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Perceived psychosocial stress and glucose intolerance among pregnant Hispanic women

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Abstract

Aim—Prior literature suggests a positive association between psychosocial stress and the risk of diabetes in non-pregnant populations, but studies during pregnancy are sparse. We evaluated the relationship between stress and glucose intolerance among 1115 Hispanic (predominantly Puerto Rican) prenatal care patients in Proyecto Buena Salud, a prospective cohort study in Western Massachusetts (2006–2011).

Methods—Cohen's Perceived Stress Scale (PSS-14) was administered in early (mean = 12.3 weeks gestation; range 4.1–18 weeks) and mid-(mean = 21.3 weeks gestation; range 18.1–26 weeks) pregnancy. Participants were classified as having a pregnancy complicated by gestational diabetes mellitus, impaired glucose tolerance, and abnormal glucose tolerance, based on the degree of abnormality on glucose tolerance testing between 24 and 28 weeks of gestation.

Results—The prevalence of gestational diabetes mellitus, impaired glucose tolerance, and abnormal glucose tolerance was 4.1%, 7.2%, and 14.5%, respectively. Absolute levels of early or mid-pregnancy stress were not significantly associated with glucose intolerance. However,

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Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Appendix A. Supplementary data

Supplementary data (French abstract) associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.diabet.2014.05.002.

participants with an increase in stress from early to mid-pregnancy had a 2.6-fold increased odds of gestational diabetes mellitus (95% confidence intervals: 1.0–6.9) as compared to those with no change or a decrease in stress after adjusting for age and pre-pregnancy body mass index. In addition, every one-point increase in stress scores was associated with a 5.5 mg/dL increase in screening glucose level (β = 5.5; standard deviation = 2.8; *P* = 0.05), after adjusting for the same variables.

Conclusion—In this population of predominantly Puerto Rican women, stress patterns during pregnancy may influence the risk of glucose intolerance.

Keywords

Epidemiology; Psychosocial stress; Gestational diabetes; Prospective; Hispanic

1. Introduction

Gestational diabetes mellitus (GDM), defined as glucose intolerance with first onset during pregnancy is found in approximately 2%–14% of pregnancies, depending on the population studied and the diagnostic test used [1,2]. Exposure to abnormal glucose levels during pregnancy is associated with pregnancy-related complications, including hypertensive disorders of pregnancy, preterm delivery, risk of stillbirth, and increased rates of caesarean deliveries [3]. GDM-related metabolic complications in the offspring include impaired glucose tolerance, diabetes, obesity, and metabolic syndrome during early youth and adolescence [4–6]. Furthermore, both GDM and milder glucose intolerance in pregnancy identify women who are at high risk for type 2 diabetes [7,8]. Women diagnosed with GDM have a 17%–63% risk of developing type 2 diabetes and obesity, with a rapid progression to diabetes within the first 5 years after delivery [7,9,10].

Currently recognized risk factors for GDM such as increasing maternal age, obesity, ethnic origin, family history of diabetes, and a previous history of GDM are absent in up to half of affected women [3,11,12]. Psychosocial stress may contribute to the risk of glucose intolerance via the hypothalamic-pituitary-adrenal axis [13,14] by raising the blood concentrations of counter regulatory hormones that inhibit insulin secretion and increase blood glucose level. Given the rising prevalence of glucose abnormalities during pregnancy, recognizing modifiable risk factors such as psychosocial stress is crucial for the prevention of glucose intolerance and its complications for both the mother and child.

Psychosocial factors such as work-related stress, general emotional stress and anxiety, life events, and life stress have been associated with increased risk of glucose abnormalities among non-pregnant populations [15–18]; however, studies during pregnancy are sparse. In a study of stress and GDM among pregnant participants in the Pregnancy Risk Assessment Monitoring System (PRAMS), the authors found that experiencing five or more stressful life events during the 12 months before delivery was associated with a 2.5-fold increased odds of GDM [19] as compared with having no stressful events. Stressful events included legal or financial problems, illness or loss of a loved one, relocation, and relationship issues with spouse/partner. However, the study relied on retrospective recall of prenatal stress during the postpartum period. In addition, measures such as life events scales are limited to a pre-

specified list of events and do not take into account perceived stress which may be more relevant to overall stress.

GDM rates among Hispanic women are almost two-fold higher than those reported among non-Hispanic White women [20]. This has notable potential public health implications, as Hispanics are the largest minority group in the United States, with the highest birth and immigration rates of any minority group [21]. Pregnant Hispanic women experience high levels of psychosocial stress [22]. In this population, factors such as increasing maternal age, pre-pregnancy alcohol and cigarette consumption, lower annual household income and English language preference have been associated with high stress during pregnancy, possibly reflecting exposure to greater number of stressors and lower availability of personal resources and social support.

We prospectively evaluated the association between perceived stress in early and mid-pregnancy and the risk of GDM and milder forms of glucose intolerance among pregnant Hispanic women. We also examined the effect of the change in perceived stress during pregnancy on the risk of these outcomes. We hypothesized that high levels of early and midpregnancy stress, as well as increase in stress from early to mid-pregnancy would be positively associated with incidence of glucose intolerance. To our knowledge, this study represents the first to examine this association among pregnant Hispanic women.

2. Methods

2.1. Study design and study population

Proyecto Buena Salud was conducted from 2006 to 2011 in the ambulatory obstetrical practices of Baystate Medical Center, an integrated health system in Western Massachusetts. Details of the study have been previously published [23]. The overall goals were to examine the relationship between physical activity, psychosocial stress, and risk of GDM in Hispanic women of Caribbean Island heritage (e.g., Puerto Rico or Dominican Republic). Bilingual interviewers recruited patients at prenatal care visits prior to 20 weeks gestation, informed them of the aims and procedures of the study and obtained written informed consent. This study was approved by the Institutional Review Boards of the University of Massachusetts-Amherst and Baystate Health.

At the time of enrollment (mean = 12.4 weeks gestation; range 4.1–18 weeks), bilingual interviewers collected information on socio-demographic, acculturation, behavioral, and psychosocial factors. Information on behavioral and psychosocial factors was updated in mid-pregnancy (mean = 21.3 weeks gestation; range 18.1–26 weeks). Interviews were conducted in Spanish or English (based on patient preference) to eliminate potential language or literacy barriers.

2.2. Eligibility

Eligibility was restricted to women of Puerto Rican or Dominican Republic heritage. Exclusion criteria included:

- current medications that adversely influence glucose tolerance;

- multiple gestation;
- history of diagnosis of diabetes, hypertension, heart disease or chronic renal disease;
- and less than 16 years of age or over 40 years of age.

A total of 1626 prenatal care patients were enrolled in Proyecto Buena Salud. For the current analysis, we excluded 68 participants who experienced a miscarriage, 142 participants who did not deliver at Baystate, and 108 participants who did not have a GDM screen. From the remaining 1308 participants information on perceived stress during early or mid-pregnancy was available for 1115 (85%), with early pregnancy stress data available for 833 (75%) participants, and mid-pregnancy stress data available for 760 (68%) participants. Reasons for missing stress information included inability to locate women at the clinic or over the telephone (e.g., due to disconnected telephone) or preterm delivery.

2.3. Perceived psychosocial stress

Early and mid-pregnancy stress was assessed using Cohen's Perceived Stress Scale (PSS-14), a validated and widely used measure of stress. The PSS-14 was designed to address the stress level experienced by an individual as a function of objective stressful events, coping processes, personality factors, and to measure the degree to which respondents find their lives unpredictable, uncontrollable, and overloading [24]. Each item was rated on a 5-point scale ranging from never (0) to almost always (4). Positively worded items were reverse scored, and the ratings were summed. Scores ranged from 0 to 56, with higher scores indicating more perceived stress.

Stress scores during early and mid-pregnancy were divided into quartiles, with the highest category representing high stress levels. For those participants (n = 478) with both early and midpregnancy stress information, we analyzed the effect of change in stress from early to mid-pregnancy (no change, decrease, or increase in stress). We defined no change in stress as within a ±2-point difference in PSS-14 scores between early and midpregnancy. Stress variables were also analyzed as continuous scores.

2.4. Glucose intolerance

Glucose values were abstracted from medical records. Baystate obstetrical practices routinely screen all prenatal care patients for GDM between 24 and 28 weeks of gestation using the 50 g, 1-hour glucose tolerance test (OGTT). Those with 1-hour plasma glucose levels > 135 mg/dL were considered at increased risk for GDM and underwent the diagnostic 3-hour OGTT. Diagnosis of GDM was based on American Diabetes Association criteria in place at the time of onset of the cohort [25]. Specifically, women were classified as having a pregnancy complicated by GDM if two or more of the following plasma glucose concentrations obtained during the 100 g, 3-hour OGTT exceeded the following values: fasting, 95 mg/dL; 1-hour, 180 mg/dL; 2-hour, 155 mg/dL; 3-hour, 140 mg/dL [25]. GDM diagnoses were confirmed by the study obstetrician, who reviewed the medical records of each suspected case. In addition, those who exceeded 135 mg/dL on the screening 50 g, 1-hour OGTT and exceeded ≥ 1 cut-point on the diagnostic 100 g 3-hour OGTT were classified as having impaired glucose tolerance (IGT). Women with plasma glucose levels >

135 mg/dL for the 50 g, 1-hour OGTT were classified as having abnormal glucose tolerance (AGT) [26]. To retain a consistent referent group of 'no glucose abnormality' for all outcomes, this group was limited to women without any level of glucose intolerance (e.g., no AGT, IGT, or GDM). Finally, we evaluated screening glucose value as a continuous outcome variable.

2.5. Covariates

At the time of enrollment, interviewers collected information on age, education, annual household income, marital status, and living situation (i.e., with a partner/spouse). Acculturation was measured via the 10-item Psychological Acculturation Scale (PAS) [27], which measures an individual's sense of psychological attachment to and belonging within Anglo-American and Latino/Hispanic cultures. Item responses are scored on a 5-point Likert scale ranging from 1 (only Hispanic/Latino) to 5 (only Anglo/American). The mean of the responses on each item was calculated to create an overall score for acculturation. Scores < 3 were defined as low acculturation and scores ≥ 3 as high acculturation. In addition, interviewers collected information on language preference for speaking/reading and generation in the Continental United States. Cigarette smoking prior to and during pregnancy was assessed using questions designed by the PRAMS, a surveillance project of the Centers for Disease Control and Prevention [28]. Pre-, early, and mid-pregnancy cigarette smoking was categorized as none, ≤ 10 cigarettes, and over 10 cigarettes per day. Depressive symptoms were assessed at each interview using the 10-item Edinburgh Postnatal Depression Scale (EPDS) available in English [29] and Spanish [30]. Each item asks how the woman felt during the previous week and includes four categorical response options (yes, most of the time, no, not at all). Items are rated on a 4-point scale (0, 1, 2, 3) with a range of 0 to 30. Women with a score ≥ 13 were considered to have at least probable minor depression and those with a score ≥ 15 were considered to have probable major depression [31]. Trait anxiety was assessed in early pregnancy using the Spielberger State-Trait Anxiety Inventory (STAI), which measures relatively stable individual differences in anxiety proneness [32]. State anxiety was assessed in mid-pregnancy via the STAI, which contains 20 statements about how the respondent generally feels.

After delivery, medical records were abstracted for medical and obstetrical history, including pre-pregnancy body mass index (BMI), parity, clinical characteristics of the current pregnancy, and reproductive history. Participants were classified as having prior adverse pregnancy outcomes if they responded yes to a history of any of the following: gestational diabetes, infant anomalies, stillbirth, macrosomia, intrauterine growth restriction, preterm premature rupture of membrane, or preterm delivery.

2.6. Data analysis

We examined the distributions of baseline characteristics and stress according to each of the glucose intolerance outcomes using Chi^2 tests. We also examined correlations between stress scores and the screening glucose levels.

Multivariable logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for the association between perceived stress and each of the glucose

intolerance outcomes. The association between perceived stress and screen glucose level was examined using multiple linear regression. Variables that were statistically significantly associated with the outcome in unadjusted logistic models at $P < 0.20$ were evaluated as potential confounders. All covariates that caused a greater than 10% change in the coefficient estimate for stress were retained in the final models. Due to the relatively small number of cases of IGT and GDM, we only included important confounders (e.g., age and pre-pregnancy BMI [33]) that were significantly associated with IGT and GDM. We did not adjust for gestational weight gain in our primary analyses, as these factors are likely on the causal pathway between stress and glucose intolerance. However, we conducted a secondary analysis adjusting for gestational weight gain to mid-pregnancy. Tests for linear trend were calculated by modeling the ordinal variables as continuous variables.

Because psychosocial factors such as anxiety and depression may reflect aspects of stress and have been correlated ($r = 0.66–0.81$, $P < 0.01$) [34], we included an interaction term for anxiety and depression in our final models. Statistical analyses were conducted using SAS® 9.3 software by SAS Institute Inc. (SAS Campus Drive, Cary, North Carolina).

3. Results

A total of 52 women (4.7%) were diagnosed with GDM, while 80 women (7.2%) and 162 women (14.5%) were classified as IGT and AGT respectively. Mean ± SD screening glucose levels were 105 ± 26.4 mg/dL (range 24–202). Overall, participants were young (71% under 24 years of age), with low levels of education (46% did not complete high school) and income (43% with < $30,000 annual household income) (Table 1). Approximately 24% of participants preferred Spanish for speaking/reading, had low levels of acculturation (75% low acculturation status), and 46% were first generation in the United States. Over 44% of participants were overweight or obese prior to pregnancy. Approximately 42% of participants were nulliparous, and 28% reported a positive family history of diabetes. In bivariate analyses, increasing age, living with a spouse/partner, Spanish language preference, being first generation, increasing levels of pre-pregnancy BMI, and a positive history of adverse pregnancy outcomes were statistically significantly and positively associated with GDM (Table 1).

Mean ± SD perceived stress scores were 26 ± 7 (range 3–48) during early pregnancy and 25 ± 7.4 (range 2–47) during mid-pregnancy, respectively. A total of 142 (29.7%) women experienced no change in stress from early to mid-pregnancy; 211 (44.1%) women experienced a decrease in stress; and 125 (26.2%) women experienced an increase in stress. Mean ± SD change in stress was −1.4 ± 6.7 (range −26 to 19). Perceived stress scores were statistically significantly correlated with anxiety (early pregnancy, $r = 0.6$, $P < 0.0001$; mid-pregnancy $r = 0.7$, $P < 0.0001$) and depression (early pregnancy, $r = 0.7$, $P < 0.0001$; mid-pregnancy, $r = 0.7$, $P < 0.0001$. Perceived stress scores were not correlated with pre-pregnancy BMI and weight gain.

We first evaluated the association between early pregnancy stress and risk of glucose intolerance (Table 2). In adjusted logistic regression analyses, there was no statistically significant association between perceived stress during early pregnancy and risk of GDM

(OR = 1.0; 95% CI: 0.4–2.5 for the top quartile vs. lowest quartile of stress, *P*-trend = 0.81). Women in the top quartile of stress had an increased odd of IGT (OR = 1.4; 95% CI: 0.7–2.8, *P*-trend = 0.67) as compared to those in the lowest quartile, after adjusting for age and pre-pregnancy BMI; however, the association was not statistically significant. Similarly, we found no statistically significant association between early pregnancy stress and the risk of AGT (OR = 1.0; 95% CI:0.6–1.9 for top quartile vs. lowest quartile of stress, *P*-trend = 0.95), after adjusting for age, higher pre-pregnancy BMI, education, living situation, generation, language, parity and history of adverse pregnancy outcomes. In linear regression models, early pregnancy stress was not statistically significantly associated with glucose levels.

We then evaluated the association between mid-pregnancy stress and risk of glucose intolerance (Table 3). In unadjusted logistic regression analyses, mid-pregnancy stress was not statistically significantly associated with risk of GDM (OR = 0.9; 95% CI: 0.3–2.8 for the top quartile vs. lowest quartile of stress, *P*-trend = 0.62), IGT (OR = 0.9; 95% CI: 0.3–2.3 for the top quartile vs. lowest quartile of stress, *P*-trend = 0.64) or AGT (OR = 0.9; 95% CI: 0.5–1.6 for the top quartile vs. lowest quartile of stress, *P*-trend = 0.45). Findings were virtually unchanged after adjusting for diabetes risk factors. However, when analyzed as a continuous outcome, every 1-point higher stress score during mid-pregnancy was associated with a 0.3 mg/dL lower screen glucose level (β = −0.3; SD = 0.1; *P* = 0.02); this association was attenuated and no longer significant after adjusting for age and pre-pregnancy BMI (β = −0.2; SD = 0.1; *P* = 0.06).

We then evaluated the association between change in stress from early to mid-pregnancy and risk of glucose intolerance (Table 4). Participants with an increase in stress from early to mid-pregnancy had a three-fold increase in the odds of GDM as compared to those with no change/decrease in stress (OR = 3.1; 95% CI: 1.2–7.6). After adjusting for age and pre-pregnancy BMI, there was slight attenuation in the association between change in stress and GDM (OR = 2.6; 95% CI: 1.0–6.9), however the association remained statistically significant. In a secondary analysis adjusting for gestational weight gain to mid-pregnancy (mean ± SD 19.4 ± 13.8; range −47 to 67), findings were virtually unchanged (OR = 3.5; 95% CI: 1.2–10.3).

Similarly, participants with increase in stress from early to mid-pregnancy had a 2.3-fold increased odd of IGT as compared to those with no change/decrease in stress (OR = 2.3; 95% CI: 1.1–5.1). When adjusted for age and pre-pregnancy BMI, the association was attenuated (OR = 2.0; 95% CI: 0.9–4.5), and no longer statistically significant. In unadjusted analyses, participants with increase in stress from early to mid-pregnancy had a 1.6-fold increased odds of AGT as compared to those with no change/decrease in stress (OR = 1.6; 95% CI: 0.9–2.8), however when adjusted for age, BMI, and history of adverse pregnancy outcomes, the association was attenuated (OR = 1.3; 95% CI: 0.7–2.3) and no longer statistically significant. In terms of the continuous glucose outcome, an increase in stress was associated with a 6.9 mg/dL increase in glucose level (β = 6.9; SD = 2.9; *P* = 0.02); however adjustment for age and pre-pregnancy BMI slightly attenuated this association (β = 5.5; SD = 2.8; *P* = 0.05).

We found no clinically meaningful associations between early ($r = -0.06$, $P = 0.07$) or mid-pregnancy stress ($r = -0.07$, $P = 0.04$) or change in stress ($r = 0.05$, $P = 0.31$) and glucose levels. We found no significant interaction between stress and anxiety (early pregnancy, $P = 0.22$; mid-pregnancy, $P = 0.69$) or stress and depression (early pregnancy, $P = 0.30$; mid-pregnancy, $P = 0.25$) in our final models for GDM. Similarly, anxiety or depression did not significantly modify the association between stress and the risk of IGT and AGT.

Finally, participants missing information on early and mid-pregnancy stress or glucose intolerance did not differ significantly from those not missing information in terms of age, education, marital status, number of children and adults in the household, pre-pregnancy BMI, smoking and alcohol consumption. However, they were more likely to have had a preterm birth (12.8% vs. 5.1%, $P < 0.0001$), be second or third generation in the United States (50.1% vs. 46.9% and 7.7% vs. 5.4%, respectively, $P = 0.05$), prefer English for speaking/ reading (81.7% vs. 76.2%, $P = 0.02$), be more acculturated (26.0% vs. 19.0%, $P = 0.02$), have more than 2 children (33.1% vs. 26.7%, $P = 0.04$), and not know/refuse to report their annual household income (71.2% vs. 50.1%, $P < 0.0001$).

4. Discussion

In this prospective cohort study among Hispanic prenatal care patients, we found no evidence of an association between absolute levels of perceived stress during early or mid-pregnancy and measures of glucose intolerance during pregnancy. However, we found that an increase in stress from early to mid-pregnancy was associated with a statistically significant 2.6-fold increased odds of GDM, but not IGT and AGT, in models adjusted for age, prepregnancy BMI, and gestational weight gain. Increase in stress levels from early to mid-pregnancy was also positively and statistically significantly associated with higher screening glucose levels.

In one of the few prior studies of the relation between stress and GDM conducted among 2854 pregnant participants from the PRAMS (12.1% Hispanic) [19], Hosler et al. found that experiencing five or more stressful events immediately prior to and during pregnancy was associated with a 2.5-fold increased odds of GDM (95% CI: 1.5–4.2) as compared with having no stressful events. In addition, among the 13-item inventory of stressful events, ‘moved to a new address’ was not associated with increased odds of GDM (OR = 1.1; 95% CI: 0.8–1.5), but having any stressful event other than moving was associated with a 1.4-fold increased odds of GDM (95% CI: 1.0–1.9). In contrast, we found no statistically significant associations between early or mid-pregnancy stress and risk of GDM or other glucose intolerance outcomes. However, unlike our study, Hosler et al. did not evaluate the effect of change in stress during pregnancy as well as associations of stress with milder forms of glucose intolerance.

Our findings for no associations between absolute levels of stress and risk of glucose intolerance are similar to those reported in two review articles [15,17] on the association between psychosocial factors and the risk of type 2 diabetes in non-pregnant populations. Specifically, in a meta-analysis [17] of 6 prospective cohort studies, there was no association between adverse psychosocial factors and the incidence of T2DM (HR = 1.0, 95% CI: 0.9–

1.1). Similarly, a systematic review [15] of 9 studies (four prospective, one case-control, and four cross-sectional) found no evidence of an association between work-related stress in the form of high demands (RR = 1.0, 95% CI: 0.8–1.1), poor decision latitude (RR = 1.0, 95% CI: 0.9–1.2), poor social support (RR = 1.0, 95% CI: 0.9–1.2), job strain (RR = 1.1, 95% CI: 0.8–1.3), or long working hours (RR = 0.8, 95% CI: 0.1–1.7) and the risk of type 2 diabetes.

Differences in findings between our study and Hosler et al. are likely due to the differences in the tools used for stress assessment, study designs, and populations. Hosler et al. [19] assessed stressful life events, an environmental indicator of stress; in contrast, we used the PSS-14, which is a perceptual indicator or a global measure of stress. Indeed, differences in the operationalization of stress have been suggested as a reason for conflicting findings in the literature examining the effects of prenatal stress on birth outcomes [35–37]. These review articles suggest that future approaches incorporate multidimensional representations of stress as latent stress factors that combine the environmental (e.g., life events), perceptual (e.g., perceived stress), and response-based (e.g., anxiety) indicators of stress [35]. It is yet unclear how particular components of stress influence glucose intolerance during pregnancy. In addition, Hosler et al. collected stress information after delivery, thus increasing the likelihood of a recall bias. That is, women who developed clinical complications of pregnancy such as glucose intolerance may be more likely to overestimate their pregnancy stress levels as compared to women with normal pregnancies. In addition, the cross-sectional study design of Hosler et al. precludes the establishment of temporality. In fact, prior studies have found a reverse association, in that a diagnosis of GDM was associated with increased stress [38]. In the current study, we were able to prospectively measure perceived stress during pregnancy, thus minimizing the occurrences of similar biases. Finally, in addition to GDM, we examined the impact on stress on multiple glucose intolerance outcomes including milder forms of glucose intolerance, thus extending prior literature.

Although recent review articles on stress in pregnancy [35] recommend studying specific pregnancy time periods during which stress could influence pregnancy outcomes, research in this area is limited. Evidence suggests that stress responses decrease as the pregnancy progresses, and these stress patterns influence health outcomes during pregnancy [39]. In the current study, stress was measured during early (< 18 weeks gestation) and mid-(18–26 weeks gestation) pregnancy. Therefore, we were able to examine the effect of change in stress in the development of glucose intolerance, and our findings support a role of stress patterns in influencing health outcomes during pregnancy. An important strength of this analysis of within-woman change in perceived stress from early to mid-pregnancy is the removal of the threat of confounding by baseline stress.

However, our study has several limitations. Cohen’s Perceived Stress Scale was not designed to be a diagnostic tool, and there are no established cut-points for high stress. Therefore, we were unable to evaluate the clinical importance of an increase in stress above a 2-point change. Although this is a prospective study, mid-pregnancy stress for 24 (2%) participants was assessed after the participant was informed of the results of their glucose screen. While women were instructed to report their stress over the past trimester, it is possible that the results of the screen could have led to an overestimate of stress during mid-

pregnancy. To address this concern, we repeated analyses excluding these participants, and results were virtually unchanged.

Participants missing data on stress were more likely to be highly acculturated. To the extent that greater acculturation is associated with high stress and glucose intolerance, this could have underestimated our observed association between stress and glucose intolerance. Although we adjusted for a number of important confounders, we lacked information on pre-pregnancy stress and prior history of stress; however these factors have been strongly correlated with pregnancy stress. In addition, the relatively small number of GDM and IGT cases reduced our power to detect statistically significant associations for these outcomes. Finally, the distribution of stress among Puerto Rican and Dominican women may differ from that found among non-Hispanic women or those from other Hispanic subgroups (e.g., Mexican Americans). Therefore, our findings may not be generalizable to non-Hispanic populations or other Hispanic subgroups.

In summary, to our knowledge, this is the first study to examine the association between stress and the risk of glucose intolerance among pregnant Hispanic women. We found no statistically significant associations between absolute levels of perceived stress and risk of glucose intolerance. However, we found that an increase in stress during pregnancy was positively associated with the risk of glucose intolerance suggesting that variation in stress levels during pregnancy may play an important role in increasing the risk of glucose intolerance. This association remained even after adjustment for gestational weight gain, suggesting that stress may act on risk of glucose intolerance via pathways aside from an increase in body weight. Such findings underscore the importance of stress management tools and interventions, which include psychosocial counselling during the early stages of pregnancy for pregnant women at risk of gestational diabetes. Early identification and recognition of modifiable risk factors such as stress in high risk Hispanic populations may provide an opportunity for prevention of glucose intolerance both during pregnancy, as well as reduction in the risk of pregnancy complications in the mother and baby.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline participant characteristics according to gestational diabetes mellitus.

	Total sample		Gestational diabetes mellitus[e]		No glucose abnormality[h]		*P*-value[f]
	n[f]	%	*n*	%	*n*	%	
Total	1115	100.0	52	4.7	953	85.5	
Demographic factors							
Age (years)							
< 20	349	31.3	7	2.0	318	91.1	< 0.0001
20–24	445	39.9	10	2.3	393	88.3	
25–29	192	17.2	15	7.8	154	80.2	
> 30	129	11.6	20	15.5	88	68.2	
Educational status							
Less than high school	512	45.9	15	2.9	447	87.3	0.06
High school graduate	349	31.3	21	6.0	300	86.0	
Some college/graduate	210	18.8	12	5.7	171	81.4	
Annual household income							0.29[g]
≤ $15,000	319	28.6	19	6.0	271	85.0	
> $15,000–$30,000	161	14.4	13	8.1	134	83.2	
> $30,000	76	6.8	2	2.6	66	86.8	
Do not know/refused/missing	559	50.1	18	3.2	482	86.2	
Marital status							
Single/divorced/separated/widowed	925	83.0	37	4.0	802	86.7	0.05
Married	117	10.5	9	7.7	92	78.6	
Live with spouse/partner							
No	520	46.6	15	2.9	462	88.8	0.01
Yes	539	48.3	33	6.1	446	82.7	
Language preference for speaking/reading							
English	850	76.2	31	3.7	741	87.2	0.00
Spanish	265	23.8	21	7.9	212	80.0	
Acculturation status[a]							

	Total sample		Gestational diabetes mellitus[e]		No glucose abnormality[h]		*P*-value[f]
	n[f]	%	*n*	%	*n*	%	
< 3	835	74.9	35	4.2	710	85.0	0.24
≥ 3	202	18.1	13	6.4	178	88.1	
Generation in the continental U.S.[b]							
First generation	516	46.3	32	6.2	423	82.0	0.02[g]
Second generation	507	45.5	15	3.0	446	88.0	
Third generation	58	5.2	1	1.7	54	93.1	
Behavioral factors							
Pre-pregnancy cigarette smoking							
None	737	66.1	36	4.9	623	84.5	0.47[g]
≤ 10 cigarettes per day	257	23.1	9	3.5	226	87.9	
> 10 cigarettes per day	80	7.2	5	6.3	98	85.0	
Psychosocial factors							
At least probable minor depression[c] (EPDS ≥ 13)							
No	589	52.8	30	5.6	504	85.6	0.58
Yes	220	19.7	9	4.6	188	85.5	
Probable major depression[d] (EPDS = 15)							
No	670	60.1	34	5.6	575	85.8	0.51
Yes	139	12.5	5	4.1	117	84.2	
Trait anxiety							
1st quartile (20–32)	208	18.7	12	6.5	173	83.2	0.87
2nd quartile (33–39)	216	19.4	9	4.7	183	84.7	
3rd quartile (40–48)	211	18.9	10	5.2	183	86.7	
4th quartile (49–76)	180	16.1	8	4.9	157	87.2	
Medical history factors							
BMI							< 0.0001[g]
Underweight	69	6.2	0	0.0	66	95.7	
Normal	540	48.4	13	2.4	485	89.8	
Overweight	244	21.9	19	7.8	197	80.7	

	Total sample		Gestational diabetes mellitus[e]		No glucose abnormality[h]		*P*-value[f]
	n[f]	%	*n*	%	*n*	%	
Obese	248	22.2	20	8.1	195	78.6	
Parity							
0	470	42.2	14	3.0	416	88.5	0.05
1	340	30.5	22	6.5	287	84.4	
≥ 2	295	26.5	16	5.4	243	82.4	
Family history of diabetes							
No	684	61.4	27	4.0	589	86.1	0.12
Yes	310	27.8	21	6.8	258	83.2	
History of adverse pregnancy outcomes[i]							
No	918	82.3	36	3.9	800	87.1	< 0.0001
Yes	133	11.9	15	95	71.4		

Provecto Buena Salud, Western Massachusetts, 2006–2011.

[a] Acculturation is measured by the Psychological Acculturation Scale and ranges from 1–5; score < 3 = low acculturation and > 3 = high acculturation.

[b] First generation: born in Puerto Rico/Dominican Republic (PR/DR) or parent born in PR/DR; second generation: born in U.S. but parents born in PR/DR; third generation: born in U.S., parents born in U.S., grandparents born in PR/DR.

[c] Women who scored > 13 on the Edinburgh Postnatal Depression Scale (EPDS).

[d] Women who scored > 15 on the Edinburgh Postnatal Depression Scale (EPDS).

[e] Women with glucose levels > 135mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least two cut-points on the 100-g 3-hour oral glucose tolerance test were classified as gestational diabetes mellitus.

[f] *P*-values from Chi2 tests for categorical variables.

[g] *P*-values from Fishers test if expected cell counts < 5. Numbers may not total to 1115 due to missing data.

[h] 'No glucose abnormality' includes women without any glucose intolerance (e.g., no abnormal glucose tolerance, impaired glucose tolerance, and gestational diabetes mellitus).

[i] Adverse pregnancy outcomes include prior history of any of the following: gestational diabetes, infant anomalies, stillbirth, macrosomia, intrauterine growth restriction, preterm premature rupture of membrane, or preterm delivery.

Table 2

Multivariable odds ratios for glucose intolerance according to early pregnancy stress.

	Total	Cases		Unadjusted			Age and BMI-Adjusted			Fully Adjusted		
	n	*n*	%	OR	95% CI		OR	95% CI		OR	95% CI	
Gestational diabetes mellitus[a]												
Perceived stress												
1st quartile (3–21)	193	14	7.3	1.0	Referent		1.0	Referent				
2nd quartile (22–26)	217	10	4.6	0.6	0.3	1.4	0.8	0.3	1.9			
3rd quartile (27–30)	154	4	2.6	0.3	0.1	1.1	0.4	0.1	1.4			
4th quartile (31–48)	188	11	5.9	0.8	0.4	1.8	1.0	0.4	2.5			
P-trend				0.43			0.81					
Continuous stress score				1.0	0.9	1.0	1.0	0.9	1.0			
Impaired glucose tolerance[b]												
Perceived stress												
1st quartile (3–21)	197	18	9.1	1.0	Referent		1.0	Referent				
2nd quartile (22–26)	224	17	7.6	0.8	0.4	1.6	1.0	0.5	2.1			
3rd quartile (27–30)	156	6	3.9	0.4	0.2	1.0	0.5	0.2	1.3			
4th quartile (31–48)	196	19	9.7	1.1	0.5	2.1	1.4	0.7	2.8			
P-trend				0.89			0.67					
Continuous stress score				1.0	1.0	1.0	1.0	1.0	1.0			
Abnormal glucose tolerance[c]												
Perceived stress												
1st quartile (3–21)	214	35	16.4	1.0	Referent		1.0	Referent		1.0	Referent[e]	
2nd quartile (22–26)	239	32	13.4	0.8	0.5	1.3	0.9	0.5	1.6	0.9	0.5	1.5
3rd quartile (27–30)	173	23	13.3	0.8	0.4	1.4	0.9	0.5	1.6	0.8	0.4	1.5
4th quartile (31–48)	207	30	14.5	0.9	0.5	1.5	1.1	0.6	1.9	1.0	0.6	1.9
P-trend				0.61			0.90			0.95		
Continuous stress score				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Screening glucose level												
				Beta[d]	SE	*P*-value	Beta[d]	SE	*P*-value			

	Total	Cases		Unadjusted			Age and BMI-Adjusted			Fully Adjusted	
	n	*n*	%	OR	95% CI		OR	95% CI		OR	95% CI
Perceived stress											
1st quartile (3–21)					Referent			Referent			
2nd quartile (22–26)				− 4.9	2.5	0.05	− 3.7	2.4	0.13		
3rd quartile (27–30)				− 5.8	2.7	0.03	− 4.7	2.7	0.08		
4th quartile (31–48)				− 3.3	2.6	0.20	− 1.9	2.5	0.46		
Continuous stress score				− 0.2	0.1	0.09	− 0.1	0.1	0.33		

Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Odds ratios (OR) and 95% confidence intervals (CI) calculated from multivariable logistic regression models. Perceived stress is measured by Cohen's Perceived Stress Scale (PSS-14) and ranges from 0–56. SE: standard error.

[a]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least two cut-points on the 100-g 3-hour oral glucose tolerance test were classified as gestational diabetes mellitus.

[b]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least one cut-point on the 100-g 3-hour oral glucose tolerance test were classified as impaired glucose tolerance.

[c]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test were classified as abnormal glucose tolerance.

[d]Beta coefficients from multiple linear regression models. Mean ± SD screening glucose levels were 105 ± 26.4 mg/dL (range 24–202).

[e]Additionally adjusted for education, living situation, generation in the U.S., language, parity and history of adverse pregnancy outcomes.

Table 3

Multivariable odds ratios for glucose intolerance according to mid-pregnancy stress.

	Total	Cases		Unadjusted			Age and BMI-adjusted			Fully adjusted		
		n	%	OR	95% CI		OR	95% CI		OR	95% CI	
Gestational diabetes mellitus[a]												
Perceived stress												
1st quartile (2–20)	190	7	3.7	1.0	Referent		1.0	Referent				
2nd quartile (21–25)	163	13	8.0	2.3	0.9	5.8	3.0	1.1	8.4			
3rd quartile (26–30)	172	8	4.7	1.3	0.5	3.6	1.6	0.5	5.0			
4th quartile (31–47)	157	5	3.2	0.9	0.3	2.8	0.8	0.2	3.0			
P-trend				0.62			0.68					
Continuous stress score				1.0	0.9	1.0	1.0	0.9	1.0			
Impaired glucose tolerance[b]												
Perceived stress												
1st quartile (2–20)	194	11	5.7	1.0	Referent		1.0	Referent				
2nd quartile (21–25)	167	17	10.2	1.9	0.9	4.2	2.4	1.0	5.5			
3rd quartile (26–30)	176	12	6.8	1.2	0.5	2.8	1.5	0.6	3.7			
4th quartile (31–47)	160	8	5.0	0.9	0.3	2.3	0.9	0.3	2.4			
P-trend				0.64			0.70					
Continuous stress score				1.0	0.9	1.0	1.0	0.9	1.0			
Abnormal glucose tolerance[c]												
Perceived stress												
1st quartile (2–20)	214	31	14.5	1.0	Referent		1.0	Referent		1.0	Referent[e]	
2nd quartile (21–25)	183	33	18.0	1.3	0.8	2.2	1.5	0.9	2.6	1.5	0.8	2.6
3rd quartile (26–30)	188	24	12.8	0.9	0.5	1.5	1.0	0.5	1.8	0.9	0.5	1.6
4th quartile (31–47)	175	23	13.1	0.9	0.5	1.6	0.9	0.5	1.7	0.9	0.5	1.7
P-trend				0.45			0.57			0.53		
Continuous stress score				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Screening glucose level												
				Beta[d]	SE	*P*-value	Beta[d]	SE	*P*-value			

	Total	Cases		Unadjusted			Age and BMI-adjusted			Fully adjusted	
		n	%	OR	95% CI		OR	95% CI		OR	95% CI
Perceived stress											
1st quartile (2–20)					Referent			Referent			
2nd quartile (21–25)				− 0.2	2.7	0.93	0.8	2.6	0.76		
3rd quartile (26–30)				− 4.0	2.7	0.14	− 2.7	2.6	0.30		
4th quartile (31–47)				− 4.6	2.7	0.09	− 3.7	2.7	0.16		
Continuous stress score				− 0.3	0.1	0.02	− 0.2	0.1	0.06		

Provecto Buena Salud, Western Massachusetts, 2006–2011.

Odds ratios (OR) and 95% confidence intervals (CI) calculated from multivariable logistic regression models. Perceived stress is measured by Cohen's Perceived Stress Scale (PSS-14) and ranges from 0–56. SE: standard error.

[a]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least two cut-points on the 100-g 3-hour oral glucose tolerance test were classified as gestational diabetes.

[b]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least one cut-point on the 100-g 3-hour oral glucose tolerance test were classified as impaired glucose tolerance.

[c]Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test were classified as abnormal glucose tolerance.

[d]Beta coefficients from multiple linear regression models. Mean ± SD screening glucose levels were 105 ± 26.4 mg/dL (range 24–202).

[e]Additionally adjusted for education, generation in the U.S., language and history of adverse pregnancy outcomes.

Table 4

Multivariable odds ratios for glucose intolerance according to change in stress from early to mid-pregnancy.

	Total	Cases		Unadjusted			Age and BMI-adjusted			Fully adjusted		
		n	%	OR	95% CI		OR	95% CI		OR	95% CI	
Gestational diabetes mellitus[b]												
Change in perceived stress[a]												
No change/decrease	318	10	3.1	1.0	Referent		1.0	Referent				
Increase	111	10	9.0	3.1	1.2	7.6	2.6	1.0	6.9			
Continuous change score				1.0	1.0	1.1	1.0	0.9	1.1			
Impaired glucose tolerance[c]												
Change in perceived stress[a]												
No change/decrease	324	16	4.9	1.0	Referent		1.0	Referent				
Increase	113	12	10.6	2.3	1.1	5.1	2.0	0.9	4.5			
Continuous change score				1.0	0.9	1.1	1.0	0.9	1.0			
Abnormal glucose tolerance[d]												
Change in erceived stress[a]												
No change/decrease	353	45	12.8	1.0	Referent		1.0	Referent		1.0	Referent[f]	
Increase	125	24	19.2	1.6	0.9	2.8	1.4	0.8	2.5	1.3	0.7	2.3
Continuous change score				1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Screening glucose level												
				Beta[e]	SE	*P*-value	Beta[e]	SE	*P*-value			
Change in perceived stress[a]												
No change/decrease					Referent			Referent				
Increase				6.9	2.9	0.02	5.5	2.8	0.05			
Continuous change score				0.1	0.2	0.44	0.1	0.2	0.69			

Proyecto Buena Salud, Western Massachusetts, 2006–2011.

Odds ratios (OR) and 95% confidence intervals (CI) calculated from multivariable logistic regression models. Perceived stress is measured by Cohen's Perceived Stress Scale (PSS-14) and ranges from 0–56. SE: standard error.

[a] Early to mid-pregnancy change in stress defined as no meaningful change = within ± 2-point change, decrease = below −2-point change, and increase = above 2-point change in PSS-14 scores.

[b] Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance test, and exceeded at least two cut-points on the 100-g 3-hour oral glucose tolerance were classified as gestational diabetes.

[c] Women with glucose levels > 135 mg/dL from a 50-g, 1-hour oral glucose tolerance, and exceeded at least one cut-point on the 100-g 3-hour oral glucose tolerance were classified as impaired glucose tolerance.

[d] Women with glucose levels > 135 mg/dL from a 50-g, 1-hour glucose tolerance test were classified as abnormal glucose tolerance.

[e] Beta coefficients from multiple linear regression models.

[f] Additionally adjusted for history of adverse pregnancy outcomes.