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Racial/Ethnic Disparities in Diabetes Diagnosis and Glycemic Control Among Women of Reproductive Age

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Abstract

Background: Types 1 and 2 diabetes mellitus complicate pregnancies and threaten the health of women of reproductive age and their children. Among older adults, diabetes morbidity disproportionately burdens racial/ethnic minorities, but diabetes emergence among younger adults has not been as well characterized. The objective of this study was to describe the distribution of diagnosed diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes among women of reproductive age across racial/ethnic backgrounds.

Materials and Methods: We analyzed data collected in 2007–2008 from 6774 nonpregnant women, ages 24–32, in the National Longitudinal Study of Adolescent to Adult Health (Add Health). Prediabetes and undiagnosed diabetes were identified by fasting glucose and glycosylated hemoglobin (A1C) and diagnosed diabetes by self-report or antihyperglycemic medication use. We used multinomial regression models to predict prediabetes or diabetes versus normoglycemia. Within women with diabetes, we used logistic regression to predict those being undiagnosed and having suboptimal preconception glycemic control based on A1C.

Results: The estimated prevalence of diabetes was 6.8%, of which 45.3% was undiagnosed. Diabetes prevalence varied by race/ethnicity ($p < 0.001$): 15.0% of non-Hispanic black women (75.6% undiagnosed), 7.5% of Hispanic women (48.1% undiagnosed), 4.8% of non-Hispanic white women (22.8% undiagnosed), and 4.5% of Asian women (11.4% undiagnosed). The prevalence of prediabetes was highest in non-Hispanic black (38.5%), followed by Hispanic (27.8%), Asian (25.1%), Native American (20.3%), and non-Hispanic white (16.6%) women.

Conclusions: Racial/ethnic disparities exist among women of reproductive age with prediabetes and diabetes. Meeting their healthcare needs requires addressing health inequities and coordination of diabetes management with reproductive health.

Keywords: diabetes, prediabetes, preconception, disparities

Introduction

More than 29 million Americans have diabetes, including 12%–14% of adults over age 20, and the prevalence is projected to increase.[1,2] Because the average age of diagnosis is declining, approximately one-third of new diagnoses now occur between ages 18 and 50 when most women can become pregnant.[3] Inadequately controlled diabetes in pregnancy is associated with fetal malformation, spontaneous abortion, stillbirth, preeclampsia, preterm birth, macrosomia, and fetal programming for obesity and diabetes later in life.[4–8] To reduce diabetes-related risks during pregnancy, the American Diabetes Association (ADA) recommends that women strive to lower their blood glucose

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until they achieve glycosylated hemoglobin (A1C) values below 6.5% by using preconception care as well as contraception to delay pregnancy until they are ready.[9] Women whose diabetes is undiagnosed, by definition, have not been identified as appropriate candidates of the ADA recommendations for care to improve glycemic control before pregnancy. Understanding the growing prevalence and distribution of diabetes diagnoses and elevated blood glucose among women of reproductive age is critical for targeting improved reproductive health service delivery, including both preconception care and family planning, in coordination with diabetes management.

In the United States (U.S.), diabetes morbidity disproportionately burdens people who are racial/ethnic minorities. Compared with non-Hispanic white adults, non-Hispanic black and Hispanic adults are more likely to have diabetes, elevated A1C, and sequelae such as lower extremity amputation, retinopathy, and kidney failure.[10–13] Diabetes incidence has been increasing at faster rates among non-Hispanic black and Hispanic adults than non-Hispanic white adults.[11] The prevalence of prepregnancy diabetes has increased among women giving birth in hospitals.[14] Among deliveries in hospitals in 19 states, the highest rates and highest absolute rate changes in prepregnancy diabetes occurred among non-Hispanic black and Hispanic women.[15] However, the prevalence of diabetes in nationally representative samples is rarely described with stratification by age, gender, and race/ethnicity in the manner necessary to understand trends in diabetes as a risk factor for adverse obstetrical outcomes. Thus, the objective of this study was to describe the distribution of prepregnancy diagnosed diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes by race/ethnicity among women of reproductive age using a nationally representative U.S. sample.

Materials and Methods

Dataset

We analyzed data from the National Longitudinal Study of Adolescent to Adult Health (Add Health). Add Health used a stratified, school-based cluster sample representative of American high schools.[16] Participants were recruited while in 7th–12th grade during the 1994–1995 school year (Wave I), and follow-up data were collected in 1996 (Wave II), 2001–2002 (Wave III), and 2007–2008 (Wave IV). Participants completed in-home interviews during each wave. During Wave IV, biological specimens were collected, and A1C was determined from capillary whole blood *via* finger prick, a valid and reliable test.[17,18] A1C represents average blood glucose over the previous 2 to 3 months. A1C values between 5.7% and 6.4% indicate prediabetes, and A1C values of 6.5% and above indicate diabetes.[9]

In all analyses, we applied sample weights to adjust for school-level clustering and unequal probability of selection to generate estimates that were nationally representative of Americans who were in 7th–12th grade during the 1994–1995 school year.

Primary outcome: diabetes status

Women were categorized as having diabetes if they had a fasting glucose ≥126 mg/dL; a nonfasting glucose ≥200 mg/dL; an A1C ≥6.5%; self-reported diabetes history (affirming they had a ''history of being told by a doctor or health care professional that you have diabetes (if female, outside of pregnancy)''); or antihyperglycemic medication use based on a prescription inventory of medications used in the preceding 4 weeks. Full details on the diabetes variables in Add Health have been described elsewhere.[18] The blood-based criteria reflected the ADA clinical guidelines for diagnosis.[9]

Among the women with diabetes, we characterized a woman as diagnosed if she had a self-reported diabetes history or antihyperglycemic medication use. Women were categorized as undiagnosed if they reported neither. Suboptimal preconception glycemic control in women with diabetes was defined as an A1C ≥6.5% based on the ADA recommendations for pregnancy.[9]

Women were considered to have prediabetes if they had an A1C of 5.7%–6.4% and no evidence of diabetes based on self-reported history of diagnoses or antihyperglycemic medication use.[9] Women without prediabetes or diabetes were categorized as normoglycemic.

Primary predictor: race/ethnicity

Five mutually exclusive categories were created based on the respondent-identified Hispanic ethnicity and race during Wave I in 1994–1995[19] (non-Hispanic white; non-Hispanic black; Hispanic of any race; non-Hispanic Native American; and non-Hispanic Asian).

Covariates: sociodemographic characteristics

Additional covariates, all from Wave IV, included educational attainment, type of health insurance, and self-reported limited access to healthcare in the preceding 12 months. In young adulthood, education is generally stable and derived from a single source, unlike household income, which is more volatile and may include multiple people and multiple sources.[20–22] Therefore, we used educational attainment as a proxy for socioeconomic position rather than income.

Statistical analyses

We used provided survey weights to compute unbiased population estimates and implemented linearization to perform design-based standard error computations. We used the second-order, Rao–Scott design-adjusted F test to examine the null hypothesis of independence between diabetes status and sociodemographic characteristics.

For the primary analysis, race/ethnicity as a predictor of diabetes status was modeled with maximum-likelihood multinomial logit regression, with normoglycemia as the base outcome and non-Hispanic white women as the reference group. The adjusted model included sociodemographic characteristics (educational attainment, insurance, and access to healthcare). The null hypothesis was that there would be no racial/ethnic differences in the odds of a woman having diabetes or prediabetes rather than normoglycemia. Beta coefficients from the regression model were exponentiated to yield adjusted odds ratios (aORs). The overall significance of each predictor was examined with an adjusted Wald test.

Subclass analyses were conducted to explore racial/ethnic differences in glycemic control and diagnosis status among women with diabetes. We attempted to fit a linear model for

A1C, but these models violated the usual regression assumptions of normality and homogeneity of the variance of residuals. Consequently, we only reported on logistic regression models with suboptimal preconception glycemic control. We fit an additional logistic regression model for those being undiagnosed versus diagnosed.

All tests were two-tailed, with a 0.05 significance level. All analyses were completed in Stata, version 14.1 (StataCorp LP), using the SVY commands to apply sampling weights. Institutional review board approval was obtained from the University of North Carolina at Chapel Hill.

Results

We used data from 6774 nonpregnant women, aged 24–32 years, with complete covariate data. Of the 7870 women who provided data at Wave IV and had sampling weights, we excluded women from this analysis for being pregnant ($n=519$) or missing values for any of the following: pregnancy status ($n=48$), insurance ($n=12$), access to care ($n=1$), ethnicity ($n=28$), race ($n=149$), or A1C ($n=551$ due to refusals, ineligibility due to incarceration, or insufficient blood sample).

We estimated that 6.8% of women between ages 24 and 32 had diabetes and 21.8% had prediabetes. Table 1 shows the weighted estimates of population prevalence. The bivariate association between diabetes status and race/ethnicity was significant ($p<0.001$). Diabetes was most prevalent among non-Hispanic black women (15.0%), followed by Native American (10.1%), Hispanic (7.5%), non-Hispanic white (4.8%), and Asian (4.5%) women. Non-Hispanic black women had the greatest proportion of prediabetes (38.5%), followed by Hispanic (27.8%), Asian (25.1%), Native American (20.4%), and non-Hispanic white (16.6%) women. Diabetes status had significant bivariate associations with education ($p<0.001$), insurance ($p=0.003$), and access to care ($p<0.001$).

Of the women with diabetes, 45.3% were undiagnosed (Table 2). Being undiagnosed had a significant bivariate association with race/ethnicity ($p<0.001$). The majority of non-Hispanic black women with diabetes were undiagnosed (75.6%), while less than half of the women with diabetes who were Hispanic (48.1%), non-Hispanic white (22.8%), or Asian (11.4%) were undiagnosed. The cell counts for Native American women with diabetes were too small to report as per Add Health guidelines. Being undiagnosed did not have significant bivariate associations with education ($p=0.29$), insurance ($p=0.61$), or access to care ($p=0.92$).

Approximately half (51.0%) of the women with diabetes had suboptimal preconception glycemic control (A1C ≥6.5%). Glycemic control had a significant bivariate association with race/ethnicity ($p<0.001$), but not education ($p=0.32$), insurance ($p=0.11$), or access to care ($p=0.07$). The majority of non-Hispanic black women with diabetes had an A1C ≥6.5% (88.2%), whereas smaller proportions of Hispanic (42.9%), non-Hispanic white (26.3%), and Asian (18.1%) women with diabetes had suboptimal preconception glycemic control.

Multinomial analysis

Table 3 shows that race/ethnicity was a significant predictor of diabetes status in the adjusted multinomial logit model ($p<0.001$). Relative to non-Hispanic white women, the odds of having prediabetes or diabetes rather than normoglycemia, even after adjusting for education, insurance, and access to care, were higher for non-Hispanic black women (diabetes: aOR = 4.8; prediabetes: aOR = 3.7) and Hispanic women (diabetes: aOR = 1.7; prediabetes: aOR = 1.9). Asian women had greater adjusted odds of having prediabetes

Table 1. Sample Characteristics and Bivariate Associations with Diabetes Status ($N=6774$)

	Normoglycemia	*Prediabetes*	*Diabetes*	*Total*	*Rao–Scott design-adjusted* F *test*
Total	4641 (71.4%)	1598 (21.8%)	535 (6.8%)	6774 (100%)	
Sociodemographic characteristics					
Race/ethnicity, *n* (%)					
Non-Hispanic white	2925 (78.6)	613 (16.6)	192 (4.8)	3730 (100)	$p<0.001$
Non-Hispanic black	752 (46.5)	584 (38.5)	222 (15.0)	1558 (100)	
Hispanic	693 (64.7)	273 (27.8)	87 (7.5)	1053 (100)	
Native American	26 (69.6)	16 (20.4)	8 (10.1)	50 (100)	
Asian	245 (70.4)	112 (25.1)	26 (4.5)	383 (100)	
Education, *n* (%)					
College graduate or more	1749 (78.9)	460 (16.8)	118 (4.3)	2327 (100)	$p<0.001$
Some college or vocational school	2021 (69.6)	779 (23.2)	276 (7.2)	3076 (100)	
High school graduate	598 (63.0)	242 (27.7)	92 (9.3)	932 (100)	
Less than high school	273 (65.8)	117 (23.8)	49 (10.4)	439 (100)	
Insurance, *n* (%)					
Private insurance	3364 (73.4)	1099 (20.7)	342 (6.0)	4805 (100)	$p=0.003$
Medicaid	444 (62.8)	192 (26.9)	84 (10.3)	720 (100)	
No insurance	833 (69.1)	307 (23.2)	109 (7.7)	1249 (100)	
Access to care, *n* (%)					
Had access	3543 (72.9)	1177 (21.2)	349 (5.9)	5069 (100)	$p<0.001$
Lacked access	1098 (66.9)	421 (23.8)	186 (9.3)	1705 (100)	

Unweighted *n* and weighted row percentages (may not add to 100.0% due to rounding).

Table 2. Diabetes Subclass Characteristics and Bivariate Associations with Diagnosis Status and Glycemic Control ($N=535$)

	Diagnosis status		*Rao–Scott design-adjusted* F *test*	*Glycemic control*		*Rao–Scott design-adjusted* F *test*
	Undiagnosed	*Diagnosed*		*A1C <6.5%*	*A1C ≥6.5%*	
Total	256 (45.3%)	279 (54.7%)		225 (49.0%)	310 (51.0%)	
Sociodemographic characteristics						
Race/ethnicity, *n* (%)						
Non-Hispanic white	46 (22.8)	146 (77.2)	$p<0.001$	137 (73.7)	55 (26.3)	$p<0.001$
Non-Hispanic black	162 (75.6)	60 (24.4)		34 (11.8)	188 (88.2)	
Hispanic	35 (48.1)	52 (51.9)		43 (57.1)	44 (42.9)	
Native American	[a]	[a]		[a]	[a]	
Asian	9 (11.4)	17 (88.6)		7 (81.9)	19 (18.1)	
Education, *n* (%)						
College graduate or more	58 (43.8)	60 (56.2)	$p=0.29$	57 (58.1)	61 (41.9)	$p=0.32$
Some college or vocational school	134 (51.2)	142 (48.8)		115 (48.2)	161 (51.8)	
High school graduate	37 (39.2)	55 (60.8)		39 (49.1)	53 (50.9)	
Less than high school	27 (33.7)	22 (66.3)		14 (36.2)	35 (63.8)	
Insurance, *n* (%)						
Private insurance	162 (42.8)	180 (57.2)	$p=0.61$	155 (54.6)	187 (45.4)	$p=0.11$
Medicaid	38 (50.8)	46 (49.2)		34 (44.7)	50 (55.3)	
No insurance	56 (47.7)	53 (52.3)		36 (36.8)	73 (63.2)	
Access to care, *n* (%)						
Had access	173 (45.1)	176 (54.9)	$p=0.92$	151 (53.1)	198 (46.9)	$p=0.07$
Lacked access	83 (45.7)	103 (54.3)		74 (41.4)	112 (58.6)	
Diagnosis, *n* (%)						
Diagnosed	—	—	—	170 (68.5)	109 (31.5)	$p<0.001$
Undiagnosed	—	—	—	55 (25.3)	201 (74.7)	

Unweighted *n* and weighted row percentage (may not add to 100.0% due to rounding).
[a]Cell count too small to publish as per Add Health guidelines.
A1C, glycosylated hemoglobin.

Table 3. Odds Ratio Estimates of Diabetes Status from Multinomial Logistic Regression ($N=6774$)

	Prediabetes vs. normoglycemia	*Diabetes vs. normoglycemia*	*Adjusted Wald test*
	aOR (95% CI)	*aOR (95% CI)*	
Race/ethnicity			
Non-Hispanic white	Ref.	Ref.	$p<0.001$
Non-Hispanic black	3.7 (3.0–4.5)***	4.8 (3.6–6.5)***	
Hispanic	1.9 (1.4–2.5)***	1.7 (1.2–2.5)**	
Native American	1.3 (0.3–5.1)	2.0 (0.5–8.3)	
Asian	1.8 (1.2–2.6)**	1.1 (0.3–3.8)	
Education			
College graduate or more	Ref.	Ref.	$p<0.001$
Some college or vocational school	1.4 (1.2–1.7)**	1.6 (1.1–2.2)**	
High school graduate	1.8 (1.4–2.5)***	2.2 (1.4–3.4)**	
Less than high school	1.4 (0.9–2.1)	2.2 (1.3–3.6)**	
Insurance			
Private insurance	Ref.	Ref.	$p=0.93$
Medicaid	1.1 (0.7–1.6)	1.2 (0.8–1.7)	
No insurance	1.0 (0.8–1.2)	1.0 (0.7–1.4)	
Access to care			
Had access	Ref.	Ref.	$p=0.04$
Lacked access	1.1 (0.9–1.4)	1.5 (1.1–2.1)*	

Base outcome is normoglycemia.
*$p<0.05$, **$p<0.01$, ***$p<0.001$.
aOR, adjusted odds ratio; CI, confidence interval.

Table 4. Odds Ratio Estimates of Diagnosis Status and Glycemic Control from Logistic Regression in Diabetes Subclass ($N=535$)

	Diagnosis status[a]		*Glycemic control*[b]	
	Undiagnosed diabetes		*A1C ≥6.5%*	
	aOR (95% CI)	*Adjusted Wald test*	*aOR (95% CI)*	*Adjusted Wald test*
Race/ethnicity				
Non-Hispanic white	Ref.	$p<0.001$	Ref.	$p<0.001$
Non-Hispanic black	11.2 (6.3–19.9)***		15.6 (7.6–32.2)***	
Hispanic	2.8 (1.0–8.1)		1.9 (0.9–4.0)	
Native American	[c]		[c]	
Asian	0.4 (0.1–1.7)		1.2 (0.5–2.7)	
Education				
College graduate or more	Ref.	$p=0.13$	Ref.	$p=0.48$
Some college or vocational school	1.0 (0.5–1.9)		1.3 (0.6–2.7)	
High school graduate	0.7 (0.3–1.8)		1.8 (0.6–5.0)	
Less than high school	0.3 (0.1–0.9)*		2.3 (0.7–7.6)	
Insurance				
Private insurance	Ref.	$p=0.36$	Ref.	$p=0.31$
Medicaid	1.6 (0.7–3.4)		1.0 (0.4–2.4)	
No insurance	1.5 (0.7–3.2)		1.9 (0.8–4.9)	
Access to care				
Had access	Ref.	$p=0.81$	Ref.	$p=0.13$
Lacked access	1.1 (0.6–1.9)		1.7 (0.9–3.2)	
Diagnosis status				
Diagnosed	NA		Ref.	$p=0.002$
Undiagnosed			3.2 (1.8–5.8)***	

[a]Reference category is being diagnosed (self-reported diabetes history or antihyperglycemic medication use).
[b]Reference category is A1C <6.5%, which the ADA recommends before becoming pregnant.[9]
[c]Cell count too small to publish as per Add Health guidelines.
*$p<0.05$, **$p<0.01$, ***$p<0.001$.
ADA, American Diabetes Association.

instead of normoglycemia than non-Hispanic white women (aOR = 1.8). Education ($p<0.001$) and access to care ($p=0.04$) were significant predictors in the model, but insurance was not ($p=0.93$).

Subclass analysis: diabetes

In the subclass analysis of women with diabetes (Table 4), non-Hispanic black women had 11.2 greater adjusted odds of being undiagnosed than non-Hispanic white women. Race/ethnicity was a significant predictor ($p<0.001$) but education, insurance, and access to care were not.

Race/ethnicity was a significant predictor of suboptimal preconception glycemic control ($p<0.001$). The adjusted odds of non-Hispanic black women having suboptimal preconception glycemic control of an A1C ≥6.5% were 15.6 greater than the odds for non-Hispanic white women. Diagnosis was also a significant predictor ($p=0.002$): undiagnosed women had over three times the odds of A1C ≥6.5% than diagnosed women (aOR = 3.2). Education, insurance, and access to care were not significant predictors.

Discussion

Diabetes, undiagnosed diabetes, suboptimal preconception glycemic control, and prediabetes burdened women of reproductive age, and the burden varied by race/ethnicity. Alarmingly, more than half of non-Hispanic black women exhibited evidence of either prediabetes or diabetes. Early identification and effective management of diabetes are critical for supporting women in optimizing their health and having safe pregnancies if and when they desire to bear children.

We estimate that 21.8% of women aged 24–32 years had prediabetes, which more than doubles the odds of developing gestational diabetes, increasing risks of macrosomia, preeclampsia, and shoulder dystocia.[9] An estimated 6.8% of women aged 24–32 years had diabetes, of whom over half (51.0%) had suboptimal preconception glycemic control. Notably, 88.2% of non-Hispanic black women with diabetes exhibited an A1C ≥6.5%. Women with diabetes can reduce the risks of adverse pregnancy outcomes, including fetal anomalies, preterm birth, and perinatal mortality, through preconception care, which includes lowering blood glucose, using contraception to time pregnancies, and other interventions.[23] Contraception use creates a window of time in which women may engage in preconception behaviors before trying to conceive. Our findings about diabetes prevalence among women of reproductive age highlight the importance of performing randomized clinical trials to identify the optimal preconception care protocol.[24]

We found a greater proportion of women, aged 24–32 years, with diabetes to be undiagnosed (45.3%) than has been observed in the overall adult population (23.8%).[25] Lack of insurance and inadequate access to care, although not significant

in our models, are well-documented barriers to diabetes screening.[26] However, underdetection also persists because of nonadherence to the ADA criteria for screening.[27] The importance of adhering to screening criteria for people under age 45, before universal screening is recommended, is underscored by our findings that the majority (74.7%) of women aged 24–32 years with undiagnosed diabetes had an A1C ≥ 6.5%.

We note several limitations. Wave IV of Add Health was collected before implementation of the Affordable Care Act; not capturing the impact of those policy changes, this analysis may serve as a point of comparison. Participants in Add Health were not asked if they had type 1 or 2 diabetes, a limitation we deemed tolerable because, in both conditions, elevated blood glucose exerts the same physiological effect, particularly during organogenesis in the early weeks of pregnancy.[9] While the Add Health sample was large enough to support stratification by both gender and race/ethnicity, the small cell counts for Native Americans should limit inferences about nonsignificant results, in light of other data about diabetes prevalence in those communities.[28–30] Nonetheless, Add Health's large sample of young adults can address the sample size limitation encountered with the National Health Examination and Nutrition Study (NHANES), the probability sample whose biomarker data are frequently used to generate population estimates about diabetes.[31]

We question how realistic it was that 49.0% of women with some evidence of diabetes had an A1C <6.5% due to excellent glycemic management. It is possible that instead this sample includes measurement errors resulting from women not correctly fasting before undergoing a fasting glucose test, self-reporting diabetes history incorrectly (*i.e.*, reporting a history of gestational diabetes despite being instructed to exclude those), or taking antihyperglycemic medications for other purposes (*i.e.*, metformin for polycystic ovarian syndrome). To address this concern, we modeled having an A1C ≥6.5% (Table 4). We found dramatically higher odds of non-Hispanic black women experiencing suboptimal preconception glycemic control than non-Hispanic white women.

Our findings should be contextualized in the larger body of evidence that non-Hispanic black women and Hispanic women are disproportionately burdened by adverse obstetric outcomes.[32–34] We recommend that future research should examine whether enhancing diabetes management in coordination with reproductive healthcare could be an innovative strategy for pursuing racial/ethnic equity in both women's health and infant health. Non-Hispanic black and Hispanic women with prepregnancy diabetes in the United States have identified numerous barriers to achieving glycemic control before, during, and after pregnancy: costs of supplies, medications, and nutritious food; challenges with maintaining diet and exercise regimens; and difficulties communicating with providers.[35] To support women to optimize their health, we must center the voices of those most affected and address structural barriers to wellness.

Conclusions

In the U.S., there is a growing population of women of reproductive age with prediabetes and diabetes, many of whom are unaware that they are at heightened risk of, or already have, elevated blood glucose, threatening health during future pregnancies. Improving population health outcomes will require providers to address both racial/ethnic disparities and potential reproductive health needs of young adult women managing diabetes.

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Disclaimer

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Author Disclosure Statement

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