RACE AND ETHNIC DIFFERENCES IN GLYCEMIC CONTROL AMONG ADULTS WITH DIAGNOSED DIABETES IN THE UNITED STATES

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Objective: Control of blood glucose levels reduces vascular complications among people with diabetes, but less than half of the adults with diabetes in the United States are achieving good glycemic control. This study examines 1999–2002 national data on the association between race/ethnicity and glycemic control among adults with previously diagnosed diabetes.

Design: We analyzed data from the National Health and Nutrition Examination Survey (NHANES) 1999–2002, a cross-sectional survey of a nationally representative sample of the non-institutionalized civilian US population. Participants were non-pregnant adults, 20 years or older, with a previous diagnosis of diabetes, and who had participated in both the interview and examination in NHANES 1999–2002 (N=843). Glycemic control was determined by levels of glycosylated hemoglobin (A1C). We compared glycemic control by race/ethnicity and potential confounders including measures of socioeconomic status, obesity, healthcare access and diabetes treatment.

Results: Overall, 44% of adults with previously diagnosed diabetes had good glycemic control (A1C levels < 7%). Mexican Americans and non-Hispanic Blacks were less likely to achieve good control (35.4% and 36.9%, respectively) compared with non-Hispanic Whites (48.6%). After multivariable adjustment for measures of socioeconomic status, obesity, healthcare access and utilization and diabetes treatment, differences in glycemic control by race/ethnicity remained.

Conclusion: Glycemic control is low among all racial/ethnic groups, but is lower among non-Hispanic Blacks and Mexican Americans. These results provide guidance for public health workers and health professionals in targeting programs to improve glycemic control among adults with diagnosed diabetes in the United States. (*Ethn Dis*. 2007;17:529–535)

Key Words: Race, Ethnicity, Diabetes, Glycemic Control

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INTRODUCTION

Diabetes affects more than 20.8 million people in the United States.[1] The disease results in considerable loss of life; patients diagnosed between the ages of 40 and 60 lose a decade or more of life expectancy.[2] Diabetes also results in increased morbidity, economic costs, and reduced quality of life. Individuals with diabetes are at increased risk for both micro-vascular complications (eg, retinopathy, nephropathy), macro-vascular complications (eg, coronary heart disease, stroke, peripheral vascular disease) and neuropathy.

The disease affects minority populations in the United States disproportionately; these populations also experience greater loss of life and rates of complications.[2] Improved glycemic control among individuals with diagnosed diabetes can reduce the risk of micro- and macrovascular disease and neuropathy.[3–5] The American Diabetes Association (ADA) regards glycemic control as one of the important strategies for the management of diabetes, and hemoglobin A1C is the best measure of glycemic level over the previous 3 months. The ADA recommends a goal of A1C <7% for people with diabetes.[6]

Studies have shown that a large proportion of people with diabetes do not achieve optimal glycemic control,[7–14] but only a few of these investigations have been nationally representative.[9,10,12–14] We previously published national data showing that <40% of US adults with diabetes achieved A1C levels <7% in 1999–2000.[13]

Although studies suggest the association of several factors (eg, race/ethnicity, insurance coverage, insulin use) with glycemic control, the current picture at the national level remains unclear.[15–16] In particular, it is unclear why disparities exist in glycemic control by race/ethnicity and to what extent such disparities are explained by socioeconomic factors, or other factors such as obesity, healthcare access and diabetes severity. A better understanding of these factors may facilitate more precise targeting of public health efforts. The objective of this analysis is to assess the association of race/ethnicity and good (A1C <7%) glycemic control after controlling for potential confounders

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among adults with diagnosed diabetes in the United States, using data from the nationally representative National Health and Nutrition Examination Survey for 1999–2002.

METHODS

Survey

The National Health and Nutrition Examination Survey (NHANES), conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention, became a continuous survey in 1999, and data are released in 2-year increments. The NHANES 1999–2002 comprised a nationally representative sample of the non-institutionalized civilian US population. Survey instruments and physical examination and laboratory measurements have been described previously.[17–20] The overall response rate for completion of the interview and physical examination was 75% during 1999–2000 and 80% during 2001–2002.

Participants

We included adults aged ≥20 years who completed the interview and examination and who answered "yes" when asked whether a physician or healthcare professional ever told them, other than in pregnancy for women, they had diabetes (N=944). Women who were pregnant at the time of interview (n=7) and participants with missing information on A1C levels (n=94) were excluded, yielding 843 participants for analysis, representing 12.4 million people with diagnosed diabetes in the United States.

Measurements and Definitions

A1C measurements were standardized to the Diabetes Control and Complications Trial (DCCT) method.[19–20] Waist circumference, height, and weight were measured using standardized techniques.[19–20] Abdominal obesity was defined as waist circumference > 102 cm for males and > 88 cm for females. Body mass index (BMI) was measured as weight (kilograms)/height (meters)^2. Overweight was defined as BMI 25 to <30 and obesity as a BMI ≥ 30.

Information on demographic factors (education, poverty status, health history, healthcare utilization, health insurance, general health status and diabetes treatment and duration) was collected during the home interview. Based on participants' self-reports, race/ethnicity was categorized as Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black, or other race (which included multiple race). Sample sizes were sufficient only for Mexican Americans, non-Hispanic Blacks and non-Hispanic Whites to present statistically reliable results for these specific race/ethnicity categories. Educational level was categorized as less than high school graduate, high school graduate, or at least some college. Poverty status was defined using the poverty index ratio (PIR) which is based on the number of family members and the annual family income and is calculated using poverty thresholds provided by the US Census Bureau.[21] Diabetes treatment was categorized into four groups: using only insulin; using only oral medication; using a combination of insulin and oral medication; and using neither insulin nor oral medication. Duration of diabetes was calculated by subtracting reported age at diagnosis from current age. Thirty adults reported an age of diabetes diagnosis >85 years. For confidentiality protection, NHANES assigns an age of 85 years to participants who are ≥85 years of age. Since we were unable to accurately calculate diabetes duration for these participants, we assigned them diabetes duration of one year.

Analysis

We defined good glycemic control as having A1C < 7% using the American Diabetes Association (ADA) standards of medical care for persons with diabetes.[6] We compared A1C levels by demographic factors, socioeconomic factors and potential confounders using chi-square tests. A P value <.05 was considered statistically significant.

Multiple logistic regression models were used to determine the multivariable adjusted percent of participants with A1C levels < 7% from the predicted margins. Predictive margins are a type of direct standardization where the predicted values from the logistic regression models are averaged over the covariate distribution in the population.[22] This statistic has several advantages over the odds ratio: it is not influenced if the outcome is common; a comparison group is not required; and it provides a measure of absolute difference rather than a relative difference. We included variables in the model based on *a priori* determination of potential factors associated with glycemic control and bivariate associations presented in Table 1. Significance was based on a Wald χ^2 P value <.05. We included race/ethnicity (non-Hispanic Whites, non-Hispanic Blacks, Mexican Americans), age (20–44 years, 45–64 years, ≥65 years), sex, education (less than high school, high school graduate, some college or higher), PIR (< 1.00, 1.00 to 2.00, ≥ 2.00), abdominal adiposity based on waist circumference (> 102 cm for males and > 88 cm for females), health utilization (as indicated by time since last blood pressure reading as < 6 months, ≥ 6 months) and healthcare access (as indicated by health insurance coverage, yes/no). We included diabetes treatment in the multivariate logistic regression model to determine if diabetes treatment explained race/ethnicity differences in glycemic control. We present results from the multivariate logistic regression without diabetes treatment (model a) and with diabetes treatment (model b) included.

We tested for interactions between race/ethnicity and socioeconomic status.

Table 1. Percent distribution across levels of A1C among adults ≥20 years of age with previously diagnosed diabetes in NHANES 1999–2002, according to factors potentially associated with glycemic control

	A1C< 7% % (SE)	A1C 7–8% % (SE)	A1C > 8% % (SE)
Overall	44.0 (2.66)	23.2 (1.52)	32.8 (2.29)
Demographics			
Age*			
20–44 years	36.5 (7.49)	17.8 (4.85)	45.7 (6.71)
45–64 years	44.1(3.65)	20.6 (2.73)	35.3 (3.53)
65 years & older	47.4 (3.47)	28.8 (3.21)	23.8 (3.72)
Sex			
Male	42.3 (3.80)	24.9 (1.59)	32.8 (2.87)
Female	45.8 (3.39)	21.5 (2.35)	32.7 (3.03)
Race/ethnicity*†			
Non-Hispanic White	48.6 (3.62)	22.4 (2.88)	29.0 (2.81)
Non-Hispanic Black	36.9 (3.26)	24.4 (2.36)	38.7 (2.61)
Mexican American	35.4 (2.92)	22.7 (3.47)	41.9 (3.69)
Socioeconomic factors			
Education			
Less than high school	40.2 (3.38)	25.0 (3.13)	34.7 (3.49)
High school graduate	48.7 (4.08)	18.0 (3.33)	33.2 (3.43)
Some college or higher	44.6 (3.95)	24.7 (2.27)	30.6 (3.89)
Poverty index ratio‡			
< 1.00	36.7 (4.88)	27.5 (3.46)	35.7 (4.08)
1.00 to ≤ 2.00	47.8 (4.83)	22.6 (3.35)	29.5 (4.68)
> 2.0	45.9 (3.73)	22.8 (3.62)	31.3 (3.46)
Diabetes treatment and age at diagnosis			
Diabetes treatment*			
Insulin only	27.1 (6.08)	25.2 (4.23)	47.7 (4.88)
Oral medication only	44.4 (2.88)	26.4 (2.00)	29.2 (3.00)
Combination	19.9 (7.32)¶	30.8 (6.82)	49.3 (6.10)
Neither	70.7 (5.70)	7.8 (3.34)¶	21.5 (5.41)
Age at diagnosis*			
< 30 years	36.8 (6.75)	20.4 (4.06)	42.8 (6.49)
30 to 64 years	43.4 (2.94)	23.6 (1.74)	33.1 (2.15)
≥65 years	57.2 (4.71)	25.0 (4.87)	17.8 (4.22)
Body measurement			
Abdominal obesity§	41.6 (2.45)	25.9 (1.98)	32.2 (2.24)
No abdominal obesity	47.5 (5.66)	17.9 (3.10)	34.6 (5.15)
BMI < 25 kg/m^2	42.8 (6.12)	20.6 (4.93)	36.6 (6.05)
25 kg/m^2 ≤ BMI < 30 kg/m^2	46.6 (5.64)	24.8 (2.64)	28.6 (4.42)
BMI ≥ 30 kg/m^2	41.0 (3.32)	24.5 (3.10)	34.4 (2.65)
Health status			
General health status*			
Excellent/very good	52.4 (5.80)	22.1 (3.28)	25.6 (6.24)
Good	47.3 (3.52)	21.3 (2.33)	31.4 (3.55)
Fair/poor	37.9 (3.15)	25.3 (2.29)	36.9 (3.33)
Health now compared to 12 months ago*			
Better	53.9 (5.01)	15.6 (3.64)	30.5 (3.98)
Worse	48.4 (5.68)	24.1 (3.84)	27.6 (5.30)
Same	39.5 (2.71)	25.2 (1.81)	35.3 (3.15)
Health care utilization			
Last blood pressure reading by doctor*			
< 6 months ago	45.1 (2.45)	23.5 (1.50)	31.4 (2.21)
≥ 6 months	32.7 (8.65)	20.5 (6.42)	46.9 (9.01)
Hospitalized overnight in the past year	38.0 (3.30)	26.9 (2.83)	35.1 (3.32)

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We also tested for interactions between diabetes treatment and race/ethnicity, diabetes treatment and education level, diabetes treatment and PIR, age and race/ethnicity, age and education level and age and PIR. None of these interactions were significant.

Analyses were performed using SUDAAN version 9.0 (Research Triangle Institute, Research Triangle Park, NC) with appropriate sampling weights to account for the complex survey design and provide nationally representative estimates.

RESULTS

Glycemic Levels

Table 1 presents A1C levels among adults with diagnosed diabetes by demographic factors, socioeconomic variables, potential confounding variables, and comorbidities. Overall, 44% of adults with diagnosed diabetes had A1C levels < 7%, and 32.8% had levels > 8%. A1C levels were higher for younger persons. There were no differences between men and women. Non-Hispanic Whites were more likely to have A1C levels < 7% (48.6%) compared to non-Hispanic Blacks (36.9%) and Mexican Americans (35.4%). We found no difference between non-Hispanic Blacks and Mexican Americans and no clear association between socioeconomic factors and good glycemic control.

Adults who reported using insulin alone or in combination were less likely to have A1C levels < 7% (27.1% and 19.9%, respectively) compared to those using oral medication alone (44.4%) or using neither (70.7%). Age at diagnosis of diabetes was significantly associated with glycemic control. Participants who were ≥65 years at age of diabetes diagnosis were more likely to have A1C levels < 7% compared to those diagnosed at age 30 to 64 years (43.4%) or at age < 30 years (36.8%). For body measurements, neither abdominal obesity nor BMI were significantly associated

Table 1. Continued

	A1C< 7% % (SE)	A1C 7–8% % (SE)	A1C > 8% % (SE)
Not hospitalized overnight in the past year	46.0 (3.4)	22.0 (1.91)	32.0 (2.70)
Health care access			
Covered by health insurance*	44. 5 (2.82)	25.0 (1.71)	30.6 (2.40)
No health insurance coverage	38.9 (6.61)	10.4 (2.72)	50.6 (6.71)

* $P<.05$ based on χ^2

† Excludes n = 79 participants with race/ethnicity as other Hispanic ($n=51$) or other race, including multiple race ($n=28$).

‡ Excludes $n=94$ participants missing income information.

§ Abdominal obesity defined as waist circumference > 102 cm for males and > 88 cm for females

¶ Estimate does not meet statistical reliability and precision (relative standard error > 30%)

with A1C levels. There was a significant decline in the percent with A1C < 7% with decreasing self-reported health status. Length of time since last blood pressure reading was significantly associated with A1C levels, with longer time since last reading associated with higher A1C levels. Adults who reported being covered by health insurance were more likely to have A1C < 7% (44.5%) compared to adults who reported no health insurance coverage (38.9%).

Race/Ethnicity and Glycemic Control

Table 2 presents the results from the multivariable logistic regression models providing the adjusted percent of adults with diagnosed diabetes who have good glycemic control.

Differences among the race/ethnicity groups continued to be significant after adjustment for age, sex, education level, PIR, waist circumference, health insurance coverage and time since last blood pressure reading (model a): Mexican Americans (32.7%) and non-Hispanic Blacks (35.8%) were less likely to have A1C levels < 7% than non-Hispanic Whites (48.7%). After adjusting further for diabetes treatment, Mexican Americans, but not Non-Hispanic Blacks, were less likely to have A1C < 7% compared to levels for non-Hispanic Whites. Socioeconomic status, as measured by education level and PIR, was not significantly associated with glycemic control in the multivariable logistic regression model. There were no significant interactions between race/ethnicity and socioeconomic status, suggesting that racial/ethnic differences were similar across different levels of socioeconomic status and that socioeconomic status does not explain these differences.

Type of diabetes treatment was highly associated with glycemic control. Compared to participants who use neither insulin nor oral medications, participants using insulin alone, oral

Table 2. Adjusted percent (95% confidence interval, CI) and odds ratio (95% CI) with A1C< 7% among adults ≥20 years of age with previously diagnosed diabetes in NHANES 1999–2002

	Multivariable adjusted* % (95% CI)	Odds Ratio* (95% CI)	Multivariable adjusted† % (95% CI)	Odds Ratio† (95% CI)
Race/ethnicity‡				
Mexican American	32.7 (25.7–39.7)	0.50 (0.32, 0.78)	31.1 (23.4–38.9)	0.43 (0.25, 0.73)
Non-Hispanic Black	35.8 (28.7–42.8)	0.58 (0.37, 0.92)	38.1 (30.0–46.2)	0.61 (0.36, 1.03)
Non-Hispanic White	48.7 (42.1–55.4)	1.00 (reference)	48.5 (42.1–54.9)	1.00 (reference)
Education				
Less than high school	43.0 (33.5–52.4)	0.87 (0.55, 1.37)	45.3 (36.5–54.1)	1.01 (0.61, 1.66)
High school graduate	45.7 (37.9–53.5)	0.97 (0.57, 1.66)	44.7 (37.4–52.0)	0.98 (0.57, 1.67)
Some college	46.4 (38.6–54.2)	1.00 (reference)	45.1 (37.4–52.8)	1.00 (reference)
Poverty index ratio				
< 1.0	47.1 (34.7–59.5)	1.28 (0.64, 2.53)	42.4 (31.5–53.2)	1.01 (0.52, 1.97)
1.0 to 2.0	51.4 (41.6–61.3)	1.53 (0.93, 2.52)	52.4 (43.3–61.5)	1.63 (0.98, 2.70)
> 2.0	41.3 (34.3–48.3)	1.00 (reference)	42.1 (35.8–48.4)	1.00 (reference)
Diabetes treatment	-----	-----		
Insulin alone	-----	-----	26.4 (13.3, 39.4)	0.10 (0.03, 0.29)
Oral medication alone	-----	-----	45.9 (40.6, 51.1)	0.24 (0.11, 0.50)
Combination	-----	-----	19.3 (5.6, 33.0)	0.06 (0.02, 0.22)
Neither	-----	-----	76.3 (65.8, 86.8)	1.00 (reference)

* Adjusted for age (20–44 years, 45–64 years, ≥65 years), sex, race/ethnicity (Mexican American, non-Hispanic Black, non-Hispanic White) education (< high school, high school, some college), poverty index ratio (< 1.0, 1.0 to ≤ 2.0, > 2.0), abdominal obesity (waist circumference > 102 cm for males and > 88 cm for females), health insurance coverage (yes/no), and time since last blood pressure reading (< 6 months, ≥ 6 months)

† Adjusted for variables in model a and diabetes treatment (insulin alone, oral medication alone, insulin and oral medication in combination, neither insulin nor oral medication)

‡ $P<.05$ based on Wald χ^2, significant for both models.

----- Not estimated from model

Excludes $n=164$ participants with race/ethnicity as other Hispanic ($n=51$) or other race, including multiple race ($n= 32$) or missing income information ($n=81$).

medication alone or a combination were all more likely to have A1C < 7%. Although the causal direction of the association of diabetes treatment and glycemic control can not be determined in our study, we included diabetes treatment in the multivariable logistic regression model to determine if race/ethnicity differences could be further explained by differences in diabetes treatment (model b). Including diabetes treatment in the model did not substantially change the results.

DISCUSSION

In 1999–2002 only 44% of adults in the United States, ≥20 years of age with diagnosed diabetes had A1C levels <7%, while 32.7% had levels >8%. Adults 20–44 years of age were least likely to achieve good control. That finding is cause for particular concern as younger people with diabetes will be exposed to longer duration of the disease and may have the highest probability of suffering a preventable complication some time in their lives.

Race/ethnicity, but not measures of socioeconomic status, was significantly associated with glycemic control. Non-Hispanic Blacks and Mexican Americans were less likely to achieve good control compared to non-Hispanic Whites. These differences persisted after adjustment for age, sex, socioeconomic status (as measured by education level and poverty status), diabetes treatment, abdominal obesity, healthcare utilization (as measured by time since last blood pressure reading by a doctor or other health professional), and healthcare access (as measured by health insurance coverage).

Race/ethnicity, but not measures of socioeconomic status, was significantly associated with glycemic control.

Intensive glycemic control can result in dramatic reductions in risk of microvascular complications. In 1993, the Diabetes Control and Complications Trial (DCCT) showed that intensive glycemic control reduced the risk of early retinopathy, early nephropathy and neuropathy by 39%–76% among persons with type 1 diabetes.[3] These benefits have been extended most recently to clinical cardiovascular events in the type 1 diabetic DCCT cohort[5] but these benefits have not been shown to reverse cardiovascular disease. Such results have led the ADA to recommend A1C target levels of <7% for people with diabetes.

Our study presents nationally representative estimates for levels of glycemic control among non-institutionalized adults with diagnosed diabetes. Nonetheless, a number of limitations should be considered when interpreting these results. First, NHANES 1999–2002 is a cross-sectional survey and, although we can look at factors that are associated with glycemic control, we can not determine whether these predictive factors are causal, especially given the complex relationship of many of the factors with glycemic control. In particular, the association of different diabetes treatments and glycemic control is difficult to disentangle in a cross-sectional study. Differences in glycemic control according to type of diabetes treatment may indicate disease severity or effectiveness of diabetes treatment. Finally, while we have attempted to control for socioeconomic factors potentially associated with glycemic control, the measures of socioeconomic status in NHANES are likely incomplete. Socioeconomic status is more complex than education level and poverty status alone and even with adjustment for these factors, residual confounding likely exists.[23]

Harris and colleagues (1999) reported results similar to ours based on data from the Third National Health and Nutrition Examination Survey (NHANES III) conducted from 1988–1994.[9] They found that non-Hispanic Blacks, Mexican Americans, and adults <60 years of age were more likely to have poor control of diabetes based on higher A1C levels. Adults in NHANES III taking oral medication were more likely to have poor glycemic control.[9,14] In our study, poor control was more common among adults using insulin alone or in combination with oral medications. The shift to poor control being more common in adults taking insulin or combination therapy may be due to recent improvements in the oral medications that are available on the market; alternatively it may be due to prescription of insulin for persons previously treated with oral medications alone who are unable to achieve adequate control.[24] Both NHANES III and the current NHANES are nationally representative surveys and there were no significant differences between the surveys on socioeconomic status.[13]

It is unclear why glycemic control differed by race/ethnicity even after adjustment for associated factors including diabetes treatment. In a recent study, Triveldi and colleagues showed that, after controlling for health plan and area of residence, racial disparities in glucose control among Medicare managed care beneficiaries did not decline from 1997 to 2003.[25] Dosage for oral medication or insulin and compliance with regimens may differ by race/ethnic group leading to greater improvements in control in some groups but not in others, but NHANES does not collect information on dosage. Another possibility is the influence of self-monitoring of blood glucose, which may differ by race/ethnic groups. Saaddine and colleagues (2002) reported only 28.8% of adults with diabetes had at least one test for A1C per year and that only 38% reported self-monitoring of blood glucose at least once a day.[12] Other possibilities include

glycemic control at time of diabetes diagnosis, diabetes education programs and severity of diabetes. These data, however, are not available in NHANES 1999–2002.

The agreement of our findings with results of other studies investigating factors associated with glycemic control is mixed. Some studies found differences between men and women.[9,11] while others, as in our study, did not.[12–14] Similar to our findings, obesity, as measured by BMI, was not associated with A1C levels in previous studies.[8] Education levels, while not significant in this study, have been demonstrated to be associated with glycemic control.[8]

In this study we found healthcare access and healthcare utilization to be associated with glycemic control, but not education or poverty. Poverty status may influence diabetes management and control since it is often associated with access to health care, healthcare utilization, use of medication, and access to good nutrition. Healthcare utilization (as measured by time since last blood pressure reading) and healthcare access (as measured by health insurance coverage) are also related to socioeconomic status and both were associated with glycemic control in logistic regression models.

Glycemic control continues to be a vital component of diabetes treatment and critically important for the prevention of diabetes complications. These results indicate that only 44% of U.S. adults with diagnosed diabetes are achieving the recommended levels of control and that race/ethnic differences exist, even after controlling for potential confounders. Healthcare professionals should be aware of these differences. Many of the National Diabetes Education Program awareness campaigns, which focus on controlling diabetes to prevent complications, are aimed at race/ethnic groups that we have shown to have particularly poor glycemic control. However research is needed on the effectiveness of these public health education efforts. These results provide guidance for public health workers and health professionals in targeting programs to improve glycemic control among adults with diagnosed diabetes in the United States. These results strengthen the importance of race/ethnic differences, particularly given the increasing efforts to improve glycemic control. Further, the results suggest that if efforts are not successful in improving race/ethnic difference, the changing demographics of the United States will make it more difficult to reduce the risk of future diabetes complications and costs.

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