RELATIONSHIP OF DIABETES WITH CARDIOVASCULAR DISEASE-RELATED HOSPITALIZATION RATES, LENGTH OF STAY, AND CHARGES: ANALYSIS BY RACE/ETHNICITY, AGE, AND SEX

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Objective: Determine relationship of diabetes with risk of cardiovascular disease hospitalizations and the effect on hospital length of stay and charges.

Design: A cross-sectional analysis of Georgia hospital discharge data for 1998 through 2001.

Patients: Patients hospitalized principally with one of six cardiovascular disease (CVD) conditions (myocardial infarction, ischemic heart disease, cardiac dysrhythmia, heart failure, cerebrovascular events, peripheral vascular disease) were identified in the hospital discharge data.

Main Outcome Measures: Aggregated CVD-related hospitalization rates, length of stay, and charges were compared by presence of diabetes. Analyses were adjusted for age, sex, and race/ethnicity.

Results: A total of 3,900,337 discharges were recorded between 1998 to 2001. Of these, 468,957 discharges (12%) had one of the six selected CVD diagnoses (average age 67 years, average length of stay 4.7 days, average total charge $15,702, 48% women, 76% non-Hispanic Whites, 22% non-Hispanic Blacks, and 1% Hispanics). Diabetes was a concurrent diagnosis in 30% of these CVD-related discharges. CVD hospitalization rates were significantly higher and length of stay and total charges were significantly greater among non-Hispanic Whites and Blacks—but not in Hispanics—with diabetes compared to persons without diabetes. Diabetes had a similar effect on CVD hospitalizations among men and women, but the effect of diabetes was lessened with increasing age.

Conclusion: These data suggests that aggressive outpatient modification of metabolic abnormalities in diabetes patients should be attempted to decrease risk of CVD-related hospitalization and lower the economic impact of these combined conditions. (*Ethn Dis*. 2007;17:714–720)

Key Words: Cardiovascular Disease, Diabetes, Hospitalizations, Length of Stay

INTRODUCTION

Cardiovascular disease (CVD) and diabetes mellitus each account for a large number of hospitalizations annually in the United States. In 2002, >4 million discharges listed heart disease as the principal diagnosis.[1] That same year, diabetes was listed as the principal diagnosis in nearly 600,000 hospital discharges.[2] When diabetes is coded as either a primary or secondary diagnosis, the total number of hospitalizations is >5 million per year.[3] Nearly one third of persons with diabetes required two or more hospitalizations in 1999,[4] and inpatient costs represent the largest proportion of direct medical expenses incurred by diabetes patients.[5]

The impact of diabetes on rates of CVD hospitalizations has been investigated only on a limited basis.[6–11] However, previous reports did not adequately adjust for age, sex, or race/ethnicity.[6–11] We have recently shown that in a large, statewide discharge dataset that "diseases of the circulatory system" was the most common hospital discharge category among diabetes patients.[12] In a subset of patients from this same dataset, we found that among urban African American with diabetes that "diseases of the circulatory system" also was the most common hospital discharge category.[13] To develop a comprehensive understanding of the relationship between diabetes and CVD-related hospitalizations, we analyzed a statewide hospital dataset to investigate differences in rates of CVD discharges by diabetes status, also including an assessment of length of stay (LOS) and direct medical charges and making comparisons by age, sex, and race/ethnicity.

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METHODS

Data Source and Methods

Hospital discharge data were obtained from the Georgia Discharge Data Set maintained by the Georgia Hospital Association. Beginning in 1997, all nonfederal community and specialty hospitals in the state were required by statute to report full calendar-year inpatient records; this process was fully implemented in 1998. Our prior experiences with this dataset have previously been published.[12–14]

A search was made of the dataset for six commonly investigated CVD categories[1,2,6] and for diabetes diagnoses using diagnostic codes from the *International Classification of Diseases*, *9th Revision*, *Clinical Modification* (ICD-9-CM). These CVD diagnostic categories (and corresponding ICD-9-CM codes) were myocardial infarction (410), ischemic heart disease (411–414), cardiac dysrhythmia (427), heart failure (428), cerebrovascular events (430–438), and peripheral vascular disease (440.21–440.24). Analyses focused on those discharges where one of these six CVD disease categories was listed as the principal diagnosis. The ICD-9-CM code 250 identified discharges with a diabetes diagnosis in the remaining diagnostic fields.[4,15–17] Retrieved data also included information on patient age, sex, race/ethnicity, LOS, and total inpatient charges. The total charges in the dataset represent the sum of everything related to the medical claim (room charge, pharmacy, radiology) for which the hospital billed.[14]

Data Analysis

Hospitalizations were counted for calendar years 1998 through 2001; discharge data of pregnant women and persons <18 years of age were excluded. The aggregate rate of the selected CVD hospitalizations among people with diabetes was compared with the CVD hospitalization rates, LOS, and charges among people without diabetes. Individual patient identifiers (eg, name, social security number) were not included in the data, so per capita hospitalization rates or readmission rates could not be calculated. Therefore, the unit of analysis was the discharge, and we report discharge rates per unit of population time. Comparisons were standardized using the Georgia population. CVD hospitalizations with diabetes were standardized to the Georgia population with diabetes, and CVD hospitalizations without diabetes were adjusted to the Georgia population without diabetes. CVD-related LOS and direct hospital charges were similarly examined by diabetes status. Rates were calculated separately for each age, sex, and race/ethnicity stratum as the number of hospitalizations (or days or charges) for that stratum divided by the sum of the population of the stratum in 1998, 1999, 2000, and 2001. The denominators for the rates were the person-years of exposure in the population of Georgia during the study period. We used 30 strata composed of five age categories, three ethnicity/race categories, and two sex categories.

The Georgia population with diabetes between 1998 and 2001 was estimated by multiplying the size of the state population by the estimated prevalence of diabetes. Diabetes prevalence was estimated by using data from the National Health and Nutrition Examination Survey (NHANES) 1999–2002, which includes estimates of both diagnosed and undiagnosed diabetes.[18] We included undiagnosed diabetes in prevalence estimates because the counts of hospitalizations with diabetes in the discharge data likely included persons who were diagnosed only during inpatient stays (ie, undiagnosed before admission), and it was not possible to distinguish between them and persons with known diabetes. The standard errors of the prevalence of diabetes for each stratum were calculated by using the Taylor series method with SUDAAN software version 9. The standard errors of the resulting rates were then calculated by using the delta propagation method. Computations for rates were performed by using SAS software version 9.

We report standardized rates of hospitalizations per 10,000 person-years, standardized rate differences, and standardized rate ratios. Hospital discharge rates are reported both for aggregate and for each of the six CVD diagnoses included here. In the adjusted comparisons, we determined the effect of sex while controlling for age and race/ethnicity, the effect of race/ethnicity while controlling for age and sex, and the effect of age while controlling for race/ethnicity and sex.

RESULTS

Characteristics of CVD Hospitalizations

There were 3,900,337 hospital discharges in Georgia between 1998 and 2001. Of these, 468,957 (12%) had one of the CVD codes listed as the principal diagnosis. The average age of patients hospitalized under a CVD diagnosis code was 67 years, and the average LOS was 4.7 days. Median total charges were $15,702; charges were recorded in 98% of discharges. In addition, 48% of primary CVD discharges were women, 76% were non-Hispanic Whites, 22% were non-Hispanic Blacks, and the remainder belonged to other racial/ethnic groups (Hispanics, Native Americans, Asian). Of these other groups, Hispanics were the largest (1% of all discharges) and were included in the analyses.

CVD Discharge Rates by Diabetes Status

Coexisting diabetes was present in 30% of the hospitalizations that listed one of the selected CVD conditions as the principal diagnosis. For CVD hospitalizations without diabetes, ischemic heart disease was the most common

Table 1. Principal cardiovascular disease-related hospitalizations (per 10,000 person-years), by diabetes status and age, sex, and race/ethnicity*†

Factor	SR		SRD (95% CI)	SRR (95% CI)
	Diabetes	No diabetes		
All CVD	369	172	197 (47–346)	2.1 (1.4–3.3)
Age, years				
18–29	62	3	58 (–57–174)	18 (2.7–116)
30–39	96	16	79 (2–156)	5.8 (2.6–13)
40–49	323	67	256 (79–433)	4.8 (2.7–8.6)
50–59	503	196	307 (144–470)	2.6 (1.8–3.7)
≥60	1067	697	369 (189–550)	1.5 (1.3–1.8)
Sex				
Male	354	193	161 (15–307)	1.8 (1.2–2.9)
Female	383	153	230 (79–381)	2.5 (1.6–3.9)
Ethnicity				
Non-Hispanic White	415	193	222 (72–371)	2.2 (1.5–3.2)
Non-Hispanic Black	308	145	163 (17–309)	2.1 (1.2–3.7)
Hispanic	65	31	34 (−80–147)	2.1 (0.4–13)

CVD, cardiovascular disease; SR, standardized rate; SRD, standardized rate difference; SRR, standardized rate ratio.
* Each category adjusted for age, sex, and race/ethnicity.
† Represents aggregate of 6 cardiovascular diagnoses searched.

diagnosis (28%), followed by cerebrovascular events (22%), heart failure (19%), myocardial infarction (16%), dysrhythmia (13%), and peripheral vascular disease (2%). For CVD hospitalizations with associated diabetes, ischemic heart disease was still the most frequent diagnosis (28%), but heart failure occurred with a higher frequency (27%), followed by cerebrovascular events (20%), myocardial infarction (14%), dysrhythmia (7%), and peripheral vascular disease (4%).

The aggregate discharge rate for the six CVD diagnoses was significantly higher among persons with diabetes than among persons without diabetes (Table 1), with more than a two-fold increase in the diabetes patients and a difference of nearly 200 discharges per 10,000 person-years compared to persons without diabetes. In all age groups, CVD hospitalizations were higher for patients with diabetes than for patients without diabetes, although the relative impact of diabetes was less with increasing age. Men and women with diabetes had higher rates of CVD hospitalizations than men and women without diabetes. Non-Hispanic Whites and Blacks with diabetes had higher rates of CVD hospitalizations compared with the population without diabetes; persons of Hispanic race/ethnicity also had higher rates, but differences were not significant (Table 1).

Diabetes was associated with a significantly higher rate of hospitalization for 5 of the 6 CVD conditions examined (Table 2); dysrhythmia was the only condition with which diabetes was not significantly associated with greater discharges. If we sum over all categories, non-Hispanics had 22 million person-years of exposure and Hispanics had 1 million person-years of exposure, for a ratio of 22:1. Men had 11 million person-years of exposure while women had 12 million person-years of exposure, for a ratio of 0.92:1.

Table 2. Individual cardiovascular disease-related hospitalizations (per 10,000 person-years) by diabetes status*

CVD diagnosis code	SR		SRD (95% CI)	SRR (95% CI)
	Diabetes	No diabetes		
Peripheral vascular disease	14	4	10 (5–15)	3.6 (2.4–5.4)
Heart failure	98	33	66 (21–110)	3.2 (2–5.3)
Ischemic heart disease	112	48	64 (12–117)	2.5 (1.5–4.2)
Myocardial infarction	52	26	26 (4–47)	2.2 (1.2–4)
Cerebrovascular events	67	39	28 (3–53)	1.9 (1.2–2.8)
Dysrhythmia	25	22	3 (−7–13)	1.2 (0.8–1.8)

CVD, cardiovascular disease; SR, standardized rate; SRD, standardized rate difference; SRR, standardized rate ratio.
* Each category adjusted for age, sex, and race/ethnicity.

Table 3. Cardiovascular disease-related hospital length of stay (days per 10,000 person-years), by diabetes status and age, sex, and race/ethnicity*†

Characteristic	SR		SRD (95% CI)	SRR (95% CI)
	Diabetes	No diabetes		
All	1739	807	932 (247–1617)	2.2 (1.4–3.3)
Age, years				
18–29	319	18	301 (−303–906)	18 (2.7–120)
30–39	423	71	352 (1–702)	5.9 (2.5–14)
40–49	1350	275	1,074 (365–1784)	4.9 (2.8–8.5)
50–59	2223	814	1,410 (709–2111)	2.7 (1.9–3.9)
≥60	5349	3,404	1,945 (1048–2842)	1.6 (1.3–1.9)
Sex				
Male	1624	867	757 (58–1457)	1.9 (1.2–3.0)
Female	1847	751	1,095 (423–1767)	2.5 (1.6–3.7)
Ethnicity				
Non-Hispanic White	1859	843	1,017 (353–1680)	2.2 (1.5–3.3)
Non-Hispanic Black	1702	841	860 (64–1657)	2.0 (1.2–3.5)
Hispanic	315	153	161 (−376–699)	2.1 (0.4–12)

SR, standardized rate; SRD, standardized rate difference; SRR, standardized rate ratio.
* Each category adjusted for age, sex, and race/ethnicity.
† Represents aggregate of 6 cardiovascular diagnoses searched.

CVD Length of Stay by Diabetes Status

Among patients hospitalized for CVD, the presence of diabetes resulted in more hospital days per 10,000 person-years; CVD accompanied by diabetes resulted in >900 more hospital days per 10,000 person-years overall compared to discharges where diabetes was not involved (Table 3). The number of hospital days for the CVD population was significantly greater for persons with diabetes in all age groups (although the impact decreased with increasing age), both sexes, and among non-Hispanic Whites and Blacks; Hispanics with CVD and diabetes also had more hospital stays, although the differences were not significant.

After stratifying analyses by the presence of coexisting diabetes, we detected higher overall rates of CVD-related hospitalizations among patients with diabetes and for five of the six individual CVD diagnoses when diabetes was present.

CVD Total Inpatient Charges by Diabetes Status

The presence of diabetes was associated with higher direct inpatient charges for the six selected CVD hospitalizations with a coexisting diabetes diagnosis (Table 4). Diabetes contributed >$288 more per person-year compared with the costs for patients without diabetes, and total charges for patients with diabetes were more than two-fold higher than those for persons without diabetes. Age, sex, and race/ethnicity differences in charges followed the same statistical patterns as for hospitalization rates and LOS.

DISCUSSION

Diabetes increases the risk of multiple forms of atherosclerotic disease, including coronary artery, cerebrovascular, and peripheral vascular diseases.[19,20] Diabetes produces numerous metabolic abnormalities that likely account for the elevated CVD risk.[19,20] Both diabetes and CVD are frequent causes of hospitalization in the United States, but comprehensive analyses, which simultaneously consider age, sex, and race/ethnicity, are lacking on how diabetes influences CVD hospitalization rates, LOS, and charges. Our analysis of a large number of patients from a statewide discharge data was comprehensive in that it did consider age, sex, and race/ethnicity.

Diabetes was listed as a coexisting diagnosis in nearly one third of all hospitalizations where CVD was the primary diagnosis. After stratifying analyses by the presence of coexisting diabetes, we detected higher overall rates of CVD-related hospitalizations among patients with diabetes and for five of the six individual CVD diagnoses when diabetes was present. Hospitalization rates attributable to CVD were higher among patients with diabetes in all age groups and in both sexes.

A detailed examination of differences in CVD-related hospital discharges according to diabetes status

Table 4. Cardiovascular disease-related direct hospital charges (dollars per person-year), by diabetes status and age, sex, and race/ethnicity*†

Characteristic	SR		SRD (95% CI)	SRR (95% CI)
	Diabetes	No diabetes		
All	559	271	288 (57–518)	2.1 (1.3–3.2)
Age, years				
18–29	88	6	82 (−96–261)	16 (2.1–123)
30–39	155	26	129 (−4–262)	6.0 (2.5–14)
40–49	494	112	381 (112–650)	4.4 (2.5–7.8)
50–59	821	338	483 (213–753)	2.4 (1.7–3.5)
≥60	1558	1066	492 (228–756)	1.5 (1.2–1.8)
Sex				
Male	565	327	238 (3–472)	1.7 (1.1–2.7)
Female	553	219	334 (110–559)	2.5 (1.6–4.0)
Ethnicity				
Non-Hispanic White	638	307	331 (98–564)	2.1 (1.4–3.1)
Non-Hispanic Black	438	220	218 (15–421)	2.0 (1.2–3.4)
Hispanic	122	54	68 (−196–333)	2.3 (0.3–21)

SR, standardized rate; SRD, standardized rate difference; SRR, standardized rate ratio.
* Each category adjusted for age, sex, and race/ethnicity.
† Represents aggregate of six cardiovascular diagnoses searched.

and race/ethnicity has not been conducted previously. In our dataset, diabetes was associated with a higher rate of CVD hospitalizations in both non-Hispanic Whites and non-Hispanic Blacks. In a recently completed analysis of hospitalization data in a population of urban African Americans with diabetes, ''diseases of the circulatory system'' was the most common discharge diagnostic category, with congestive heart failure being the most common condition listed.[13]

Although we did find that Hispanics with diabetes in this dataset did have higher rates of CVD hospitalizations, longer LOS, and greater inpatient charges compared with the CVD population without diabetes, these differences were not significant. There could be several explanations for these observations. It is possible, as some authors have suggested,[21,22] that Hispanics may have a lower rate of CVD. A recent study of urban diabetes outpatients indicated that Hispanics have lower prevalences of heart disease and stroke.[23] On the other hand, Hispanics represent a diverse group with different countries of origin, and consequently, inaccurate reporting of race/ethnicity is possible in our data. To our knowledge, no hospital data relating to CVD, diabetes, and hospitalizations are available for this fast-growing US demographic group, and further study is therefore required to confirm the relationship among these variables in this population.

Given the increased risk conferred by diabetes, one area of future investigation would be to determine if there are modifiable factors that could predict a CVD hospitalization among the diabetes population. For instance, in a recently completed analysis, we found that among African Americans with diabetes, the odds of having a CVD-related hospital stay were greater with increasing age, diabetes duration, systolic blood pressure, and low-density lipoprotein cholesterol.[24] Variables such as systolic blood pressure and low-density lipoprotein cholesterol are potentially modifiable through pharmacologic intervention, and aggressive outpatient treatment of these metabolic abnormalities may have the potential to decrease the need for a CVD hospitalization among the diabetes population.

Our data indicate that the presence of diabetes was associated with a more than two-fold greater LOS among persons with a CVD-related hospitalization, which is in agreement with other studies.[9–11] When hospital charges were considered, the economic impact of CVD was higher in the presence of diabetes, after adjusting for age, race/ethnicity, and sex. Among the race/ethnic groups included in this analysis, diabetes was significantly associated with longer LOS and greater charges among non-Hispanic Whites and Blacks, but not among Hispanics. LOS and inpatient charges could serve as useful endpoints when planning and assessing cost-effectiveness of interventions designed to affect the care of the inpatient population with CVD and diabetes.

An unexpected outcome of our analysis was that the association of diabetes on CVD hospitalization rate, LOS, and charges was less with increasing patient age. One explanation for this observation is that among older patients with diabetes, other factors (eg, hypertension, hyperlipidemia) made greater contributions to the risk of CVD in addition to diabetes. The greatest contribution made by diabetes to CVD hospitalization risk occurred

among the youngest patients. It is likely that this youngest population represented the group with longstanding type 1 diabetes, and because of their young age, other risk factors for CVD may not have been present, thus enhancing the relationship of diabetes with CVD hospitalization.

There are some limitations to our study. First, we did not have unique patient identifiers, so our unit of analysis was individual discharges rather than individual patients; thus, we could not determine whether the presence of diabetes was associated with higher readmission rates among those with CVD. Second, underreporting of diabetes in hospital data may occur because of such factors as a lack of recognition of the disease, and all diabetes cases may not be identified.[25,26] Finally, our study included analysis of a discharge dataset only from a single state. A broader analysis of a national sampling of discharges would better explicate the influence of diabetes on the risk for CVD hospitalization.

In calculating the number of cases of diabetes in Georgia, we sought to take into account estimates of undiagnosed cases.[27] Accounting for undiagnosed diabetes was necessary because the dataset did not distinguish hospitalizations for patients with previously diagnosed diabetes from those with preexisting diabetes that may have been identified only during their hospitalization. To incorporate estimates of undiagnosed diabetes, we used data from the most recent NHANES, which most closely encompassed the hospitalization period of an analysis here. Another advantage of the NHANES is that it includes data on patients diagnosed with diabetes through laboratory testing, as opposed to self-reported diagnosis.[28] A disadvantage of the NHANES is that region-specific data are not available. Exclusion of the undiagnosed patients from the denominator in the rate calculations would simply inflate the rates of CVD discharges associated with diabetes. Therefore, including an estimate of the undiagnosed diabetes population allowed the most conservative approach to our analyses.

Our study examined in detail the relationship between diabetes and the rates of CVD-associated hospital discharges, accounting for influences attributable to age, sex, and race/ethnicity. In addition to being associated with higher rates of discharges, diabetes was related to longer LOS and total charges for persons admitted with a CVD diagnosis. Further study is needed not only to confirm these findings but also to ascertain whether aggressive modification of metabolic abnormalities in persons with diabetes can lower the risk of a CVD-related hospitalization.

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