Increased Costs of Diabetes Therapy Not Related to Glycemic Control at Three Veterans Affairs Medical Outpatient Clinics

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ABSTRACT
Our goal was to determine whether the type of primary care provider and the site of care influenced pharmaceutical costs and glycemic control at three Veterans Affairs outpatient clinics. Overall, we identified 4,265 veterans who received anti-hyperglycemic medications during 1997. We found that prescribing patterns, monthly total costs, and glycemic control differed according to hospital site. The primary care provider type and the intensity of treatment were associated with monthly medication costs, monthly total costs, and glycemic control; however, the costs of monthly medications and the total costs were not associated with improved glycemic control.

Key words: Diabetes mellitus, outcome and process assessment (health care), economics, pharmaceutical, veterans, physicians’ practice patterns

INTRODUCTION
Diabetes mellitus is a prevalent condition that imparts a heavy toll on the health of affected individuals. This illness affects an estimated 6% of the U.S. population1 and approximately 12% of patients within the Veterans Affairs (VA) medical system.2 Conditions directly attributable to hyperglycemia or hypoglycemia, such as diabetic coma, account for a small portion of diabetes-related morbidity and mortality. Most illnesses and deaths are secondary to the accompanying microvascular and macrovascular complications.3 It is clear that improved glycemic control slows the development and progression of the microvascular complications3–6 and tends to reduce the incidence of macrovascular complications as well.3,5,7 Diabetes mellitus is an expensive disease.8 Although inpatient utilization of hospital services is higher in patients with diabetes than in nondiabetic patients,1,2,9 diabetic patients demonstrate a disproportionate use of outpatient services.1,10 and pharmaceutical expenditures.2,11,12 For the VA, pharmacy acquisition costs for oral hypoglycemic agents increased from $68 million in 2001 to $103 million in 2002, and more than $45 million was spent on home glucose-monitoring strips, according to the Pharmacy Benefits Strategic Healthcare Group in 2002.13 Because diabetes is a prevalent and costly condition, it is important to determine whether there are “best practices” that might be used to guide disease management.14 As a first step in this process, we retrospectively examined administrative and pharmacy records of diabetic patients to determine how the type of primary care provider (PCP) and the site of care influenced pharmaceutical costs and glycemic control at three VA medical centers in Veterans Integrated Service Network (VISN) 4. Site of care has been shown to be more predictive of diabetic process measures than individual providers.15

The VA health care system is an ideal setting in which to assess the relationships between site of care, medication use, and outcomes: all patients receive medications at minimal to no cost, and data regarding medication and laboratory use are recorded in a standardized clinical database.

METHODS
We conducted a multicenter, retrospective cohort study at three VA hospitals in Pennsylvania using data for patients who received outpatient prescriptions for the treatment of diabetes mellitus during the 1997 calendar year. Two academic urban referral hospitals (sites A and B) and one rural community hospital (site C) were included. This study was designed to determine whether the primary care provider type and the site influenced diabetes-related outpatient pharmaceutical costs and glycemic control.

Study Patients and Medical Providers
Inclusion Criteria. Patients were eligible for enrollment in the study if they received one or more anti-hyperglycemic medications during the three months prior to the start of the study period (October 1, 1996, through December 31, 1996).

Exclusion Criteria. Patients were excluded from the study if:

• they died during the study period.
• they received diabetes-related prescriptions from more than one study site.

Disclosure. This project was supported by a Veterans Affairs Medical System, Veterans Integrated Service Network (VISN) 4, Competitive Pilot Project Fund award to Dr. Good.
Increased Diabetes Costs and Glycemic Control

- they received fewer than 180 unique days of antihyperglycemic medications during the study period.
- they were unlikely to receive all of their medical care at the VA clinic.
- they tended to be nonadherent to the medication regimen.
- their only diabetes-related prescriptions were for syringes or self-glucose monitoring supplies (because these patients were more likely to be taking other injectable medications or their diabetes was being controlled by diet).
- their primary care providers were reimbursed on a contractual basis (because the patients’ glycosylated hemoglobin [HbA1c] results were not obtained through VA medical centers).

Identification of Patients. Patients were identified by a computerized algorithm that searched pharmacy records for diabetes-related prescriptions dispensed from October 1, 1996, to December 31, 1996. We chose this method to ensure that patients were already receiving diabetic medications before the study’s start date. One of the authors (Dr. Fultz) developed the list of eligible diabetic medications and self-glucose monitoring supplies at each individual site and used all diabetes-related items listed in that site’s pharmacy records.

Identification of Primary Care Providers. Primary care providers were identified for each patient. The “primary care provider” was defined as the health care provider who prescribed more than 50% of the diabetes-related prescriptions for that patient during the study period. This assignment was based on the total number of medication-days prescribed. Primary care providers were eligible for inclusion if they were general internal medicine attending physicians or house officers, primary care nurse practitioners, physician’s assistants, or endocrinologists.

We allocated all diabetes-related medication costs for the patients to their primary care providers, whom we considered to be responsible for making most therapeutic decisions related to disease management. Patients who did not have a health care provider who met the eligibility criteria for primary care provider were classified as having “no primary care provider” for purposes of the analyses.

Usage and Costs of Antihyperglycemic Medications

The computerized algorithm was then used to extract all diabetes-related prescriptions dispensed between October 1, 1996, and December 31, 1997. The three-month lead time was necessary to capture prescriptions with 90-day fills, which would extend into the study period. Extracted pharmacy data included the following:

- name of the medication
- prescriber’s name
- date on which the prescription was filled
- length of the prescription (in days)
- quantity of medication dispensed

We used VA acquisition costs to arrive at the cost calculations. Costs were calculated for medications prescribed during the time period from January 1, 1997, through December 31, 1997. We pro-rated the prescriptions that extended beyond the study’s start or end dates to include only resources consumed during the study period.

Monthly costs were calculated for each prescription, and aggregated costs were calculated for three categories:

- oral agents (sulfonylureas, troglitazone, acarbose [Precose, Bayer], metformin)
- insulin (including syringe costs)
- self-glucose monitoring supplies

The supply category included test strips and testing solutions but not the cost of self-glucose monitoring machines, which are not dispensed through VA pharmacies. Monthly medication costs and monthly total costs (medication costs plus supply costs) were analyzed.

The use of concurrent medications, which have the potential to influence glycemic control, was extracted as a simple yes–no variable. These medications included diuretics and systemic corticosteroids.

Collection of Patient Data

We extracted patient demographic data from the computer system at each hospital using the same computerized algorithm that was used to identify eligible patients. Extracted data included age, sex, race, marital status, and the date of the patient’s death (if it had occurred).

For a subset of patients, we performed an in-depth chart review to determine whether the severity of diabetes or presence of coexisting illnesses differed among the study sites. For primary care providers at sites B and C, who had more than 10 diabetic patients in their panel, we selected 10 patients at random. Electronic and paper charts were examined for the presence of the following diabetic microvascular complications:

- neuropathy, defined as an abnormal monofilament, as determined by testing, or documentation of this condition by a medical care provider or podiatrist.
- nephropathy, defined as fixed proteinuria, not including microalbuminuria, or by clinical documentation of this condition by a medical care provider.
- retinopathy, considered to exist if patients had undergone previous laser surgery of the eye or if diabetic retinopathy had been documented by a medical care provider.

Because the ophthalmology clinic at site B served as the referral site for all patients at site C, we also reviewed the records at this clinic. We examined the patients’ charts for evidence of any coexisting illnesses based on the Charlson Comorbidity Index.

We searched the laboratory data files at each institution for HbA1c values for all patients, extracted their HbA1c levels that were determined during the study period, and recorded their average and most recent concentrations.

Methods of Analysis

Statistical analyses were performed with Software Statistical Package for the Social Sciences, version 10.0 (SPSS, Inc., Chicago). We used chi-square to compare proportions. For
Continuous variables, we used Student’s t-test to compare means. Cost data and the patients’ last HbA1c levels were log-transformed before the analysis because of a non-normal distribution and a rightward skew of the data.

We performed multivariable modeling with an analysis of variance (ANOVA) using the last HbA1c, the monthly medication cost, and monthly total cost as the dependent variables. These models examined the effect of site, the type of primary care provider, and the treatment group. They were adjusted for age, marital status, and race because these factors differed across the sites.

We carried out multivariable logistic regression analyses for two clinically relevant dichotomous levels of glycemic control (HbA1c below 8% or above 9.5%) based on the patients’ most recent HbA1c levels while also controlling for age, marital status, and race. These cutoffs were based on the VA practice of reporting on a site-specific and VISN-specific basis the percentage of diabetic patients with good control, defined by the VA as an HbA1c reading of less than 8%, and poor control, defined as an HbA1c level greater than 9.5%.

An ordinal Diabetes Severity Score was used to analyze the chart review substudy data. This score was the sum of the occurrence of the individual microvascular complications (range, 0–3). We analyzed the Charlson Comorbidity Index as a continuous variable. Possible scores ranged from 0 to 32.

**RESULTS**

**Demographics and Prescribing Profiles**

Overall, 4,265 patients met the study’s eligibility criteria: 1,363 patients (32%) from site A; 2,188 patients (51%) from site B; and 714 patients (17%) from site C. As expected in a VA population, most patients at all sites were elderly and male (Table 1). The two academic sites (sites A and B) consisted of a higher proportion of African-American patients and fewer patients who were married at the time.

At the community hospital site, attending physicians in internal medicine provided primary care to most of the patients (see Table 1). At the academic sites, patient care was more evenly distributed among attending physicians, internal medicine house staff, and nurse practitioners, or patients had no defined primary care provider.

A small number of patients at sites A and B received most of their diabetes care from endocrinologists; none of the patients at site C received diabetes care from an endocrinologist because of the lack of these specialists on staff there.

The concomitant use of diuretics was similar among patients at the three sites. The rate of corticosteroid usage was highest at site B (4.8%), compared with rates of 3.2% at site A and 3.6% at site C (P = .05).

Medication-prescribing profiles differed significantly at the three hospital sites (Table 2):

- Patients at site B (63.3%) and at site C (65.3%) were more likely (P = .001) to receive one or more oral agents than patients at site A (58.3%) because of differences in the use of sulfonylureas (55.0% at site A, 60.3% at site B, and 63.7% at site C) (P < .0005).
- The use of troglitazone, acarbose, or metformin did not differ among the sites.
- The frequency of insulin usage was highest at site A (49.4%), compared with rates of 44.2% at site B and 42.3% at site C (P = .002).
- Patients at site B were more likely to receive self-glucose-monitoring supplies (%).

**Table 1**  **Patient Demographics at Three Veterans Affairs Health System Outpatient Clinics**

| Site  | No. of Patients | Mean Age (Years) (± SD) | Sex (% Male) | Race (%) | Marital Status (%) | Oral Antihyperglycemic Agents (%)
|-------|-----------------|------------------------|--------------|-----------|-------------------|-------------------------------
| A     | 1,363           | 65.3 (± 11.5)          | 98.5         | 35.8      | 51.4              | 58.3                          |
| B     | 2,188           | 67.3 (± 10.5)          | 98.1         | 78.4      | 56.4              | 63.3                          |
| C     | 714             | 69.0 (± 9.7)           | 98.3         | 95.4      | 66.9              | 65.3                          |

**Table 2**  **Prescribing Patterns for Diabetic Patients by Hospital Site**

<table>
<thead>
<tr>
<th>Site</th>
<th>Oral Antihyperglycemic Agents (%)</th>
<th>Sulfonylureas</th>
<th>Troglitazone</th>
<th>Acarbose</th>
<th>Metformin</th>
<th>Insulin (%)</th>
<th>Glucose-Monitoring Supplies (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>58.3</td>
<td>55.0</td>
<td>0.8</td>
<td>0.1</td>
<td>18.3</td>
<td>49.4</td>
<td>36.5</td>
</tr>
<tr>
<td>B</td>
<td>63.3</td>
<td>60.3</td>
<td>1.0</td>
<td>0.1</td>
<td>20.9</td>
<td>44.2</td>
<td>73.5</td>
</tr>
<tr>
<td>C</td>
<td>65.3</td>
<td>63.7</td>
<td>1.4</td>
<td>0.3</td>
<td>18.8</td>
<td>42.3</td>
<td>26.3</td>
</tr>
</tbody>
</table>

* Percentages may add up to more than 100 because some patients received more than one medication.
† No longer on the market.
monitoring supplies (73.5%) than patients at site A (36.5%) and at site C (26.3%) \( \left( P < .0005 \right) \).

**Monthly Medication Costs and Total Costs**

Complete demographic information was available for only 3,763 (88%) patients for incorporation into the multivariable models. As shown in Table 3, the overall monthly medication cost ($6.16) and monthly total cost ($8.44) were lowest at site C, compared with costs at site A ($7.15 and $12.19) and at site B ($6.62 and $15.85).

For patients who received only oral agents, site C showed the lowest monthly medication cost and monthly total cost ($2.99 and $3.79), compared with site A ($3.20 and $5.20) and site B ($3.15 and $8.17).

For patients who received only insulin therapy, site B was associated with the lowest monthly medication costs ($13.66) compared with site A ($14.53) and site C ($14.24), but its monthly total costs ($31.53) were higher than those at site A ($26.91) or at site C ($21.65).

For patients who received both oral agents and insulin therapy, site A showed the lowest monthly medication costs ($24.55) and the lowest monthly total costs ($36.83), com-

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### Table 3  Median Monthly Costs and Glycemic Control at Three VA Health System Outpatient Clinics

<table>
<thead>
<tr>
<th></th>
<th>Cost Outcomes</th>
<th>Glycemic Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Patients</td>
<td>Monthly Medication Cost</td>
</tr>
<tr>
<td><strong>All Patients</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site A</td>
<td>1,195</td>
<td>$7.15</td>
</tr>
<tr>
<td>Site B</td>
<td>1,957</td>
<td>$6.62</td>
</tr>
<tr>
<td>Site C</td>
<td>611</td>
<td>$6.16</td>
</tr>
<tr>
<td><strong>Oral Agents Only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site A</td>
<td>594</td>
<td>$3.20</td>
</tr>
<tr>
<td>Site B</td>
<td>1,070</td>
<td>$3.15</td>
</tr>
<tr>
<td>Site C</td>
<td>350</td>
<td>$2.99</td>
</tr>
<tr>
<td><strong>Insulin Therapy Only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site A</td>
<td>504</td>
<td>$14.53</td>
</tr>
<tr>
<td>Site B</td>
<td>729</td>
<td>$13.66</td>
</tr>
<tr>
<td>Site C</td>
<td>215</td>
<td>$14.24</td>
</tr>
<tr>
<td><strong>Both Oral Agents and Insulin Therapy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site A</td>
<td>97</td>
<td>$24.55</td>
</tr>
<tr>
<td>Site B</td>
<td>158</td>
<td>$35.75</td>
</tr>
<tr>
<td>Site C</td>
<td>46</td>
<td>$30.52</td>
</tr>
</tbody>
</table>

HbA1c = glycosylated hemoglobin.

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### Table 4  Multivariate Models* for Costs and Last Glycosylated Hemoglobin Readings (HbA1c) for Diabetic Patients

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Monthly Medication Costs</th>
<th>Monthly Total Costs</th>
<th>Last HbA1c Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( F (df) )</td>
<td>( P ) Value</td>
<td>( F (df) )</td>
</tr>
<tr>
<td><strong>Covariate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (in years)</td>
<td>126.737 (1)</td>
<td>&lt;.0005</td>
<td>167.266 (1)</td>
</tr>
<tr>
<td>Married</td>
<td>2.108 (1)</td>
<td>.1</td>
<td>4.337 (1)</td>
</tr>
<tr>
<td>White race</td>
<td>8.521 (1)</td>
<td>.004</td>
<td>0.000 (1)</td>
</tr>
<tr>
<td><strong>Main Effect</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td>0.119 (2)</td>
<td>.9</td>
<td>61.351 (2)</td>
</tr>
<tr>
<td>PCC type</td>
<td>7.769 (4)</td>
<td>&lt;.0005</td>
<td>9.224 (4)</td>
</tr>
<tr>
<td>Treatment group‡</td>
<td>843.233 (2)</td>
<td>&lt;.0005</td>
<td>744.870 (2)</td>
</tr>
</tbody>
</table>

*Denominator degrees of freedom (df) are 3,726 for both cost models and 2,973 for the HbA1c model.

‡The F statistic is a generalization of the T statistic when the means of more than two groups are being compared.

‡ Defined as patients taking oral agents only, insulin only, or both oral agents and insulin.

PCP = primary care provider.
compared with site B ($35.75 and $59.18) and site C ($30.52 and $45.39).

As shown in Table 4, increasing age was independently associated with lower monthly medication costs and monthly total costs (P < .0005 for both). Being currently married was associated with higher monthly total costs (P = .04) but not with monthly medication costs (P = .1).

White race was associated with higher monthly medication costs (P = .004) but not with monthly total costs (P = .99). The hospital site was associated with monthly total costs (P < .0005); costs at site B were higher than those at site A, and costs for site A were higher than those at site C.

Treatment group, defined as patients receiving oral agents only, insulin only, or both oral agents and insulin therapy, was related to both monthly medication costs and monthly total cost (P < .005 for both). Costs were highest for patients who received both oral agents and insulin, followed by costs for patients taking insulin only, and followed by costs for patients taking oral agents only.

The primary care provider type was strongly associated with both monthly medication costs and monthly total costs (P < .0005 for both). Both costs were higher for management by an endocrinologist, whereas the costs were similar for management by other primary care provider types.

**Glycemic Control**

In the univariate analysis (Table 3), patients at site B had higher mean last HbA1c values across all treatment groups (8.3% for all patients, 8.1% for patients taking oral agents only, 8.4% for patients taking insulin only, and 9.0% for patients taking both agents) than patients at site A and site C. Site B also included fewer patients whose last HbA1c level was less than 8.0% and more patients whose last HbA1c reading was higher than 9.5%.

The multivariable analysis of predictors of the last HbA1c showed that increasing age was associated with decreasing HbA1c values (P < .005). The site was a significant predictor of the last HbA1c (P < .0005); patients at site B had the highest values, and the values at sites A and C were similar.

Treatment group was strongly associated with the last HbA1c (P < .0005). Patients who received oral agents and insulin had higher last HbA1c results than patients receiving only insulin. Patients who received only oral agents had the lowest HbA1c levels.

Marital status (P = .4), race (P = .1), and primary care provider type (P = .4) were not significantly associated with the last HbA1c measurement.

In logistic regressions predicting the last HbA1c to be less than 8.0% (Table 5), white race and older age were associated with improved glycemic control; HbA1c was more likely to be less than 8.0% (P = .001, and P < .0005, respectively). Differences in sites were associated with varying levels of glycemic control (P < .0005), whereas the primary care provider type (P = .06) and treatment group (P = .3) were not.

Monthly medication costs (P < .005) and monthly total costs (P = .01) were both associated with glycemic control, but higher costs were predictive of reduced glycemic control. Similar results were obtained for the last HbA1c reading above 9.5%.

### Table 5 Logistic Regression Predicting Last Glycosylated Hemoglobin (HbA1c) Below 8.0%

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>Wald Value (df)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariate</td>
<td>Chi-Square (df)</td>
<td></td>
</tr>
<tr>
<td>Age (in years)</td>
<td>56.4 (1)</td>
<td>&lt;.0005</td>
</tr>
<tr>
<td>Married</td>
<td>0.01 (1)</td>
<td>.90</td>
</tr>
<tr>
<td>White race</td>
<td>11.4 (1)</td>
<td>.001</td>
</tr>
<tr>
<td>Main Effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site</td>
<td>186.3 (3)</td>
<td>&lt;.0005</td>
</tr>
<tr>
<td>PCP type</td>
<td>9.1 (4)</td>
<td>.06</td>
</tr>
<tr>
<td>Treatment group*</td>
<td>2.6 (2)</td>
<td>.30</td>
</tr>
<tr>
<td>Monthly medication cost</td>
<td>28.3 (1)</td>
<td>&lt;.0005</td>
</tr>
<tr>
<td>Monthly total cost</td>
<td>6.1 (1)</td>
<td>.01</td>
</tr>
</tbody>
</table>

* Defined as patients taking oral agents only, insulin only, or both oral agents and insulin.

df = degrees of freedom; PCP = primary care provider.

### Table 6 Chart Review: Substudy Demographics, Diabetic Complications, and Charlson Comorbidity Scores

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of Patients</th>
<th>Mean Age (Years) (± SD)</th>
<th>Sex (% Male)</th>
<th>Race (%)</th>
<th>Currently married (%)</th>
<th>Retinopathy (%)</th>
<th>Neuropathy (%)</th>
<th>Nephropathy (%)</th>
<th>Mean Charlson Comorbidity Index (± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>360</td>
<td>67.4 (±10.0)</td>
<td>98.3</td>
<td>68.6</td>
<td>60.5</td>
<td>24.7</td>
<td>26.7</td>
<td>5.6</td>
<td>1.4 (±1.6)</td>
</tr>
<tr>
<td>C</td>
<td>70</td>
<td>69.7 (±9.6)</td>
<td>98.6</td>
<td>87.1</td>
<td>71.4</td>
<td>30.0</td>
<td>24.3</td>
<td>5.7</td>
<td>1.5 (±1.9)</td>
</tr>
</tbody>
</table>

Overall, 360 patients from site B and 70 patients from site C were included in the chart review substudy (Table 6). The Diabetes Severity Score did not differ across sites (P = .4) or across primary care provider type (P = .09; data not shown).

There was no difference by site in the prevalence of the individual microvascular complications of retinopathy (P = .4), neuropathy (P = .7), or nephropathy (P = 1.0).

Peptic ulcer disease was more common in patients at site C (17.1%) than at site B (7.5%) (P = .01), but the mean Charlson Comorbidity Index score did not differ significantly (score at site B, 1.4; score at site C, 1.5) (P = .6). Among the three sites, other components of the Charlson Comorbidity Index did not differ significantly.
DISCUSSION

Variations in the prescribing profiles and in the level of glycemic control, as measured by HbA1c, existed for the three hospital sites within VISN 4 of the VA health care system. Variations in practice patterns have been shown for multiple conditions, including treatment of diabetes mellitus.[17–21] At the time of this study, national VA guidelines for the management of diabetes were in use and no separate guidelines existed for VISN 4. In addition to the guidelines, site-specific information focusing on levels of glycemic control and the percentage of patients with HbA1c levels below 8% was available to each institution.

In our study, differences in prescribing profiles were associated with variations in both monthly medication costs and monthly total costs. As expected, the costs were greater for patients who required higher levels of pharmaceutical care, either because they used insulin rather than oral agents or because they used insulin in addition to oral agents.

White race was associated with higher monthly medication costs, but not monthly total costs, because nonwhite patients were prescribed self-glucose monitoring supplies less frequently than white patients.

Despite the small number of endocrinologists in this study, the monthly medication and monthly total costs were higher for patients who were cared for by these specialists; the costs of care by house staff members, internal medicine attending physicians, nurse practitioners, and physicians’ assistants were similar. This finding probably reflects the fact that patients who are referred to endocrinologists typically have diabetic illness that is more difficult to control. In the multivariable analysis, the three sites did not incur different monthly medication costs, but they did show significantly different monthly total costs as a result of the increased use of self-glucose monitoring supplies at site B.

Although treatment costs varied significantly, increased treatment costs were not associated with improved glycemic control. In fact, site B, where the monthly total costs were highest, included patients with the highest mean last HbA1c reading, the lowest percentage of patients with their last HbA1c reading of less than 8.0%, and the largest proportion of patients with their last HbA1c reading greater than 9.5%. In the logistic regression, the increased monthly medication and monthly total costs were associated with worse glycemic control.

Thus, in our study, the increased use of self-glucose monitoring supplies was not associated with improved glycemic control. Previous studies of self-glucose monitoring in type-2 (non–insulin-dependent) diabetes had yielded mixed results;[22,23] as a result, such use has been questioned.[24] Nevertheless, this supply item remains a significant cost to the VA system.

The results of the chart review substudy did not support a difference in diabetes-related coexisting illnesses or in the Charlson Comorbidity Index scores in patient populations between site B and site C. Therefore, it is unlikely that the difference in costs of treatment or HbA1c levels can be explained by differences in the patient population or by the severity of their diabetes.

We acknowledge several limitations to this research.

First, this study was performed in the VA health care system, with its older population of diabetic patients and a much higher proportion of men. Although the study might be limited in its ability to generalize these results, it still has useful advantages. Because of the disproportionate age distribution, the costs of caring for diabetic patients disproportionately affect the VA and provide an incentive for the determination of best practices.

Second, the increased prevalence of diabetes within the VA system provides easier access to a large number of diabetic patients. Our reliance on administrative databases precluded us from determining whether the patients were receiving additional medications or supplies from providers outside the VA system. It is unlikely that this was a significant factor, because patients must often pay much higher prescription costs than the $2 copayment that was charged by the VA at the time of this study.

By looking only at the costs for medications and self-glucose monitoring supplies, we examined only a small portion of costs related to health care in diabetic patients. Because we used VA acquisition costs, we could not extrapolate costs to other health care systems.

This study was limited to outpatient management, and we did not examine the pharmaceutical costs associated with inpatient care.

Because of the retrospective nature of this study, HbA1c levels were processed at each site. We attempted to adjust for any differences in measurement resulting from methodology by examining the difference between patient values and the upper limit of normal at each site and obtained similar results.

At the time of our study, the use of thiazolidinodiones (e.g., troglitazone) was limited and had only a minor effect on pharmacy costs. Since the time of our study, troglitazone has been removed from the market and has been replaced by pioglitazone (Actos®, Takeda/Eli Lilly) and rosiglitazone (Avandia®, GlaxoSmithKline). The use of these agents has increased significantly and greatly influences overall pharmacy costs. While it had a negligible effect on overall diabetic medication costs at the time of our study, this drug class accounted for 27% of overall diabetic medication costs for site A, 11.5% for site B, and 10.7% for site C in 2001.13

Despite the recent publication of VA treatment guidelines for diabetes,25 the use of the thiazolidinodione drug class varied greatly throughout the VA system in 2001, accounting for 0.05% to 4.5% of overall drug budgets among different sites.13 Thus, it is unclear how differences in the use of this drug class today influence the cost of diabetic care and glycemic control in all sites of care.

It is also unclear whether the use of different agents to treat diabetes will affect long-term patient outcomes. Metformin therapy can decrease diabetes-related adverse outcomes in overweight diabetic patients compared with the sulfonylureas and insulin.28 Even though there are theoretical reasons why the use of the thiazolidinodiones or other newer, more expensive agents might improve long-term clinical outcomes beyond glycemic control, there is no current evidence to support this claim. Because our study focused solely on HbA1c levels as our outcome measure, it is possible that evidence in the future will show that the use of drugs with higher acquisition costs might reduce overall costs of care.
CONCLUSION

Despite the potential limitations of this study and the narrow scope of our focus, our work demonstrates variability in the management of diabetic patients among several outpatient VA settings. Because diabetes continues to be an increasingly significant public health problem, identifying best practices requires further study as well as examining whether adherence to clinical practice guidelines will improve care. Our study provides several directions for future research and identifies possible ways to provide more cost-effective care, such as limiting the use of self-glucose monitoring supplies.

Acknowledgment. Some aspects of this information were presented at the Society of General Internal Medicine Conference in May 2001 and at the Veterans Affairs Health Services Research and Development Conference in February 2000.

REFERENCES