Race/Ethnicity, Educational Attainment, and Pregnancy Complications in New York City Women with Pre-existing Diabetes

Tamarra James-Todd,[a] Teresa Janevic,[b] Florence M. Brown,[c] David A. Savitz[d]

[a]Connors Center for Women's Health and Gender Biology, Brigham and Women's Hospital and Harvard Medical School, Boston, MA

[b]Department of Epidemiology, Rutgers School of Public Health, Piscataway, NJ

[c]Joslin Diabetes Center and Harvard Medical School, Boston, MA

[d]Departments of Epidemiology and Obstetrics and Gynecology, Brown University, Providence, RI

Abstract

Background: More women are entering pregnancy with pre-existing diabetes. Disease severity, glycaemic control, and predictors of pregnancy complications may differ by race/ethnicity or educational attainment, leading to differences in adverse pregnancy outcomes.

Methods: We used linked New York City hospital record and birth certificate data for 6291 singleton births among women with pre-existing diabetes between 1995 and 2003. We defined maternal race/ethnicity as non-Hispanic white, non-Hispanic black, Hispanic, South Asian, and East Asian, and education level as <12, 12, and >12 years. Our outcomes were pre-eclampsia, preterm birth (PTB) (<37 weeks gestation and categorised as spontaneous or medically indicated), as well as small-for-gestational age (SGA) and large-for-gestational age (LGA). Using multivariable binomial regression, we estimated the risk ratios for pre-eclampsia, SGA, and LGA. We used multivariable multinomial regression to estimate odds ratios (OR) for PTB.

Results: Compared with non-Hispanic white women with pre-existing diabetes, non-Hispanic black and Hispanic women with pre-existing diabetes had a 1.50-fold increased risk of pre-eclampsia compared with non-Hispanic whites with pre-existing diabetes, after full adjustment. Non-Hispanic black and Hispanic women with pre-existing diabetes had adjusted ORs of 1.72 [adj. 95% confidence interval (CI) 1.38, 2.15] and 1.65 [adj.95% CI 1.32, 2.05], respectively, for medically indicated PTB. South Asian women with pre-existing diabetes had the highest risk for having an SGA infant [adj. OR: 2.29; adj. 95% CI 1.73, 3.03]. East Asian ethnicity was not associated with these pregnancy complications.

Conclusions: Non-Hispanic black, Hispanic, and South Asian women with pre-existing diabetes may benefit from targeted interventions to improve pregnancy outcomes.

Keywords: *pre-existing diabetes, preterm birth, small-for-gestational age, large-for-gestational age, pre-eclampsia, race, non-Hispanic blacks, Hispanics, South Asians, education.*

Among pregnant women, the prevalence of pre-existing diabetes increased over two-fold between 1999 and 2005, from <1% to ~2%.[1] The growing obesity epidemic is likely to be a primary reason for this increase,[2] which could lead to a further rise in the prevalence of pre-existing diabetes in the coming years. Numerous studies have reported higher risk of adverse pregnancy outcomes in women with pre-existing diabetes.[3–5] For example, pre-existing diabetes is associated with a three- to four-fold increased risk of pre-eclampsia and a two- to three-fold increased risk of preterm birth (PTB).[6] Pre-existing diabetes is also associated with a three- to five-fold increased risk of delivering a large-for-gestational age infant (LGA).[7–9]

Good glycaemic control is an important determinant of adverse pregnancy outcomes in women with pre-existing diabetes.[4,10–13] However, social factors, such as race/ethnicity and educational attainment, may also be associated with adverse pregnancy outcomes. Social determinants of adverse birth outcomes have been extensively studied in women without pre-existing diabetes.[14–16] For example, multiple studies of women without pre-existing diabetes have shown that

Correspondence:
Tamarra James-Todd, Brigham and Women's Hospital/Harvard Medical School, 1620 Tremont St., Division of Women's Health, 3rd Floor, Boston, MA 02120, USA.
E-mail: tjames-todd@bics.bwh.harvard.edu

non-Hispanic black women are at increased risk of PTB and pre-eclampsia.[14,17,18] Asian and non-Hispanic black women without pre-existing diabetes are at increased risk of delivering low birthweight infants.[15,16,19] However, no studies to our knowledge have examined disparities in adverse pregnancy outcomes among the growing population of women with pre-existing diabetes. Evaluating this research question among women with pre-existing diabetes may be particularly relevant, given that non-white race/ethnicity and lower socio-economic status are associated with poorer glycaemic control,[20–23] which could contribute to adverse pregnancy outcomes.

As such, the purpose of this exploratory study was to evaluate the associations between race/ethnicity, educational attainment, and risk of pregnancy complications and adverse birth outcomes in women with pre-existing diabetes. We used population-based linked hospitalisation and birth certificate data from 1995 to 2003 in New York City to evaluate whether racial/ethnic minorities or women of lower educational attainment were at increased risk of pre-eclampsia, PTB, as well as delivering an infant who was small-for-gestational age (SGA) or LGA. By determining the association between race/ethnicity and education as they relate to pregnancy complications in women with pre-existing diabetes, we can better develop and target interventions for this high-risk group.

Methods

Data source

Linked hospital and birth certificate data for $n = 1\,067\,356$ singleton livebirths for the years 1995–2003 were obtained from the New York State Department of Health. The New York State Department of Health linked birth record data with hospital discharge data from the Statewide Planning and Research Cooperative System. Based on earlier research,[24,25] women with pre-existing diabetes were identified and selected from the dataset ($n = 6542$). Pre-existing diabetes was defined using a combination of information from the birth certificate and the hospital record. Women were considered to have pre-existing diabetes if it was indicated on the birth certificate by checkbox, or in the hospital record by diagnoses codes ICD-9, 250.00–250.82, 362.01, 648.01–648.02. This algorithm has been found to best approxi-

mate the classification based on full medical record review.[24,25] In fact, a previous study showed that the combination of birth certificate and hospital discharge data had a true-positive fraction of 97% compared with only 52% when birth certificate data were used alone.[26] Women were excluded with missing information on ethnicity ($n = 88$), maternal education ($n = 82$) or birth outcome ($n = 56$). Women were also excluded with 'other' ethnicity ($n = 41$), for a total analytic sample size of $n = 6291$.

Race/ethnicity and education

Information on maternal race/ethnicity and educational attainment was obtained from the birth certificate. When evaluating birth certificate data, the positive predictive value for non-Hispanic whites, non-Hispanic blacks, Hispanics, and Asian/Pacific Islander was high at ~97%.[27] Race/ethnicity was categorised as non-Hispanic black, Hispanic, East Asian, South Asian vs. non-Hispanic white (reference). Asian was divided into two categories (East and South) due to the previously reported difference in risk of certain pregnancy complications between these two groups.[24] Women classified as East Asian were from countries such as China, Japan, Korea, etc., whereas women classified as South Asian were from countries that included India, Pakistan, Bangladesh, etc. Non-Hispanic whites were chosen as the reference category for this exploratory analysis, given that their rates of PTB, SGA, and pre-eclampsia have been shown to be lower compared with non-whites in US populations without pre-existing diabetes. Maternal education was categorised as <12 years, 12 years vs. >12 years (reference).

Pregnancy complications and outcomes

Pre-eclampsia was obtained using hospital record data with the International Classification of Diseases, Ninth Revision (ICD-9) codes 642.3–642.7. Gestational age was obtained from the birth certificate. We defined PTB as <37 weeks and term as ≥37 weeks gestation. PTB was categorised as spontaneous and medically indicated. Medically indicated PTBs were classified using the ICD-9 hospital discharge diagnosis and procedure codes. If a woman delivered <37 weeks gestation and had ICD-9 codes that indicated premature rupture of membranes (658.1x, 658.2x), pre-labour caesarean deliveries (74.x), or artificial rupture of

membranes, induction of labour by artificial rupture of membranes, or other surgical or medical induction of labour (ICD-9 codes 73.0, 73.01, 73.09, 73.1, 73.4), she was considered to have had a medically indicated PTB. In addition, we classified women who delivered <37 weeks, who did not have codes indicating labour or spontaneous delivery (644.0x, 644.1x, 644.2x), as also having a medically indicated PTB. We classified the remaining women who delivered <37 weeks as spontaneous PTB. Term birth (≥37 weeks) was our referent category.

Infant birthweight was obtained from birth certificate data. Small-for-gestational-age and large-for-gestational-age were defined as infants weighing less than the 10th percentile of weight or greater than the 90th percentile of weight for gestational age.[26]

Potential confounders and covariates

Based on previous literature, we considered variables available from the birth records as potential confounders and important covariates, including maternal age (≤25 years, 26–30, 31–35, 36–40, ≥41), pre-pregnancy weight (<125 lbs, 125–149, 150–174, 175–199, ≥200), tobacco use during pregnancy (yes/no) and parity (0, 1, ≥2). We also examined timing of the first prenatal visit [first trimester (reference), second trimester, third trimester].

Statistical analysis

All analyses were conducted among women with pre-existing diabetes. We used multivariable binomial regression models to evaluate the association between race/ethnicity and educational attainment and the following dichotomous outcomes: pre-eclampsia, SGA, and LGA. Race/ethnicity and educational attainment were modelled separately to evaluate their independent effect on these outcomes. We calculated the risk ratios and 95% confidence intervals [CI] for these associations. We used multinomial logistic regression to estimate odds ratios (OR) and 95% CI for the associations between race/ethnicity, educational attainment, and PTB (spontaneous PTB; medically indicated PTB vs. term birth). All models were adjusted for maternal age, pre-pregnancy weight, smoking status, prenatal care, and parity.

Results

In Table 1, we describe the characteristics of the study population. The majority of the population was non-

white, with close to 70% being non-Hispanic black or Hispanic. Most women (76.7%) had 12 years of education or greater, and half of the population was born outside of the US and received Medicaid. Despite having pre-existing diabetes, more than a quarter of women (27.4%) did not initiate prenatal care until the second or third trimester. In our study population, 11.4% had pre-eclampsia, 13.7% had medically indicated PTB, and 5.9% had a spontaneous PTB. Also, 11.4% of women had an SGA infant, while 17.7% had an LGA infant.

Race/ethnicity, education, and pre-eclampsia

Non-Hispanic black and Hispanic women with pre-existing diabetes had a significantly increased risk of pre-eclampsia. In fact, the unadjusted association showed a ~50% increased risk among these women compared with non-Hispanic white women with pre-existing diabetes (Table 2). Adjustment for maternal age, education, and other reproductive and behavioural factors did little to change this association. Education was not associated with pre-eclampsia.

Race/ethnicity, education, and PTB

In Table 3, we present the association among race/ethnicity, education, and PTB among women with pre-existing diabetes. Neither race/ethnicity nor education appeared to be significantly associated with an increased risk of spontaneous PTB. However, a suggestion of an elevated risk appeared for non-Hispanic black women, who had a 28% increased risk of spontaneous PTB, after adjusting for confounders [adj. 95% CI 0.95, 1.73].

When evaluating medically indicated PTB in women with pre-existing diabetes, we found that non-Hispanic black and Hispanic women had a significantly increased risk compared with non-Hispanic white women with pre-existing diabetes (Table 3). In fact, non-Hispanic black women with pre-existing diabetes had a 65% increased risk of having a medically indicated PTB [adj. 95% CI 1.32, 2.05] relative to non-Hispanic white women with pre-existing diabetes after adjusting for confounders. Hispanic women had a similarly increased risk, with a 72% increased risk of having a medically indicated PTB compared with non-Hispanic white women with pre-existing diabetes, even after adjustment for confounders [adj. 95% CI

Table 1. Study population characteristics

	n (%)	Pre-eclampsia	Spontaneous preterm	Medically indicated preterm	Term	Small-for-gestational age	Large-for-gestational age
Maternal age							
<25	838 (13.3)	157 (21.8)	64 (17.2)	117 (13.5)	657 (13.0)	99 (13.9)	143 (12.9)
25–29	1305 (20.7)	135 (18.8)	88 (23.7)	163 (18.9)	1054 (20.9)	139 (19.4)	241 (21.7)
30–34	1864 (29.6)	182 (25.3)	96 (25.8)	236 (27.3)	1532 (30.3)	182 (25.5)	339 (30.5)
35–39	1596 (25.4)	160 (22.3)	78 (21.0)	247 (28.6)	1271 (25.1)	185 (25.9)	294 (26.4)
≥40	688 (10.9)	85 (11.8)	46 (12.4)	101 (11.7)	541 (10.7)	110 (15.4)	95 (8.5)
Race/ethnicity							
Non-Hispanic black	2181 (34.8)	284 (39.7)	148 (39.9)	331 (38.5)	1702 (33.8)	284 (39.9)	343 (30.9)
Hispanic	2257 (36.0)	285 (39.9)	124 (33.4)	353 (41.1)	1780 (35.3)	245 (34.4)	428 (38.6)
East Asian	144 (2.3)	7 (1.0)	5 (1.4)	14 (1.6)	125 (2.5)	10 (1.4)	14 (1.3)
South Asian	348 (5.6)	23 (3.2)	18 (4.9)	25 (2.9)	305 (6.1)	69 (9.7)	35 (3.2)
Non-Hispanic white	1338 (21.4)	116 (16.2)	76 (20.5)	137 (15.9)	1125 (22.3)	104 (14.6)	290 (26.1)
Education							
<12 years	1466 (23.3)	180 (25.0)	86 (23.1)	200 (23.2)	1180 (23.3)	182 (25.5)	244 (21.9)
12 years	2149 (34.2)	251 (34.9)	133 (6.2)	312 (36.1)	1704 (33.7)	257 (35.9)	385 (34.6)
>12 years	2676 (42.5)	288 (40.1)	153 (41.1)	352 (40.7)	2171 (43.0)	276 (38.6)	483 (43.4)
Mother's place of birth							
US	3182 (50.8)	427 (59.7)	214 (57.7)	482 (56.2)	2486 (49.4)	347 (48.7)	508 (46.0)
Outside US	3077 (49.2)	288 (40.3)	157 (42.3)	375 (43.8)	2545 (50.6)	365 (51.3)	597 (54.0)
Initiation of prenatal care							
First trimester	4016 (72.6)	447 (70.1)	244 (74.2)	548 (73.1)	3224 (72.4)	427 (68.0)	732 (74.8)
Second trimester	1193 (21.6)	153 (24.0)	69 (21.0)	156 (20.8)	968 (21.8)	148 (23.6)	194 (19.8)
Third trimester or none	321 (5.8)	38 (6.0)	16 (4.9)	46 (6.1)	259 (5.8)	53 (8.4)	53 (5.4)
Insurance status							
Medicaid	3106 (50.1)	391 (54.9)	197 (53.5)	441 (51.8)	2468 (49.5)	401 (56.6)	505 (46.0)
Other	3100 (49.9)	321 (45.1)	171 (46.5)	411 (48.2)	2518 (50.5)	308 (43.4)	593 (54.0)
Pre-pregnancy weight (lbs)							
<125	796 (13.6)	73 (11.2)	42 (12.2)	106 (13.3)	648 (13.7)	121 (18.7)	80 (7.70)
125– ≤ 150	1564 (26.7)	170 (26.0)	93 (27.1)	193 (24.2)	1278 (27.1)	196 (30.3)	231 (22.3)
150– ≤ 175	1250 (21.3)	124 (18.9)	62 (18.1)	178 (22.3)	1010 (21.4)	117 (18.1)	227 (22.0)
175– ≤ 200	948 (16.2)	121 (18.5)	63 (13.4)	130 (16.3)	755 (16.0)	86 (13.3)	186 (18.0)
≥200	1299 (22.2)	167 (25.5)	83 (24.2)	190 (23.8)	1026 (21.8)	127 (19.6)	310 (30.0)
Parity							
0	2085 (33.1)	185 (25.7)	110 (29.6)	284 (32.9)	1691 (33.5)	221 (30.9)	434 (39.0)
1	1876 (29.8)	174 (24.2)	112 (30.1)	231 (26.7)	1533 (30.3)	171 (23.9)	364 (32.7)
2+	2330 (37.0)	360 (50.1)	150 (40.3)	349 (40.4)	1831 (36.2)	323 (45.2)	314 (28.2)
Smoking during pregnancy							
Ever	263 (4.2)	29 (4.0)	13 (3.6)	43 (5.0)	207 (4.1)	33 (4.7)	34 (3.1)
Never	5979 (95.8)	688 (96.0)	353 (96.5)	816 (95.0)	4810 (95.9)	674 (95.3)	1066 (96.9)

1.38, 2.15]. Maternal education was not associated with an increased risk of spontaneous or medically indicated PTB.

Race/ethnicity, education, and birthweight

South Asian, non-Hispanic black, and Hispanic women with pre-existing diabetes were more likely to deliver an SGA infant compared with non-Hispanic white women with pre-existing diabetes (Table 4). The strongest association was seen among South Asian women, who had a 2.5-fold increased risk of SGA compared with non-Hispanic white women [adjusted OR = 2.29, 95% CI 1.73, 3.03]. Non-Hispanic black women and Hispanic women also experienced an elevated risk of SGA [adj. risk ratio (RR) for non-Hispanic black women: 1.94, 95% CI 1.56, 2.42; and adj. RR for Hispanic women: 1.48, 95% CI 1.18, 1.85].

Table 2. Association among race/ethnicity, educational attainment, and pre-eclampsia in women with pre-existing diabetes

	Pre-eclampsia Risk ratio [95% CI]	
	Unadjusted	Adjusted[a]
Race		
Non-Hispanic black	1.48 [1.21, 1.81]	1.50 [1.22, 1.85]
Hispanic	1.43 [1.17, 1.75]	1.46 [1.18, 1.80]
East Asian	0.55 [0.26, 1.16]	0.59 [0.28, 1.24]
South Asian	0.75 [0.49, 1.15]	0.81 [0.52, 1.24]
Non-Hispanic white	1.00 [Reference]	1.00 [Reference]
Education		
<12 years	1.14 [0.96, 1.36]	1.07 [0.88, 1.29]
12 years	1.09 [0.93, 1.27]	1.03 [0.87, 1.21]
>12 years	1.00 [Reference]	1.00 [Reference]

[a]Adjusted for education, maternal age, parity, self-reported pre-pregnancy weight, and smoking status.

Interestingly, compared with non-Hispanic white women with pre-existing diabetes, non-Hispanic blacks, Hispanics, and South Asians experienced a reduced risk of delivering an LGA infant. East Asian ethnicity was not significantly associated with birthweight.

Finally, a modest association existed between maternal education and SGA. Women who had <12 years of education had a slight increased risk of having an SGA infant compared with women with >12 years education, who had pre-existing diabetes [adj. RR: 1.27, 95% CI 1.05, 1.53]. Associations were somewhat attenuated for women with 12 years of education. No association existed between maternal educational attainment and LGA among women with pre-existing diabetes.

Comment

In this study of women with pre-existing diabetes, we found race/ethnicity and educational attainment to be predictors of certain pregnancy complications. Risk of pre-eclampsia was only elevated in non-Hispanic black and Hispanic women. Only non-Hispanic black women were at a modestly increased risk of spontaneous PTB. Non-Hispanic black and Hispanic women with pre-existing diabetes had a ~70% increased risk of experiencing a medically indicated PTB compared with non-Hispanic white women with pre-existing diabetes. South Asian women had the highest increased risk (over two-fold) for having an SGA infant. Non-Hispanic black and Hispanic women were also at increased risk of having an SGA infant. Only non-white women were at reduced risk of LGA. Education was inversely associated with SGA, but not with LGA.

Previous studies have documented racial/ethnic differences in adverse pregnancy outcomes among women without pre-existing diabetes living in New York City, noting that non-Hispanic blacks and Hispanics are at increased risk of PTB.[28,29] We also found similar associations among those with pre-existing diabetes; however, our findings showed non-Hispanic

Table 3. Association of race/ethnicity and educational attainment with preterm birth among women with pre-existing diabetes

	Spontaneous preterm		Medically indicated preterm	
	OR [95% CI]			
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Race				
Non-Hispanic black	1.29 [0.97, 1.72]	1.28 [0.95, 1.73]	1.58 [1.28, 1.95]	1.65 [1.32, 2.05]
Hispanic	1.03 [0.77, 1.39]	0.99 [0.73, 1.35]	1.61 [1.31, 1.98]	1.72 [1.38, 2.15]
East Asian	0.59 [0.24, 1.50]	0.61 [0.24, 1.54]	0.91 [0.51, 1.62]	0.92 [0.51, 1.65]
South Asian	0.88 [0.52, 1.49]	0.90 [0.53, 1.53]	0.66 [0.43, 1.04]	0.68 [0.43, 1.06]
Non-Hispanic white	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Education				
<12 years	1.03 [0.79, 1.36]	1.01 [0.75, 1.36]	1.05 [0.87, 1.26]	0.94 [0.76, 1.15]
12 years	1.11 [0.87, 1.41]	1.08 [0.84, 1.38]	1.13 [0.96, 1.33]	1.06 [0.90, 1.26]
>12 years	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]

[a]Adjusted for education, maternal age, parity, self-reported pre-pregnancy weight, and smoking status.

Table 4. Association between race/ethnicity, educational attainment with small-for-gestational age (SGA) and large-for-gestational age (LGA) in women with pre-existing diabetes

	SGA		LGA	
	Risk ratio [95%CI]			
	Unadjusted	Adjusted[a]	Unadjusted	Adjusted[a]
Race				
Non-Hispanic black	1.65 [1.34, 2.05]	1.94 [1.56, 2.42]	0.73 [0.64, 0.84]	0.62 [0.53, 0.71]
Hispanic	1.38 [1.11, 1.72]	1.48 [1.18, 1.85]	0.88 [0.77, 1.01]	0.82 [0.71, 0.94]
East Asian	0.88 [0.47, 1.65]	0.69 [0.36, 1.34]	0.45 [0.27, 0.75]	0.61 [0.37, 1.02]
South Asian	2.52 [1.91, 3.33]	2.29 [1.73, 3.03]	0.47 [0.37, 0.65]	0.53 [0.38, 0.73]
Non-Hispanic white	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Education				
<12 years	1.20 [1.01, 1.44]	1.27 [1.05, 1.53]	0.92 [0.81, 1.06]	0.85 [0.73, 0.98]
12 years	1.16 [0.99, 1.36]	1.19 [1.01, 1.40]	0.99 [0.88, 1.12]	0.92 [0.81, 1.04]
>12 years	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]

[a]Adjusted for education, maternal age, parity, self-reported pre-pregnancy weight, and smoking status.

blacks and Hispanics to be more similar in their increased risk of medically indicated PTB when compared with non-Hispanic white women. In the present study, it is unclear what factors may lead to the increased risk of medically indicated PTB in non-Hispanic black and Hispanic women with pre-existing diabetes compared with non-Hispanic white women with pre-existing diabetes. One possibility is that women of these racial/ethnic groups have higher rates of poorer blood glucose control, as indicated by previous studies evaluating racial/ethnic differences in glycaemic control in the overall population.[22,30,31] For example, non-Hispanic black and Hispanic women could have poorer access and availability to medical services that could improve glycaemic control during pregnancy. This poorer glycaemic control could subsequently lead to adverse pregnancy outcomes. Given that poor blood glucose control can lead to poor pregnancy outcomes,[10–12,32–34] the higher risk of medically indicated PTB within these subgroups could be a consequence of poorly managed pre-existing diabetes during pregnancy.

Alternatively, due to social and behavioural factors, such as inability to modify diet, non-Hispanic black and Hispanic women may be more likely to be overweight or obese. Due to the higher prevalence of overweight or obesity among non-Hispanic black and Hispanic women, a greater proportion of these women could have type 2 diabetes compared with non-Hispanic white women. While we are uncertain of the distribution of type 1 and type 2 diabetes in this population, it has become clear that type 2 diabetes may lead to worse pregnancy outcomes than type 1 diabetes, despite better glucose control.[35] It is thought that this may primarily be attributed to the addition of obesity, given that obesity coupled with other metabolic conditions, such as hypertriglyceridemia and insulin resistance, could lead to endothelial dysfunction. In fact, endothelial dysfunction is a key factor in the development of pre-eclampsia, with pre-eclampsia often resulting in medically indicated PTB.[36] Non-Hispanic black and Hispanic women in our study population had higher pre-pregnancy weight, as such it is likely that these women were more likely to be overweight/obese, which is associated with these adverse pregnancy outcomes. In fact, non-Hispanic black and Hispanic women in this population appear to have both an increased risk of pre-eclampsia and medically indicated PTB.

Alternatively, non-Hispanic black and Hispanic women with pre-existing diabetes might be more likely to have co-morbid conditions, such as chronic hypertension, compared with non-Hispanic white women with pre-existing diabetes. The presence of such co-morbid conditions could lead to complications during pregnancy that could result in a medically indicated PTB or even delivery of an SGA infant.[30,31,36–38] In the present study, non-Hispanic blacks and Hispanics had substantially higher pre-existing chronic hypertension (13.3% and 7.5%, respectively) compared with non-Hispanic whites (5.8%). Therefore, the difference in the prevalence of this co-morbid

condition may explain some of the differences seen in pregnancy outcomes between these racial/ethnic groups. Differences in pregnancy outcomes could also be due to variations in genetic heritage based on geographic origin or from the influence of epigenetic effects arising from environmental factors.

South Asian women are at increased risk for delivering an SGA infant, which may be partly attributed to physiological differences based on geographic heritage, as well as a variety of social and environmental factors.[29,39] However, our study is one of the first to document South Asian women with pre-existing diabetes also having this increased risk of SGA compared with non-Hispanic white women. Typically, LGA is also of concern in women with pre-existing diabetes. Yet non-white women with diabetes appeared to be at decreased risk of LGA and increased risk of SGA relative to non-Hispanic white women with diabetes. The increased risk of SGA could be attributed to a higher prevalence of diabetic complications associated with increased vascular disease among non-whites.[30,31] Vascular disease is known to restrict growth and could lead to decreased birthweight.[40,41] The increased risk of LGA in non-Hispanic whites could be attributed to longer duration of *in utero* exposure to elevated glucose levels via the placenta. In fact, non-Hispanic whites were more likely to deliver at term in this study population.

In addition to hypothesising that race/ethnicity would impact pregnancy outcomes among women with pre-existing diabetes, we also posited that educational attainment would be associated with pregnancy outcomes, likely through more poorly managed blood glucose levels during pregnancy. While education was only modestly associated with SGA, we found little overall evidence in our study to support this hypothesis. In fact, PTB and pre-eclampsia were not associated with education among women with pre-existing diabetes in our study. Given that race/ethnicity is highly correlated with educational attainment and that educational attainment is associated with blood glucose control, it is unclear why associations existed for race/ethnicity, but not education. Maternal education is a known determinant of many maternal health outcomes. However, we were unable to explore other social determinants of health, such as income and wealth. In particular, in this very diverse population of women, half of whom are foreign-born, the link between maternal education with income and wealth may differ across subpopulations.

Study limitations and strengths

The present study has several limitations. First, this study used birth certificate data to assess the association among race/ethnicity, educational attainment, and adverse pregnancy outcomes. A limitation of birth certificate data is that we did not have information on glucose measures or dietary information that may have been associated with pregnancy outcomes. In addition, we did not have data on pre-pregnancy height, which precluded the ability to estimate pre-pregnancy body mass index. However, we did have pre-pregnancy weight and adjusted for this in the present analysis. Second, we were unable to determine the level of blood glucose control during pregnancy among women with pre-existing diabetes. Third, we were unable to evaluate potential differences in adverse pregnancy complications between women with type 1 and type 2 diabetes. However, both conditions are known to increase the risk of adverse pregnancy outcomes.[1,35] Fourth, we were unable to account for history of diabetic complications within this population. Given that a disproportionate number of non-white women with diabetes may have diabetes-related complications,[30] future studies will need to determine whether this disparity explains the differences in adverse pregnancy complications seen among women with pre-existing diabetes. Finally, based on the birth certificate data, we did not have information on income or wealth, as such we were unable to explore these factors as predictors of adverse pregnancy outcomes among women with pre-existing diabetes. In addition, these findings may not be generalisable, as this is an urban, largely immigrant study population.

Despite these limitations, this study has a number of strengths. First, this is a large, population-based study of women who gave birth in New York City. We were able to identify women with pre-existing diabetes through medical record data. Unlike hospital-based or survey-based data, our study has no issues of selection bias, as a population-based study. Second, we had a large enough study population to evaluate racial/ethnic differences in pregnancy outcomes in our study population, with over half of the women being non-Hispanic black or Hispanic. In addition, due to the data source, we had sufficient numbers to evaluate East Asian and South Asian women, separately, as these women have differing risk profiles for adverse pregnancy complications.[29,39] Third, we

evaluated two social determinants of health, race/ethnicity and educational attainment, to evaluate their impact on adverse pregnancy outcomes among women with pre-existing diabetes.

Conclusions

While pre-existing diabetes is less common than gestational diabetes, the prevalence of this condition is increasing in women of reproductive age.[1,35] Based on the present study, non-Hispanic black, Hispanic, and South Asian women with diabetes are at increased risk of certain adverse pregnancy outcomes compared with non-Hispanic white women with this condition. Lower educational attainment also appeared to be associated with an increased risk of SGA. If our findings are replicated, providing targeted interventions for specific subgroups of women with pre-existing diabetes, including culturally appropriate preconception counselling and educational materials, could aid in preventing specific pregnancy complications in this high-risk group.

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