Racial and Ethnic Differences in Glycemic Control of Adults With Type 2 Diabetes

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OBJECTIVE — To evaluate glycemic control in a representative sample of U.S. adults with type 2 diabetes.

RESEARCH DESIGN AND METHODS — The Third National Health and Nutrition Examination Survey included national samples of non-Hispanic whites, non-Hispanic blacks, and Mexican Americans aged ≥20 years. Information on medical history and treatment of diabetes was obtained to determine those who had been diagnosed with type 2 diabetes by a physician before the survey (n = 1,480). Fasting plasma glucose and HbA_{1c} were measured, and the frequencies of sociodemographic and clinical variables related to glycemic control were determined.

RESULTS — A higher proportion of non-Hispanic blacks were treated with insulin and a higher proportion of Mexican Americans were treated with oral agents compared with non-Hispanic whites, but the majority of adults in each racial or ethnic group (71–83%) used pharmacologic treatment for diabetes. Use of multiple daily insulin injections was more common in whites. Blood glucose self-monitoring was less common in Mexican Americans, but most patients had never self-monitored. HbA_{1c} values in the nondiabetic range were found in 26% of non-Hispanic whites, 17% of non-Hispanic blacks, and 20% of Mexican Americans. Poor glycemic control (HbA_{1c} >8%) was more common in non-Hispanic black women (50%) and Mexican-American men (45%) compared with the other groups (35–38%), but HbA_{1c} for both sexes and for all racial and ethnic groups was substantially higher than normal levels. Those with HbA_{1c} >8% included 52% of insulin-treated patients and 42% of those taking oral agents. There was no relationship of glycemic control to socioeconomic status or access to medical care in any racial or ethnic group.

CONCLUSIONS — These data indicate that many patients with type 2 diabetes in the U.S. have poor glycemic control, placing them at high risk of diabetic complications. Non-Hispanic black women, Mexican-American men, and patients treated with insulin and oral agents were disproportionately represented among those in poor glycemic control. Clinical, public health, and research efforts should focus on more effective methods to control blood glucose in patients with diabetes.

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Blood glucose may be the most important clinical characteristic of diabetic patients. Not only does the level of blood glucose define the disease (1), it is a major risk factor for complications of diabetes. Control of hyperglycemia can reduce the incidence of acute diabetic complications and long-term end-stage microvascular complications in both type 1 and type 2 diabetes (2–4). There are indications that high blood glucose is implicated in the pathogenesis of coronary heart disease and is a risk factor for mortality in patients with diabetes (5–7). Further, poor glycemic control is associated with increased costs of medical care for patients with diabetes (8).

Despite the clear importance of hyperglycemia, no studies have measured glycemic control in a representative national sample of people with diabetes, although several community studies found higher glucose levels in blacks, Hispanics, and Native Americans compared with whites (9–12). To investigate whether glycemic control differs by racial or ethnic group among U.S. adults with type 2 diabetes, we included a diabetes component in the Third National Health and Nutrition Examination Survey (NHANES III). This survey included probability samples of non-Hispanic whites, non-Hispanic blacks, and Mexican Americans whose medical history included a physician diagnosis of type 2 diabetes and whose fasting plasma glucose and HbA_{1c} were measured. These data were evaluated in relation to American Diabetes Association (ADA) standards for glycemic control (13).

RESEARCH DESIGN AND METHODS

— Details on NHANES III have been published (14). Briefly, the survey was conducted in 1988–1994 and included a nationally representative sample of the U.S. civilian, noninstitutionalized population based on a multistage probability cluster design, with oversampling of blacks and Mexican Americans. For those aged ≥20 years, 18,822 people selected to take part in the survey completed a household interview in which information was obtained about sociodemographic characteristics, race, and Hispanic ethnicity. Information on medical history of diabetes and diabetes therapy was used to identify individuals with diabetes diagnosed by a physician before the survey (n = 1,608). Women with diabetes diagnosed only during pregnancy (n = 105) and subjects with type 1 diabetes, defined as those with age at diagnosis <30 years who had continuous or almost continuous insulin use since diagnosis (n = 23), were deleted from analysis. The remaining 1,480 subjects were considered to have type 2 diabetes and included 590 non-Hispanic

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Abbreviations: ADA, American Diabetes Association; NHANES III, Third National Health and Nutrition Examination Survey; OR, odds ratio.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

whites, 405 non-Hispanic blacks, 450 Mexican Americans, and 35 individuals of other race or ethnicity. Of the subjects, 1,312 participated in a clinical examination, and HbA_{1c} was obtained for 1,253. A half-sample of survey participants was examined in the morning after an overnight (9- to 24-h) fast, excluding insulin-treated individuals, who were not asked to fast. Fasting plasma glucose was obtained for 422 subjects with type 2 diabetes who were treated with oral agents or diet alone. HbA_{1c} and fasting plasma glucose were also obtained for a representative sample of 6,566 adults without diagnosed diabetes. Those individuals were classified by ADA diagnostic criteria (1) as having undiagnosed diabetes (n = 274), impaired fasting glucose (n = 599), or normal fasting glucose (n = 5,693).

HbA_{1c} was measured using a high-performance liquid chromatographic assay as in the Diabetes Control and Complications Trial. The upper limit of normal for HbA_{1c} in the assay system is 6.1%, defined as the mean + 2SD (5.27% + 0.86%) for the group of people with fasting plasma glucose <110 mg/dl and 2-h postchallenge glucose <140 mg/dl. This value (6.1%) is virtually identical to the upper limit of normal (6.0%) recommended by the ADA using the same assay system (13). Plasma glucose was measured using a hexokinase enzymatic method. The upper limit of normal for fasting plasma glucose in this group of people was 110 mg/dl (mean + 2 SD, 95 mg/dl + 15 mg/dl), which is also equal to the ADA definition of normal fasting glucose (13).

Statistical analyses were carried out using SAS. Data were weighted to correct for the oversampling of Mexican Americans and non-Hispanic blacks to produce estimates that were representative of the U.S. population. Data are presented for the total type 2 diabetic population and for non-Hispanic whites, non-Hispanic blacks, and Mexican Americans. People of other races or ethnicities were not analyzed separately because of the small sample size and heterogeneous nature of this group. Standard errors and tests of statistical significance were calculated using SUDAAN (15), a program that takes into account the nonrandom cluster sample design in calculating variance estimates. Multiple logistic regression modeling was conducted by a forward stepwise procedure with HbA_{1c} >8.0% as the dependent variable. Models for the total group and for each sex and racial/ethnic group were created. Throughout the model building process, the odds ratios (ORs) for the racial/ethnic and sex groups were stable, indicating that the effects of race/ethnicity and sex were not influenced by other variables in the model.

RESULTS — The mean age at diagnosis of diabetes in adults with type 2 diabetes was 52.0 years, and the mean duration of diabetes since diagnosis was 9.5 years. The racial/ethnic distribution was 74.4% non-Hispanic white, 15.0% non-Hispanic black, 5.8% Mexican-American, and 4.8% other. Of all the subjects with type 2 diabetes, 27.3% were treated with insulin (including 3.4% who used both insulin and oral agents), 45.5% were treated with oral agents without insulin, and 27.2% were treated with diet alone. Table 1 shows characteristics of therapy for diabetes by racial or ethnic group and sex. A larger proportion of non-Hispanic black men and women were treated with insulin compared with non-Hispanic whites and Mexican Americans. This finding was complemented by a smaller proportion of non-Hispanic blacks using oral agents, such that the proportions who were treated pharmacologically were similar for each racial or ethnic group (71.2–82.5%).

For those treated with insulin, there was little difference by race/ethnicity or sex in the mean number of insulin units taken per day (Table 1). Two or more insulin injections per day were used by 54.7% of subjects. A higher proportion of non-Hispanic whites used multiple insulin injections compared with non-Hispanic blacks and Mexican Americans. Of all subjects, 32.6% self-monitored their blood glucose at least once per week, 14.6% at least once per day. There were few differences in these proportions by race/ethnicity or sex. The proportion who self-monitored at least once per day ranged from 8.0 to 19.6%, but most patients had never self-monitored (Table 1).

Insulin use increased from 18.6% at age 20–44 years to 33.4% at age ≥65 years; use of oral agents varied from 40 to 50% across the age range. A greater effect was associated with duration of diabetes: insulin use increased from 14.8% among those <5 years since diagnosis of diabetes

Table 1—*Adults with type 2 diabetes according to therapy for diabetes, frequency of insulin injections, and blood glucose self-monitoring*

	Non-Hispanic white		Non-Hispanic black		Mexican-American		All subjects	
	Men	Women	Men	Women	Men	Women	Men	Women
n	278	312	166	239	189	261	645	835
Diabetes therapy								
Insulin	19.0	31.4	44.5	39.8	23.3	26.6	22.3	31.3
Oral agents	52.4	40.1	37.6	35.9	59.3	44.6	52.1	40.3
Diet alone	28.6	28.5	18.0	24.3	17.5	28.8	25.7	28.4
Insulin-treated subjects								
Insulin units (mean per day)	43.3	42.2	37.2	40.3	39.5	43.6	41.2	41.5
≥2 injections per day	56.7	62.3	36.7	46.1	37.2	36.9	51.1	56.7
≥3 injections per day	1.2	9.9	0.0	0.0	1.1	2.9	0.9	7.5
Blood glucose self-monitoring								
Never	56.9	53.1	60.3	67.8	62.9	78.8	59.3	58.6
<1 time per week	8.3	9.7	6.8	10.0	9.0	5.0	7.8	9.0
1–6 times per week	23.3	17.7	18.1	9.7	18.0	8.2	21.5	15.2
≥1 time per day	11.5	19.6	14.8	12.6	10.1	8.0	11.4	17.2

Data are % unless otherwise indicated. All subjects include people of all races and ethnicities, including those not shown separately. The insulin group includes 3.4% of subjects who used both insulin and oral agents.

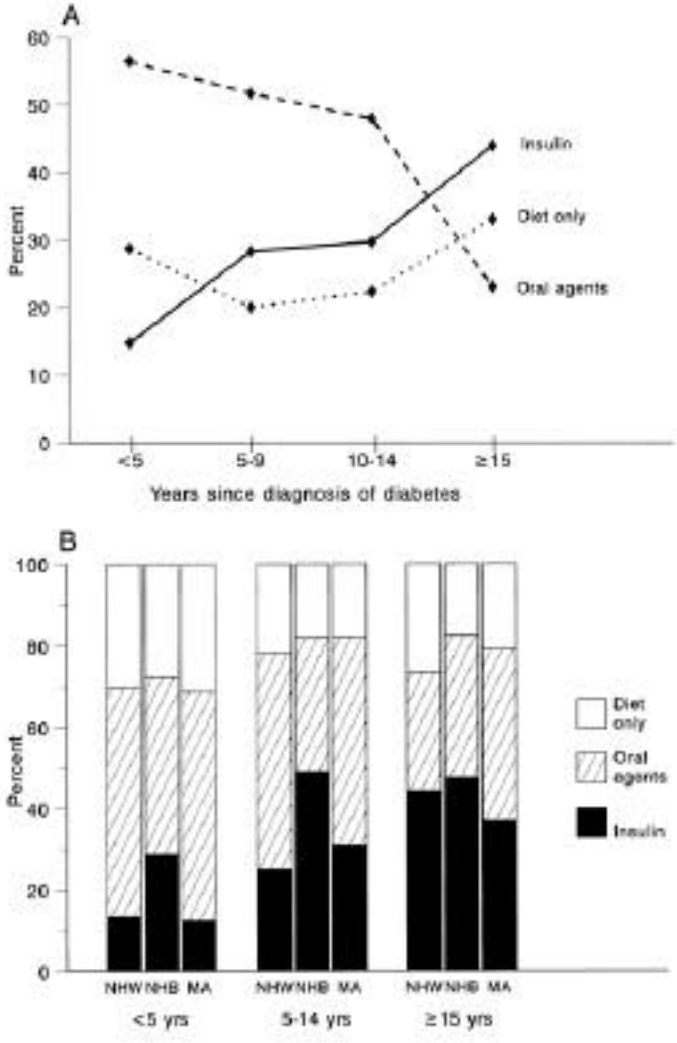

Figure 1—*Therapies for diabetes used by adults aged ≥20 years, by years since diagnosis of diabetes. A: Total type 2 diabetic population; B: non-Hispanic whites (NHW), non-Hispanic blacks (NHB), and Mexican Americans (MA) with type 2 diabetes.*

to 43.9% among those ≥15 years (Fig. 1). Concomitantly, use of oral agents declined from 56.5 to 23.1%. About 20–30% of subjects were treated with diet alone in each of the diabetes duration groups. Similar patterns of increasing insulin use and decreasing oral agent use with longer duration of diabetes were found for all three racial/ethnic groups (Fig. 1). The higher proportion of insulin treatment among non-Hispanic blacks compared with non-Hispanic whites and Mexican Americans was predominantly in those <15 years since diagnosis of diabetes.

The mean HbA_{1c} for all adults with type 2 diabetes was 7.6%, significantly higher than the value of 5.2% for nondiabetic adults ($P < 0.01$). Mean HbA_{1c} was similar for those treated with insulin (8.3%) or oral agents (8.0%) and was lower for those treated with diet alone (6.4%, $P < 0.01$). The mean fasting plasma glucose for people with diabetes treated with oral agents (193 mg/dl) or diet alone (138 mg/dl) was also significantly higher than the value for nondiabetic adults (95 mg/dl); the value for those treated with insulin was not obtained because they were not asked to fast. Figure 2 shows mean HbA_{1c} according to racial or ethnic group and sex. All groups with diabetes had substantially higher HbA_{1c} than individuals with normal glucose values. Among those with diagnosed type 2 diabetes, non-Hispanic black women and Mexican-American men had higher HbA_{1c} values than the other groups ($P < 0.01$). For those with undiagnosed diabetes, HbA_{1c} was higher for blacks and Mexican Americans. There were indications that those two racial/ethnic groups also had higher levels of HbA_{1c} than whites at the stages of normal fasting glucose and impaired fasting glucose.

Table 2 shows the proportions of adults with type 2 diabetes according to ADA criteria for glycemic control. About 24.7% of patients were in the nondiabetic range (HbA_{1c} <6%), and 44.6% had achieved the goal of HbA_{1c} <7%. Patients treated with insulin were less likely to have HbA_{1c} <7% than those treated with oral agents, who in turn had a substantially lower proportion with HbA_{1c} <7% than those treated with diet alone. Fasting plasma glucose was measured in patients who were treated with oral agents or diet alone: 8.6 and 40.0%, respectively, were in the nondiabetic range (<110 mg/dl) and 12.0 and 52.3% were within the goal range of 80–120 mg/dl.

The ADA standards call for additional action to improve glycemic control when HbA_{1c} reaches 8% or fasting plasma glucose exceeds 140 mg/dl. Of all patients with type 2 diabetes, 37.1% had HbA_{1c} >8%, including 51.5% of insulin-treated patients, 42.4% of those taking oral agents, and 15.0% of those treated with diet alone (Table 2). For fasting glucose, 71.5% of those treated with oral agents and 30.7% of those treated with diet alone exceeded 140 mg/dl. The proportions who had even higher glycemic values are also shown in Table 2. For example, 20.1% of insulin-treated patients exceeded an HbA_{1c} value of 10%, and 22.5% of oral agent–treated patients exceeded a fasting plasma glucose value of 250 mg/dl.

Among the racial and ethnic groups, HbA_{1c} levels <6% were found in 26.1% of non-Hispanic whites, 16.7% of non-Hispanic blacks, and 20.0% of Mexican Americans. Glycemic control was poorer for non-Hispanic blacks (45.7% with HbA_{1c} >8%) and Mexican Americans (40.8%) than for non-Hispanic whites (35.7%). Figure 3 shows the proportion of patients with HbA_{1c} >8% according to race or ethnicity and sex. More non-Hispanic black women and Mexican-American men had HbA_{1c} >8% compared with the other groups. All groups were markedly hyperglycemic, however, since an HbA_{1c} level of 8% is equivalent to about 6 SD above the mean value of a population with normal fasting and postchallenge glucose.

Table 3 shows the proportions with HbA_{1c} >8% according to characteristics that are believed to be predictive of glycemic control. The characteristics include measures of socioeconomic status,

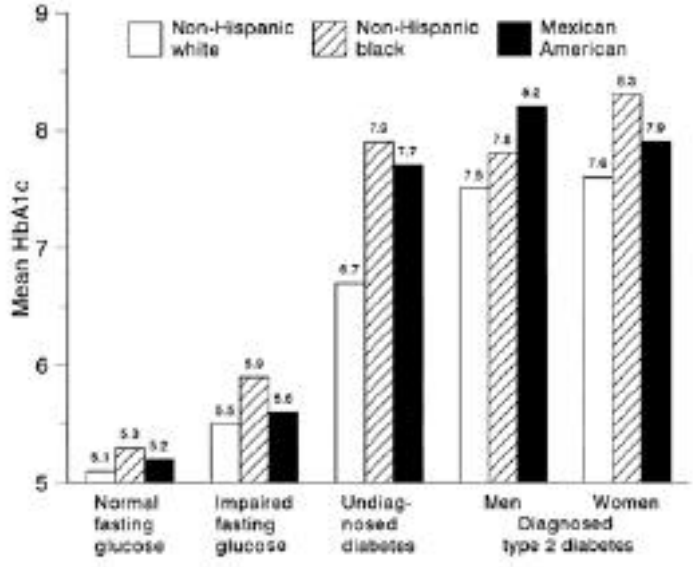

Figure 2—*Mean HbA_{1c} for adults aged ≥20 years with normal fasting glucose, impaired fasting glucose, undiagnosed diabetes, and diagnosed diabetes, according to race or ethnicity. Subjects were categorized by diagnostic criteria of the ADA (1).*

access to and utilization of medical care, and self-care practices. Except for blood glucose self-monitoring, none of the variables had a statistically significant relationship with glycemic control. The proportion of individuals with HbA_{1c} >8% was higher in those who self-monitored their blood glucose, indicating that patients with poorer control have a greater tendency to self-monitor.

The strength and statistical significance of the relationship of these characteristics to HbA_{1c} >8% were also tested by logistic regression. A regression model for the total population of patients with type 2 diabetes that included the variables in Table 3 showed no statistically significant association of any of the variables with HbA_{1c} (except the negative association with self-monitoring). Separate models for each sex and racial/ethnic group showed the same nonsignificant relationships. We examined whether the race/ethnicity and sex ORs were modified by any of the variables. Table 4 shows the results of a logistic regression model that included only the race/ethnicity and sex variables and of one that included all variables; the ORs were similar in the two analyses. Non-Hispanic black women had significantly higher odds of having HbA_{1c} >8% relative to non-Hispanic white men (P = 0.01). Although Mexican-American men had an OR of 1.4, it was not statistically significant (P = 0.2).

Table 2—***Adults with type 2 diabetes who met or exceeded ADA standards for glycemic control***

	All subjects	Diabetes therapy		
		Insulin	Oral agents	Diet alone
HbA_{1c} (%)				
Nondiabetic range (<6)	24.7	9.1	16.4	53.3
Goal (<7)	44.6	26.5	37.7	73.2
Additional action recommended				
>8	37.1	51.4	42.2	14.9
>9	22.8	32.3	27.4	6.1
>10	14.1	20.1	17.0	3.5
>11	7.0	6.8	10.2	2.0
>12	3.0	2.1	5.1	0.5
Fasting plasma glucose (mg/dl)				
Nondiabetic range (<110)	—	—	8.6	40.0
Goal (80–120)	—	—	12.0	52.3
Additional action recommended				
>140	—	—	71.5	30.7
>160	—	—	64.4	25.6
>180	—	—	49.5	23.2
>200	—	—	43.0	13.7
>250	—	—	22.5	3.4

Data are %. Missing data are not available because subjects who were treated with insulin were not asked to fast. The ADA standards for glycemic control are taken from Ref. 13. The insulin group includes 3.4% of subjects who used both insulin and oral agents.

CONCLUSIONS — These data, based on a national survey conducted in 1988–1994, indicate that a large proportion of patients with type 2 diabetes in the U.S. have unacceptable glycemic control. Only 44.6% of patients had HbA_{1c} values <7%, a level that the ADA considers to be the goal for patients with diabetes, even though it is equivalent to about 4 SD above the mean value of a population with normal fasting and postchallenge glucose. Fully 37.1% had HbA_{1c} values >8%, a level at which the ADA recommends intensification of therapy to improve glycemic control. An HbA_{1c} level of 8% is markedly hyperglycemic.

Non-Hispanic black women, Mexican-American men, insulin-treated and oral agent–treated patients, and individuals aged <60 years were disproportionately represented among those in poor glycemic control. A substantial proportion of those with undiagnosed diabetes also had HbA_{1c} >8%. These findings are disturbing because these groups of individuals are at high risk for complications of diabetes: minorities because they have higher risk of complications even after adjusting for differences in glycemic control, younger patients because their duration of glycemic exposure will be greater than those diagnosed at older ages, and the undiagnosed because they are unrecognized and untreated.

The level of glycemic control in the NHANES III patient population was achieved with the traditional therapies of diet, exercise, sulfonylureas, and insulin,

Table 3—*Percentage of adults with type 2 diabetes whose HbA_{1c} value exceeded 8.0%*

Characteristic	%
Education (years)	
<9	35.9
9–12	35.9
>12	41.4
Annual family income ($)	
<20,000	36.1
20,000–39,999	39.0
≥40,000	36.3
Any type of health insurance	
No	40.3
Yes	36.6
Private health insurance	
No	34.0
Yes	38.1
Physician visits per year	
<4	41.5
4–6	35.4
7–10	39.8
>10	30.9
Self-monitors blood glucose at least once per week	
No	31.4*
Yes	48.2*
Number of injections per day (insulin-treated patients)	
<2	48.4
≥2	53.5
BMI (kg/m^2)	
<25	38.0
25 to <30	32.6
≥30	40.4
Physically active	
No	36.4
Yes	38.5
Current smoker	
No	36.3
Yes	40.7

*$P < 0.001$; for all other variables, $P > 0.2$.

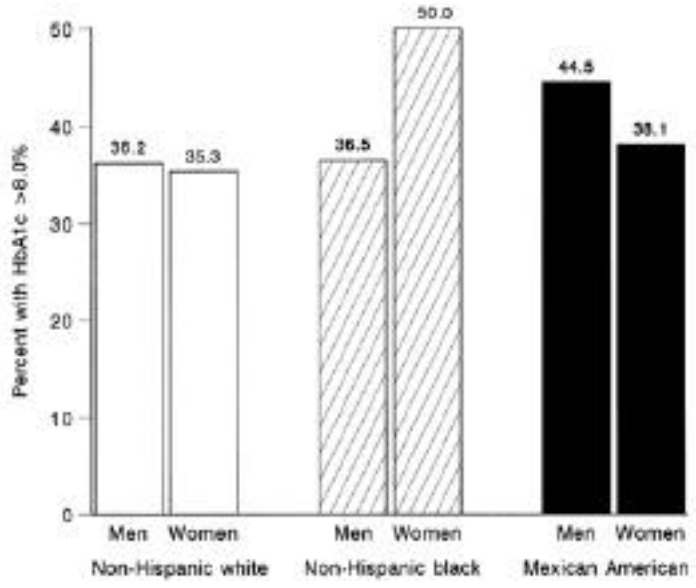

Figure 3—*Proportion of U.S. adults aged ≥20 years with diagnosed type 2 diabetes who have HbA_{1c} >8.0%, according to sex and race or ethnicity.*

since the survey predated the introduction of biguanides, disaccharidase inhibitors, and insulin sensitizers in the U.S. The survey also predated the reports of the Diabetes Control and Complications Trial in type 1 diabetes and the U.K. Prospective Diabetes Study in type 2 diabetes, both of which showed that glycemic control reduces the risk of microvascular complications (2,3). The effect of these new therapies and research findings may generate a secular trend in management of type 2 diabetes toward more intensive control. The fact that 54.7% of insulin-treated subjects in NHANES III took two or more injections of insulin per day is evidence that a trend toward more intensive treatment may be occurring nationally. Among type 2 diabetes patients in southern Wisconsin, there were higher proportions in 1992 compared with 1980 who used insulin, used multiple insulin injections, and self-monitored their blood glucose, although the changes were not associated with better glycemic control (16). Among outpatients with type 2 diabetes at Massachusetts General Hospital, a higher proportion of those seen in 1993 used insulin or oral agents, had HbA_{1c} measured, and self-monitored compared with those seen in 1985 (17). There was only a small decline in HbA_{1c} levels during this period, attributable to better control in patients treated with insulin.

We analyzed reasons for the racial and ethnic differences in glycemic control using stratified analysis and logistic regression. We found that education, income, health insurance coverage, number of physician visits per year, and other variables were not predictive of poor glycemic control. The lack of association of glycemic control with socioeconomic status was also found in a Michigan community study of whites (18) and a South Carolina study of blacks and whites (9) in which poor glycemic control was not associated with educational level. In San Antonio, Texas, low socioeconomic status was not predictive of greater levels of hyperglycemia or retinopathy in either non-Hispanic whites or Mexican Americans (19). The finding that socioeconomic status is not associated with poor glycemic control is in marked contrast to relationships in nondiabetic patients, where socioeconomic status is often an important factor in morbidity.

Table 4—*ORs from logistic regression models for sex and racial/ethnic groups having an HbA_{1c} value >8.0%*

Group	Model with race/ethnicity and sex variables only	Full model
Non-Hispanic white men	1.00 (reference group)	1.00 (reference group)
Non-Hispanic white women	0.96 (0.59–1.58)	1.04 (0.56–1.94)
Non-Hispanic black men	1.02 (0.61–1.69)	0.98 (0.52–1.88)
Non-Hispanic black women	1.77 (1.13–2.77)*	2.01 (1.13–3.58)*
Mexican-American men	1.42 (0.80–2.51)†	1.36 (0.65–2.85)†
Mexican-American women	1.09 (0.70–1.70)	1.15 (0.58–2.28)

Data are ORs (95% CI). Full model includes education, income, health insurance coverage, frequency of physician visits, blood glucose self-monitoring, BMI, physical activity, cigarette smoking, age, and duration of diabetes. *$P = 0.01$; †$P = 0.2$; for all other groups, $P \geq 0.7$.

In this study, we did not find that obesity was related to glycemic control. This is probably because the study captures a cross-section, in time, of individuals with type 2 diabetes, including patients in good control who have gained weight and patients with poor glycemic control who have lost weight due to disease processes.

The NHANES III data indicate a call to action to identify high-risk individuals and focus on achieving better glycemic control. President Clinton has announced a public health initiative to eliminate the disparity in the incidence of diabetes and its complications in U.S. minority populations by the year 2010. Our data confirm that some differences exist by racial and ethnic group in HbA_{1c} levels and that many patients are in poor control. Improving glycemic control in patients with diabetes is a high priority.

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