe the differences in costs among patients with T2DM and MVD, patients with T2DM but without MVD, patients without diabetes but with MVD, and patients without diabetes or MVD. Chi-square analysis was used to detect differences in age distribution (30-35 years, 36-40 years, 41-45 years, 46-50 years, 51-55 years, 56-60 years, and 61-65 years) and sex distribution among the 4 groups. All summary statistics are presented as mean ± standard deviation for continuous variables and as percentages for categorical variables.

Skewed data are often encountered in economic evaluations. Although statistics such as the median are of interest descriptively, economic analysis is fundamentally concerned with mean values. The median is not well suited to allowing policymakers to determine the total cost of treatment for a group of patients.[26-29] When the cost data are skewed, bootstrapping is an applicable technique.[30] The bootstrapping approach allows a comparison of means while avoiding distributional assumptions.[26,31] The bootstrapping procedure we used involved random sampling of data, with replacement, to obtain a new sample of equal size. This process was iterated 1,000 times in order to obtain the 95% confidence intervals (CIs) around the costs. SAS Version 8.2 was employed for data management and statistical analyses. The a priori level of significance was set at <0.05.

## Results

After the application of the eligibility criteria, 9,059 patients with T2DM were identified (Figure 1). A comparison group of 9,059 patients without diabetes with continuous enrollment for 2 years was created by matching with the T2DM group on age and sex. Table 2 presents the age-group and sex distribution based on 1:1 matching between patients with T2DM and those without diabetes. The Table 2 data show that although patients with T2DM and patients without diabetes were matched by age group and sex, patients with and without MVD within the T2DM group and nondiabetic group were not matched on these variables.

Table 3 displays the characteristics of the groups based on diabetes and MVD status. The mean age ± standard deviation of patients with T2DM was 51.7 ± 8.6 years, whereas the mean age ± standard deviation of patients without diabetes was 51.1 ± 8.5 years. The T2DM group had a higher proportion of male patients (54.7%). Patients with MVD and T2DM were, on average, a year younger than patients with MVD but without diabetes (54.55 ± 6.9 years vs. 55.55 ± 6.6 years, $P$ <0.001). Patients with T2DM but without MVD were nearly the same age as patients with neither diabetes nor MVD (50.44 ± 8.6 vs. 50.58 ± 8.5 years, $P$ = 0.092). Of the total study population, patients with MVD were significantly older compared with patients without MVD (54.82 ± 6.9 vs. 50.45 ± 8.4 years, $P$ <0.001). Nearly half of all members were women (45.3%), but in both groups, patients with MVD were less likely to be women (38.8% of patients with T2DM and 33.8% of the control group).

Table 4 shows that the annual medical cost for patients with T2DM and MVD was significantly (as evidenced by nonover-

**TABLE 3** Characteristics of Patient Groups

| Characteristic | T2DM MVD | T2DM No MVD | No DM MVD | No DM No MVD |
|---|---|---|---|---|
| N | 2,441 | 6,618 | 1,027 | 8,032 |
| Baseline age ± SD* | 54.55 ± 6.9 | 50.44 ± 8.6 | 55.45 ± 6.6 | 50.58 ± 8.5 |
| Women (%) | 38.8 | 47.8 | 33.8 | 46.8 |
| Obesity (%) | 9.6 | 5.9 | 3.6 | 1.3 |
| Nephropathy (%) | 5.9 | 2.1 | 2.3 | 0.0 |
| Neuropathy (%) | 5.5 | 3.7 | 0.3 | 0.0 |
| Retinopathy (%) | 12.6 | 11.2 | 0.3 | 0.0 |
| Other metabolic diseases (%) | 5.1 | 3.5 | 2.3 | 0.0 |
| Hyperlipidemia (%) | 37.3 | 24.1 | 35.4 | 5.8 |

** Age is not significantly different between the cohorts with T2DM and without diabetes; however, within both cohorts, age is significantly different between those who did and did not experience MVD (P <0.001).*

*MVD = macrovascular disease; T2DM = type 2 diabetes mellitus.*

lapping CIs) higher than for patients with T2DM but without MVD for all categories of costs. The total costs were $10,450 (95% CI, $9,692-$11,279) PPPY for patients with T2DM and MVD compared with $3,385 (95% CI, $3,232-$3,546) PPPY for patients with T2DM but without MVD. The inpatient costs were $4,583 (95% CI, $4,027-$5,225) PPPY for patients with T2DM and MVD compared with $584 (95% CI, $483-$695) PPPY for patients with T2DM but without MVD. The inpatient costs represented 44% of total costs in patients with T2DM and MVD compared with 17% for patients with T2DM but without MVD. The prescription costs were 1.63 times higher for patients with T2DM and MVD compared with patients with T2DM but without MVD ($3,032 [95% CI, $2,924-$3,143] and $1,861 [95% CI, $1,813-$1,914], respectively). The outpatient costs were 3.24 times higher for patients with T2DM and MVD compared with patients with T2DM but without MVD ($1,730 [95% CI, $1,522-$1,984] and $533 [95% CI, $495-$576] respectively). Similarly, the ancillary costs were 2.67 times higher for patients with T2DM and MVD compared with patients with T2DM but without MVD ($1,086 [95% CI, $998-$1,180] and $407 [95% CI, $382-$431], respectively).

The annual cost for patients without diabetes but with MVD was significantly (as evidenced by nonoverlapping CIs) higher than for patients with neither diabetes nor MVD for all categories of costs. The total costs were $6,090 (95% CI, $5,331-$6,862) PPPY for patients without diabetes but with MVD compared with $1,351 (95% CI, $1,280-$1,434) PPPY for patients with neither diabetes nor MVD. The inpatient costs were $3,006 (95% CI, $2,401-$3,716) PPPY for patients without diabetes but with MVD compared with $197 (95% CI, $154-$249) PPPY for patients with neither diabetes nor MVD. The inpatient costs represented 49.4% of total costs in patients without diabetes but with MVD compared with 15% for patients with neither diabetes nor MVD. The prescription costs were 2.5 times higher for patients without diabetes but with MVD compared with patients with neither diabetes nor MVD ($1,373 [95% CI, $1,245-$1,522] and $545 [95% CI, $519-$569], respectively). The outpatient costs were 2.75 times higher for patients without diabetes but with MVD compared with patients with neither diabetes nor MVD ($964 [95% CI, $862-$1,081] and $351 [95% CI, $323-$382], respectively). Similarly, the ancillary costs were 2.74 times higher for patients without diabetes but with MVD compared with patients with neither diabetes nor MVD ($715 [95% CI, $624-$813] and $261 [95% CI, $246-$275], respectively).

The annual cost for patients with T2DM and MVD was significantly (as evidenced by nonoverlapping CIs) higher than for patients without diabetes but with MVD for all categories of costs. The total costs were $10,450 (95% CI, $9,692-$11,279) PPPY for patients with T2DM and MVD compared with $6,090 (95% CI, $5,331-$6,862) PPPY for patients without diabetes but with MVD. Patients in both these groups experienced a similarly high inpatient intensive distribution of costs (44%-49% of total cost).

## Discussion

A retrospective study design using eligibility data and medical and pharmacy claims was used to determine the impact of MVD on the mean annual costs incurred by patients with T2DM and patients with no diabetes. The results show that patients with MVD experience significantly higher annual medical costs. Annual health care costs incurred for patients with both T2DM and MVD were 7.7 times greater than those for patients with neither diabetes nor MVD, 3 times greater than those for patients with T2DM but without MVD, and almost twice those of patients without diabetes but with MVD. When MVD occurs in patients with T2DM, it is more expensive when compared with MVD in patients without diabetes.

MVD remains a common and costly comorbidity in T2DM. Diabetes markedly elevates the risk for MVD, and, according to ADA, diabetes-related cardiovascular disease directly accounts for $500 million yearly in lost productivity.[4] In addition to these indirect costs associated with lost productivity, it is important to have accurate estimates of the direct costs of care for T2DM and MVD. Such cost data allows policymakers and health plans to estimate the savings that might be achieved by investing in early intervention and preventive programs.

The annual cost for patients with T2DM and MVD in 2004 dollars was $10,450 (95% CI, $9,692-$11,279) while that for patients without diabetes but with MVD was $6,090 (95% CI, $5,331-6,862). This is slightly lower than the annual cost (adjusted to 2004 dollars) reported by Nichols and Brown[17] for CVD with diabetes at $12,587 and CVD with no diabetes at $7,915; however, there are differences between the 2 studies. Our estimates are conservative since we excluded costs relating

**TABLE 4** One-Year Health Care Costs in 2004 Dollars by Diabetes and MVD Status

| Characteristic | T2DM Group (95% CI) | | Comparison Group Without Diabetes (95% CI) | |
|---|---|---|---|---|
| **MVD status** | **MVD** | **No MVD** | **MVD** | **No MVD** |
| N | 2,441 | 6,618 | 1,027 | 8,032 |
| **Pharmacy costs ($)** | | | | |
| Mean (95% CI) | 3,032 (2,924-3,143) | 1,861 (1,813-1,914) | 1,373 (1,245-1,522) | 545 (519-569) |
| % of total cost | 29.0% | 55.0% | 22.5% | 40.3% |
| Median | 3,031 | 1,861 | 1,369 | 545 |
| **Outpatient costs ($)** | | | | |
| Mean (95% CI) | 1,730 (1,522-1,984) | 533 (495-576) | 964 (862-1,081) | 351 (323-382) |
| % of total cost | 16.6% | 15.7% | 15.8% | 26.0% |
| Median | 1,723 | 532 | 960 | 351 |
| **Inpatient costs ($)** | | | | |
| Mean (95% CI) | 4,583 (4,027-5,225) | 584 (483-695) | 3,006 (2,401-3,716) | 197 (154-249) |
| % of total cost | 43.9% | 17.3% | 49.4% | 14.6% |
| Median | 4,572 | 582 | 2,983 | 195 |
| **Ancillary costs ($)** | | | | |
| Mean (95% CI) | 1,086 (998-1,180) | 407 (382-431) | 715 (624-813) | 261 (246-275) |
| % of total cost | 10.4% | 12.0% | 11.7% | 19.3% |
| Median | 1,085 | 407 | 713 | 261 |
| **Total costs ($)** | | | | |
| Mean (95% CI) | 10,450 (9,692-11,279) | 3,385 (3,232-3,546) | 6,090 (5,331-6,862) | 1,351 (1,280-1,434) |
| Median | 10,432 | 3,387 | 6,096 | 1,350 |

*CI = confidence interval; MVD = macrovascular disease; T2DM = type 2 diabetes mellitus.*

to injuries, pregnancies, neoplasms, etc., whereas the other study did not exclude these costs. Moreover, all of our study sample were aged between 30 to 65 years and represented a younger population. Nearly half of the sample in the study by Nichols and Brown[17] was aged 65 years and above and therefore represented an older population. Since many of the national statistics indicate that the largest burden of illness is in those older than 60 years,[32] our data illustrate the substantial cost of illness associated with T2DM and MVD in a younger, working-age population.

Our findings show that inpatient costs were higher as a proportion of total costs for patients with both T2DM and MVD (44%) compared with patients with T2DM but without MVD (17%). Pharmacy costs represented the largest cost component (55%) in patients with T2DM but without MVD. Although the actual percentages vary, the results are comparable with those of a large Pacific Northwest HMO[17] in which inpatient costs represented 51% of total costs in persons with diabetes and CVD compared with 31% in persons with diabetes but without CVD. Inpatient cost for persons with MVDs ranged from 44% to 49%, whereas those for persons without MVD were in the range of 15% to 17%, regardless of the presence of diabetes. The finding that inpatient costs represent a large proportion of the annual medical costs in patients with MVD is consistent with earlier studies.[12,13,19,33] These studies also suggest that much of the added cost of MVDs results from hospitalizations for heart attacks, heart failure, and other major cardiovascular events.

Patients with MVD tended to be significantly older when compared with those without MVD (55 years versus 51 years) regardless of the presence of diabetes. Therefore, it is possible that the increased costs seen in these patients could be related to patients being older. However, since the HMO population in the present study represented a younger, employed population, and those with MVD were on average only 4 years older when compared with those without MVD, age is not likely to fully explain the large cost differential.

Observations from MCOs suggest that annual management costs for patients with diabetes are 1.5 to 2 times higher than those for patients without diabetes.[8,34] Glauber and Brown estimated that the HMO spent 4.5 times per person more on CVD care for members with diabetes than for members without diabetes.[15] As diabetes-related complications develop and progress, care management costs increase.[12,19] Our findings show that direct medical costs for patients with both T2DM and MVD were 3 times higher than the costs incurred for patients with

T2DM but without MVD. The HMO in the present study spent nearly 2 times more on MVD care in patients with T2DM than in patients without T2DM. The cost differential between patients with T2DM with MVD and without MVD was on the order of $7,065 PPPY ($10,450-$3,385). The large difference in costs between all 4 patient groups (among patients with T2DM and MVD, patients with T2DM but without MVD, patients without T2DM but with MVD, and patients without T2DM and MVD) was an expected result of this study. The magnitude of the cost differential is suggestive of the cost savings potential from initiatives aimed at preventing macrovascular events.

An important consideration in this analysis is that we could not detect undiagnosed T2DM in the control population. If T2DM was undetected in this population, especially among those with MVD, then the estimated costs of MVD might be understated in the T2DM group and overstated in the control group. Although patients with T2DM and patients without diabetes were matched by age group and sex, patients with and without MVD for comparisons within the T2DM population were not matched on age group and sex. Thus, in these data, patients with T2DM but without MVD are more likely to be recently diagnosed diabetic patients with potentially lower costs.

The relative proportion of inpatient hospital costs in patients with T2DM—43.9% for patients with MVD versus 17.3% for patients without MVD—suggests the potential value of disease management interventions to encourage effective prevention and treatment of MVD. Considerable evidence suggests that strategies such as primary and secondary prevention of coronary artery disease, control of blood pressure, and control of lipids provide more clinical benefits at less cost on a population basis.[35] Strategies targeted at preventing the onset of T2DM[36,37] or delaying the progression of its complications[38] could produce substantial savings to the health care system. The findings from this study may be helpful in framing the context for measuring the economic implications of various interventions, such as disease management programs or newer drug therapies designed to improve glycemic control and other clinical outcomes in diabetic patients with T2DM.

## Limitations

Patients with both incident and prevalent T2DM and MVD were included in this analysis. This means that at the initial observation point in our analysis, the patients were mixed with respect to duration of their disease. Our findings are, however, a likely reflection of a steady state that one would expect to find within the given population, but the findings are less useful for estimating lifetime disease burden. Also, the patients with the conditions studied may have more health care use than controls simply because of opportunities for contact with the system. This is probably minimized by the requirement that all comparison patients without diabetes had at least 1 outpatient visit. We also note that we were unable to match the comparison group on other patient characteristics, such as race/ethnicity, income level, region, etc., since this information was not available in the database.

This is a descriptive cost analysis only. Outcomes data, such as hemoglobin A1c laboratory values, blood pressure measurements, body weight, and lipid levels, would provide additional value to the study results. Other potentially valuable patient characteristics, such as body mass index and vital signs at office visits, were also unavailable. The descriptive analyses reported in this study do not control for comorbidities among the different groups. Choosing a comparison group based on propensity score matching would allow for a better comparison of costs between the groups, while simultaneously controlling for a variety of factors that may drive costs. However, propensity score matching only controls for known or measurable factors.[39] Although we report the proportion of patients with a claim for obesity as comorbidity, it should be recognized that obesity is quite likely underreported in administrative claims, except in the case of morbid obesity, and therefore may not present a true picture of the prevalence of the condition. Nevertheless, the relative proportion of patients with a diagnosis code for obesity among the 4 patient groups and between the 2 groups with and without T2DM provides some additional indication of comorbidity.

The cost findings in the present study are most likely not generalizable to all patients with T2DM. Treatment patterns for this disease may differ according to individual physician practice styles, health plan guidelines, and geographic region. Any out-of-pocket expenditures that resulted from the use of diabetes- and cardiovascular-related services by the HMO members were not captured by the claims data and therefore were not included in the study, resulting in analyses primarily from the health plan perspective. It is important to note that the analysis focuses exclusively on direct medical costs and hence does not include other costs associated with T2DM and MVD such as productivity costs and caregiver burden.

The results are based on claims data collected for administrative purposes, primarily payment of claims. Due to inaccuracies in the coding of services and diagnoses, some patients and services provided may have been miscoded and/or misclassified. The use of medical claims data also precludes the use of patient assessments, and, as a result, the analysis cannot examine quality of life, functional status, or any other clinical outcomes. Also, because claims data are available only for a limited period of time for each patient, it was not possible to ascertain the length of time since initial diagnosis of T2DM. Thus, the present study is also limited by the inability to control for duration of T2DM.

The results of this study may not be generalizable to other populations. The sample consisted of continuously enrolled members of an East Coast HMO who had a pharmacy benefit. These individuals may not be similar to individuals who are not

employed or have not been continuously enrolled in the same health plan for at least 2 years. The generalizability of the results is also limited by the geographic and demographic characteristics of the study population. For example, it was necessary to set an upper age limit of 65 years to remove the Medicare patient population because their medical benefits are typically different from those of the commercial population, and the coordination of payment between Medicare and supplemental or other private payment hinders the ability to capture all relevant claims data.

## Conclusions

Direct medical costs aggregated for HMO members with T2DM and MVD are 1.7 times higher than for HMO members with MVD but without diabetes. This analysis of administrative claims data for HMO members between the ages of 30 and 65 years also suggests that MVD may triple the total medical care costs in patients with T2DM. These economic consequences would appear to support the importance of interventions intended to prevent macrovascular events in patients with T2DM.

### DISCLOSURES

No outside funding supported this research. Author Shravanthi R. Gandra discloses that a portion of the work in this article was part of her doctoral dissertation when she was a doctoral candidate at the University of Louisiana at Monroe. The coauthors, Lesa W. Lawrence, Bhash M. Parasuraman, Robert M. Darin, Justin J. Sherman, and Jerry L. Wall disclose no potential bias or conflict of interest relating to this article.

Gandra served as principal author of the study. Study concept and design were contributed by all authors. Data collection was the work of Gandra; data interpretation was primarily the work of Gandra, Darin, and Sherman, with input from the coauthors. Writing of the manuscript was the work of Gandra; its revision was the work of Lawrence, Parasuraman, and Wall, with input from the coauthors.

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