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Original Article

Racial Disparities in Prevalence of Gestational Diabetes by Maternal Nativity and Length of US Residence in an Urban Low-Income Population in the United States

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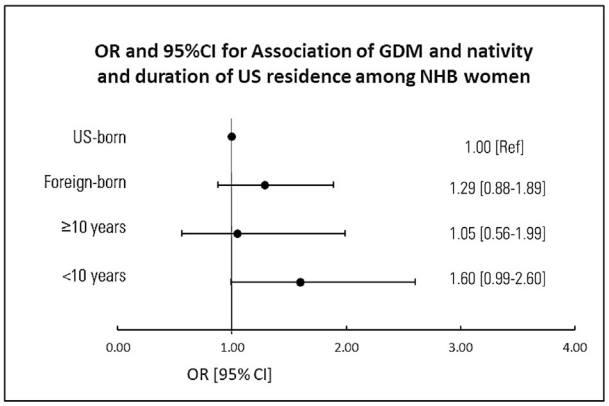

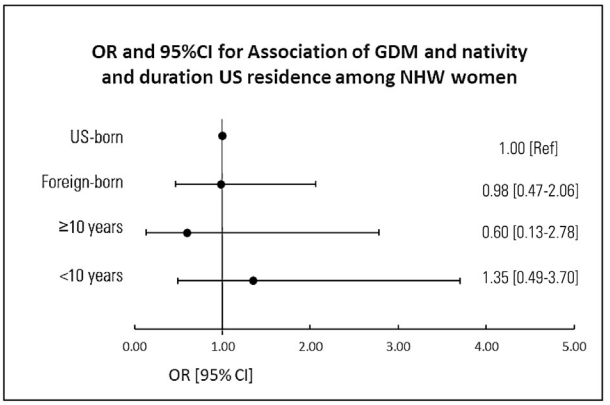

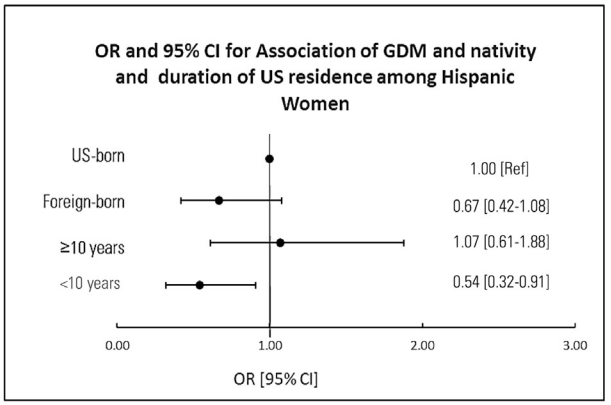

Models adjusted for maternal age, education, marital status, stress, chronic hypertension, , parity, BMI and smoking

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is associated with increased risk of cardiovascular disease (CVD). Racial/ethnic differences in GDM prevalence have been described, but disparities by nativity and duration of US residence are not well studied.

Methods: We analyzed data from 6088 women (mean age: 27.5 years [standard deviation: 6.3 years]) from the Boston Birth Cohort who self-identified as non-Hispanic Black (NHB; n = 2697), Hispanic (n = 2395), or non-Hispanic White (NHW; n = 996). Using multivariable logistic regression, we examined the cross-sectional association of nativity and duration of US residence (< 10 vs ≥ 10 years) with GDM within each race/ethnicity group.

Results: Foreign-born NHB, NHW, and Hispanic women with a duration of US residence of < 10 years had a lower prevalence of CVD risk factors than those with US residence of ≥ 10 years, respectively, as follows: smoking (NHB: 1.7% vs 3.1%; NHW: 5.7% vs 8.1%; Hispanic: 0.4% vs 2.6%); obesity (NHB: 17.1% vs 23.4%; NHW: 3.8% vs 15.6%; Hispanic: 10.9% vs 22.7%); and severe stress (NHB: 8.7% vs 11.9%; NHW: 5.7% vs 28.1%; Hispanic: 3.8% vs 7.3%). In analyses adjusting for sociodemographic characteristics and CVD risk factors, foreign-born NHB women with a duration of US residence of < 10 years had higher odds of having GDM (adjusted odds ratio: 1.60, 95% confidence interval: 0.99-2.60), compared with their US-born counterparts, whereas foreign-born Hispanic women with a duration of US residence of < 10 years had lower odds of having GDM (adjusted odds ratio: 0.54, 95% confidence interval: 0.32-0.91). The odds of having GDM in Hispanic and NHB women with a duration of US residence of ≥ 10 years were not significantly different from those of their US-born counterparts.

Conclusions: The "healthy immigrant effect" and its waning with longer duration of US residence apply to the prevalence of GDM among Hispanic women but not NHB women. Further research on the intersectionality of race and nativity-based disparities is needed.

RÉSUMÉ

Introduction : Le diabète sucré gestationnel (DSG) est associé à l'augmentation du risque de maladies cardiovasculaires (MCV). Les différences raciales/ethniques dans la prévalence du DSG ont été décrites, mais les disparités selon le lieu de naissance et la durée de résidence aux É.-U font l'objet de peu d'études.

Méthodes : Nous avons analysé les données de 6 088 femmes (âge moyen : 27,5 ans [écart type : 6,3 ans]) de la Boston Birth Cohort qui ont déclaré être noires non hispaniques (NNH; n = 2 697), hispaniques (n = 2 395) ou blanches non hispaniques (BNH; n = 996). À l'aide de la régression logistique multivariée, nous avons examiné l'association transversale entre le lieu de naissance et la durée de résidence aux É.-U. (< 10 *vs* ≥ 10 ans), et le DSG dans chaque groupe racial/ethnique

Résultats : Les femmes NNH, BNH et hispaniques nées à l'étranger qui avaient une durée de résidence aux É.-U. de < 10 ans avaient une prévalence plus faible des facteurs de risque de MCV que celles qui avaient une résidence aux É.-U. de ≥ 10 ans, et ce, de façon respective comme suit : le tabagisme (NNH : 1,7 % *vs* 3,1 %; BNH : 5,7 % *vs* 8,1 %; hispaniques : 0,4 % *vs* 2,6 %); l'obésité (NNH : 17,1 % *vs* 23,4 %; BNH : 3,8 % *vs* 15,6 %; hispaniques : 10,9 % *vs* 22,7 %); le stress important (NNH : 8,7 % *vs* 11,9 %; BNH : 5,7 % *vs* 28,1 %; hispaniques : 3,8 % *vs* 7,3 %). Lors de l'ajustement des caractéristiques sociodémographiques et des facteurs de risque de MCV, les femmes NNH nées à l'étranger qui avaient une durée de résidence aux É.-U. de < 10 ans montraient une plus grande probabilité d'avoir le DSG (rapport de cotes ajusté : 1,60, intervalle de confiance à 95 % : 0,99-2,60) que leurs homologues nées aux É.-U., alors que les femmes hispaniques nées à l'étranger qui avaient une durée de résidence aux É.-U. de < 10 ans montraient une plus faible probabilité d'avoir le DSG (rapport de cotes ajusté : 0,54, intervalle de confiance à 95 % : 0,32-0,91). La probabilité que les femmes hispaniques et NNH qui avaient une durée de résidence aux É.-U. de ≥ 10 ans aient le DSG n'était pas significativement différente de celles de leurs homologues nées aux É.-U.

Conclusions : L'« effet de l'immigrant en bonne santé » et son déclin associé à la plus longue durée de résidence aux É.-U. s'appliquent à la prévalence du DSG chez les femmes hispaniques, mais non chez les femmes NNH. D'autres recherches sur l'intersectionnalité entre la race et les disparités selon le lieu de naissance sont nécessaires.

Gestational diabetes mellitus (GDM) affects approximately 6% of all pregnancies in the US, and 4.4%-10.6% of pregnancies worldwide, and its prevalence is increasing.[1-3] Defined as glucose intolerance that is first recognized during pregnancy, GDM is associated with both short- and long-term implications for the health of the mother and the child.[2,4] In comparison with women without GDM, those who have had GDM are almost 10 times more likely to develop type 2 diabetes mellitus (DM) later in life (relative risk 9.51, 95% confidence interval [CI] 7.14-12.67 across 20 studies).[5] In addition, the absolute longitudinal risk for type 2 diabetes among women with GDM increases linearly, from 20% at 10 years, up to 60% at 50 years.[6,7]

Moreover, GDM is independently associated with cardiovascular disease (CVD),[4,8,9] with one study reporting a 68% increased risk of subsequent CVD, compared with that for women without GDM.[9] Although this increased risk is partially attributable to the development of DM, studies suggest that an independent association exists between GDM and CVD, one that persists despite adjustment for traditional CVD risk factors.[8] In fact, recently published data from the **C**oronary **A**rtery **R**isk **D**evelopment **i**n Young **A**dults (CARDIA) cohort show that even if women with previous GDM subsequently achieve normoglycemia, they still have increased midlife CVD risk.[10] This study also found that women with a history of GDM had a 2-fold higher risk of coronary artery calcification across all subsequent levels of glucose tolerance (normoglycemia, prediabetes, and incident diabetes),

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Ethics Statement: The BBC study protocol was approved by the institutional review boards at the Boston Medical Center and the Johns Hopkins Bloomberg School of Public Health. This current study is within the scope of the institutional review board approval for the cohort.

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See page 549 for disclosure information.

independent of sociodemographic, clinical, and lifestyle behavioral risk factors.[10] GDM is additionally associated with increased carotid artery intima media thickness, even in women without subsequent DM or metabolic syndrome and independent of pre-pregnancy body mass index (BMI).[11] Thus, the 2020 updated recommendations for primary prevention of cardiovascular disease in women from the American College of Cardiology specifically highlight the role of unique risk factors related to female sex, including pregnancy-associated conditions such as GDM, when assessing future CVD risk.[12]

Disparities in GDM prevalence by race/ethnicity can be seen: the prevalence is 4.8% among non-Hispanic Black (NHB) women, 6.6% among Hispanic women, and 5.3% among non-Hispanic White (NHW) women.[1] However, the differential prevalence of CVD risk factors, and the association of GDM with maternal nativity (US-born vs foreign-born) and duration of US residence, a measure of acculturation, is not well studied.[13] Acculturation is a phenomenon whereby continuous contact between people of different cultures leads to the acquisition of cultural values or practices that differ from those of the original culture. Foreign-born women tend to have a health advantage over their US-born counterparts, but with longer duration of stay in the US, this advantage wanes.[14,15] We have previously found nativity-related disparities in other adverse pregnancy outcome (APOs) conditions, such as preeclampsia and preterm birth.[16] In this analysis, we extended our findings to GDM and examined the association of nativity and duration of US residence with GDM and explored the differential prevalence of CVD risk factors in a multiracial, urban, low-income population.

Methods

Data from the Boston Birth Cohort (BBC), a racially diverse cohort with data on maternal place of birth and duration of US residence, were utilized for this study.[17] The BBC was initiated in 1998 at Boston Medical Center, which serves a predominantly low-income, racially diverse, inner-city population.[17] Inclusion criteria for women were completion of delivery of live singleton births at the Boston Medical Center, whereas women with pregnancies resulting from in vitro fertilization or that involved multiple gestations, fetal chromosomal abnormalities, or major birth defects were excluded.[17] Eligible participants who provided informed consent were recruited 24-72 hours postpartum, and sociodemographic information was obtained using questionnaires. Maternal medical history and delivery information was abstracted from the electronic medical records by trained research staff. A detailed description of the BBC is available elsewhere.[18] The BBC study protocol was approved by the Institutional Review Board at the Boston Medical Center and the Johns Hopkins Bloomberg School of Public Health. This current study is within the scope of this review board approval for the cohort.

We used 1998-2016 data from the BBC with 8509 mother-baby pairs. This study focused on data from 6088 women from the BBC with data on GDM, who self-identified as NHB (n = 2697; 44.3%), NHW (n = 996; 16.4%), or Hispanic (n = 2395; 39.3%). Women who identified as Asian were excluded, due to small sample size (n = 180). Of the 1092 foreign-born NHB women, 220 foreign-born NHW women, and 1840 foreign-born Hispanic women, respectively, 776 (71.1%), 138 (62.7%), and 1644 (89.4%) had data on duration of US residence and were therefore included in the analysis of GDM and duration of residence (Fig. 1). A comparison of the sociodemographic and clinical risk factors between the women who were included in this study vs those who were excluded due to missing data on duration of US residence is presented in Supplemental Table S1.

Exposures of interest

Race/ethnicity was self-reported, with participants choosing an option from categories as defined by the standard questionnaire interview. Women born in any of the 50 US states, the District of Columbia, or other US territories were considered US-born, whereas those born outside these regions were considered foreign-born. Duration of US residence was defined as the number of years between immigration to the US and the index pregnancy and was categorized as < 10 years or ≥ 10 years. Duration of US residence has been used extensively as a proxy for acculturation level in immigrants, with 10 years being the standard cutoff based on previous literature, which shows that immigrants residing in the US for ≥ 10 years have a higher level of acculturation than do those with residence duration of < 10 years.[15,16]

Outcome

The primary outcome in this study was GDM, based on electronic medical record diagnosis of GDM at Boston Medical Center. At the prenatal care practices, GDM diagnosis was based on the American College of Obstetricians and Gynecologists definition of GDM at the time. From 2018, it required a 2-step process (1-hour and 3-hour oral glucose tolerance test).[19]

Covariate assessment

Maternal sociodemographic characteristics were self-reported and included maternal age at delivery (< 20, 20-34, or ≥ 35 years), parity (0, 1, or 2+), marital status (married, single, or divorced/separated/widowed), maternal education (secondary school or less, general education development/high school graduate, or college education/degree), and self-reported maternal perceived stress (mild, moderate, or severe).

Pre-pregnancy or during-pregnancy CVD risk factors that were assessed at the time of delivery included smoking in the index pregnancy (yes/no), history of chronic hypertension (yes/no), preeclampsia (yes/no), and self-reported pre-pregnancy BMI (< 25, 25.0-29.9, and ≥ 30 kg/m^2). Presence of chronic hypertension and preeclampsia was based on physician diagnosis as documented in the electronic medical record.[20] BMI was calculated from self-reported weight and height.

Statistical analyses

Pearson's χ^2 test and analysis of variance were used to explore the differences between maternal sociodemographic and CVD risk factors in each category of race-ethnicity, maternal nativity, and duration of US residency. Multivariable logistic regression was performed to investigate the association of nativity and duration of US residence (< 10 vs $\geq$

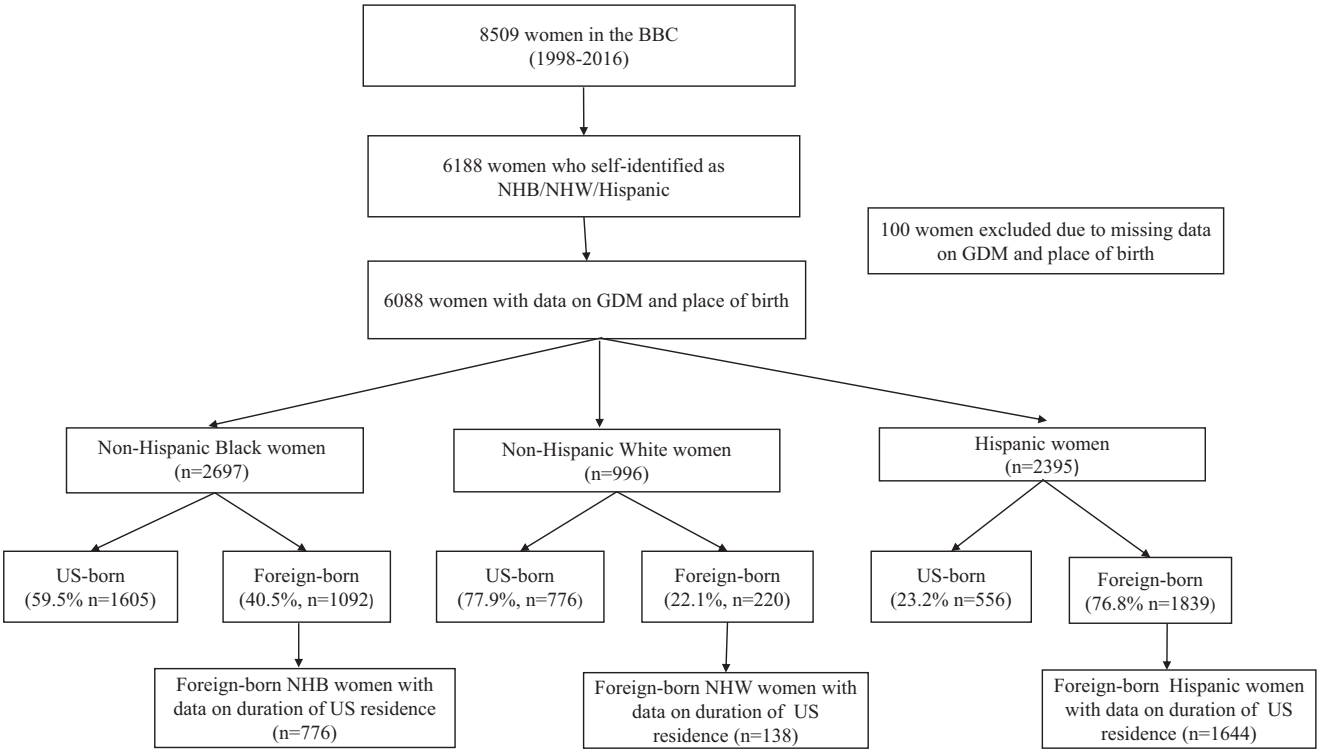

Figure 1. Flowchart of the analytic sample. BBC, Boston Birth Cohort; GDM, gestational diabetes mellitus; NHB, non-Hispanic Black; NHW, non-Hispanic White.

10 years) with GDM, by race-ethnicity (NHB, Hispanic, and NHW). Model 1 was unadjusted, model 2 was age-adjusted, model 3 was additionally adjusted for education, maternal perceived general stress, and marital status. Model 4 (fully adjusted model) was model 3 in addition to CVD risk factors—pre-pregnancy BMI, smoking, chronic hypertension, and parity. Sequential modeling was chosen to show how adjustment for these unique variables influenced the association between our outcome and exposure. The reference group was US-born women in all the models. All reported P values were 2-sided, and $P < 0.05$ was considered to indicate statistical significance. All statistical analyses were conducted in Stata IC version 16 (StataCorp LLC, College Station, TX).

Results

Of the 6088 women included in this study, 2697 (44.3%) self-identified as NHB, 996 (16.4%) as NHW, and 2395 (39.3%) as Hispanic. Foreign-born women comprised 40.5% (n = 1092) of the NHB women, 22.1% (n = 220) of the NHW women, and 76.8% (n = 1840) of the Hispanic women. The overall prevalence of GDM was 6.0% (n = 363). Among NHB, NHW, and Hispanic women, 5.9%, 5.7%, and 6.2%, respectively, had GDM (Fig. 1).

Maternal sociodemographic characteristics and cardiovascular risk factors by race/ethnicity

Maternal sociodemographic characteristics and cardiovascular risk factors differed by race/ethnicity (Table 1). NHB women, compared with NHW and Hispanic women, included the highest proportion of single women (72.0% vs 58.7% vs 65.8%, respectively) and women with chronic hypertension (7.6% vs 2.8% vs 2.7%, respectively), preeclampsia (11.0% vs 7.1% vs 8.9%, respectively), and obesity (BMI $\geq$ 30: 24.4% vs 15.3% vs 15.9%, respectively). NHW women, compared with Hispanic and NHB women, were older at the time of delivery (mean age 28.5 vs 27.2 vs 27.3 years, respectively), had the highest proportion of severe stress (19.1% vs 6.7% vs 13.0%, respectively), and were more likely to have smoked in the index pregnancy (42.6% vs 5.3% vs 14.2%, respectively). They also had a higher education level, compared with that of Hispanic and NHB women (college education or higher: 43.8% vs 18.6% vs 36.9%, respectively).

Maternal sociodemographic characteristics and cardiovascular risk factors by nativity

In general, US-born women in each of the 3 racial/ethnic groups were younger and more likely to be obese, single, have severe stress, and smoke during pregnancy than were foreign-born women. The prevalence of chronic hypertension did not differ significantly between groups (Table 2). US-born NHB women were more likely to have preeclampsia (12.2% vs 9.3%) but less likely to have a college or higher level of education (31.7% vs 44.4%), compared with their foreign-born counterparts. US-born NHW women were more likely to be multiparous (22.4% vs 12.3%) but less likely to have a college or higher level of education (41.6% vs 51.4%), compared with their foreign-born counterparts. In contrast, US-born Hispanic women were more likely to have a college or higher education level (23.4% vs 17.2%), compared with their foreign-born counterparts.

Table 1. Characteristics of study participants by race

Characteristic	NHB women n = 2697	NHW women n = 996	Hispanic women n = 2395	*P*
Maternal demographics and obstetrical characteristics				
Maternal age, y, mean (SD)	27.3 (6.5)	28.5 (5.8)	27.2 (6.3)	**< 0.001**
Parity				**< 0.001**
0	1122 (41.6)	509 (51.1)	985 (41.1)	
1	764 (28.3)	286 (28.7)	684 (28.6)	
2+	811 (30.1)	201 (20.2)	726 (30.3)	
Preeclampsia				**0.001**
No	2400 (89.0)	925 (92.9)	2183 (91.2)	
Yes	297 (11.0)	71 (7.1)	212 (8.9)	
Social and environmental factors				
General stress				**< 0.001**
Mild	847 (31.4)	191 (19.2)	1182 (49.3)	
Moderate	1477 (54.8)	605 (60.7)	1036 (43.3)	
Severe	350 (13.0)	190 (19.1)	161 (6.7)	
Missing	23 (0.8)	10 (1.0)	16 (0.7)	
Educational level				**< 0.001**
Secondary or less	640 (23.7)	183 (18.4)	1264 (52.8)	
High school graduate	1008 (37.4)	356 (35.7)	646 (27.0)	
College/higher	994 (36.9)	436 (43.8)	446 (18.6)	
Missing	55 (2.0)	21 (2.1)	39 (1.6)	
Marital status				**< 0.001**
Married	657 (24.4)	355 (35.7)	708 (29.6)	
Single	1942 (72.0)	585 (58.7)	1577 (65.8)	
Divorced/separated/widowed	58 (2.1)	38 (3.8)	72 (3.0)	
Missing	40 (1.5)	18 (1.8)	38 (1.6)	
Cardiovascular disease risk factors				
Chronic hypertension				**< 0.001**
No	2481 (92.0)	963 (96.7)	2315 (96.7)	
Yes	204 (7.6)	28 (2.8)	65 (2.7)	
Missing	12 (0.4)	5 (0,5)	15 (0.6)	
Chronic diabetes				**0.012**
No	2589 (96.0)	953 (95.7)	2331 (97.3)	
Yes	108 (4.0)	43 (4.3)	64 (2.7)	
Gestational diabetes				0.84
No	2539 (94.1)	939 (94.3)	2247 (93.8)	
Yes	158 (5.9)	57 (5.7)	148 (6.2)	
Smoking in pregnancy				**< 0.001**
No	2297 (85.2)	570 (57.2)	2248 (93.9)	
Yes	383 (14.2)	424 (42.6)	128 (5.3)	
Missing	17 (0.6)	2 (0.2)	19 (0.8)	
Body mass index, kg/m^2				**< 0.001**
< 25	1176 (43.6)	580 (58.2)	1153 (48.1)	
25–29.9	744 (27.6)	232 (23.3)	624 (26.1)	
≥ 30	657 (24.4)	152 (15.3)	380 (15.9)	
Missing	120 (4.4)	32 (3.2)	238 (9.9)	

Values are n (%), unless otherwise indicated. Boldface indicates significance.
NHB, non-Hispanic Black; NHW, non-Hispanic White.

Maternal sociodemographic characteristics and cardiovascular risk factors by duration of US residence

In general, women with a duration of US residence < 10 years in all 3 racial/ethnic groups had the lowest prevalence of CVD risk factors (severe stress, smoking in pregnancy, obesity BMI ≥ 30 kg/m^2), compared with those with ≥ 10 years of US residence and US-born women (Table 3). NHB women with < 10 years of US residence also had a lower prevalence of chronic hypertension, but the prevalence of chronic hypertension in NHW vs Hispanic women based on nativity or duration of US residence was not significantly different.

Foreign-born NHB women with a duration of US residence < 10 years, compared with those with ≥ 10 years of US residence and US-born women, were older (30.1 vs 29.8 vs 25.8 years), less likely to have preeclampsia (8.3% vs 9.3% vs 12.2%), less likely to be multiparous (24.7% vs 34.8% vs 30.6%), and less likely to be single (42.1% vs 55.5% vs 86.3%) than those with ≥ 10 years of US residence and US-born women. NHB women with ≥ 10 years of US residence were more likely to have a college or higher education level, compared with foreign-born women with < 10 years of US residence and US-born women (48.5% vs 46.4% vs 31.7%, respectively).

Foreign-born NHW women with US residence duration of ≥ 10 years were older than those with < 10 years US residence and US-born women (31.5 vs 30.1 vs 28.2 years, respectively). Foreign-born NHW women with a US residence duration of < 10 years were less likely to be multiparous, compared with those with ≥ 10 years of US residence and US-born NHW women (8.5% vs 21.9% vs 22.4%, respectively).

Table 2. Characteristics of study participants by maternal place of birth

Characteristic	NHB women n = 2697			NHW women n = 996			Hispanic women n = 2395		
	US-born n = 1605	Foreign-born n = 1092	*P*	US-born n = 776	Foreign-born n = 220	*P*	US-born n = 555	Foreign-born n = 1840	*P*
Maternal demographics and obstetrical characteristics									
Maternal age, y, mean (SD)	25.8 (6.2)	29.5 (6.4)	**< 0.001**	28.1 (5.8)	29.4 (5.6)	**0.0039**	24.7 (6.1)	27.9 (6.1)	**< 0.001**
Parity			0.066			**0.004**			0.07
0	686 (42.7)	436 (40.0)		384 (49.5)	125 (56.8)		249 (44.9)	736 (40.0)	
1	428 (26.7)	336 (30.8)		218 (28.1)	68 (31.0)		140 (25.2)	544 (29.6)	
2+	491 (30.6)	320 (29.3)		174 (22.4)	27 (12.3)		166 (29.9)	560 (30.4)	
Preeclampsia			**< 0.016**			0.925			0.382
No	1409 (87.8)	991 (90.8)		721 (92.9)	204 (92.8)		511 (92.1)	1672 (90.9)	
Yes	196 (12.2)	101 (9.3)		55 (7.1)	16 (7.3)		44 (7.9)	168 (9.1)	
Social and environmental factors									
General stress			**< 0.001**			**< 0.001**			**< 0.001**
Mild	413 (25.7)	434 (39.7)		111 (14.3)	80 (36.4)		172 (31.0)	1010 (54.9)	
Moderate	949 (59.1)	528 (48.4)		494 (63.7)	111 (50.5)		303 (54.6)	733 (39.8)	
Severe	230 (14.3)	120 (11.0)		164 (21.1)	26 (11.8)		76 (13.7)	85 (4.6)	
Missing	13 (0.8)	10 (0.9)		7 (0.9)	3 (1.4)		4 (0.7)	12 (0.7)	
Educational level			**< 0.001**			**0.014**			**< 0.001**
Secondary or lower	433 (27.0)	207 (19.0)		155 (20.0)	28 (12.7)		255 (46.0)	1009 (54.8)	
High school graduate	631 (39.3)	377 (34.5)		279 (36.0)	77 (35.0)		156 (28.1)	490 (26.6)	
College /higher	509 (31.7)	485 (44.4)		323 (41.6)	113 (51.4)		130 (23.4)	316 (17.2)	
Missing	32 (2.0)	23 (2.1)		19 (2.5)	2 (0.9)		14 (2.5)	25 (1.4)	
Marital status			**< 0.001**			**< 0.001**			**< 0.001**
Married	177 (11.0)	480 (44.0)		218 (28.1)	137 (62.3)		93 (16.8)	615 (33)	
Single	1384 (86.2)	558 (51.1)		516 (66.5)	69 (31.4)		436 (78.6)	1141 (62)	
Divorced/separated/widowed	26 (1.6)	32 (2.9)		30 (3.9)	8 (3.6)		18 (18.2)	54 (2.9)	
Missing	18 (1.1)	22 (2.0)		12 (1.6)	6 (2.7)		8 (1.4)	30 (1.6)	
Cardiovascular disease risk factors									
Chronic hypertension			0.400			0.925			0.972
No	1475 (91.9)	1006 (92.1)		749 (96.7)	214 (97.3)		538 (97.0)	1777 (96.6)	
Yes	125 (7.8)	79 (7.2)		23 (3.0)	5 (2.3)		14 (2.5)	51 (2.8)	
Missing	5 (0.3)	7 (0.6)		4 (0.5)	1 (0.5)		3 (0.5)	12 (0.7)	
Chronic diabetes			0.585			0.573			**0.002**
No	1538 (95.8)	1051 (96.3)		741 (95.5)	212 (96.4)		530 (95.5)	1801 (97.9)	
Yes	67 (4.2)	41 (3.8)		35 (4.5)	8 (3.6)		25 (4.5)	39 (2.1)	
Gestational diabetes			**0.007**			0.846			0.732
No	1527 (95.1)	1012 (92.7)		731 (94.25)	208 (94.6)		519 (93.5)	1728 (93.9)	
Yes	78 (4.86)	80 (7.3)		45 (5.8)	12 (5.5)		36 (6.5)	112 (6.1)	
Smoking in pregnancy			**< 0.001**			**< 0.001**			**< 0.001**
No	1268 (79)	1029 (94.2)		393 (50.6)	177 (80.5)		456 (82.1)	1792 (97.4)	
Yes	330 (20.6)	53 (4.9)		382 (49.2)	42 (19.1)		98 (17.7)	30 (1.6)	
Missing	7 (0.4)	10 (0.9)		1 (0.1)	1 (0.5)		1 (0.2)	18 (1.0)	
Body mass index			**< 0.001**			**0.003**			**< 0.001**
< 25	694 (43.2)	482 (44.1)		445 (57.4)	135 (61.4)		266 (47.9)	887 (48.2)	
25–29.9	417 (26.0)	327 (30.0)		180 (23.2)	52 (23.6)		137 (24.7)	487 (26.5)	
≥ 30	443 (27.6)	214 (20.0)		132 (17.0)	20 (9.1)		132 (23.8)	248 (13.5)	
Missing	51 (3.8)	69 (6.3)		19 (2.5)	13 (5.9)		20 (3.6)	218 (11.9)	

Values are n (%), unless otherwise indicated. Boldface indicates significance.
SD, standard deviation.

Foreign-born Hispanic women with a US residence duration of ≥ 10 years were also older (30.9 vs 24.7 vs 27.3 years), less likely to be single (53.2% vs 78.8% vs 63.6%) than US-born women or foreign-born Hispanic women with < 10 years US residence. Foreign-born Hispanic women with < 10 years of US residence were less likely to be multiparous (25.7% vs 47.7% vs 29.9%), and less likely to have a college or higher level of education, compared with those with ≥ 10 years US residence and US-born Hispanic women (15.9% vs 23.5% vs 23.4%, respectively).

Odds of having GDM, by race/ethnicity

In all the models, the odds of having GDM for NHW vs NHB women were not significantly different, nor were the odds of having GDM for NHW vs Hispanic women (Table 4).

Odds of having GDM, by nativity

Overall, no significant difference was found in GDM prevalence between US-born and foreign-born women. When analyses were stratified by race, this lack of significance generally persisted (Table 5). Among NHW women, no significant difference was found between US-born and foreign-born women. Among NHB women, foreign-born women were 55% more likely to have GDM (odds ratio [OR] 1.55, 95% confidence interval [CI] 1.12-2.13), but this difference was not significant after adjustment for covariates. Similarly, the difference in GDM prevalence between US-born and

Table 3. Characteristics of study participants by nativity and duration of US residency

Characteristic	NHB women				NHW women				Hispanic women			
	US-born n = 1605	Foreign-born, < 10 y n = 539	Foreign-born, ≥ 10 y n = 227	*P*	US-born n = 776	Foreign-born, < 10 y n = 106	Foreign-born, ≥ 10 y n = 32	*P*	US-born n = 555	Foreign-born, < 10 y n = 1300	Foreign-born, ≥ 10 y n = 344	*P*
Maternal demographics and obstetrical characteristics												
Maternal age, y, mean (SD)	25.8 (6.2)	30.1 (5.7)	29.8 (6.7)	**< 0.001**	28.2 (5.8)	30.1 (5.5)	31.5 (4.7)	**< 0.001**	24.7 (6.1)	27.3 (5.8)	30.9 (6.4)	**< 0.001**
Parity				**0.006**				**0.014**				**< 0.001**
0	686 (42.7)	234 (43.4)	79 (34.8)		384 (49.5)	66 (62.3)	14 (43.8)		249 (44.9)	578 (44.5)	84 (24.4)	
1	428 (26.7)	172 (31.9)	69 (30.4)		218 (28.1)	31 (29.3)	11 (34.4)		140 (25.2)	388 (29.9)	96 (27.9)	
2+	491 (30.6)	133 (24.7)	79 (34.8)		174 (22.4)	9 (8.5)	7 (21.9)		166 (29.9)	334 (25.7)	164 (47.7)	
Preeclampsia				**0.031**				0.65				0.33
No	1409 (87.8)	494 (91.7)	206 (90.8)		721 (92.9)	97 (91.5)	29 (90.6)		511 (92.1)	1188 (91.4)	307 (89.2)	
Yes	196 (12.2)	45 (8.3)	21 (9.3)		55 (7.1)	9 (8.5)	3 (9.4)		44 (7.9)	112 (8.6)	37 (10.8)	
Social and environmental factors												
General stress				**< 0.001**				**< 0.001**				**< 0.001**
Mild	413 (25.7)	272 (50.5)	66 (29.1)		111 (14.3)	49 (46.2)	6 (18.9)		172 (31.0)	757 (58.2)	169 (49.1)	
Moderate	949 (59.1)	217 (40.3)	129 (56.8)		494 (63.7)	49 (46.2)	17 (53.1)		303 (54.6)	483 (37.2)	149 (43.3)	
Severe	230 (14.3)	47 (8.7)	27 (11.9)		164 (21.1)	6 (5.7)	9 (28.1)		76 (13.7)	50 (3.8)	25 (7.3)	
Missing	13 (0.8)	3 (0.6)	5 (2.2)		7 (0.9)	2 (1.9)	0 (0.0)		4 (0.7)	10 (0.8)	1 (0.3)	
Educational level				**< 0.001**				**0.001**				**< 0.001**
Secondary or lower	433 (27.0)	100 (18.5)	34 (15.0)		155 (20.0)	7 (6.6)	2 (6.3)		255 (46.0)	737 (56.7)	166 (48.3)	
High school graduate	631 (39.3)	187 (34.7)	83 (36.6)		279 (36.0)	35 (33.0)	10 (31.3)		156 (28.1)	350 (26.9)	94 (27.3)	
College /higher	509 (31.7)	250 (46.4)	110 (48.5)		323 (41.6)	63 (59.4)	20 (62.5)		130 (23.4)	207 (15.9)	81 (23.5)	
Missing	32 (2.0)	2 (0.4)	0 (0.0)		19 (2.5)	1 (1.0)	0 (0.0)		14 (2.5)	6 (0.5)	3 (0.9)	
Marital status				**< 0.001**				**< 0.001**				**< 0.001**
Married	177 (11.0)	291 (54.0)	92 (40.5)		218 (28.1)	83 (78.3)	21 (65.6)		93 (16.8)	423 (32.5)	139 (40.4)	
Single	1384 (86.3)	227 (42.1)	126 (55.5)		516 (66.5)	20 (18.9)	6 (18.8)		436 (78.6)	826 (63.6)	183 (53.2)	
Divorced/separated/widowed	26 (1.6)	16 (3.0)	6 (2.7)		30 (3.9)	3 (2.8)	5 (15.6)		18 (3.2)	30 (2.3)	18 (5.2)	
Missing	18 (1.1)	5 (0.9)	3 (1.3)		12 (1.6)	0 (0.0)	0 (0.0)		8 (1.4)	21 (1.6)	4 (1.2)	
Cardiovascular disease risk factors												
Chronic hypertension				0.76				0.54				0.26
No	1475 (91.9)	500 (92.8)	205 (90.3)		749 (96.5)	104 (98.1)	30 (93.8)		538 (96.9)	1263 (97.1)	326 (94.8)	
Yes	125 (7.8)	38 (7.0)	22 (9.7)		23 (3.0)	2 (1.9)	2 (6.3)		14 (2.5)	31 (2.4)	15 (4.3)	
Missing	5 (0.3)	1 (0.2)	0 (0.0)		4 (0.5)	0 (0.0)	0 (0.0)		3 (0.6)	6 (0.5)	3 (0.9)	
Chronic diabetes				0.89				0.61				**< 0.001**
No	1538 (95.8)	516 (95.7)	219 (96.5)		741 (95.5)	101 (95.3)	32 (100.0)		530 (95.5)	1280 (98.5)	328 (95.4)	
Yes	67 (4.2)	23 (4.3)	8 (3.5)		35 (4.5)	5 (4.7)	0 (0.0)		25 (4.5)	20 (1.5)	16 (4.6)	
Gestational diabetes				**0.016**				0.95				**< 0.001**
No	1527 (95.1)	495 (91.8)	213 (93.8)		731 (94.2)	100 (94.3)	30 (93.8)		519 (93.5)	1240 (95.4)	302 (87.8)	
Yes	78 (4.9)	44 (8.2)	14 (6.2)		45 (5.8)	6 (5.7)	2 (6.2)		36 (6.5)	60 (4.6)	42 (12.2)	
Smoking in pregnancy				**< 0.001**				**< 0.001**				**< 0.001**
No	1268 (79.0)	525 (97.4)	220 (96.9)		393 (50.7)	99 (93.4)	23 (71.9)		456 (82.2)	1284 (98.8)	331 (96.2)	
Yes	330 (20.6)	9 (1.7)	7 (3.1)		382 (49.2)	6 (5.7)	9 (28.1)		98 (17.6)	5 (0.4)	9 (2.6)	
Missing	7 (0.4)	5 (0.9)	0 (0.0)		1 (0.1)	1 (0.9)	0 (0.0)		1 (0.2)	11 (0.8)	4 (1.2)	
Body mass index, kg/m^2				**< 0.001**				**< 0.001**				**< 0.001**
< 25	694 (43.2)	234 (43.4)	103 (45.4)		445 (57.4)	73 (68.9)	14 (43.8)		266 (47.9)	671 (51.6)	135 (39.2)	
25–29.9	417 (26.0)	170 (31.5)	64 (28.2)		180 (23.2)	19 (17.9)	13 (40.6)		137 (24.7)	332 (25.5)	103 (29.9)	
≥ 30	443 (27.6)	92 (17.1)	53 (23.4)		132 (17.0)	4 (3.8)	5 (15.6)		132 (23.8)	141 (10.9)	78 (22.7)	
Missing	51 (3.2)	43 (8.0)	7 (3.1)		19 (2.4)	10 (9.4)	0 (0.0)		20 (3.6)	156 (12.0)	28 (8.1)	

Values are n (%), unless otherwise indicated. Boldface indicates significance.

NHB, non-Hispanic Black; NHW, non-Hispanic White; SD, standard deviation.

Table 4. Crude and adjusted odds ratio (OR) with 95% confidence interval (CI) for association between gestational diabetes mellitus (GDM) and race, for each model

Race/place of birth	n	% with GDM	OR and 95% CI for GDM							
			Model 1	*P*	Model 2	*P*	Model 3	*P*	Model 4	*P*
NHW women	996	5.7	Ref		Ref		Ref		Ref	
NHB women	2697	5.9	1.03 (0.75−1.40)	0.88	1.10 (0.80−1.50)	0.57	1.12 (0.81−1.53)	0.50	0.86 (0.61−1.21)	0.38
Hispanic women	2395	6.2	1.09 (0.79−1.49)	0.61	1.19 (0.87 − 1.64)	0.29	1.10 (0.78−1.54)	0.59	0.94 (0.65−1.36)	0.76

Model 1: unadjusted; Model 2: age-adjusted; Model 3: Model 2 + education, marital status, and stress; Model 4: Model 3 + hypertension, parity, body mass index, and smoking.

NHB, non-Hispanic Black; NHW, non-Hispanic White; Ref, referent.

foreign-born Hispanic women was not significant after adjusting for all potential confounders (Table 5).

Odds of having GDM, by duration of US residence

Foreign-born NHB women with a duration of US residence of < 10 years had higher odds of having GDM (OR 1.74, 95% CI 1.19-2.55), compared with US-born NHB women; this association became less strong in the fully adjusted model (adjusted OR [aOR]: 1.60, 95% CI 0.99-2.60; Table 6).

In contrast, foreign-born Hispanic women with a duration of US residence of < 10 years had lower odds of having GDM, compared with US-born Hispanic women (aOR 0.54, 95% CI 0.32-0.91). The odds of having GDM for Hispanic and NHB women with a US residence duration of ≥ 10 years were not significantly different from those of their US-born counterparts. Duration of US residence was not associated with the odds of having GDM among NHW women (Table 6).

Discussion

This study uniquely highlights the heterogeneity of GDM based on race/ethnicity, maternal nativity, and duration of residence in a high-risk, low-income population, and the association of CVD risk factors and GDM within this context. An interesting finding is that of a dissociation of relationship of CVD risk factors and GDM in the 3 racial/ethnic groups studied. Although in all the racial/ethnic groups, foreign-born women had overall less burden of CVD risk factors compared with that of their age-matched US-born counterparts, this relationship did not hold for corresponding GDM risk in all groups. Foreign-born Hispanic women had lower odds of having GDM, whereas NHB women had greater odds of having GDM as a group overall, compared with those of their NHW counterparts.

We found that the overall prevalence of GDM was 6.0%, a level similar to the national prevalence of GDM.[1] Although the proportion of those with GDM was highest among the Hispanic women, the odds of having GDM were not significantly different by racial/ethnic group in our study population. However, we found striking differences in the prevalence of GDM when analyses were stratified by maternal nativity within each race/ethnicity and duration of US residence (< 10 years or > 10 years). Our study found a significantly lower risk of GDM in foreign-born Hispanic women with < 10 years US residence that was lost when the length of time spent living in the US increased past 10 years. In contrast, Hispanic women and NHB women had different prevalence rates. Foreign-born Hispanic women with < 10 years of US residence had 46% lower odds of having GDM, compared with the odds for US-born Hispanic women, and foreign-born NHB women with < 10 years of US residence had 60% higher odds of having GDM, compared with the odds for US-born NHB women.

Several explanations for these dissociations are possible. Our finding that foreign-born Hispanic women with < 10 years of US residence had lower odds of having GDM is in line with findings of previous research by our team and

Table 5. Crude and adjusted odds ratio (OR) with 95% confidence interval (CI) for association between gestational diabetes mellitus (GDM) and maternal place of birth, for each model

Race/place of birth	n	% with GDM	OR and 95% CI for GDM							
			Model 1	*P*	Model 2	*P*	Model 3	*P*	Model 4	*P*
Overall										
US-born	2936	5.4	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born	3152	6.5	1.21 (0.98−1.50)	0.08	0.98 (0.79−1.22)	0.88	0.86 (0.66−1.11)	0.23	0.97 (0.74−1.27)	0.83
NHW women										
US-born	776	5.8	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born	220	5.5	0.94 (0.49−1.80)	0.85	0.86 (0.45−1.67)	0.66	0.82 (0.40−1.66)	0.58	0.98 (0.47−2.06)	0.96
NHB women										
US-born	1605	4.9	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born	1092	7.3	**1.55 (1.12−2.13)**	**0.008**	1.11 (0.80−1.56)	0.52	1.13 (0.78−1.62)	0.52	1.29 (0.88−1.89)	0.20
Hispanic women										
US-born	555	6.5	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born	1840	6.1	0.93 (0.63−1.38)	0.73	0.68 (0.45−1.02)	0.06	**0.55 (0.36−0.84)**	**0.006**	0.67 (0.42−1.08)	0.10

Model 1: unadjusted; Model 2: age-adjusted; Model 3: Model 2 + education, marital status, and stress; Model 4: Model 3 + hypertension, parity, body mass index, and smoking. Boldface indicates significance.

NHB, non-Hispanic Black; NHW, non-Hispanic White; Ref, referent.

Table 6. Crude and adjusted odds ratio (OR) with 95% confidence interval (CI) for association between gestational diabetes mellitus (GDM) and duration of US residency, for each model

Place of birth and duration of stay in the US	n	% with GDM	OR and 95% CI for preeclampsia: Model 1	P	Model 2	P	Model 3	P	Model 4	P
Overall										
US-born	2936	5.4	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born, ≥ 10 y	603	9.6	**1.86 (1.36–2.55)**	**< 0.001**	1.29 (0.93–1.79)	0.12	1.12 (0.78–1.61)	0.53	1.18 (0.81–1.72)	0.39
Foreign-born, < 10 y	1945	5.7	1.05 (0.82–1.34)	0.72	0.89 (0.69–1.15)	0.38	0.77 (0.57–1.04)	0.09	0.92 (0.66–1.27)	0.60
NHW										
US-born	776	5.8	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born, ≥ 10 y	32	6.3	1.08 (0.25–4.68)	0.92	0.88 (0.20–3.82)	0.86	0.67 (0.15–3.08)	0.61	0.60 (0.13–2.78)	0.52
Foreign-born, < 10 y	106	5.7	0.97 (0.41–2.34)	0.95	0.86 (0.35–2.08)	0.74	0.96 (0.37–2.50)	0.94	1.35 (0.49–3.70)	0.57
NHB										
US-born	1605	4.9	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born, ≥ 10 y	227	6.2	1.29 (0.72–2.31)	0.40	0.90 (0.50–1.65)	0.74	0.92 (0.50–1.70)	0.79	1.05 (0.56–1.99)	0.87
Foreign-born, < 10 y	539	8.2	**1.74 (1.19–2.55)**	**0.005**	1.25 (0.84–1.85)	0.28	1.28 (0.82–2.00)	0.27	1.60 (0.99–2.60)	0.05
Hispanic										
US-born	555	6.5	1.00 (Ref)		1.00 (Ref)		1.00 (Ref)		1.00 (Ref)	
Foreign-born, ≥ 10 y	344	12.2	**2.00 (1.25–3.20)**	**0.004**	1.15 (0.70–1.90)	0.57	0.96 (0.57–1.61)	0.87	1.07 (0.61–1.88)	0.82
Foreign-born, < 10 y	1300	4.6	0.70 (0.46–1.07)	0.10	**0.55 (0.36–0.86)**	**0.008**	**0.43 (0.27–0.70)**	**0.001**	**0.54 (0.32–0.91)**	**0.021**

Model 1: unadjusted; Model 2: age-adjusted; Model 3: Model 2 + education, marital status, and stress; Model 4: Model 3 + hypertension, parity, body mass index, and smoking. Boldface indicates significance.

NHB, non-Hispanic Black; NHW, non-Hispanic White; Ref, referent.

others.[21] Other studies have shown that foreign-born status is protective against other APOs, such as preterm birth and preeclampsia, and that this protection wanes with more time spent in the US.[16,22,23] This finding is consistent with the well-documented "healthy immigrant" phenomenon, which postulates that immigrants may have a health advantage over their US-born counterparts despite generally adverse social and economic factors.[16,24-26] This advantage is thought to be due to the positive self-selection of healthier individuals who are willing to undergo the experience of immigrating to a new country.[26] Additionally, new immigrants may bring healthier habits and lifestyles, such as physical activity, low-calorie diets, and protective cultural factors.[26]

However, as seen in our study, evidence indicates that this initial foreign-born advantage may erode with increased acculturation to the host country, due to the adoption of the unhealthy behaviors of the host-country population.[15,25,27] We found that foreign-born women of all 3 racial/ethnic groups who had resided in the US for > 10 years had similar odds of having GDM as did their US-born counterparts, possibly due to behavioral changes associated with acculturation. But our work shows a deviation from this pattern among NHB women with < 10 years US residence. This group of women had a higher risk of having GDM, despite having a lower risk of having preeclampsia.[16] Differences in cardiovascular risk profiles do not appear to explain the higher risk of having GDM among NHB women with < 10 years (vs > 10 years) of US residence. In fact, we found that foreign-born women with < 10 years of US residence in all 3 racial/ethnic groups (including NHB women) had the lowest prevalence of CVD risk factors, including smoking during pregnancy, obesity, severe stress, and multiparity, compared to women with ≥ 10 years of US residence and US-born women.

Several explanations are possible for these divergent findings—of increased prevalence of GDM among NHB women with < 10 years of US residence. First, increasing evidence indicates that socioeconomic status (SES) may affect the relationship between acculturation and risk for diabetes.[26,27] Research shows that increased exposure to the US environment leads to a higher risk of DM in immigrants with lower SES because immigrants with fewer resources may experience a decline in healthy diet habits that has effects that are compounded by a longer duration in the US.[26,27] In contrast, immigrants with higher SES may derive benefit from increased exposure and acculturation to the US, with higher likelihood of achieving steady employment, higher income, and increased ability to satisfy healthier food preferences and engage in regular physical activity.[26,27]

Data from the Pew Research Group show that the median household income for NHB immigrants is higher than that for Hispanic immigrants.[28,29] In addition, NHB immigrants from Africa have higher than average rates of educational advanced degree attainment.[29,30] Thus, the increased risk of GDM seen in foreign-born NHB women with < 10 years of US residence may result from the comparatively lower amount of time they have had to engage with the US healthcare system and attain the financial freedom needed to engage in healthier dietary and lifestyle behaviors.

Lastly, complex interactions are likely among race/ethnicity, immigration status, diet and cultural associations, neighborhood segregation, racism and social determinants, such as housing, access to healthcare, and financial

toxicity that impact the likelihood of having, GDM, as with any other APOs.[31,32] This study highlights that clinicians evaluating these women at risk of developing GDM based on their CVD risk factor profile need to be aware of the complexities that impact risk of GDM and that considerable heterogeneity exists among different race/ethnicities. Larger studies with detailed information on the social context of patients would be helpful in unlocking the divergent risks and outcomes.

One major strength of this study is that the BBC cohort is a diverse racial cohort with data on maternal place of birth, length of US residence, APOs, and other CVD risk factors, thus allowing for granular exploration of nativity-related disparities in pregnancy-associated disorders and CVD risk factors within different racial/ethnic groups. A recent cross-sectional analysis of data from the National Centre for Health Statistics showed that, in addition to Hispanic and NHB women, Asian/Pacific Islander women also have significantly increased risk for developing GDM.[3] In fact, GDM rates were the highest in Asian Indian participants (129.1 per 1000 live births; relative risk, 2.24 [95% CI, 2.15-2.33]).[3] Thus, future studies examining the association between GDM and CVD risk factors , and how it varies by nativity and measures of acculturation, would benefit from additionally including Asian and Pacific Islander women, who were not included in our current analyses due to limited sample size. In addition, future studies should examine how SES affects GDM risk in immigrants with differential levels of acculturation, as that information was not available in our dataset.

Another limitation of our dataset is the lack of data on diet and physical exercise, which should also be incorporated into future studies due to their critical importance in the development of GDM. Also, a considerable number of foreign women did not have data on duration of US residence and were therefore excluded from the analyses by duration of US residence. However, a comparison of the women who were excluded vs those included in our study showed that they were very similar in terms of age, parity, and the proportion with risk factors such as preeclampsia, severe stress, chronic diabetes, and gestational diabetes. Our study was also unable to capture other social determinants of health measures, including access to healthcare, insurance status, neighborhood, and English-language speaking proficiency.

These limitations further highlight that the amalgamation of social determinants of health, acculturation experience, environmental exposures, and changes in cultural traditions experienced by groups of immigrants with similar life experiences influence health outcomes. Thus, when examining health disparities by race/ethnicity, future studies must include and explore the contributions of factors such as the social determinants of health—which are often a consequence of racial classifications—and acculturation level. Similarly, solutions to decrease disparities in APOs and cardiovascular health outcomes after APOs must include interventions related to the social determinants of health and acculturation. These include helping mitigate language barriers, with a special focus on improving health literacy and navigating the American healthcare system, increasing the availability of low-cost, nutritious foods, and improving the built environment in immigrant-dense neighborhoods to support healthy lifestyles.

Our work provides evidence of nativity-related disparities in the prevalence of GDM and traditional CVD risk factors. The prevalence of traditional CVD risk factors is lower among foreign-born immigrants with < 10 years of residence in the US. In addition, foreign-born Hispanic women with < 10 years of US residence have a lower risk of GDM compared to that of US-born Hispanic women, suggesting that the "healthy immigrant phenomenon" applies to this population. However, we found unexpectedly that GDM prevalence is higher in foreign-born NHB women with a shorter duration of US residence, despite better risk-factor profiles, which may be explained by socioeconomic factors. Our findings highlight the heterogeneity of immigrants to the US and suggest that GDM risk may be heavily influenced by the specific acculturation experience, social determinants of health, environmental exposures, and changes in cultural traditions.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

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