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Disparities in the risk of gestational diabetes by race-ethnicity and country of birth

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Abstract

Little information exists on the association between maternal country of birth and risk of gestational diabetes (GDM). We examined within each race-ethnicity group whether the risk of GDM differs between women born inside and outside the US. The study was a cohort study of 216 089 women who delivered an infant between 1995 and 2004 with plasma glucose data from the screening 50-g glucose challenge test and the diagnostic 100-g, 3-h oral glucose tolerance test. The age-adjusted prevalence of GDM varied by race-ethnicity and was lowest for non-Hispanic white (4.1%) and highest among Asian Indians (11.1%). In multivariable models, being born outside of the US was associated with an increased risk of GDM among black, Asian Indian, Filipina, Pacific Islanders, Chinese, Mexicans and non-Hispanic white women, whereas, Japanese and Korean foreign-born women had a decreased risk of GDM. Clinicians should be aware that among certain race-ethnicity groups women born outside the US may be at increased risk of GDM and may warrant special preventive and culturally sensitive care.

Keywords

gestational diabetes; ethnic origins; maternal place of birth

Introduction

Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance with onset or first recognition during pregnancy. The incidence of GDM has increased dramatically in the past decade in all race-ethnicity groups¹ but the reasons underlying this increase remain unclear. Women with gestational diabetes have increased insulin resistance and decreased insulin secretion in response to glucose, and are at high risk of developing type 2 diabetes within the first 5 years after delivery.² Women of ethnic minority groups, especially Hispanic and Asian, have consistently been found to have an increased risk of GDM compared with non-Hispanic white women.^{1,3–6} However, most studies to date on racial differences in risk of GDM have aggregated all Asian and Hispanic subgroups together.^{4,5} Two recent studies that examined Asian subgroups separately suggest there is substantial

heterogeneity in the prevalence of GDM within Asian Americans^{7,8} and one study also found GDM prevalence varied within Hispanic subgroups.⁷

In 2006, the foreign-born population accounted for 12.5% of the total US population⁹ and accounted for 44% of the population growth. Approximately 42% of immigrant women are of reproductive age (between 25–44 years of age), compared with 26% of native-born women.¹⁰ Migrant populations have been shown to have a higher prevalence of type 2 diabetes compared with the prevalence in their native country.^{11,12} This suggests that GDM is influenced by environmental factors in addition to genetic predisposition. Little information exists on the association between country of birth and risk of gestational diabetes and results are somewhat conflicting;^{7,13} however, all previous studies included women with different degrees of access to health care and did not have uniform screening and a standard definition of GDM.^{7,8,13}

The growing segment of the US population represented by recent immigrants and the increasing racial-ethnic diversity in the US may influence the proportion of women diagnosed with GDM and ultimately type 2 diabetes. Increased knowledge regarding the epidemiology of GDM may lead to novel approaches to reduce the prevalence of GDM and therefore type 2 diabetes in women and their offspring. The aim of this study was to examine racial/ethnic differences in the prevalence of GDM and the effect of maternal country of birth on the risk of GDM among 11 race-ethnicity groups in a large cohort of 216 089 women belonging to a health maintenance organisation (HMO) with equal access to health care and uniform screening and diagnosis of GDM.¹

Materials and methods

Study design

The study setting was the Kaiser Permanente of Northern California (KPNC), which currently provides comprehensive medical services through 14 delivery hospitals and 23 outpatient clinics to over three million members located in a 14-county region in Northern California. From the results of the 1990 and 2000 censuses, we know that the KPNC membership is representative of the population living in the 14 county geographical area served by the health plan with regard to demographics, ethnicity and socio-economic status, except that the KPNC under-represents the very poor and the very wealthy.^{14,15}

Cohort identification

The cohort of pregnancies and of the GDM cases described below was identified through the KPNC Gestational Diabetes Registry, which has been described in detail elsewhere.¹ Briefly, the Registry first searches the Northern California Kaiser Permanente Diabetes Registry¹⁶ to identify and exclude women with recognised diabetes prior to the index pregnancy. This registry is an active surveillance programme that identifies diabetic members from automated health plan sources, including inpatient and outpatient diagnosis of diabetes, pharmacy prescriptions of hypoglycaemic medications and abnormal HbA1c values. Women were considered to have diabetes prior to the index pregnancy if they were identified by the Northern California Kaiser Permanente Diabetes Registry at least 9 months

prior to their delivery date. We identified 320 942 deliveries in KPNC from January 1995 to December 2004; of these 5726 (1.8%) did not match to a California birth certificate record. We then excluded 2628 (0.8%) women identified as having pre-existing diabetes. After linking to the KPNC GDM registry¹ we identified 279 382 pregnancies that were screened for GDM and, if abnormal, had the recommended follow-up 3-h oral glucose tolerance test, and resulted in a livebirth(s) among women aged 15–45. If a woman had more than one pregnancy we restricted the data to the first pregnancy during the study period ($n = 221\,928$). Maternal glucose values from the 50-g, 1-h oral challenge test and any 100-g, 3-h oral glucose tolerance tests were obtained from the KPNC regional laboratory database that records all laboratory tests and results performed at the KPNC regional laboratory. Women were classified as having GDM if two or more of the four plasma glucose values obtained during the 100-g, 3-h oral glucose tolerance test were abnormal according to the American Diabetes Association (ADA) criteria¹⁷ (plasma glucose thresholds: fasting 95 mg/dL, 1-h 180 mg/dL, 2-h 155 mg/dL, 3-h 140 mg/dL).

The California birth certificate electronic records were used to obtain information on self-reported maternal education, parity, race, ethnicity and country of birth. Maternal birthplace was categorised as inside or outside the 50 US states and Washington, DC. We excluded all women from race-ethnic groups without at least 50 GDM cases (Native Americans $n = 847$) and women who indicated they were Asian, but did not specify what type of Asian they were ($n = 2416$) as well as all those with other or unknown race-ethnicity ($n = 2576$). We included the following race-ethnic groups [non-Hispanic white, black, Mexican, other Hispanic (includes: 64% Central/South American, 9.8% Puerto Rican, 1.3% Cuban and 24.8% other Hispanics), Chinese, Japanese, Korean, Southeast Asian (includes: Vietnamese, Cambodian, Hmong, Thailand Laotian), Filipina and Asian Indian]. The black race-ethnic group included some women who also reported being of Hispanic ethnicity. The final cohort consisted of 216 089.

Weight during pregnancy was obtained from an electronic database that collects weights reported at the time of the alpha-fetoprotein test, performed on average at 16 weeks' gestation and available on a subset of 139 813 women. Among a subsample of $n = 82\,680$ women with data on both weight and height, body mass index (BMI) was calculated as weight, in kilograms, divided by height, in metres, squared.

Statistical analysis

The age-adjusted prevalence and 95% confidence intervals (CI) of GDM were calculated within each race-ethnicity group before and after stratifying by country of birth using the direct method in which the age distribution of the entire study cohort was used as the standard. Unconditional logistic regression was used to obtain odds ratios (OR) as estimates of the relative risk of GDM associated with maternal birthplace outside the US separately among each race-ethnic group. We first present unadjusted ORs relating maternal birthplace (outside the continental US vs. inside) to risk of GDM within each race-ethnic group. Multiple logistic regression was used to adjust for age at delivery, education (high school graduate or less, partial college, college graduate or higher, unknown), parity, maternal weight in kilograms in the second trimester (modelled as a three-level variable: racial/ethnic

group-specific percentile <90th, 90th and missing) and gestational age at the second trimester weight measurement. Sensitivity analyses were conducted restricting to the subsets with maternal weight and to determine whether results changed after further adjusting for these variables. Because results did not change we feel confident in presenting data for the full cohort and adjusting for the three-level weight variable that includes a category for missing data on weight (35%). Sensitivity analyses were also conducted restricted to the subsets with maternal BMI. Maternal BMI and maternal weight were highly correlated ($R^2 = 0.86$). SAS version 9.1 (SAS Institute Inc., Cary, NC) was used for all analyses.

This study was approved by the human subjects committee of the Kaiser Foundation Research Institute and the California State IRB.

Results

The age-adjusted GDM prevalence varied by race-ethnicity group: it was lowest among non-Hispanic white women (4.2%, 95% CI 4.1, 4.3), blacks (4.4%, 95% CI 4.1, 4.7), other Hispanics (5.4%, 95% CI 5.0, 5.8) and Japanese (5.5%, 95% CI 4.0, 7.1) and intermediate among Koreans (6.7%, 95% CI 5.0, 8.3), Mexicans (7.1%, 95% CI 6.8, 7.4), Pacific Islanders (7.2%, 95% CI 6.1, 8.3), and Chinese (7.9%, 95% CI 7.3, 8.5) and highest among Southeast Asians (8.8%, 95% CI 7.7, 9.0), Filipinas (9.6%, 95% CI 9.1, 10.0) and Asian Indians (11.1%, 95% CI 10.4, 12.0).

The proportion of women born outside of the US ranged from 8.8% for blacks to 97.4% for Asian Indians (Fig. 1). Women born outside of the US weighed less and had a lower BMI but were older and less likely to be primiparous. Women born outside the continental US were also more likely to have GDM compared with US-born women (Table 1).

The age-adjusted prevalence of GDM by country of birth varied substantially by race-ethnicity group (Fig. 2). Table 2 shows the race- and ethnicity-specific multiple adjusted regression models assessing the association between being born outside of the US and risk of GDM. In the fully adjusted models including age, parity, education, maternal weight during pregnancy and gestational age at maternal weight measurement, there was an increased risk associated with being born outside of the US that was approximately 80% higher among Asian Indian, black and Filipina women; 50% higher among Chinese and Pacific Islanders; and 35% higher among non-Hispanic white and Mexican women compared with women born inside the US. In contrast, there was no association between being born outside of the US and risk of GDM among other Hispanics, whereas Japanese and Korean women born outside of the US had a 50% decreased risk of GDM. The data were also suggestive of an increased risk of GDM among Southeast Asian women born outside of the US, although this did not reach statistical significance.

In analyses restricted to the 82 690 women with BMI data the strength and the direction of the observed race/ethnicity-specific associations between country of birth and risk of GDM remained (data not shown).

Discussion

In our multi-ethnic cohort of women undergoing universal screening for GDM, there was significant variation in the risk of GDM by race-ethnicity group. While Asian Indian women had the highest prevalence of GDM, several Asian subgroups (Chinese, Southeast Asian and Filipina) also had a high prevalence of GDM as did Mexicans and Pacific Islanders. In contrast non-Hispanic white and black women had the lowest prevalence. Maternal birthplace outside of the US was associated with an increased risk of GDM for most race-ethnic groups. However, among Hispanic women born outside of Mexico there was no association and among Japanese and Korean women there was an inverse association. The observed associations were independent of known GDM risk factors, such as maternal body weight, age, parity and education.

A major strength of this study is the uniform screening and diagnosis of GDM by the ADA's recommended two-step procedure in this cohort with equal access to medical care. This is important as screening for GDM in the general US population outside of a health maintenance organisation is likely to be lower among recent immigrants who are less likely to have access to medical care.¹⁸ We were also able to exclude women with recognised pre-existing diabetes. Prior studies examining differences in country of birth and GDM have relied on birth certificate data for GDM diagnosis and this is subject to incomplete or inaccurate reporting of pregnancy complications.^{8,19} In addition, we are the only study to date that has been able to adjust for maternal weight and prepregnancy BMI in a subset. Self-reported race-ethnicity in the California birth certificate appears to be very accurate, a validation study comparing race-ethnicity reported on the California birth certificate with that obtained from face-to-face postpartum interviews in 7424 women found the sensitivity of the birth certificate data ranged from 94 to 99 for African Americans, Asians/Pacific Islanders, Caucasians and Hispanics;²⁰ we expect self-reported country of birth to be as accurate if not more so.

This study also had some limitations. We lacked information on how long women had been living in the US and on the degree of acculturation, both of which may have influenced the risk of GDM. We did not have information on maternal height on a large portion of our sample so we were unable to control for BMI on all women in the cohort. However, sensitivity analyses among women with BMI data found similar results. Controlling for maternal body fat distribution, dietary practices and physical activity levels between women born outside of the US vs. those born inside the US may have reduced or increased the size of the observed associations; however, we did not have information on these potential confounders. Certain Asian subgroups consisted of 97% foreign-born, while all of our multiple logistic regression models converged suggesting they were statistically stable, it will be interesting to see if the observed associations persist as more US-born women in these ethnic groups give birth.

We found GDM prevalence was lowest among non-Hispanic white women (4.2%) and blacks (4.4%); the prevalence varied by Hispanic subgroups: other Hispanics (5.4%) and Mexicans (7.1%) and by Asian subgroups: Japanese (5.5%), Koreans (6.7%), Pacific Islanders (7.2%) and Chinese (7.9%) and was highest among Southeast Asians (8.8%),

Filipinas (9.6%) and Asian Indians (11.1%). Our findings that the prevalence of GDM varied within Asian subgroups are generally consistent with two prior studies.^{7,8} Savitz *et al.* used birth certificate data or hospital discharge diagnosis to assess the prevalence of GDM in New York City and found the prevalence of GDM varied within Asian subgroups as follows: 3.0% for Japanese, 3.3% for Korean, 6.2% for East Asian women, 8.6% in South East Asian and Pacific Islanders and 14.3% in South Central Asian women. Chu *et al.* used birth certificate data from several states and found Asian and Pacific Islanders (6.3%) had a higher prevalence of GDM than non-Hispanic whites (3.8%), blacks (3.5%) or Hispanics (3.6%) and among the Asian subgroups Asian Indian (8.6%) had the highest prevalence and Japanese women had the lowest (3.7%). Three prior studies also found variations in the association between maternal country of birth and GDM by race-ethnicity group.^{7,8,13} Kieffer *et al.* used birth certificate data from the US population in the early 1990s and found an increased risk of diabetes during pregnancy associated with being born outside the US among Asian Indian, non-Hispanic black, Filipina, Puerto Rican and Central and South Americans, but they found a decreased risk of diabetes among Mexican and Japanese foreign-born women.¹³ In contrast, we found Mexican women born outside of the US were at increased risk of GDM but there was no association among other Hispanic women born outside of Mexico. Savitz found that the association with being foreign-born varied within subgroups of Hispanic women, with foreign-born South American and Mexican women having a 50–70% increased risk of GDM and no association between foreign-born Hispanic women from the Caribbean and Central America.⁷ In our population the majority of our other Hispanic women were born in Central or South America (64%); however, we did not have adequate numbers to look at these subgroups separately. Similar to our findings, Chu *et al.* found an increased risk of GDM among all foreign-born Asian subgroups, except for Japanese and Korean.⁸ The strength of the associations observed in previous studies tended to be smaller than those we observed, but they relied on birth certificate data for GDM diagnosis, whereas we used a standard definition of GDM based on plasma glucose values. In addition all women in our study were members of a health plan, in other studies women may have had varying degrees of access to medical care, especially recent immigrants who may be less likely to undergo screening for GDM.

In contrast to our finding most studies comparing the prevalence of diabetes among foreign-born compared with US-born populations have found the foreign-born to have a lower prevalence of diabetes and lower all cause mortality across ethnic groups.²¹ Among Hispanic populations the lower prevalence of diabetes and all cause mortality among the foreign-born has been called the ‘Hispanic Paradox’. It has been speculated that this paradox may be due to the salmon-bias effect whereby sicker immigrants return to their native country.²² The fact that GDM occurs in previously healthy young women of reproductive age may explain why our findings are contradictory to what has been found with type 2 diabetes in Hispanic populations.

The reasons why some but not all women born outside the continental US have an increased risk of GDM are not clear. The process of westernisation associated with migration often leads to the abundance of calorie-dense low-fibre foods and the adoption of sedentary lifestyles. The effect of acculturation on diabetes risk may vary by ethnic group depending

on the frequency of diabetes in the host country and the country of origin and on the extent of acculturation adopted by the migrant population.

While both recent migrants and those born in the US are exposed to the 'western' diet and its effects on weight gain, it is possible that the rapid change in diet, physical activity and stress levels occurring after migration puts extra stress on the β -cells in migrant populations. A recent study found a strong inverse association between a woman's own birthweight and her subsequent risk of GDM²³ that was stronger among lean women and independent of BMI. The 'fetal origins' hypothesis suggests that intrauterine malnutrition during the critical period of fetal development results in impaired β -cell function.²⁴ Immigrants from countries with high rates of malnutrition may have lower birthweights and may be programmed *in utero* to develop GDM when exposed to a high energy density food and sedentary environment. Therefore, it is possible that the increased risk of GDM is due to a combination of the rapid changes in environmental factors among migrant populations programmed *in utero* to be susceptible to diabetes. It appears that the increased risk of GDM among foreign-born women is attributable to factors other than obesity, as women born outside the continental US weighed less and had a lower BMI than women born inside the US.

Another potential ecological explanation of our findings could be that the differences we observed are due to differences in environmental exposures in the country of origin. Persistent organic pollutants, most notably serum levels of organochlorine pesticides and polychlorinated biphenyl congeners, have been associated with a higher prevalence of type 2 diabetes and insulin resistance.^{25,26} These chemicals were banned in many developed countries during the 1970s, but a number of these pollutants continue to be used in developing countries. India, China and Mexico are the three largest remaining persistent organic pollutant producers in the world.²⁷ Women born in countries with higher levels of these persistent pollutants may have higher levels of these diabetogenic environmental exposures, which could in turn increase their risk of GDM.

In conclusion, race and foreign-born disparities in the risk of GDM need to be further studied to develop prevention programmes for GDM and its progression to type 2 diabetes. It is possible that rapid transitions in life style and other environmental factors in migrant populations may interact with genetic susceptibility to influence the risk of GDM. Increased knowledge regarding the epidemiology of GDM may lead to novel approaches to reduce the incidence of GDM. Clinicians should be aware that some women born outside the continental US appear to be at increased risk of GDM and may warrant special preventive and culturally sensitive care. More information is needed to determine why the risk of GDM is elevated in some, but not all immigrant subgroups.

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Figure 1.
Proportion of women born outside the US by race-ethnicity group.

Figure 2.

Age-adjusted prevalence of gestational diabetes mellitus (GDM), by race-ethnicity group and country of birth.

Table 1Characteristics of the cohort ($n = 216\,089$), by maternal place of birth^a

Characteristic	US	Outside of US
	<i>n</i> (%) or mean $\pm$ SD	
Age at delivery (years)	27.8 $\pm$ 6.3	29.4 $\pm$ 5.4
15–24	44 175 (32.5)	15 179 (18.9)
25–29	36 584 (26.9)	25 807 (32.2)
30–34	33 683 (24.8)	24 318 (30.4)
35–45	21 553 (15.8)	14 790 (18.5)
Parity		
0	76 628 (56.3)	39 318 (49.1)
1	35 441 (26.1)	23 618 (29.5)
2+	23 905 (17.6)	17 122 (21.4)
Unknown	21 (0.02)	36 (0.04)
Educational attainment		
High school graduate or lower	55 844 (41.1)	36 561 (45.7)
Partial college	41 501 (30.5)	18 453 (23.0)
College graduate or higher	37 664 (27.7)	24 147 (30.1)
Unknown	986 (0.7)	933 (1.2)
Weight during pregnancy (kg) ^b	72.9 $\pm$ 17.2	63.7 $\pm$ 12.6
Gestational age of fetus at pregnancy weight ascertainment ^b		
9–14	965 (1.1)	649 (1.2)
15–17	62 550 (71.7)	34 990 (66.5)
18–20	23 425 (26.9)	16 791 (31.9)
21–24	250 (0.3)	193 (0.4)
Gestational diabetes mellitus (GDM) ^c		
No	130 100 (95.7)	73 326 (91.5)
Yes	5895 (4.3)	6768 (8.5)
Race-ethnicity		
Non-Hispanic white	82 462 (60.6)	10 204 (12.7)
Black	18 410 (13.5)	1784 (2.2)
Chinese	1240 (0.9)	7858 (9.8)
Japanese	663 (0.5)	723 (0.9)
Korean	120 (0.09)	1238 (1.6)
Southeast Asian	235 (0.2)	6127 (7.7)
Filipina	2887 (2.1)	12 015 (15.0)
Asian Indian	192 (0.1)	7161 (8.9)
Pacific Islander	937 (0.7)	1147 (1.4)
Mexican	23 803 (17.5)	25 122 (31.4)
Other Hispanic	5046 (3.7)	6715 (8.4)

^aBorn in the continental US or outside of US.

^b For subset of women in cohort who had a weight measurement during pregnancy ($n = 139\,813$).

^c GDM defined using ADA criteria.

Table 2

Association between maternal country of birth and risk of gestational diabetes mellitus (GDM), by racial/ethnic group: adjusted odds ratios [95% CI] for birth outside US

	Racial/ethnic group (number of GDM cases) ^d										
	Non-Hispanic white (4084)	Black (771)	Chinese (931)	Japanese (89)	Korean (90)	Southeast Asian (536)	Asian Indian (793)	Filipina (1537)	Pacific Islander (138)	Mexican (3078)	Other Hispanic (616)
Model 1 ^b	1.25 [1.14, 1.37]	1.61 [1.32, 1.96]	1.50 [1.20, 1.89]	0.59 [0.38, 0.91]	0.43 [0.23, 0.81]	1.44 [0.62, 3.35]	1.72 [0.95, 3.11]	1.60 [1.33, 1.91]	1.54 [1.05, 2.26]	1.25 [1.16, 1.35]	1.00 [0.84, 1.19]
Model 2 ^c	1.27 [1.16, 1.39]	1.64 [1.34, 2.00]	1.42 [1.13, 1.79]	0.60 [0.38, 0.94]	0.42 [0.22, 0.80]	1.46 [0.63, 3.39]	1.76 [0.97, 3.19]	1.60 [1.34, 1.92]	1.55 [1.05, 2.28]	1.23 [1.13, 1.33]	0.97 [0.82, 1.15]
Model 3 ^d	1.36 [1.24, 1.49]	1.78 [1.46, 2.18]	1.51 [1.20, 1.91]	0.63 [0.40, 1.00]	0.48 [0.25, 0.92]	1.58 [0.68, 3.70]	1.84 [1.02, 3.34]	1.78 [1.48, 2.15]	1.58 [1.07, 2.32]	1.34 [1.23, 1.46]	1.06 [0.89, 1.27]

^a African American subgroup includes Hispanic ethnicity; otherwise, non-Hispanic unless specified as such.

^b Model 1: adjusted for maternal age at delivery.

^c Model 2: Model 1 plus adjusted for parity and educational attainment (as four categories: high school graduate or less (referent group), partial college, college graduate or higher, unknown).

^d Model 3: Model 2 plus adjusted weight during pregnancy (modelled as three-level variable: <90th vs. 90th racial/ethnic group-specific percentile vs. missing/unknown) and gestational age of fetus at weight ascertainment.