Poor Glycemic Control Increases Risk of Hospitalization in Urban African Americans with Diabetes

Curtiss B. Cook, MD; Joseph G. Hentz, MS; Circe Tsui, BBA; David C. Ziemer, MD; Dorothy B. Naylor, MN; William J. Miller, PhD

Objective: Hospitalizations due to diabetes are more frequent among African Americans, but risk factors are not known. We analyzed data from an urban African American patient population to identify variables associated with hospitalizations attributable principally to diabetes.

Design: Demographic, disease, and metabolic characteristics on patients seen in an outpatient diabetes clinic during 1991 to 1997 were extracted from an electronic patient tracking system. Data were linked to a statewide hospital discharge dataset to capture all in-state hospitalizations from 1998 to 2001. Persons who required a hospitalization for diabetes were compared to the remainder of individuals in the database.

Results: A total of 3397 diabetes patients (average age 56 years; 65% women; 92% African American) were included in the analysis; 12% had a hospitalization primarily due to diabetes. Persons with a diabetes hospitalization were younger and had diabetes longer, and fewer were women. In addition, persons who had a diabetes-related hospitalization had evidence of poorer glycemic control with higher hemoglobin A1C (HbA1C) levels. Both the absolute change and rate of decline in HbA1C was less in persons who were hospitalized. In adjusted analyses, duration of diabetes and HbA1C remained significantly associated with risk of a diabetes hospitalization.

Conclusions: In this predominantly African American patient sample with diabetes, poorer glycemic control increased the chances of hospitalization due to diabetes. Continued efforts to aggressively control hyperglycemia could decrease the need for a diabetes hospitalization in this population. (*Ethn Dis*. 2006; 16:880–885)

Key Words: African American, Diabetes, Hospitalizations

From the Division of Endocrinology (CBC) and the Biostatistics Unit (JGH), Mayo Clinic Arizona, Scottsdale, Arizona; the Emory University Schools of Medicine (CT, DCZ) and the Georgia Hospital Association (DBN), Atlanta, Georgia; and the Department of Health Sciences, Western Carolina University, Cullowhee, North Carolina (WJM).

Introduction

Diabetes mellitus is a major cause of morbidity in the United States.[1] More than 7% of the US population is now affected by diabetes, and its prevalence is increasing.[2] Diabetes is expected to rise dramatically over the next several years, and the greatest increases are anticipated to occur in minority populations.[3,4]

The frequency of hospitalization is increased among persons with diabetes.[5] Diabetes is the fourth leading comorbid condition associated with any US hospital discharge.[6] In 2001 in the United States, 562,000 hospital discharges listed diabetes as a principal diagnosis, and >4 million listed diabetes as a codiagnosis.[1,7,8] Nearly one third of diabetes patients may require two or more hospitalizations in any given year,[9] and inpatient stays account for the largest proportion of direct medical expenses incurred by persons with the disease.[10]

Diabetes disproportionately affects minority populations, who have higher disease prevalence[1] and more complications.[11,12] Diabetes disparities also extend to hospitalization risk. African Americans with diabetes have higher rates of hospitalization due to diabetes,[13,14] and the risk of being hospitalized for a diabetes-related cause is more than twice as high among non-Hispanic Blacks vs Whites.[15] In addition, compared to Whites, Blacks had a longer length of stay and accrued higher hospital charges when hospitalized for diabetes.[15] Diabetes-related diagnoses were one of the major causes underlying hospitalization in a cohort of patients composed mainly of African Americans.[16] If effective risk assessment and prevention strategies are to be developed to reduce inpatient stays for African Americans with diabetes, more information is needed about the demographic, disease, or metabolic variables that might increase the risk of a diabetes-related hospitalization in this group. To identify which characteristics are associated with a diabetes hospitalization, we analyzed data from a large cohort of African Americans with diabetes who were receiving care through an urban outpatient clinic.

To identify which characteristics are associated with a diabetes hospitalization, we analyzed data from a large cohort of African Americans with diabetes who were receiving care through an urban outpatient clinic.

Address correspondence and reprint requests to Curtiss B. Cook, MD; Division of Endocrinology; Mayo Clinic; 13400 East Shea Boulevard; Scottsdale, AZ 85259; Cook.Curtiss@mayo.edu

Methods

Patient Population

Patients selected for analysis were adults ≥18 years of age who received care through an outpatient diabetes

clinic affiliated with a county hospital system located in metropolitan Atlanta, Georgia. Previous reports have detailed the characteristics of the patient population served by the health system and have consistently shown that members typically lack health insurance, are low income, mostly have type 2 diabetes, and are African American.[17–19]

Beginning in 1991, a longitudinal electronic diabetes patient tracking system (DPTS) was established to record demographic, pharmacologic, and metabolic parameters on all patients who received care at the diabetes clinic. Over the years, the DPTS has been used in numerous and varied analyses, and its validity is well established.[17,19–25] During a 10-year period (1992–2001), the racial/ethnic mix of the diabetes patient population has remained 90% African American.[26]

Data Extraction

The study population was the cohort of diabetes patients seen in the clinic between 1991 to 1997. To include discharge data from hospitalizations that occurred both within and outside the public hospital system, we extracted data from the DPTS on patients who had a visit at the clinic between 1991 and 1997 and linked this file with the discharge dataset of the Georgia Hospital Association (GHA) for the calendar years 1998 to 2001. The GHA did not start accruing full calendar-year discharge information until January 1, 1998, which is why our hospitalization data begin with that year. Nearly all the hospitals in the state submit data to the GHA. The DPTS provided the demographic variables, disease characteristics, and metabolic factors that were included in the analysis to assess the risk of a diabetes-related hospitalization.

The electronic file returned from the GHA contained data on which patients had a hospital discharge for the period between 1998 and 2001. Discharges principally due to diabetes were identified by using *International Classification of Diseases, 9th Revision, Clinical Modification* codes 250.xx; if a patient had more than one diabetes hospitalization, the date of the first diabetes-related discharge was used to classify the patient as having a diabetes hospitalization. Thus, the DPTS patients were stratified into two categories: those who had a diabetes hospitalization (cases), and patients who had no diabetes hospitalization (controls). The cases included the subset of patients who only had a diabetes discharge plus persons who had a diabetes discharge but who also may have had a discharge for some other reason during 1998 to 2001. The controls consisted of patients who had no hospitalizations plus individuals who had no record of a diabetes discharge diagnosis but had a hospitalization for some other reason.

Analytic Design

The diabetes clinic began recording metabolic data in the DPTS in 1991. Hospitalizations throughout the state of Georgia were recorded in the GHA discharge database starting in 1998. Therefore, we evaluated how well data between 1991 and 1997 (baseline exposure period) could predict whether a patient was hospitalized primarily because of diabetes between 1998 and 2001 (hospitalization period). Thus, all patients had known diabetes before the hospitalization period, and the baseline period represents the time when patients would have been exposed to the metabolic factors that might predispose to a diabetes hospitalization. To be included in the analysis, the DPTS had to show that the patient was present in the health system both during the baseline exposure period and the hospitalization period. The analysis was further limited to patients who had type 2 diabetes. During the baseline exposure period, laboratory techniques to determine hemoglobin A1C (HbA1C), lipids, and urinary albumin/creatinine ratio did not change.[23,25,27]

Statistical Analysis

The following characteristics were assessed: age, sex, race/ethnicity, diabetes duration (self-reported), body mass index, systolic blood pressure, HbA1C, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, triglycerides, total cholesterol, and urinary albumin/creatinine ratio. Age was the patient's age on December 31, 1997. Duration of diabetes was from the time of reported diagnosis to December 31, 1997. Body mass index (BMI) was calculated by using the height from the first visit at the diabetes clinic between 1991 and 1997. Weight, systolic blood pressure, HbA1C, LDL cholesterol, HDL cholesterol, triglycerides, total cholesterol, and urinary albumin/creatinine ratio levels for the analysis were from the most recent annual average before 1998. Finally, we calculated the absolute and annual rates of change in metabolic markers from the first annual average level to the most recent annual average level for persons who had data available for at least two years.

The prevalence of characteristics and mean levels was compared between the "diabetes hospitalization" patients and the "no diabetes hospitalization" patients. Statistical significance was calculated by using the Pearson χ^2 statistic or the two-sample t statistic. In addition, multiple logistic regression was used to create a multivariable model. A forward selection strategy was used because of the large number of variables. Terms were included in the model if the nominal adjusted level of significance was $<.001$. Terms were also tested for all pairwise interactions among factors that were nominally significant at the .05 level in the univariable comparisons. Interaction terms were included in the model if the nominal adjusted significance level was $<.0001$. Models resulting from other inclusion criteria were also explored, and these models were compared by using the Akaike information criterion. No other modeling

strategy produced a model that improved the statistic for model fit. The diagnostic power for predicting diabetes hospitalization with the multivariate model was calculated by using the jackknife method. We used receiver-operating characteristics analysis to determine the cutoff score that yielded the highest likelihood ratio.[28] Analyses and procedures were approved by the institutional review boards of the participating institutions.

Table 1. General characteristics of 3397 diabetes patients

Characteristic	Total Number	Value*
Age, years	3397	56 (13)
Female sex	3397	65%
African American race	3397	92%
Diabetes duration, years	3397	8.4 (7.7)
BMI, kg/m^2	3393	32.5 (7.8)
Hb1AC, %	3377	8.5 (2.4)
Systolic blood pressure, mm Hg	3381	128 (19)
Urinary albumin/creatinine ratio, mg/g	303	2.0 (1.6)
Lipids, mg/dL		
Low-density lipoprotein	3295	134 (40)
High-density lipoprotein	3389	47 (15)
Triglycerides	3389	170 (190)
Total cholesterol	3391	204 (49)

* Data are mean (standard deviation) or frequency (percentage).
BMI=body mass index; HbA1C=hemoglobin A1C.

RESULTS

General Patient Characteristics

A total of 3397 patients with type 2 diabetes were included in the analysis (Table 1). The average age was 56 years, 65% were women, and 92% were African American. Mean diabetes duration was 8.4 years, BMI was 32.5 kg/m^2, HbA1C was 8.5%, systolic blood pressure was 128 mm Hg, and albumin/creatinine ratio was 2-mg albumin to 1-g creatinine. Average lipid levels were 134 mg/dL for LDL, 47 mg/dL for HDL, 170 mg/dL for triglycerides, and 204 mg/dL for total cholesterol (Table 1). Of these 3397 patients, 63% required hospitalization for some reason but 12% had evidence of a hospitalization with diabetes as the principal diagnosis.

Characteristics of Diabetes vs No Diabetes Discharges

Persons who had evidence of a hospitalization principally due to diabetes were slightly but significantly younger but had diabetes longer compared with persons without a diabetes discharge (Table 2). Fewer women had evidence of a diabetes discharge. Patients who had a hospitalization for diabetes had significantly higher average HbA1C values during the baseline exposure period compared to persons with no diabetes hospitalization. No significant differences were detected in race, BMI, systolic blood pressure, LDL cholesterol, HDL cholesterol, triglycerides, total cholesterol, or urinary albumin/creatinine ratio (Table 2).

Changes in Metabolic Variables

To assess the magnitude of changes in metabolic variables occurring over time, we calculated the absolute change for all patients from the first annual average level to the most recent average annual level for persons who had data available for at least two years. During the baseline exposure period, BMI (n=2082) increased overall an average ($\pm$ standard deviation) of .5 $\pm$ 3.0 kg/m^2, HbA1C (n=2020) declined by .5% $\pm$ 2.7%, and systolic blood pressure (n=2085) increased 5 $\pm$ 20 mm Hg. Low density lipoprotein (LDL) cholesterol (n=1191), triglycerides (n=1241), and total cholesterol (n=1694) decreased an average of 13 $\pm$ 36, 5 $\pm$ 200, and 9 $\pm$ 46 mg/dL, respectively, and HDL cholesterol (n=1238) and urinary albumin/creatinine ratio (n=52) increased by 4 $\pm$ 11 mg/dL and .5 $\pm$ 1.7 mg/g.

When comparing the absolute change in average values of the metabolic variables during the baseline exposure period, persons who had a diabetes hospitalization had less of a decline in the absolute value of HbA1C. Hemoglobin A1C (HbA1C) decreased an average of .2% in the diabetes hospitalization group but .6% in the no diabetes hospitalization group (P=.05). Low-density lipoprotein (LDL) cholesterol decreased less (by 5 mg/dL) in the diabetes hospitalization group compared to the no diabetes hospitalization patients (decreased by 13 mg/dL, P=.02). The rate of decline in HbA1C was also lower in the diabetes hospitalization patients. In the diabetes hospitalization group, HbA1C fell an average of .1% per year, but declined by .3% per year in the no diabetes hospitalization patients (P=.04). No significant differences in rate of change were seen in the other metabolic variables.

Variables Associated With a Risk of Diabetes Hospitalization

A regression model (Table 3) was constructed to determine which variables were predictive of having a diabetes hospitalization. The risk of hospitalization primarily due to diabetes rose with increasing diabetes duration and with higher HbA1C levels. The regression model yielded a simple equation score that evaluated the likelihood of having a diabetes hospitalization in this population. The equation to calculate the score is:

$$\text{Score} = -3.86 + .0405 * \text{diabetes duration (years)} + .167 * \text{HbA1C (\%)}$$

Table 2. Differences between patients with or without diabetes hospitalizations

Characteristic	Diabetes Hospitalization		No Diabetes Hospitalization		*P* value
	Value*	No.	Value*	No.	
Age, years	54 (13)	407	57 (13)	2990	<.001
Diabetes duration, years	10.8 (8.5)	407	8.0 (7.5)	2990	<.001
Female sex	55%	407	66%	2990	<.001
African American race	93%	407	91%	2990	.25
BMI, kg/m^2	31.9 (7.4)	407	32.6 (7.9)	2986	.06
HbA1C, %	9.5 (2.7)	402	8.4 (2.4)	2975	<.001
Systolic blood pressure, mm Hg	127 (21)	401	129 (19)	2980	.49
Lipids, mg/dL					
Low-density lipoprotein	136 (41)	396	134 (39)	2899	.44
High-density lipoprotein	48 (16)	406	47 (15)	2983	.15
Triglycerides	170 (200)	406	170 (190)	2983	.58
Total cholesterol	206 (52)	406	204 (49)	2985	.37
Urinary albumin/creatinine ratio, mg/g	2.3 (1.8)	50	1.9 (1.5)	253	.08

* Data are mean (standard deviation) or frequency (percentage).
BMI=body mass index; HbA1C=hemoglobin A1C.

A patient with a score greater than −.94 had a 28% chance of having a hospitalization due to diabetes within the next three years, while a patient with a score not greater than −.94 had a 12% chance of hospitalization due to diabetes within the next 3 years.

DISCUSSION

Recent data have shown that non-Hispanic Blacks have high rates of hospitalization attributable to diabetes.[13–16] The economic impact is greater as well; non-Hispanic Blacks require a longer length of stay and accrue greater hospital charges.[15,16] However, little data describe what factors may increase hospitalization risk in African American patient populations.

We used a large, well-established clinical database to assess variables associated with a diabetes hospitalization in what historically has been a disadvantaged African American patient population. Although the patients in our sample obtained care through an outpatient diabetes program of a large urban public hospital system, they still could have sought hospitalization elsewhere, and previous data indicated that 44% of patients seen in the clinic were admitted to some other facility.[16] The ability to link our clinical data with a larger, state-level discharge data warehouse permitted us to include most discharges occurring in Georgia. In the adjusted analysis, diabetes duration and HbA1C were both significantly associated with the likelihood of having a hospitalization principally for a diabetes cause. The equation that describes the relationship between these variables and a diabetes hospitalization may be useful in the assessment of risk in the outpatient setting for this study population and requires prospective evaluation.

Table 3. Results of multiple logistic regression model and variables significantly associated with a diabetes discharge*

Factor	OR	95% CI	*P* value
Diabetes duration, per 10-year increase	1.50	1.33–1.69	<.001
HbA1C, per 3-percentage point increase	1.65	1.46–1.86	<.001

* Compared with ''no diabetes hospitalization'' group; other variables in Table 2 are not significant.
OR=odds ratio; CI=confidence interval.

Data from the United Kingdom Prospective Diabetes Study indicate that as the duration of diabetes increases, hyperglycemia worsens.[29,30] Our analysis indicates that longer diabetes duration is also related to the risk of hospitalization. Prior reports on the association between the severity of glycemic control and risk of hospitalization are limited but suggest that higher HbA1C levels are associated with more inpatient stays.[31] We found a similar relationship in our data, in which higher HbA1C levels significantly increased the chances for a diabetes-related hospital stay.

While diabetes duration is not a modifiable risk factor, glycemic control can be improved with effective

In the adjusted analysis, diabetes duration and HbA1C were both significantly associated with the likelihood of having a hospitalization principally for a diabetes cause.

outpatient management; control of hyperglycemia can reduce diabetes complications,[29,30,32] and that reduction in HbA1C can lead to lower healthcare utilization and a potentially positive economic impact on the healthcare system.[33–35]

What is less clear is whether outpatient improvements in HbA1C lower the number of hospitalizations among diabetes patients.[35] Previous analyses, however, aggregated all hospitalizations and did not distinguish between the different diagnoses.[35] Glycemic control would not likely have any impact on hospitalizations due to such causes as trauma, elective procedures, or psychiatric diseases, so when assessing the connection between glycemic control and hospital risk among diabetes patients, specific diagnoses should be considered. Given the relationship between outpatient HbA1C and risk of diabetes hospitalization in our data, closer collaboration between the hospital system and its outpatient affiliates to promote good glycemic control in the ambulatory setting would seem reasonable and could decrease the effect of the disease on the acute care facility.

Our retrospective study design and the structure of the DPTS dataset imposed some limitations on our analysis. Although the DPTS contains pharmacotherapy data, numerous medication classes are available to treat hyperglycemia, and the complex and changing types and doses of medications that most likely occurred during the baseline exposure period preclude incorporating them into a retrospective study design. Furthermore, the patients we studied received care from a specialty outpatient diabetes program with extensive experience in caring for urban African Americans. Therefore, the variables associated with a diabetes hospitalization in this group, and the associated equation derived from the regression model, may not apply to other types of clinical settings or to other racial/ethnic populations.

Despite these limitations, our study provides insight on variables that increase the risk for a diabetes hospitalization in this largely African American patient population. These variables can be incorporated into a model that may be useful in assessing outpatients at risk for a hospitalization. Although diabetes duration cannot be modified, hyperglycemia can be effectively managed. Additional studies are needed to determine whether good glycemic control translates into lower rates of hospitalization due to diabetes in African American patients such as the one studied here.

ACKNOWLEDGMENTS

This report was made possible through a cooperative agreement between the Association of Teachers of Preventive Medicine (ATPM) and the Centers for Disease Control and Prevention (CDC), award number U50/CCU300860 TS-0760; its contents are the responsibility of the authors and do not necessarily reflect the official views of ATPM or CDC.

REFERENCES

1. Engelgau MM, Geiss LS, Saaddine JB, et al. The evolving diabetes burden in the United States. *Ann Intern Med*. 2004;140:945–950.
2. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA*. 2003;289:76–79.
3. Wild S, Roglic G, Green A, Sicree R, Hilary K. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care*. 2004;27:1047–1053.
4. Boyle JP, Honeycutt AA, Venkat Narayan KM, et al. Projection of diabetes burden through 2050. *Diabetes Care*. 2001;24:1936–1940.
5. Aubert RE, Geiss LS, Ballard DJ, Cocanougher B, Herman WH. Diabetes-related hospitalization and hospital utilization. In: *Diabetes in America*. Bethesda, Md: National Institutes of Diabetes and Digestive Diseases; 1995:553–563.
6. Elixhauser A, Yu K, Steiner C, Bierman AS. *Hospitalization in the United States, 1997*. Rockville, Md: Agency for Healthcare Research and Quality; 2000.
7. Centers for Disease Control and Prevention. *Hospitalizations for Diabetes as Any-Listed Diagnosis*. Atlanta, Ga: CDC; 2004.
8. Centers for Disease Control Prevention. *Hospitalization for Diabetes as First-Listed Diagnosis*. Atlanta, Ga: CDC; 2004.
9. Jiang HJ, Stryer D, Friedman B, Andrews R. Multiple hospitalizations for patients with diabetes. *Diabetes Care*. 2003;26:1421–1426.
10. American Diabetes Association. Economic costs of diabetes in the US in 2002. *Diabetes Care*. 2003;26:917–932.
11. Carter JS, Pugh JA, Monterrosa A. Non-insulin-dependent diabetes mellitus in minorities in the United States. *Ann Intern Med*. 1996;125:221–232.
12. Centers for Disease Control and Prevention Division of Disease Translation. *1999 Diabetes Surveillance Report*. Atlanta, Ga: CDC, Dept of Health and Human Services; 2000.
13. Elixhauser A, Harris R, Coffey RM. *Trends in Hospital Diagnoses for Black Patients and White Patients: 1980–1987*. Rockville, Md: Public Health, Agency for Health Care Policy and Research; 1995. Service Provider Studies Research Note 24.
14. Davis SK, Liu Y, Gibbons GH. Disparities in trends of hospitalization for potentially preventable chronic conditions among African Americans during the 1990s: implications and benchmarks. *Am J Public Health*. 2003;93:447–455.
15. Cook CB, Naylor DB, Hentz JG, et al. Disparities in diabetes-related hospitalizations: relationship of age, sex, and race/ethnicity with hospital discharges, lengths of stay, and direct inpatient charges. *Ethn Dis*. 2006;16(1):126–131.
16. Cook CB, Tsui C, Ziemer DC, Naylor DB, Miller WJ, Hentz JG. Common reasons for hospitalization in urban diabetes patients. *Ethn Dis*. 2006;16(2):391–397.
17. Ziemer DC, Goldschmid M, Musey VC, et al. Diabetes in urban African Americans. III. Management of type II diabetes in a municipal hospital setting. *Am J Med*. 1996;101:25–33.
18. Wheeler K, Crawford R, McAdams D, et al. Inpatient to outpatient transfer of care in urban diabetes patients: patterns and determinants of immediate post-discharge follow-up. *Arch Intern Med*. 2004;164:447–453.
19. Rhee MK, Cook CB, Dunbar VG, et al. Limited healthcare access impairs glycemic control in urban African Americans with type 2 diabetes. *J Health Care Poor Underserved*. 2005;16:734–746.
20. Thaler LM, Ziemer DC, Gallina DL, et al. Diabetes in urban African Americans. XVII. Availability of rapid hemoglobin A1C measurements enhances clinical decision-making (abstract). *Diabetes*. 1999;48:A191.
21. Cook CB, Ziemer DC, El-Kebbi IM, et al. Diabetes in urban African Americans. XVI. Overcoming clinical inertia improves glycemic

control in patients with type 2 diabetes. *Diabetes Care*. 1999;22:1494–1500.
22. Thaler LM, Ziemer DC, El-Kebbi IM, Gallina DL, Cook CB, Phillips LS. Diabetes in urban African Americans. XIX. Prediction of the need for pharmacological therapy. *Diabetes Care*. 2000;23:820–825.
23. Cook CB, Erdman DE, Ryan GJ, et al. The pattern of dyslipidemia among urban African Americans with type 2 diabetes. *Diabetes Care*. 2000;23:319–324.
24. Cook CB, Mann LJ, King EC, et al. Management of insulin therapy in urban diabetes patients is facilitated by use of an intelligent dosing system. *Diabetes Technol Ther*. 2004;6:326–335.
25. Rhee MK, Slocum W, Ziemer DC, et al. Patient adherence improves glycemic control. *Diabetes Educator*. 2005;31:240–250.
26. Dunbar VG, King EC, George CD, et al. Evolving demographics and disparities in an urban diabetes clinic: implications for diabetes education and treatment. *Ethn Dis*. 2005; 15:173–178.
27. Thaler LM, El-Kebbi IM, Ziemer DC, et al. High prevalence of albuminuria among African Americans with short duration of diabetes [letter]. *Diabetes Care*. 1998;21:1576–1577.
28. Lang TA, Secic M. *Determining the Presence or Absence of Disease: Reporting the Characteristics of a Diagnostic Test*. Philadelphia, Pa: American College of Physicians; 1997.
29. Anonymous. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). UK Prospective Diabetes Study (UKPDS) Group. *Lancet*. 1998;352:837–853.
30. Anonymous. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). UK Prospective Diabetes Study (UKPDS) Group. *Lancet*. 1998;352:854–865.
31. Menzin J, Langley-Hawthorne C, Friedman M, Boulanger L, Cavanaugh R. Potential short-term economic benefits of improved glycemic control. *Diabetes Care*. 2001;24: 51–55.
32. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications of insulin-dependent diabetes mellitus. *N Engl J Med*. 1993;329:977–986.
33. Testa MA, Simonson DC. Health economic benefits and quality of life during improved glycemic control in patients with type 2 diabetes mellitus. *JAMA*. 1998;280: 1490–1496.
34. Wake N, Hisashige A, Katayama T, et al. Cost-effectiveness of intensive insulin therapy for type 2 diabetes: a 10-year follow-up of the Kumamoto study. *Diabetes Res Clin Pract*. 2000;48:201–210.
35. Wagner EH, Sandhu N, Newton KM, McCulloch DK, Ramsey SD, Gorthaus LC. Effect of improved glycemic control on healthcare costs and utilization. *JAMA*. 2001;285:182–189.

AUTHOR CONTRIBUTIONS

Design concept of study: Cook, Ziemer, Naylor
Acquisition of data: Cook, Tsui, Ziemer, Naylor, Miller
Data analysis interpretation: Hentz, Tsui, Ziemer, Miller
Manuscript draft: Cook, Hentz
Statistical expertise: Hentz
Acquisition of funding: Cook
Administrative, technical, or material assistance: Tsui, Ziemer, Naylor, Miller
Supervision: Cook