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Cigarette Smoking and Gestational Diabetes Mellitus in Hispanic Woman

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Abstract

Aims—Hispanic women are at increased risk of gestational diabetes mellitus (GDM) as compared to non-Hispanic white women. While smoking has been associated with increased risk of type 2 diabetes, studies of smoking and GDM are sparse and conflicting. Therefore, we evaluated the relationship between cigarette smoking and GDM in Hispanic women.

Methods—We conducted a pooled analysis of two Hispanic datasets based in Massachusetts: the UMass Medical Health Care dataset and the Proyecto Buena Salud dataset. A total of 3,029 Hispanic prenatal care patients with singleton gestations were included. Cigarette smoking prior to and during pregnancy was collected via self-report. Diagnosis of GDM was abstracted from medical records and confirmed by study obstetricians.

Results—One-fifth of participants (20.4%) reported smoking prior to pregnancy, and 11.0% reported smoking in pregnancy. A total of 143 women (4.7%) were diagnosed with GDM. We did not observe an association between pre-pregnancy cigarette smoking and odds of GDM (multivariable OR=0.77, 95% CI 0.47–1.25). In contrast, smoking during pregnancy was associated with a 54% reduction in odds of GDM (OR=0.46, 95% CI 0.22, 0.95). However, this association was no longer statistically significant after adjustment for age, parity, and study site (OR=0.47, 95% CI 0.23, 1.00).

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Conflict of Interest Statement
None

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Conclusions—In this population of Hispanic pregnant women, we did not observe statistically significant associations between pre-pregnancy smoking and odds of GDM. A reduction in odds of GDM among those who smoked during pregnancy was no longer apparent after adjustment for important diabetes risk factors.

Keywords

cigarettes; smoking; gestational diabetes; pregnancy; Latina

INTRODUCTION

Gestational diabetes mellitus (GDM) is defined as glucose intolerance with onset or first recognition in pregnancy. GDM is one of the most common complications of pregnancy, affecting 3–5% of pregnancies [1]. GDM has been associated with significant immediate and long-term health risks for both mother and offspring; long-term associations include maternal type 2 diabetes mellitus risk and cardiovascular sequelae, and offspring risk of obesity, metabolic syndrome and diabetes across the life span [2–5]. GDM occurs more frequently in Hispanics as compared to non-Hispanic whites with rates 1.5 to 2 times higher depending upon the Hispanic subgroup studied [6, 7].

With evidence of increasing GDM prevalence in the U.S. [1], efforts are needed to identify modifiable factors that could be targeted for GDM prevention. Cigarette smoking has been associated with an increased risk of type 2 diabetes mellitus [8–10] but studies examining smoking and risk of GDM are relatively sparse, conflicting, face methodologic limitations, and have been conducted predominantly in non-Hispanic white women [11].

As Hispanics are the largest minority group in the U.S., with the highest birth and immigration rates of any minority group [12], the objective of this study was to evaluate the relationship of smoking as a modifiable behavior, with GDM risk, among Hispanic prenatal care patients.

MATERIALS and METHODS

Study design and population

We conducted a pooled analysis of data from two datasets in Massachusetts: (1) the University of Massachusetts Memorial Health Care (UMMHC) dataset in Central Massachusetts based upon data abstracted from a clinical care database at UMMHC and (2) Proyecto Buena Salud (PBS) a prospective cohort study based at Baystate Medical Center (BMC) in Western Massachusetts. The Institutional Review Boards of the University of Massachusetts Medical School, Baystate Medical Center, and the University of Massachusetts Amherst provided approval for this study.

For the UMMHC dataset, the UMMHC Department of Obstetrics and Gynecology's automated Labor & Delivery electronic medical records export database was used to assemble a study population. This database began collecting detailed information on the timing of cigarette smoking (e.g., pre-pregnancy and pregnancy smoking) in January 2007. Therefore, eligibility was restricted to 2,071 Hispanic women delivering singleton gestations from January 1, 2007 to March 31, 2011 without pregestational diabetes mellitus. For the purposes of the current analysis we excluded 227 women missing data on cigarette use both prior to and during pregnancy. For women with more than one pregnancy during this time period, the first pregnancy in the database was selected. This resulted in a final sample size of 1,844 women in the UMMHC dataset.

Details of PBS have been previously published [13]. The overall goal of PBS was to investigate the relationships among physical activity, psychosocial stress and risk of GDM in Hispanic women. Eligibility was restricted to women of Puerto Rican and Dominican heritage (Caribbean Islanders) enrolled between January 2006 and 2011. Exclusion criteria included: (1) current medications thought to adversely influence glucose tolerance (e.g., prednisone), (2) multiple gestation, (3) pregestational diabetes, hypertension, heart disease or chronic renal disease, and (4) < 16 years and > 40 years of age. From this sample of 1,300 eligible participants, we exclude 115 women missing data on cigarette use both prior to and during pregnancy resulting in a final sample size of 1,185 in the PBS dataset.

Assessment of Cigarette Smoking Status

Cigarette smoking was the primary exposure of interest in these analyses. UMMHC patients were asked questions regarding cigarette use by the admitting nurse at the time of admission to the labor floor for delivery. Specifically, women were asked the frequency of cigarette use prior to pregnancy as well as during overall pregnancy. Patients answered by providing the number of cigarettes smoked per day.

PBS participants were asked questions regarding cigarette use by interviewers at the time of enrollment (mean 13.0 weeks gestation), in mid pregnancy (19–26 weeks gestation), and in late pregnancy (>26 weeks gestation) using questions designed by the Pregnancy Risk Assessment Monitoring System (PRAMS) [14]. Specifically, women were asked the frequency of cigarette use in the year prior to pregnancy, and the number of cigarettes smoked during the previous month at each pregnancy time period.

To enable pooling the datasets, we created a summary PBS pregnancy smoking variable to make it comparable to the UMMHC pregnancy smoking variable using the following procedure. If participants stated that they currently smoked at any of the 3 pregnancy interviews (early, mid, or late), they were coded as a smoker during pregnancy. Remaining participants that denied smoking at all of the 3 interviews were coded as a non-smoker during pregnancy. Among pregnancy smokers, smoking frequency was averaged across interviews.

In the pooled dataset, the pregnancy smoking variable was defined as: non-smoker (referent category), smoker (1–10, >10 cigarettes/day), former smoker, and missing. Non-smokers were defined as participants who did not smoke prior to and during pregnancy. Former smokers were defined as those who smoked prior to pregnancy but not during pregnancy. Subjects were classified as missing the pregnancy smoking variable if: (1) not a pregnancy smoker and missing data on pre-pregnancy smoking or (2) missing data on pregnancy smoking regardless of available information on pre-pregnancy smoking.

Assessment of Gestational Diabetes Mellitus

The study sites for both UMMHC and PBS practice universal screening for GDM at 24–28 weeks gestation. The screening test consists of a non-fasting oral glucose challenge test in which venous blood is sampled 1 hour after a 50-g oral glucose load. If the plasma glucose concentration is >135 mg/dl, a 3 hour 100-g glucose tolerance test is performed. Diagnosis of GDM was defined according to American Diabetes Association criteria as 2 or more elevated values at fasting (≥95 mg/dL) and 1 hour (≥180 mg/dL), 2 hour (≥155 mg/dL), or 3 hours (≥ 140 mg/dL) post-glucose load [15].

Covariates

For both the UMMHC dataset and the PBS dataset, pre-pregnancy body mass index (BMI), parity, and clinical characteristics of the current pregnancy were abstracted from medical records. Pre-pregnancy BMI was considered as a continuous variable and was also categorized according to 2009 Institute of Medicine (IOM) categories to be consistent with World Health Organization categories as follows: underweight (BMI < 18.5 kg/m^2), normal weight (18.5 kg/m^2 ≥ BMI < 25 kg/m^2), overweight (25 kg/m^2 ≥ BMI < 30 kg/m^2) and obese (BMI ≥ 30 kg/m^2) [16]. If pre-pregnancy weight was missing from the medical record, it was based upon self-reported pre-pregnancy weight collected at the time of enrollment (PBS) or delivery (UMMHC); based on data from Phelan et al., self-reported pre-pregnancy weight has a high correlation with measured weight (r=0.95) [17][18]. Total gestational weight gain (GWG) was defined as the difference between maternal weight at delivery and maternal pre-pregnancy weight. GWG was considered as a continuous variable and also categorized as inadequate, appropriate, or excessive based on the IOM's 2009 pre-pregnancy BMI-specific gestational weight gain guidelines: specifically: 28–40 pounds for women who were underweight before pregnancy, 25–35 pounds for women of normal weight, 15–25 pounds for overweight women, and 11–20 pounds for obese women [16]. Age was considered continuously and also categorized as 13–19 years, 20–24 years, 25–29 years, ≥ 30 years, and missing. Parity was categorized as 0, 1, ≥ 2 and missing. Additionally, study site was considered in multivariable analyses.

Statistical analyses

Analyses were performed using SAS (version 9.2, SAS Institute Inc., Cary, NC) statistical analysis software. Summary statistics for demographic and clinical characteristics are presented as either mean ± standard deviation for continuous variables or as frequency measures for categorical variables. Categorical variables were compared using chi-squared or Fischer's exact test where appropriate. Continuous variables were compared using student's t-test and analysis of variance (ANOVA) F-test where appropriate.

Logistic regression was used to generate odds ratios (ORs), 95% confidence intervals (CIs), and P values for the association between smoking status in pre pregnancy and pregnancy, respectively, and odds of GDM. Multivariable logistic regression models included factors associated with GDM in the prior literature. Because pre-pregnancy BMI and gestational weight gain may be mediators of the association between smoking and risk of GDM (i.e., on the causal pathway) [16], these variables were not included in multivariable models. However we evaluated the extent of this mediation using PROC GENMOD in SAS.

Confounding by additional covariates was assessed by evaluating changes in the odds ratios for smoking when each covariate was included in the regression model. A change of 10% or greater was used as an indicator of confounding and, based on this criteria age (continuous), parity, and study site were included in multivariable models. Tests of trend were calculated by modeling the pre-pregnancy smoking variable (non-smoker, smoker 1–10 cigarettes/day, >10 cigarettes/day) as an ordinal variable (i.e., 1, 2, 3); and modeling the pregnancy smoking variable (non-smoker, former smoker, smoker 1–10 cigarettes/day, >10 cigarettes/day) as an ordinal variable (i.e., 1, 2, 3, 4). Interactions by study site were evaluated by inspection of stratum specific odds ratios and by including multiplicative interaction terms in the multivariable models and assessing their statistical significance at $p<0.05$ using likelihood ratio chi-square tests.

RESULTS

The final pooled sample size was 3,029 with 61% (n=1,844) of participants from the UMMHC dataset and 39% (n=1,185) from the PBS dataset. Overall, women were young (mean 24.1 years of age) and almost half were overweight/obese (48.5%) with a mean pre-pregnancy BMI of 26.2 kg/m^2. At the time of admission for delivery, 58.3% of subjects were parous. The mean gestational weight gain was 31.4 pounds with the majority of women exceeding IOM gestational weight gain guidelines (55.8%). The UMMHC dataset did not differ from the PBS dataset in terms of mean BMI, parity, adherence to gestational weight gain recommendations, and weight at delivery. However, the UMMHC dataset was, on average, older with lower gestational weight gain, and a slightly greater likelihood of being classified as overweight/obese (Table 1).

As compared to non-smokers and current pregnancy smokers, former smokers (smoked prior to pregnancy) were younger, had higher pre-pregnancy BMI, gained more weight during pregnancy, and were more likely to exceed gestational weight gain recommendations (Table 2). Approximately one-fifth of subjects (20.4%) reported smoking cigarettes prior to pregnancy, while 11.0% of subjects reported smoking in pregnancy (Table 3). Women who smoked in pregnancy (n=334) were predominantly light smokers with 92.2% smoking 1–10 cigarettes per day and 7.8% smoking more than 10 cigarettes per day. Rates of pre-pregnancy smoking were higher in the PBS dataset (31.7%) as compared to the UMMHC dataset (13.2%, $P<0.001$) although the majority of smokers in PBS were light smokers (1–10 cigarettes per day) (Table 3). Similarly, rates of pregnancy smoking were higher in the PBS dataset (15.3%) as compared to the UMMHC dataset (8.3%, $P<0.001$), however only 7 women in the PBS dataset reported smoking more than 10 cigarettes/day in pregnancy (Table 3).

A total of 4.7% (n=143) of subjects were diagnosed with GDM and these rates did not differ significantly by dataset (4.8% UMMHC versus 4.6% PBS). In unadjusted and age-adjusted (OR 0.81, 95% CI 0.51, 1.30) analyses, we did not observe an association between smoking prior to pregnancy and risk of GDM regardless of dose of smoking ($P_{trend}=0.36$) (Table 4). Findings were virtually unchanged after additional adjustment for parity and study site (OR 0.77, 95% CI 0.47, 1.25).

In terms of smoking during pregnancy, in unadjusted analyses smokers had a significantly decreased risk of GDM (OR 0.46, 95% CI 0.22, 0.95) compared to non-smokers (Table 4). Findings were similar for smokers of 1–10 cigarettes/day (OR 0.44, 95% CI 0.20, 0.95), however due to small numbers of heavy smokers (>10 cigarettes/day) and only 1 GDM case in this group, confidence intervals for heavy smokers were wide and not statistically significant. After adjustment for age, parity, and study site, findings for smokers were slightly attenuated and no longer statistically significant (OR 0.47, 95% CI 0.23, 1.00, P_{trend}=0.09). Finally, we observed no association between former smoking and GDM risk in unadjusted or multivariable models (OR 1.03, 95% CI 0.57, 1.87).

We then evaluated whether gestational weight gain and BMI may be on the causal pathway between smoking and risk of GDM. Both current (β = 11.6, SE=2.3, p<0.0001) and former smoking (β = 5.1, SE=2.2, p=0.02) were statistically significant predictors of maternal weight at delivery adjusting for age. Similarly, current smoking (β = 2.5, SE=1.0, p=0.01) was a significant predictor of gestational weight gain.

We then evaluated data from each site individually (Table 4). Similar trends of a non-significant protective effect for pregnancy smoking were observed in both datasets although confidence intervals were wider due to the smaller sample sizes and case numbers. Lastly, we did not observe effect modification of the relationship between smoking and GDM by study site.

DISCUSSION

In this dataset of Hispanic women, we did not observe an association between cigarette smoking prior to or during pregnancy and risk of GDM after adjustment for important GDM risk factors. However, in unadjusted analyses, smoking during pregnancy (<10 cigarettes/day) was associated with a reduction in GDM risk. This finding was attenuated and no longer statistically significant after adjustment for age, parity, and study site but the odds ratio remained protective.

Prior studies of the association between smoking and GDM have been relatively sparse and conflicting. A meta-analysis performed by Wendland et al. [11] included studies published prior to 2007 (32 studies reviewed, 12 studies included) and found that the unadjusted odds ratio for GDM for smokers compared to non-smokers was 1.03 (95% CI 0.85–1.25; 9 studies). When limited to studies that presented adjusted analyses (4 studies), the odds ratio was 0.95 (95% CI 0.85–1.07, 4 studies). Since the publication of this review article, three studies have found no association [19–21] between smoking and GDM risk while 2 retrospective studies and one prospective study reported a protective effect of smoking on GDM risk [22, 23].

In the Nationwide Inpatient Sample (NIS) relying upon discharge codes, Roelands et al. observed an odds ratio of 0.9 (95% CI 0.9–1.0) for the association between pregnancy smoking and GDM risk [24]. In a prospective cohort of 4,766 Brazilian women, Wendland et al. observed an unadjusted odds ratio for GDM of 0.80 (95% CI 0.61–1.04) and an adjusted odds ratio of 0.69 (95% CI 0.50–0.96) for smokers vs. nonsmokers [22]. When the analysis was stratified by parity, there was a stronger protective effect among nulliparous women (OR 0.31, 95% CI 0.13–0.75). Based on postpartum interviews of smoking status, Dode and Santos noted a protective effect of first (OR 0.40, 95% CI 0.20–0.79) and second trimester (OR 0.43, 95% CI 0.21–0.87) smoking on GDM risk [23]. Similarly, we observed that women who smoked during pregnancy had an unadjusted OR of 0.46 (95% CI 0.22, 0.95); however this effect was attenuated in multivariable analyses and no longer statistically significant.

Differences in study findings are likely due to differences in study populations and corresponding smoking rates as well as differences in diagnostic criteria for GDM. For example, GDM rates were higher in the Wendland cohort (7.5%) largely due to the fact that the majority of women were diagnosed based on the findings of 2 hour 75g oral glucose tolerance test [22] as compared to our findings of 4.7% based on a 100g 3 hour diagnostic oral glucose tolerance test (4.7%). Additionally, in the Wendland cohort, smoking during pregnancy was common with a rate of 26% as compared to 11% in our pooled dataset, although our rate of pre-pregnancy smoking was similar at 20.4%. However, given our sample size, we had the power to detect a clinically significant reduction in risk of 0.46 or larger for pre-pregnancy smoking and 0.30 or larger for pregnancy smoking. These odds ratios are well within the range of the odds ratio of 0.31 observed by Wendland et al. among nulliparous women.

Given evidence of racial/ethnic differences in nicotine metabolism which may result in higher and lower nicotine exposure per cigarette in women [25, 26], it is important to consider the few studies that focused on this topic specifically in Hispanic populations. A study by Berkowitz et al. included a diverse racial/ethnic population and found no significant difference in frequency of GDM in women who did and did not smoke [27]. However, findings were not stratified by Hispanic ethnicity. In an earlier prospective cohort study at Baystate Medical Center, the Latina GDM Study, Haskins et al. found the suggestion of a protective effect for smoking in early (OR=0.48, 95% CI 0.21–1.10) and mid (OR=0.38, 95% CI 0.13–1.11) pregnancy and risk of abnormal glucose tolerance (defined as exceeding 135 mg/dl on the routine 1-hour oral glucose tolerance screening test) which was not statistically significant [28]. To our knowledge this is the first study to evaluate the association between smoking and frank GDM in Hispanic women.

Strengths of our study include our large sample of Hispanic women, a previously understudied at-risk population, as well as the ability to evaluate mediation of this association by gestational weight gain. However, we did not have information on acculturation. While acculturation has been associated with smoking in nonpregnant women [29, 30], prior studies among the Baystate Medical Center Hispanic prenatal care population found no association between smoking and birthplace and language preference in this predominantly Puerto Rican Hispanic prenatal care population [28, 31].

An additional limitation of our study is that information on smoking was based on self-report. Although reporting bias is a concern given the general social unacceptability of smoking in pregnancy, several recent studies indicate high validity for self-reported tobacco use as compared with plasma cotinine levels [32, 33]; although this has not been investigated specifically in a Hispanic population. Our overall observation of a 11% self-report pregnancy-smoking prevalence rate is comparable to nation-wide rates from PRAMS (12.2%) and birth-certificate (10.2%) self-report data [34] and thus lends credibility to our data.

Prevalence rates of smoking during pregnancy differed between the UMMHC dataset (8.4%) versus the PBS dataset (15.5%). These differences in rates were statistically significant. Such differences may be due, in part, to the collection of data for clinical as opposed to research purposes, as well as to differences in the frequency and timing of data collection in the two datasets. While participants in PBS were asked about smoking prospectively during pregnancy, the UMMHC participants were asked to recall smoking at the time of admission to the labor floor for delivery. In addition, the time period of data collection differed slightly between the two datasets as the UMMHC dataset only began collecting information on the timing of smoking in 2007, but PBS began in 2006. However, it is unlikely that secular trends in pregnancy smoking rates would differ substantively over the course of one year.

Given that information on smoking was collected from both datasets prior to delivery and birth outcomes, concerns regarding recall bias due to adverse pregnancy outcomes are diminished. However, it is possible that in the UMMHC dataset, that knowledge of the GDM screen results may have influenced recall. However, given the fact that the hypothesized association between smoking and GDM is not widely known, the possibility of recall bias for the UMMHC dataset is unlikely. In addition, our observed rates of smoking during pregnancy are representative of the counties in which these datasets are based with observed smoking rates of 7.8% in Worcester County (site of UMMHC dataset) and 12.1% in Hampden (site of PBS dataset) [36]. While there are no published findings on the validity and reliability of the UMMHC dataset per se, prior studies have relied upon the UMMHC dataset to detect significant associations between such variables as gestational weight gain, self-reported pre-pregnancy weight, and fetal growth [35].

Unlike many prior papers which included smoking as a dichotomous variable, we were able to account for timing (pre-pregnancy versus during pregnancy) and dose (1–10 versus 10+ cigarettes/day) of smoking. However, our ability to evaluate the impact of a high dose of smoking was limited by small numbers especially in the 10+ cigarettes/day category where an effect has the potential to be most robust. Finally, we were not able to evaluate the impact of smoking at different gestational time points which would be useful given the evidence for differential effects of smoking exposure over the course of pregnancy [11].

We found the suggestion of a protective effect for smoking during pregnancy on GDM risk. The concept of smoking as protective for adverse maternal outcomes is not unprecedented. Recent evidence suggest an association between smoking and a reduced risk of metabolic disorders, diabetes, autoimmune diabetes in women and men [37–39] with evidence of up to a 50% dose-dependent reduction in preeclampsia risk with increasing smoking dose for multigravidas and primigravidas, singleton and multifetal pregnancies and mild and severe disease [40]. The protective mechanism of action is not clear for preeclampsia but likely works through alterations in pro- and anti- angiogenic factors, immune-mediated events and/or endothelial function. As GDM and preeclampsia have common risk factor profiles [22], a common etiology is possible.

In summary, we found no statistically significant association between smoking prior to or during pregnancy and risk of GDM in a Hispanic population; however, there was a trend towards a protective effect for smoking in pregnancy (<10 cigarettes/day). Findings extend prior research to Hispanic women. Future studies would be strengthened by consideration of the timing of exposure to cigarette smoke as relates to gestational age and quantifiable biologic exposure assessments as opposed to self-report. Understanding whether smoking has a detrimental or protective effect on GDM risk has the potential to reveal underlying pathophysiologic mechanisms and thus potentially inform treatment and prevention.

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Table 1

Demographic and Clinical Characteristics according to Study Site; Pooled Hispanic Datasets, Massachusetts 2006–2011.

	Total Pooled Sample[a] (N=3029)		UMMHC Dataset (n=1,844)		PBS Dataset (n=1,185)		
	mean	SD	mean	SD	mean	SD	p-value[b]
Age (years)	24.1	5.7	25.1	6.0	22.7	4.9	<0.0001
Prepregnancy BMI (kg/m^2)	26.2	6.3	26.3	6.1	26.0	6.5	0.15
Weight at Delivery (pounds)	178.8	37.8	178.3	37.2	179.7	38.6	0.32
Gestational Weight Gain (pounds)	31.4	16.5	30.5	15.8	32.9	17.4	<0.0001
	n	%	n	%	n	%	
Age (years)							
13–19	740	24.4	367	19.9	373	31.5	<0.0001
20–24	1068	35.3	591	32.1	477	40.3	
25–29	640	21.1	438	23.8	202	17.1	
≥30	581	19.2	448	24.3	133	11.2	
Parity							
0 live births	1246	41.6	751	41.3	495	42.1	0.67
1 live birth	916	30.6	551	30.3	365	31.1	
≥2 live births	830	27.7	515	28.3	315	26.8	
Prepregnancy BMI (kg/m^2)							
Underweight (<18.5)	160	5.3	85	4.6	75	6.4	<0.01
Normal weight (≥18.5–<25)	1393	46.2	832	45.1	561	47.9	
Overweight (≥25–<30)	775	25.7	508	27.6	267	22.8	
Obese (≥30)	687	22.8	419	22.7	268	22.9	
Adherence to Weight Gain Recommendations							
Inadequate gain	599	20.2	377	20.5	222	19.9	0.07
Appropriate gain	708	23.9	464	25.2	244	21.8	
Excessive gain	1653	55.8	1001	54.3	652	58.3	

Abbreviations: BMI (body mass index), kg/m^2 (kilograms per meter squared)

[a]Numbers may not add to total due to missing data.

[b]P values derived from ANOVA F-test for continous data and chi-square tests for categorical data.

Table 2

Demographic and Clinical Characteristics according to Smoking Status in Pregnancy; Pooled Hispanic Datasets, Massachusetts 2006–2011.

	Smoking Status in Pregnancy[a]						
	Non-Smoker (N=2,353)		Former Smoker (N=300)		Current Smoker (N=334)		
	mean	**SD**	**mean**	**SD**	**mean**	**SD**	**p-value[b]**
Age (years)	24.2	5	23.2	4.6	24.2	5.2	0.02
Prepregnancy BMI (kg/m^2)	26	6.1	27.2	7.4	26.4	6.3	<0.01
Weight at delivery (pounds)	177.2	36.6	188.0	44.3	182.3	38.1	<0.01
Gestational Weight Gain (pounds)	31.1	15.8	33.8	18.4	31.6	19.1	0.03
	n	%	n	%	n	%	
Age (years)							
13–19	595	25.3	64	21.3	74	22.2	<0.0001
20–24	781	33.2	143	47.7	127	38	
25–29	504	21.4	57	19	71	21.3	
≥30	473	20.1	36	12	62	18.6	
Parity							
0 live births	1007	43.4	128	43.2	99	29.8	<0.0001
1 live birth	713	30.7	91	30.7	98	29.5	
≥2 live births	602	26	77	26	135	40.7	
Prepregnancy BMI (kg/m^2)							
Underweight (<18.5)	129	5.5	11	3.7	18	5.4	0.23
Normal weight (≥18.5–<25)	1094	46.8	131	43.8	149	44.6	
Overweight (≥25–<30)	606	25.9	76	25.4	79	23.7	
Obese (≥30)	511	21.8	81	27.1	88	26.4	
Adherence to Weight Gain Recommendations							
Inadequate gain	470	20.4	48	16.4	72	22.4	<0.01
Appropriate gain	582	25.3	49	16.8	68	21.1	
Excessive gain	1253	54.4	195	66.8	182	56.5	

Abbreviations: BMI (body mass index), kg/m^2 (kilograms per meter squared)

[a]Numbers may not add to total due to missing data.

[b] P values derived from ANOVA F-test for continous data and chi-square tests for categorical data.

Table 3

Distribution of Cigarette Smoking According to Study Site; Pooled Hispanic Datasets, Massachusetts 2006–2011.

	Total Pooled Sample[a] (n=3,029)		UMMHC Dataset (n=1,884)		PBS Dataset (n=1,185)	
	n	%	n	%	n	%
Pre-Pregnancy[b]						
Non-smoker	2388	78.8%	1584	85.9%	804	67.8%
Smoker	619	20.4%	243	13.2%	376	31.7%
1 to 10 cigarettes/day	437	14.4%	153	8.3%	284	24.0%
>10 cigarettes/day	182	6.0%	90	4.9%	92	7.8%
Missing	22	0.7%	17	0.9%	5	0.4%
During Pregnancy[c]						
Non-smoker	2353	77.7%	1571	85.2%	782	66.0%
Former smoker	300	9.9%	94	5.1%	206	17.4%
Smoker	334	11.0%	153	8.3%	181	15.3%
1 to 10 cigarettes/day	308	10.2%	134	7.3%	174	14.7%
>10 cigarettes/day	26	0.9%	19	1.0%	7	0.6%
Missing	42	1.4%	26	1.4%	16	1.4%

Abbreviations: PBS (Proyecto Buena Salud), UMMHC (UMass Memorial Health Care)

[a] Numbers may not add to total due to missing data.

[b] P-value for comparison between UMMHC and PBS datasets for smoking status prior to pregnancy <0.001

[c] P-value for comparison between UMMHC and PBS datasets for smoking status during pregnancy <0.001

Table 4

Odds ratios and 95% Confidence Intervals for the Association between Cigarette Smoking and Gestational Diabetes Mellitus (GDM); Pooled Hispanic Datasets, Massachusetts 2006–2011.

	GDM Cases		Unadjusted		Age-Adjusted		Multivariable Model[a]	
	n	%	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Pooled Datasets (n=3,029)								
Pre-Pregnancy								
Non-smoker	120	4.0%	1.0	Referent	1.0	Referent	1.0	Referent
Smoker	22	0.7%	0.70	(0.44, 1.11)	0.81	0.51, 1.30	0.77	(0.47, 1.25)
1 to 10 cigarettes/day	15	0.5%	0.67	(0.39, 1.16)	0.85	(0.49, 1.48)	0.78	(0.44, 1.37)
>10 cigarettes/day	7	0.2%	0.76	(0.35, 1.65)	0.73	(0.33, 1.61)	0.75	(0.34, 1.67)
P_{trend}				0.18		0.36		0.32
Pregnancy								
Non-smoker	119	3.9%	1.0	Referent	1.0	Referent	1.0	Referent
Former smoker	14	0.5%	0.92	(0.52, 1.62)	1.16	(0.65, 2.06)	1.03	(0.57, 1.87)
Smoker	8	0.3%	0.46	(0.22, 0.95)	0.48	(0.23, 1.00)	0.47	(0.23, 1.00)
1 to 10 cigarettes/day	7	0.2%	0.44	(0.20, 0.95)	0.47	(0.22, 1.02)	0.45	(0.21, 1.00)
>10 cigarettes/day	1	0.0%	0.75	(0.10, 5.59)	0.62	(0.08, 4.76)	0.71	(0.09, 5.43)
P_{trend}				0.05		0.11		0.09
UMMHC Dataset (n=1,844)								
Pre-Pregnancy								
Non-smoker	80	4.3%	1.0	Referent	1.0	Referent	1.0	Referent
Smoker	8	0.4%	0.64	(0.31, 1.30)	0.7	(0.33, 1.49)	0.75	(0.35, 1.59)
1 to 10 cigarettes/day	6	0.3%	0.77	(0.33, 1.70)	0.94	(0.40, 2.21)	0.97	(0.41, 2.29)
>10 cigarettes/day	2	0.1%	0.43	(0.10, 1.70)	0.40	(0.10, 1.68)	0.45	(0.11, 1.87)
P_{trend}				0.19		0.24		0.32
Pregnancy								
Non-smoker	80	4.3%	1.0	Referent	1.0	Referent	1.0	Referent
Former smoker	6	0.3%	1.27	(0.54, 2.99)	1.46	(0.61, 3.50)	1.49	(0.62, 3.59)
Smoker	2	0.1%	0.25	(0.06, 1.01)	0.25	(0.06, 1.03)	0.27	(0.07, 1.13)
1 to 10 cigarettes/day	1	0.1%	0.14	(0.02, 1.02)	0.14	(0.02, 1.05)	0.15	(0.02, 1.13)

	GDM Cases		Unadjusted		Age-Adjusted		Multivariable Model[a]	
	n	%	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
>10 cigarettes/day	1	0.1%	1.04	(0.14, 7.85)	0.98	(0.13, 7.64)	1.11	(0.14, 8.69)
P_{trend}				0.11		0.13		0.18
PBS Dataset (n=1,185)								
Pre-Pregnancy								
Non-smoker	40	3.4%	1.0	Referent	1.0	Referent	1.0	Referent
Smoker	14	1.2%	0.74	(0.40, 1.38)	0.75	(0.40, 1.41)	0.78	(0.41, 1.48)
1 to 10 cigarettes/day	9	0.8%	0.63	(0.30, 1.31)	0.68	(0.32, 1.43)	0.69	(0.33, 1.47)
>10 cigarettes/day	5	0.4%	1.10	(0.42, 2.86)	0.94	(0.35, 2.50)	1.04	(0.39, 2.78)
P_{trend}				0.59		0.53		0.66
Pregnancy								
Non-smoker	39	3.3%	1.0	Referent	1.0	Referent	1.0	Referent
Former smoker	8	0.7%	0.77	(0.52, 1.62)	0.84	(0.38, 1.86)	0.86	(0.39, 1.90)
Smoker[b]	6	0.5%	0.65	(0.22, 0.95)	0.59	(0.24, 1.43)	0.61	(0.25, 1.50)

Abbreviations: PBS (Proyecto Buena Salud), UMMHC (UMass Memorial Health Care)

[a]Adjusted for age (continuous), parity, study site (for pooled dataset only).

[b]Small numbers of pregnancy smokers in this dataset precluded evaluation according to number of cigarettes/day.