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Race/Ethnicity Disparities in Dysglycemia Among U.S. Women of Childbearing Age Found Mainly in the Nonoverweight/Nonobese

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OBJECTIVE—To describe the burden of dysglycemia—an abnormal glucose metabolism indicative of diabetes or high risk for diabetes—among U.S. women of childbearing age, focusing on differences by race/ethnicity.

RESEARCH DESIGN AND METHODS—Using U.S. National Health and Nutrition Examination Survey data (1999–2008), we calculated the burden of dysglycemia (i.e., prediabetes or diabetes from measures of fasting glucose, A1C, and self-report) in nonpregnant women of childbearing age (15–49 years) by race/ethnicity status. We estimated prevalence risk ratios (PRRs) for dysglycemia in subpopulations stratified by BMI (measured as kilograms divided by the square of height in meters), using predicted marginal estimates and adjusting for age, waist circumference, C-reactive protein, and socioeconomic factors.

RESULTS—Based on data from 7,162 nonpregnant women, representing >59,000,000 women nationwide, 19% (95% CI 17.2–20.9) had some level of dysglycemia, with higher crude prevalence among non-Hispanic blacks and Mexican Americans vs. non-Hispanic whites (26.3% [95% CI 22.3–30.8] and 23.8% [19.5–28.7] vs. 16.8% [14.4–19.6], respectively). In women with BMI <25 kg/m², dysglycemia prevalence was roughly twice as high in both non-Hispanic blacks and Mexican Americans vs. non-Hispanic whites. This relative increase persisted in adjusted models (PRRadj 1.86 [1.16–2.98] and 2.23 [1.38–3.60] for non-Hispanic blacks and Mexican Americans, respectively). For women with BMI 25–29 99 kg/m², only non-Hispanic blacks showed increased prevalence vs. non-Hispanic whites (PRRadj 1.55 [1.03–2.34] and 1.28 [0.73–2.26] for non-Hispanic blacks and Mexican Americans, respectively). In women with BMI >30 kg/m², there was no significant increase in prevalence of dysglycemia by race/ethnicity category.

CONCLUSIONS—Our findings show that dysglycemia affects a significant portion of U.S. women of childbearing age and that disparities by race/ethnicity are most prominent in the nonoverweight/nonobese.

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While national trends show that diabetes prevalence among all U.S. adults (men and women) has risen in recent years, seemingly concomitantly with rates of overweight and obesity, non-Hispanic blacks and Mexican Americans continue to be disproportionately affected, with rates almost twice those of non-Hispanic whites (1,2). This has also been the trend for impaired fasting glucose (IFG), a marker of future diabetes risk (1,2). Previous research on racial disparities of diabetes prevalence has focused on disparities for common risk factors for the disease: obesity and poverty, among others (3,4). However, findings from these studies show that there appears to be a residual effect of race/ethnicity (3,4), while controlling for the effect of BMI and social factors, with no concrete explanation as to why this might be so.

Little attention has been paid specifically to investigating factors associated with disparity in glucose levels among women in their reproductive years. However, this proves an important population to target, not only because of the woman’s health needs and subsequent risk for type 2 diabetes (5), but also because of her role as a caregiver and the potential adverse consequences for her offspring if exposed to gestational hyperglycemia (6–8). We therefore conducted an analysis using U.S. national data to describe the burden of dysglycemia—diabetes, IFG, or high risk for diabetes by A1C criteria—among women of childbearing age, focusing specifically on differences by race/ethnicity. We also explored the extent to which measurements of obesity—measured by BMI and waist circumference—might modify these associations.

RESEARCH DESIGN AND METHODS

Sample population and data source

The National Health and Nutrition Examination Survey (NHANES) is an ongoing national survey conducted by the National Center for Health Statistics (NCHS) (9). It uses a complex multistage probability sample so as to represent the civilian, noninstitutionalized U.S. population. Participants of the survey complete in-home interviews followed by medical and laboratory examinations in mobile examination centers. Additionally, half of those who participate in the medical examination centers. Additionally, half of those who participate in the medical examination centers.
examination are asked to fast overnight for laboratory testing, comprising a nationally representative fasting subsample. Our study focuses on nonpregnant females 15–49 years of age who underwent the interview and medical and/or laboratory examinations of NHANES, combined from five survey cycles from 1999 to 2008. Pregnancy status was by self-report, confirmed with a laboratory test. For fasting measures, we included women who were part of the morning fasting session and excluded women from the fasting subsample if their fasting times were <8 h. The NCHS Research Ethics Review Board approved the surveys, and documented consent was obtained from all participants. The interview, examination, and laboratory procedures have previously been described (9).

Study variables

Demographic variables. Demographic information was collected on the basis of self-report during the in-home interviews. Race/ethnicity was categorized according to NHANES guidelines for comparing across survey cycles and included “non-Hispanic white,” “non-Hispanic black,” “Mexican American,” and “other.” We chose not to present estimates from women in the “other” category because of the small sample size for, and heterogeneity of, this group. We considered age as a continuous variable and dichotomized education attainment as having completed less than high school or having completed high school (or the equivalent) or more. We categorized civil status as single or married/cohabitating and the number of live births. Other covariates included family income, race/ethnicity, pregnancy status, age, education attainment, and PIR. Statistical analysis by using the Taylor series linearization method. Estimates were considered reliable if degrees of freedom were ≥12 and the relative SE ≤30% (9). We used fitted multiple logistic regression models to estimate crude and adjusted odds ratios (ORs) and prevalence risk ratios (PRRs) with accompanying 95% CIs for our outcome variable dysglycemia (17,18). Our calculation of the PRR was performed as a function of the average marginal predictions from the fitted regression models (17). We considered the following variables for confounding, based on previous literature: age, PIR, education, number of live births, waist circumference, and CRP. We elected to keep the covariates stated above in the model if they changed the full model OR by ≥10% (19). Our final models therefore adjusted for age, education, PIR, waist circumference, and CRP. We assessed model fit using the Hosmer-Lemeshow goodness of fit, Satterthwaite-adjusted F test (20). Correlation among independent variables was assessed via the variance inflation factor and condition indices, using accepted criteria (20); we found no presence of multicollinearity. We assessed effect modification by using fully adjusted models containing all relevant two-way interaction terms; because the interaction between race/ethnicity and BMI was significant in our models (P < 0.05), we present our findings stratified on BMI category. To assess possible sample

Dysglycemia in U.S. women of childbearing age

Statistical analysis

Women were considered eligible for the analysis if they attended the medical exam and had complete information for race/ethnicity status, pregnancy status, age, education attainment, and PIR. Statistical analyses were performed using SAS-callable SUDAAN, version 9.2 (SAS Institute, Cary, NC). The five survey cycles (1999–2000, 2001–2002, 2003–2004, 2005–2006, and 2007–2008) were merged into one dataset, and 10-year sampling weights were calculated based on guidelines recommended by NCHS for analyses that combine two or more survey cycles (9). For those variables not meeting normality assumptions (i.e., number of live births) the categorical variable was used for analyses. All analyses incorporated the correct sample weights for the subsample and complex survey design. We calculated mean values (95% CI) for continuous variables and prevalence estimates (95% CI) for categorical variables. SEs were estimated using the Taylor series linearization method. Estimates were considered reliable if degrees of freedom were ≥12 and the relative SE ≤30% (9). We used fitted multiple logistic regression models to estimate crude and adjusted odds ratios (ORs) and prevalence risk ratios (PRRs) with accompanying 95% CIs for our outcome variable dysglycemia (17,18). Our calculation of the PRR was performed as a function of the average marginal predictions from the fitted regression models (17). We considered the following variables for confounding, based on previous literature: age, PIR, education, number of live births, waist circumference, and CRP. We elected to keep the covariates stated above in the model if they changed the full model OR by ≥10% (19). Our final models therefore adjusted for age, education, PIR, waist circumference, and CRP. We assessed model fit using the Hosmer-Lemeshow goodness of fit, Satterthwaite-adjusted F test (20). Correlation among independent variables was assessed via the variance inflation factor and condition indices, using accepted criteria (20); we found no presence of multicollinearity. We assessed effect modification by using fully adjusted models containing all relevant two-way interaction terms; because the interaction between race/ethnicity and BMI was significant in our models (P < 0.05), we present our findings stratified on BMI category. To assess possible sample

Nephelometer (Siemans Healthcare Diagnostics, Deerfield, IL).
bias from the limited data of A1C, we conducted a sensitivity analysis restricted to data from 1999–2006 and arrived at the same conclusions as for the full dataset (1999–2008); therefore, we presented our findings based on the full 1999–2008 dataset.

RESULTS—After exclusion of women with inadequate fasting times (n = 421), our final sample totaled 7,162 women, with 2,950 eligible for the fasting analyses. Women who were excluded from the analysis because of invalid fasting times did not differ from those included in the analysis in race/ethnicity category, PIR, parity, BMI, waist circumference, or CRP values. We did notice that women who were excluded were slightly younger than women included in the analysis (P < 0.05) by ~2 years (mean [SD] age for included vs. excluded women, respectively: 29.8 [10.6] vs. 27.8 [10.6]). Demographic characteristics of the study population are provided in Table 1. The mean age of our population was 33 years, with Mexican American women slightly younger than the total population and both non-Hispanic white and non-Hispanic black women. Most women surveyed in the total population were married or cohabitating, with at least a high school education, and had had at least one live birth. Compared with non-Hispanic whites, both non-Hispanic blacks and Mexican Americans were more likely to be near poor or below the poverty line (55.4% and 65.9% vs. 30.2%, respectively) and less likely to have attained a high school degree or greater (71.0 and 50.7 vs. 84.6%, respectively; P < 0.01 for each comparison). More than 50% of U.S. women of childbearing age were overweight, obese, or morbidly obese. Prevalence obesity was significantly higher in non-Hispanic black and Mexican American women compared with non-Hispanic white women (prevalence estimates: 47.0% [95% CI 44.6–49.5], 36.3% [33.1–39.6], and 28.0% [25.8–30.3] for non-Hispanic black, Mexican American, and non-Hispanic white women, respectively; P < 0.01 for each comparison) (Fig. 1). Additionally, high central adiposity (waist circumference ≥88 cm) affected almost 50% of all women in this population, with proportions reaching 58% or greater for both non-Hispanic blacks and Mexican

Table 1—Population statistics for nonpregnant U.S. women of childbearing age: NHANES 1999–2008

| Social factors | Total population | Non-Hispanic white | Non-Hispanic black | Mexican American |
|---------------|------------------|--------------------|--------------------|------------------|
|               | (n weighted = 59,465,044) | (n weighted = 39,758,373) | (n weighted = 7,853,867) | (n weighted = 5,109,137) |
| **Age (years)†** | | | | |
| <20          | 2,954 19.0 (17.2 | 29.0 (25.8–32.5 | 49.4 (45.5–53.2 | 50.7 (46.8–54.5 | |
| 20–24        | 1,747 24.6 (23.2 | 23.9 (23.2–24.9 | 29.1 (25.7–32.7 | 33.0 (29.8–36.4 | |
| 25–29        | 1,505 29.0 (26.6 | 26.6 (26.6–27.5 | 30.7 (30.3–31.2 | 30.8 (29.2–31.4 | |
| 30–34        | 1,211 34.0 (31.4 | 31.8 (30.0–33.6 | 32.7 (29.5–36.0 | 27.3 (23.9–31.1 | |
| ≥35          | 3,854 35.6 (32.5 | 32.6 (32.1–33.2 | 34.1 (32.1–37.0 | 34.2 (31.6–37.1 | |
| **Number of live births†** | 3,822 2.2 (2.1–2.2 | 2.0 (2.0–2.1 | 2.3 (2.2–2.4 | 2.5 (2.4–2.6 | |
| 0            | 245 6.5 (6.1–7.8 | 6.6 (6.1–8.4 | 7.7 (7.0–10.2 | 3.0 (2.5–4.7 | |
| 1            | 1,005 25.0 (23.3–26.8 | 25.7 (23.2–28.3 | 23.3 (20.8–23.9 | 23.2 (19.9–26.8 | |
| 2            | 1,211 36.0 (34.1–38.9 | 35.9 (35.0–40.4 | 32.7 (29.5–36.0 | 27.3 (23.9–31.1 | |
| ≥4           | 3,854 22.3 (20.8–23.9 | 22.2 (20.2–24.3 | 20.8 (17.9–23.9 | 27.5 (25.0–30.3 | |
| **BMI (kg/m²)†** | 7,027 27.6 (27.3–27.9 | 27.0 (26.6–27.5 | 30.7 (30.3–31.2 | 28.7 (28.2–29.1 | |
| BMI <25 kg/m² | 3,065 44.6 (42.5–46.7 | 48.9 (45.9–52.0 | 26.4 (24.3–28.7 | 32.8 (30.1–33.7 | |
| 25 ≤ BMI <30 kg/m² | 1,747 24.6 (23.2–26.2 | 23.1 (21.3–24.9 | 26.6 (24.3–29.0 | 30.9 (28.7–33.2 | |
| BMI ≥30 kg/m² | 2,215 30.8 (29.1–32.6 | 28.0 (25.8–30.3 | 47.0 (44.6–49.5 | 36.3 (33.1–39.6 | |
| **Waist circumference (cm)†** | 9,600 90.5 (89.8–91.2 | 89.7 (88.7–90.7 | 95.8 (94.8–96.7 | 92.7 (91.8–93.6 | |
| ≥88 cm (high) | 3,331 48.8 (46.7–50.9 | 46.1 (43.3–48.9 | 62.4 (60.1–64.6 | 58.4 (55.0–61.8 | |
| **CRP (mg/dL)†** | 6,696 0.4 (0.4–0.5 | 0.4 (0.4–0.5 | 0.6 (0.5–0.6 | 0.5 (0.5–0.6 | |
| ≥0.3 (elevated) | 2,435 37.1 (35.5–38.8 | 35.4 (33.1–37.7 | 44.6 (41.9–47.4 | 44.5 (41.1–47.9 | |
| **FPG (mg/dL)†** | 2,950 93.3 (92.5–94.1 | 92.1 (91.1–93.1 | 95.2 (92.6–97.4 | 97.1 (94.8–99.5 | |
| **A1C (%)** | 5,764 5.2 (5.2–5.3 | 5.2 (5.1–5.2 | 5.5 (5.4–5.5 | 5.4 (5.3–5.4 | |

Data are percent (95% CI) unless otherwise indicated. *Unweighted n. †Mean (95% CI). ‡P value < 0.05 compared with non-Hispanic whites. §P value < 0.01 compared with non-Hispanic whites. †<12 df and relative SE >30%; presenting adjusted CI (9). *Self-report of diabetes or taking diabetes medicines from the interview, FPG ≥100 mg/dL, or A1C ≥5.7% (39 mmol/mol) from laboratory measures.
Americans compared with 46% for non-Hispanic whites (Table 1).

We observed higher FPG, A1C, and CRP levels among non-Hispanic blacks and Mexican Americans compared with non-Hispanic whites (Table 1). Almost 20% of all nonpregnant U.S. women of childbearing age had some measure of dysglycemia. Higher proportions of dysglycemia were seen among minority groups compared with non-Hispanic whites: 26.3% (95% CI 22.3–30.8) in non-Hispanic blacks and 23.8% (19.5–28.7) in Mexican Americans vs. 16.8% (14.4–19.6) in non-Hispanic whites.

In stratified analyses (Table 2 and Supplementary Table 1), within normal to underweight women, we saw higher prevalence of dysglycemia among both non-Hispanic black and Mexican American women compared with non-Hispanic white women. For this BMI category, in our unadjusted models, prevalence of dysglycemia was twice as high in both non-Hispanic blacks and Mexican Americans compared with non-Hispanic whites. These observations held when models were adjusted for age, socioeconomic factors, waist circumference, and CRP levels, though the estimates were slightly attenuated (PRRadj 1.86 [95% CI 1.16–2.98] for non-Hispanic blacks and 2.23 [1.38–3.60] for Mexican Americans) (Table 2). Lower education attainment was also significantly associated with higher prevalence of dysglycemia within this BMI category, as was having a waist circumference ≥88 cm. Among overweight women, we observed that non-Hispanic blacks had ~1.5 times the prevalence of dysglycemia compared with non-Hispanic whites; this disparity persisted after adjusting for age, socioeconomic status, waist circumference, and CRP (PRRadj 1.55 [1.03–2.34]), with the same effect for both lower education attainment and waist circumference observed as seen in the normal and underweight women. We found no significant differences in dysglycemia prevalence between overweight Mexican American women and overweight non-Hispanic white women. Additionally, among obese and morbidly obese women, we did not observe any differences in dysglycemia by race/ethnicity status in either crude or adjusted models (Fig. 2).

CONCLUSIONS—Using nationally representative data collected over 10 years and representing >50 million women, we found that almost 1 in 5 U.S. women of childbearing age were affected by some form of dysglycemia. Additionally, more than one-half of all U.S. women of childbearing age were overweight or obese, and nearly 50% had high central adiposity. We also observed the disproportionate burden of dysglycemia among racial and ethnic minorities compared with non-Hispanic whites, with prevalence estimates in minorities ~1.5 times those in non-Hispanic whites. When stratified by BMI category, we continued to see disparities in dysglycemia prevalence by race/ethnicity status, though this was restricted to distinct BMI categories. Within the normal-to-underweight group, both non-Hispanic blacks and Mexican Americans had almost twice the prevalence of dysglycemia versus non-Hispanic whites. In the overweight group, only non-Hispanic blacks had increased prevalence, at almost 1.5 times that of non-Hispanic whites.

Hyperglycemia among women of childbearing age poses a risk not only to the woman as she progresses through various life stages (3) but also to her fetus if she becomes pregnant (6–8). These effects could impact the long-term health of her child, including increased risk of obesity and type 2 diabetes later in life (21,22). However, little attention has been paid to diabetes and measures of dysglycemia specifically among nonpregnant women of childbearing age. Most estimates from U.S. data for this particular population subgroup are derived from analyses using broad age ranges, as well as pregnant and nonpregnant women. Previously reported prevalence estimates range between 3 and 7.5% for self-reported diabetes and 8 and 23% for clinical measures of IFG (1,2), with higher estimates for both measures in minority groups and higher age categories. Our results for overall dysglycemia (which includes diabetes and prediabetes measures, including IFG) are comparable with these estimates, despite our younger cohort. This is of note, since diabetes and dysglycemia in general increase with age (23), and highlights the importance of focusing interventions on this younger age-group.

Research focusing specifically on nondiabetic women of childbearing age shows disproportionate levels of obesity and other clinical characteristics of the metabolic syndrome, including IFG, among both non-Hispanic blacks and Hispanics compared with non-Hispanic whites (24). Since these data excluded diabetic women, our study is the first to investigate diabetes and prediabetes measures specifically among women of childbearing age. Other findings from national data have shown variations in diabetes prevalence by BMI group. A recent study (25) looking at 30 years of NHANES data shows variation in racial/ethnic disparities of diabetes by BMI group: in normal and overweight individuals, minority groups experience a greater increase in diabetes prevalence than whites over the time period studied, but in obese and severely obese groups this disparity is less pronounced. Though this recent study includes a larger

Figure 1—Prevalence of under/normal weight, overweight, and obese (by BMI cutoffs) among nonpregnant U.S. women of childbearing age (15–49 years) for total population and by race/ethnicity, NHANES 1999–2008. *P ≤ 0.05 vs. non-Hispanic white. MA, Mexican American; NHB, non-Hispanic black; NHW, non-Hispanic white.
Table 2—Crude PRRs and PRR\textsubscript{adj} (95% CI) for dysglycemia in nonpregnant U.S. women of childbearing age (15–49 years) by BMI category\textsuperscript{2}:

| Race/ethnicity | Under- or normal-weight BMI (n = 1,118, n\textsubscript{weighted} = 23,213,172) | Overweight BMI (n = 640, n\textsubscript{weighted} = 12,462,018) | Obese or morbidly obese (n = 830, n\textsubscript{weighted} = 16,222,072) |
|----------------|--------------------------------|--------------------------------|--------------------------------|
|                | Crude model | Adjusted model\textsuperscript{1} | Crude model | Adjusted model\textsuperscript{1} | Crude model | Adjusted model\textsuperscript{1} |
| Non-Hispanic white | Reference category | Reference category | Reference category | Reference category | Reference category | Reference category |
| Non-Hispanic black | 1.81 (1.09–3.01) | 1.86 (1.16–2.98) | 1.54 (1.06–2.24) | 1.55 (1.03–2.34) | 0.99 (0.75–1.30) | 1.06 (0.81–1.39) |
| Mexican American | 2.12 (1.37–3.30) | 2.23 (1.38–3.60) | 1.41 (0.87–2.29) | 1.28 (0.73–2.26) | 0.94 (0.72–1.23) | 0.99 (0.74–1.32) |
| Education | | | | | | |
| ≥ High school | Reference category | Reference category | Reference category | Reference category | Reference category | Reference category |
| < High school | 2.24 (1.34–3.77) | 1.71 (1.04–2.81) | | | 1.09 (0.87–1.36) | |
| Waist circumference (cm) | | | | | | |
| ≤ 88 | Reference category | Reference category | Reference category | Reference category | Reference category | Reference category |
| > 88 | 2.30 (1.21–4.38) | 1.89 (1.00–3.57) | | | 1.21 (0.30–4.80) | |
| PIR | | | | | | |
| ≥ Middle class | Reference category | Reference category | Reference category | Reference category | Reference category | Reference category |
| Near poor | 0.76 (0.44–1.33) | 1.20 (0.67–2.14) | | | 1.00 (0.75–1.33) | |
| Below poverty line | 0.78 (0.42–1.46) | 0.69 (0.30–1.63) | | | 1.21 (0.95–1.59) | |
| CRP (mg/dL) | | | | | | |
| ≤ 0.3 | Reference category | Reference category | Reference category | Reference category | Reference category | Reference category |
| > 0.3 | 1.30 (0.78–2.13) | 0.94 (0.60–1.48) | | | 1.41 (1.02–1.96) | |

\textsuperscript{1}Adjusted for age (continuous), waist circumference (<88 or ≥88 cm), education (<high school or ≥high school), PIR (<1, poor; ≥1 but <2, near poor; or ≥2, middle or high income), and CRP (≤0.3 or >0.3 mg/dL).\textsuperscript{2}Normal and underweight: BMI <25.0 kg/m\textsuperscript{2}, overweight: BMI 25–29.99 kg/m\textsuperscript{2}, and obese or morbidly obese: BMI ≥30 kg/m\textsuperscript{2}.

Figure 2—PRR\textsubscript{adj} (95% CI) for dysglycemia in different race/ethnicities in nonpregnant U.S. women of childbearing age, stratified by BMI category. Adjusted for age (continuous), waist circumference (<88 or ≥88 cm), education (<high school or ≥high school), PIR (<1, poor; ≥1 but <2, near poor; or ≥2, middle or high income), and CRP (≤0.3 or >0.3 mg/dL). Under or normal weight: BMI <25.0 kg/m\textsuperscript{2} (n = 1,118; n\textsubscript{weighted} = 23,213,172); overweight: BMI 25–29.99 kg/m\textsuperscript{2} (n = 640; n\textsubscript{weighted} = 12,462,018), and obese or morbidly obese: BMI ≥30 kg/m\textsuperscript{2} (n = 830; n\textsubscript{weighted} = 16,222,072).
among those women with normal-weight obesity, insulin sensitivity was significantly decreased. Additionally, the researchers found an increased risk of cardiovascular mortality among these women, suggesting that classifying a person as "normal" based on BMI alone might mask the effects of that person's body fat content. However, the body fat measures used in these clinical studies did not account for the distribution of fat—specifically, the location of the fat stores. Although visceral adipose has been linked to increased diabetes incidence (14), clinical studies have shown that African American women have less visceral adipose stores compared with European American women have less visceral adipose stores. Although visceral adipose has been shown to be a strong predictor of dysglycemia prevalence by race/ethnicity among women with a normal BMI, the use of these clinical indices alone may not identify some women at increased risk for impaired glucose tolerance.

Differences in dysglycemia by race/ethnicity may also be due to factors unrelated to glucose control and could be a result of genetic or ancestral differences, particularly related to A1C variation. Several epidemiological studies have reported higher A1C values in African Americans vs. whites, independent of FPG levels (36,37). Results from the Diabetes Prevention Program show that among individuals with impaired glucose tolerance, both blacks and Hispanics had higher A1C levels than whites, even after adjusting for cofactors such as age, sex, education, BMI, blood pressure, and insulin resistance (38). Previous research estimates that genetic factors might explain >50% of variation in A1C (39) and supports the exploration for a genetic loci unique to A1C. However, recent research from the Atherosclerosis Risk in Communities (ARIC) study shows a small contribution of genetic ancestry relative to social and metabolic factors in explaining A1C variation among African Americans, indicating that ancestral genetic differences might not explain significantly the observed race/ethnicity differences in A1C (40). More research is warranted to investigate the role of genetic factors in these specific associations.

While our analysis uses robust, nationally representative survey data, there are some limitations to our study. NHANES data are based on a cross-sectional survey; consequently, there is no way to assess causality. Also, because of possible disclosure risks, for the 2007–2008 survey cycle only pregnancy status information for women aged 20–44 years was available. We therefore may have missed some nonpregnant women aged 15–19 and 45–49 years in the survey. We also restricted our analyses to only three race/ethnicity categories; small sample size and wide heterogeneity of a fourth category ("other") did not allow for reliable comparison with the other defined categories for race/ethnicity. Additionally, fasting measures are based on one FPG value, and fasting state is based on the participants’ self-report. For clinical diagnoses, it is recommended that the subject be retested in the presence of a normal result; we did not have this opportunity. Therefore, it is likely that some prevalence estimates from the use of FPG values might be overestimated. Also, diagnosed diabetes is by self-report; however, we are able to use laboratory values for diabetes measures to help eliminate any biases of self-report. Finally, we are missing values of A1C from the 2007–2008 NHANES cycle. NHCS released a statement in March 2012 noting an increase in the proportion of A1C values between 5.7 and 6.4% (39–48 mmol/mol) and subsequent shift to the right (increased values) of A1C distribution in NHANES 2007–2010 compared with 1999–2006. However, after extensive investigation, the specific source for this observation is currently unknown (9). Since our analyses are focused on those persons with higher A1C—particularly, 5.7% (39 mmol/mol) and above—inclusion of these data from 2007–2008 may have biased our results; therefore, we chose not to include these data in our analyses. Because of this, some individuals may have been misclassified on their status of dysglycemia. To test how this might affect our results and subsequent conclusions from our findings, we conducted a sensitivity analysis using only data from 1999–2006. We observed no significant changes to our conclusions using this data subset and therefore presented results from the full dataset, 1999–2008. A breakdown of our outcome showed that 8.3% of our population were categorized as having dysglycemia by A1C criteria, 16.2% by FPG criteria, and 2.7% by interview response (i.e., with diagnosed diabetes). Within the whole study sample, 3.0% were categorized as having dysglycemia by meeting both A1C and FPG criteria, 1.3% by A1C criteria alone, and 8.4% by FPG criteria alone. However, the fact that we were able to include both laboratory measures for glucose and A1C, as well as a self-report of doctor-diagnosed diabetes, adds to the robustness of our study.

In summary, we found that approximately one in five of the nation’s nonpregnant women of childbearing age is affected by some form of dysglycemia. This corresponds to almost 9 million U.S. women between the ages of 15 and 49 years, with a greater burden among minorities compared with non-Hispanic whites. While our findings confirm the presence of disparities in dysglycemia prevalence by race/ethnicity, contrary to previous literature we find this difference is explained not by obesity but, rather, by differences within normal to underweight groups. These findings suggest that special attention should be paid specifically to the disparities among nonobese individuals both in clinical practices and in development of public health programs and interventions.

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No potential conflicts of interest relevant to this article were reported. J.A.M. assisted with project conception, conducted the statistical analysis, reviewed the data and results, and wrote the manuscript. C.J.A. researched the data, led the statistical analysis, provided statistical consultation, and reviewed and edited the manuscript. K.M.V.N. reviewed the results, contributed to the discussion, and reviewed and edited the manuscript. H.S.K. contributed to the data analysis, reviewed the results, contributed to the discussion, and reviewed and edited the manuscript. J.R. researched data, contributed to the discussion, and reviewed and edited the manuscript. A.C. assisted with project conception, reviewed the results, contributed to the discussion, and reviewed and edited the manuscript. A.C. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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