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Pre-pregnancy BMI and Preterm Birth Among Hispanic Teens

Allison C. Hope
University of Massachusetts Amherst

PRE-PREGNANCY BODY MASS INDEX AND PRETERM BIRTH AMONG HISPANIC TEENS

A Thesis Presented

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ALLISON C. HOPE

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ALLISON C. HOPE

Approved as to style and content by:

Lisa Chasan-Taber, Chair

Brian Whitcomb, Member

Penelope Pekow, Member

Paula L. Stamps, Graduate Program Director

School of Public Health and Health Sciences

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ABSTRACT

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ALLISON C. HOPE, B.S. UNIVERSITY OF MASSACHUSETTS AMHERST

M.S., UNIVERSITY OF MASSACHUSETTS AMHERST

Preterm birth affects 12% of infants in the United States annually and is the main contributor to infant deaths and long-term neurological disabilities in offspring. Obesity is a growing problem in the U.S., and is increasingly being considered a major risk factor for adverse health outcomes. Puerto Rican teenagers have disproportionately high rates of preterm birth and obesity when compared to non-Hispanic White teenagers. Studies evaluating risk factors for preterm birth among adolescents are sparse, have inconsistent findings, and were conducted among predominantly non-Hispanic populations. Therefore, we investigated the association between BMI and preterm birth among the 419 teenage (ages 16-19) participants in Proyecto Buena Salud, a prospective cohort study of predominantly Puerto Rican prenatal care patients in Massachusetts. Pre-pregnancy BMI was abstracted from medical records and defined using CDC adolescent BMI-for-age percentile categories. Preterm birth classifications were abstracted from the delivery record and confirmed by the study obstetrician. Seventy-six (18%) participants were overweight and 58 (14%) were obese. A total of 49 (11.7%) preterm births were observed, consisting of 36 (73%) spontaneous and 13 (27%) medically indicated. After adjusting for pregnancy complications, previous preterm birth, age, acculturation, and

gestational weight gain, obese teens had a reduced odds of total preterm birth (OR: 0.12, 95% CI: 0.02, 0.61) and had a mean gestational age at delivery of 0.9 weeks higher (95% CI: 0.19, 1.56) as compared to normal weight teens. When evaluating preterm birth by subtype, overweight/obese teens had a reduced odds of spontaneous (OR: 0.36, 95% CI: 0.13, 1.02) and medically indicated (OR: 0.054, 95% CI: 0.004, 0.70) preterm birth compared to normal weight teens. This study adds to the body of literature on the impact of obesity on birth outcomes and extends this work to Hispanic teenagers.

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CHAPTER I

BACKGROUND AND SIGNIFICANCE

A. Introduction

Preterm birth affects over 12% of infants in the United States every year, accounting for approximately 500,000 births.[3] Preterm birth and low birth weight are among the leading causes of infant mortality and morbidity in the United States.[15, 17] Puerto Rican women experience disparities in these adverse birth outcomes with disproportionately high rates when compared to non-Hispanic Whites, despite comparable or only slightly higher rates among Hispanic women overall.[5,13,16] Preterm birth is the main contributor to infant deaths in the United States. Preterm birth also contributes more significantly to long-term neurological disabilities in children than any other cause.[3] In the United States, teenage mothers are at higher risk of preterm birth compared to women in their 20s, with rates of 13.3% and 11%, respectively.[10] Hispanic women are also at an increased risk of preterm birth when compared to white women, with rates of approximately 12% and 10%, respectively.[9] Puerto Rican women experience disparities in these adverse birth outcomes with disproportionately high rates when compared to non-Hispanic Whites, despite comparable or only slightly higher rates among Hispanic women overall.[5,13,16]

Preterm birth is defined as any birth occurring before 37 weeks gestation[3] and can be separated further into categories according to the timing of birth.[3] 'Extreme preterm birth' is defined as that occurring before 28 weeks gestation, 'very preterm birth' is used to describe births between 28 weeks and 32 weeks gestation, and 'moderate to late

preterm birth' is used for those births that occur between 32 weeks and 37 weeks gestation. The final weeks of gestation are important for fetal development, and the timing of the preterm birth directly affects risk and type of disability in the baby; [3] however, important health risks occur in babies born in all categories of preterm birth.[26]

Similarly, preterm birth can be separated into categories of type of delivery. Spontaneous preterm birth occurs with preterm labor or premature rupture of membranes and is usually associated with some existing morbidity such as preeclampsia, intrauterine infection, or gestational hypertension.[26] 'Medically indicated' is used to describe preterm births that occur when medical intervention at preterm gestational ages are prompted by maternal and/or fetal conditions such as preeclampsia, and other maternal morbidities.[26]

Established risk factors for preterm labor and preterm birth include hypertension, previous preterm birth, placenta previa, gestational diabetes, smoking, stress, substance abuse, sexually transmitted infections, and urinary tract infections.[19] Body mass index has been positively associated with the risk of medically indicated preterm birth in adults and adolescents, specifically, however, the evidence is unclear whether BMI is positively associated with the risk of spontaneous preterm birth.[24,25] Hispanic teens have higher rates of overweight and obesity in the US compared to non-Hispanic white teens. It is estimated that 36.5% of Hispanic teens are overweight or obese compared to 31% of non-Hispanic white teens.[20]

B. Physiology of Exposure-Outcome Relationship

The physiology of the association between BMI and preterm birth among teens is largely unknown. There are three hypothesized physiologic mechanisms by which BMI may affect spontaneous and medically indicated preterm birth.

In terms of spontaneous preterm birth, it had been proposed that normal weight and underweight women may be at risk of the development of insufficient cervical membranes during the prenatal period, which has been linked to insufficient nutrient intake and smoking during pregnancy. A thin cervix may increase the likelihood of intrauterine infection as well as premature rupture of membranes, leading to the outcome of spontaneous preterm birth.[18,22] A second potential mechanism operates through an ascending intra-amniotic infection mechanism, potentially induced by change in the vaginal microbial ecosystem. Excess sex steroid hormones, such as estrogens, can promote the accretion of glycogen in the vaginal epithelium, increasing the likelihood of bacterial infection occurring in the lower vaginal tract and thereby triggering preterm birth.[20] Women who are overweight or obese may have higher levels of estrogen due to increased secretion from adipose tissue.[14]

In terms of medically indicated preterm birth, there are two closely associated physiologic mechanisms that may be at work. First, high pre-pregnancy BMI has been associated with increased risk of the development of gestational diabetes, preeclampsia, and high blood pressure in pregnancy.[18] In turn, gestational diabetes and preeclampsia are two of the most prevalent indicators for the decision to medically induce preterm birth by a physician.[3]

C. Epidemiology of Exposure-Outcome Relationship

Few epidemiologic studies have investigated the association between BMI and preterm birth among teens,[1,9,22] with the majority of studies having been conducted among adults. A meta-analysis of prepregnancy and preterm birth conducted in 2009, including women of all ages, found that women with class I obesity (BMI >29.9≤34.9 kg/m^2) had a similar risk of overall preterm birth (0.98, 95% CI:0.93-1.05), a reduced risk of spontaneous preterm birth (OR:0.83, 95%CI: 0.75-0.92), and an increased risk of medically indicated preterm birth (OR:1.27, 95%CI:0.89-1.81) compared to normal weight women. Women who were obese II or III (BMI≥35) had an increased risk for both spontaneous and medically indicated when compared to normal weight women.[25]

To our knowledge, there have been no studies investigating this association among a predominately Hispanic population of teens, which may represent women at particularly high risk for preterm birth. Three retrospective cohort studies have examined the association between BMI and preterm birth among adolescent mothers. Only one of the three studies separated medically indicated preterm birth from spontaneous preterm birth,[23] and two studies only examined spontaneous preterm birth.[1,9] The study that examined spontaneous and medically indicated preterm birth separately found that women who were overweight and obese had an increased risk of medically indicated preterm birth, and a reduced risk of spontaneous preterm birth.[22] Studies that excluded participants with medically indicated preterm birth at baseline, thereby examining,[23-] while the studies that examined only spontaneous preterm birth,[1,9] found that overweight and obese women had a reduced risk of spontaneous preterm birth.

In a 2014 retrospective cohort, Baker et al. studied spontaneous preterm birth among a total of 650 teens from the Washington Hospital Center who were primarily African American. Information on maternal prepregnancy weight was self-reported and abstracted from medical records. In this study, normal weight mothers (BMI <24.9 kg/m^2) had an increased risk of spontaneous preterm birth (RR: 3.35 CI: 1.98-5.64) while teens that were morbidly obese (BMI ≥35 kg/m^2) had a 63% reduced risk (95% CI: 0.16-0.82) of spontaneous preterm birth as compared to normal weight teenagers.[1] Findings were limited in this study because investigators examined only spontaneous preterm birth. This study was also limited by the use of adult classifications of BMI in an adolescent population. Teenagers with medically indicated preterm birth were excluded from the analysis to focus on spontaneous preterm birth.

In another retrospective cohort at the Washington Hospital center in 2009, Haeri et al. investigated the association between BMI and spontaneous preterm birth among 458 predominantly African American teenagers.[9] Information on self reported prepregnancy weight and height from medical records were used to calculate prepregnancy BMI. The outcome of preterm birth was also abstracted from medical records. Overweight and obese teens had a reduced odds of spontaneous preterm birth (OR: 0.29; 95% CI: 0.12, 0.16) as compared to normal weight teens.[9] Limitations of this study were the consideration of only one stratum of preterm birth (spontaneous) as the investigators excluded women who experienced medically indicated preterm birth, and the exclusion of underweight teens. By excluding teens with medically indicated preterm birth, authors were unable to draw inferences regarding the association between pre-pregnancy BMI and preterm birth among their teenage population. The exclusion of

underweight women, given the evidence that lack of sufficient pre-pregnancy nutrient intake may increase the risk of preterm birth, may have underestimated their results.

The third study investigated the association of BMI and preterm birth in 27,967 young women (≤24 years old) including both spontaneous and medically indicated.[23] Maternal BMI was extracted from birth certificates and dichotomized as obese (BMI ≥30 kg/m^2), and non-obese (BMI ≥29.9 kg/m^2). Obese women had an increased risk of medically indicated preterm birth (OR: 1.07, 95% CI:0.84, 1.38), and a decreased risk of spontaneous preterm birth (OR: 0.87, 95% CI:0.72-1.03) as compared to non-obese women, though these results were not statistically significant. Combing both underweight and overweight women in the "non-obese" category complicated interpretation of the results, potentially overestimating the protective effect of obesity on the risk of preterm birth, as women who are underweight and normal weight have been suggested to have a higher risk of spontaneous preterm birth. Additionally, investigators did not conduct a separate analysis to examine the association between pre-pregnancy BMI and preterm birth by age category, teenage and adult, and therefore, are unable to draw inferences based on the potential effects pre-pregnancy BMI may have by age on preterm birth.

D. Summary of Significance and Innovation

To our knowledge, there have been no previous studies investigating the association between BMI and preterm birth among Hispanic teens. Previous studies of BMI and preterm birth among teens were limited by either dichotomized classifications of BMI,[23] or only evaluated spontaneous preterm birth.[1,9] For example, women who were underweight were combined into the normal weight category in all three studies. One

previous study examined both medically indicated and spontaneous preterm birth, but failed to address the association among the teenage population only.[22]

Thus, we examined the association between BMI and preterm birth using data from Proyecto Buena Salud, a prospective cohort study conducted at Baystate Medical Center in Springfield, Massachusetts with an entirely Hispanic population. The significance of this study was indicated through the novel examination of this association in a Hispanic teen population. The study is innovative through its use of a prospective design, accepted classification of BMI categories for adolescents, evaluation of both types of preterm birth, and the prospectively gathered information on covariates specific to research purposes.

CHAPTER II

SPECIFIC AIMS AND HYPOTHESES

Specific Aim #1: *To evaluate the association between BMI and preterm birth in a Hispanic teenage population.*

Hypothesis #1a: BMI will be positively associated with the risk of preterm birth.

Hypothesis #1b: Overweight and obese teens will have an increased risk of preterm birth as compared to normal weight teens.

Specific Aim #2: *To evaluate the association between BMI and type of preterm birth, spontaneous and medically indicated, in a Hispanic teenage population.*

Hypothesis #2a: Overweight and obese teens will have an increased risk of medically indicated preterm birth when compared to normal weight teens.

Hypothesis #2b: Overweight and obese teens will have a decreased risk of spontaneous preterm birth when compared with normal weight teens.

CHAPTER III

STUDY DESIGN AND METHODS

A. Overall Strategy

Using data from Proyecto Buena Salud, we investigated the association between body mass index (BMI) and preterm birth specifically among Hispanic teens. Proyecto Buena Salud is a prospective cohort study based in Baystate Health in Springfield, Massachusetts. Eligibility for the study was restricted to women of Puerto Rican or Dominican heritage and women who were sixteen years of age or older. Approximately 1,500 Latina women were recruited between January 2006 and 2011. Participants were recruited at Baystate Health at or before twenty weeks gestation and provided written consent after being informed of study procedures and aims. Bilingual interviewers conducted interviews at baseline in Spanish and English as preferred by the participant. Information on smoking and alcohol consumption, and other covariates were collected at baseline. Participants were followed through gestation and information on pregnancy outcomes were collected at the end of their pregnancy.

B. Study Population

Baystate Health serves both a socioeconomically and ethnically diverse population, with about 57% Hispanic, 17% African American, 23% non-Hispanic white, and 3% other ethnicity individuals. Inclusion criteria was comprised of self-identifying as Latina; specifically, having been born in the Caribbean Islands themselves, having a parent who was born in the Caribbean islands, or having two grandparents born in the

Caribbean Islands. To be included, participants had to have their first prenatal visit at or before twenty weeks gestation. For the purposes of our assessment, we excluded women greater than or equal to 20 years of age in order to focus on the teenage population. We excluded women who are missing data on prepregnancy BMI, or gestational age, or preterm birth diagnosis.

C. Exposure Assessment

Self-reported prepregnancy weight and measured height were abstracted through medical records. These measures were used to calculate pre-pregnancy BMI for each participant. Study participants were classified using the WHO and CDC formulas for calculating adolescent BMI in girls under 20 years old. Classifications of BMI included underweight, normal weight, overweight, and obese. BMI was also be evaluated within our study on a continuous scale. BMI was calculated for participants in our study using the CDC sex and age specific BMI percentiles for girls ages two to nineteen years old[4]. Weight-for-height percentiles were used because fat composition changes with age and differs between boys and girls.

Maternal recall of pregnancy related information including prepregnancy height has been suggested to be reliable and accurate.[24] In a validation study of maternal recall of pregnancy and delivery information, a subset of 154 women who participated in the National Collaborative Perinatal Project (NCPP) were mailed questionnaires regarding reproductive history, prenatal visits, labor, and delivery on two separate occasions. Information from the two questionnaires were compared to assess reliability, and these were compared against information collected prospectively previously, from the same participant, for the NCPP to assess validity. Reliability of recalled height and weight was

observed to be very high, with spearman correlation coefficients of 0.95. Maternal recall of height and weight accurately reflected prospectively collected data in the NCPP study, with correlation coefficients of 0.90 for height and 0.86 for weight. Reported means and standard deviations of prepregnancy weight through maternal report on the mailed questionnaire and extracted data from the NCPP study varied only slightly (54.3 ± 8.0kg vs. 55.0 ± 8.7kg).

D. Outcome Assessment

The outcome of preterm birth was defined as less than 37 weeks gestation and collected from medical records at Baystate Health, and was reported by the physician as medically indicated or spontaneous preterm birth. Spontaneous preterm birth was defined as any birth occurring due to spontaneous preterm labor or preterm rupture of membranes, and medically indicated preterm birth was defined as any preterm birth occurring due to medically induced labor. Total preterm birth was evaluated dichotomously with "yes" or "no" values related to having had a preterm birth or not having had a preterm birth. Values of spontaneous and medically indicted preterm birth were dichotomous. Gestational age at birth was also collected through medical records and will be evaluated as a continuous variable. Gestational age was predicted clinically through sonographic techniques. Specifically, to estimate gestational age through ultrasound, a physician took various measurements of the fetus, including biparietal diameter, head circumference, and femur length. Combinations of measurements depend on the estimated trimester of pregnancy derived from the LMP date. Using standard

formula, measurements of the fetus are compared to age-specific references for gestational aging.[10]

Extraction from medical records of this outcome is considered the gold standard as it is the most clinically accurate way of measuring gestational age The algorithm used to estimate gestational age is much more accurate than using only LMP as an indicator. In a validation study of obstetric estimates of gestational age on birth certificates, it was found that gestational ages were reported with 83% sensitivity and 98.1% specificity.[6]

In a validation study of use of ICD-9-CM Codes to identify selected categories of obstetric complications conducted at Baystate Health. To adjust for sampling, inverse proportional weighting was used to estimate both sensitivity and specificity for each selected category of obstetric complication. Authors found that the range of weighted sensitivity was 0.15 to 1.00 (95%CI: 0.11, 0.20) (obesity being 0.15 and infection 1.00) and specificity ranged from 0.994 to 0.999 (95%CI: 0.987, 0.999) (obesity having the lowest and intrauterine infection having the highest).[7] Authors concluded that use of the ICD may be a valid method to determine if patients experienced these categories of complications.[8]

E. Covariate Assessment

Information on covariates was collected at baseline and prospectively gathered throughout gestation if appropriate. Baseline pregnancy variables including parity, maternal age, history of preterm birth, pregnancy complications, stress, anxiety, depression and prepregnancy smoking will be used in our analysis, and have been found to contribute to the outcome of preterm birth,[1,2,3,10,19,23,26] while other baseline variables

such as acculturation status, generation in the US, and language preference have not been tested in association to preterm birth, but may be relevant in our study population.

Variables collected prospectively in early pregnancy include smoking in pregnancy, consumption of alcohol in pregnancy and have been found to be associated with preterm birth.[2, 3,11,12,13,16] Pregnancy complications was comprised of experiencing one or more of the following: preeclampsia, uterine infection, and placenta previa.

CHAPTER IV

DATA ANALYSIS

Specific Aim #1: To evaluate the association between BMI and preterm birth in a Hispanic teenage population.

Specific Aim #2: To evaluate the association between BMI and type of preterm birth, spontaneous and medically indicated, in a Hispanic teenage population.

A. Univariate Analysis Plan

Numbers and percentages of participants were determined within our study before and after exclusion criteria were applied (Table 1). We have presented the mean and standard deviation of BMI as a continuous variable, as well as the percent distribution of BMI as a categorical variable based on BMI percentiles for children ages two to nineteen years old (Table 2). Numbers and percentages are presented for the dichotomous outcome of preterm birth and the mean and standard deviation will be presented for gestational age (Table 3).

B. Bivariate Analysis Plan

For all bivariate and multivariable analyses, we used BMI as a categorical variable. We have presented unadjusted tables cross-tabulating BMI by our outcomes, total preterm birth, medically indicated preterm birth, and spontaneous preterm birth (Table 4). Then, we cross-tabulated covariates with BMI (Table 5) and total preterm birth, medically indicated preterm birth, and spontaneous preterm birth (Table 6). Chi-

squared tests were used to derive p-values. In the case of small expected cell counts, Fisher's exact tests were used. ANOVA was used to derive p-values for continuous variables.

C. Multivariable Analysis Plan

We utilized multiple logistic regression and present relevant odds ratios (OR) and 95% confidence intervals (CI) to evaluate the association between BMI and each preterm birth outcome variable (Table 7). Adjustments were made for confounding variables that caused a 10% change or greater in the BMI coefficients when included in the model. Because age and previous preterm birth are known predictors of preterm birth,[2,3,19,22] we included these covariates in all models. Goodness-of-Fit was assessed in logistic models using the Hosmer-Lemeshow test. We used multiple linear regression to evaluate the association between BMI and gestational age adjusting for covariates in the manner described above (Table 8). We assessed the normality of gestational age using qqplots and conducted an additional analyses using log-transformed gestational age.

CHAPTER V

RESULTS

Participants had an average age of 17 (SD= 1.02) (Table 5) with a range from 16 to 19 years old. The mean BMI of the study population was 24.5 (SD= 5.6) (Table 2), and the mean gestational age at delivery was 39 weeks (SD= 2.8) (Table 3). There were 49 (11.7%) total preterm births with 36 (73%) spontaneous and 13 (27%) medically indicated preterm birth (Table 3).

We then cross-tabulated BMI percentile categories with total preterm birth, medically indicated preterm birth, and spontaneous preterm birth and presented Ns and percents (Table 2.4). The unadjusted association between prepregnancy BMI and all types of preterm birth are also presented (Table 4). In this analysis, there were no statistically significant associations between BMI and preterm birth..

Compared to teens in other weight categories, obese teens smoked cigarettes more frequently before becoming pregnant (Table 5). When compared to other groups in the BMI distribution, underweight women tended to have a higher acculturation level. Total gestational weight gain differed among BMI groups with obese teens being more likely to gain less weight on average. Other sociodemographic, behavioral, and medical factors did not differ significantly across BMI categories in our population (Table 5)

Teens who had a medical history of hypertension or preeclampsia, pregnancy complications, or a history of preterm birth were more likely to experience preterm birth and lower gestational ages at birth, on average, as compared to teens without this medical history (Table 6). Other covariates did not differ significantly among participants who did and did not experience preterm birth.

We then evaluated the unadjusted and age-adjusted associations between prepregnancy BMI and total preterm birth, but findings were not statistically significant (Table 7). For example, the unadjusted and adjusted odds ratios of preterm birth for obese participants as compared to normal/underweight participants were 0.36 (95% CI: 0.11, 1.22) and 0.36 (95% CI: 0.10, 1.22), respectively.. After adjusting for age, pregnancy complications, previous preterm birth, acculturation level, and total gestational weight gain, obese teens had a reduced odds of total preterm birth (OR: 0.12, 95%CI:0.02,0.61) as compared to normal weight teens (Table 7). When underweight participants (N=11) were removed from the normal weight group in a separate analysis, the strength of the association increased slightly. In this analysis, overweight teens had a non significant decreased risk of total preterm birth when compared to normal weight teens (OR: 0.72, 95% CI: 0.25, 2.04) and obese teens had a significantly reduced risk of total preterm birth when compared to normal weight teens (OR: 0.10, 95% CI: 0.01, 0.59). Similarly, in multivariable models, each one-unit increase in BMI was associated with a significant poisitive effect on total preterm birth (OR: 0.87, 95%CI: 0.80, 0.96) (Table 7).

We then evaluated the association between BMI and spontaneous preterm birth. In unadjusted and age adjusted analyses, prepregnancy BMI was not significantly associated with this outcome (Table 7). After adjusting for age, acculturation level, total gestational weight gain, and history of preterm birth, however, overweight and obese women had a borderline significant reduced odds of experiencing spontaneous preterm birth when compared to normal weight women (OR: 0.89, 95%CI: 0.13, 1.02) (Table 7). When underweight participants (N=11) were removed from the normal weight group in a separate analysis, the strength of the association decreased slightly. In this analysis,

overweight and obese teens had a non-significant decreased risk of total preterm birth when compared to normal weight teens (OR: 0.40, 95% CI: 0.14, 1.14). In a multivariate model adjusting for the same confounding factors, a one-unit change in BMI was found to reduce the odds of experiencing spontaneous preterm birth (OR: 0.89, 95% CI: 0.81, 0.98) (Table 7). In a multivariate model adjusting for the same confounding factors, every one-unit change in BMI reduced the odds of experiencing spontaneous preterm birth (OR: 0.89, 95%CI: 0.81, 0.98) (Table 7)

We then evaluated the association between BMI and medically indicated preterm birth. In unadjusted and age adjusted analyses, we did not observe significant association between prepregnancy BMI and medically indicated preterm birth (Table 7). After adjusting for age, total gestational weight gain, pregnancy complications, and stress level, overweight and obese women had a reduced odds of experiencing medically indicated preterm birth when compared to normal weight women (OR: 0.05, 95%CI: 0.004, 0.70,). When underweight participants (N=11) were removed from the normal weight group in a separate analysis, the strength of the association remained about the same. In this analysis, overweight and obese teens had a non-significant decreased risk of total preterm birth when compared to normal weight teens (OR: 0.05, 95% CI: 0.004, 0.69). After adjusting for the same confounding factors, each one-unit change in BMI was associated with a reduction in the odds of medically indicated preterm birth (OR: 0.74, 95% CI: 0.58, 0.94) (Table 7).

We then evaluated the association between BMI and gestational age at delivery as a continuous outcome among the entire sample. After adjusting for age, we did not find that obese participants had a significant reduction in mean gestational age at delivery

(β=0.57, 95% CI: -0.20,1.36) as compared to normal weight participants (Table 8). However, after adjusting for

age, acculturation level, total gestational weight gain, pregnancy complications, and history of preterm birth, obese teens had, on average, 0.88 weeks higher mean gestational age, compared to normal weight teens (95% CI: 0.19, 1.56) (Table 8). Repeating this analysis using log-transformed gestational age did not yield significantly different findings.

CHAPTER VI

DISCUSSION

In this prospective cohort study among Hispanic teens, we found a 88% decreased odds of total preterm birth and spontaneous preterm birth among obese teens, as well as 95% reduced odds of medically indicated preterm births among both overweight and obese women as compared to normal weight teens after adjusting for important preterm birth risk factors. Each one-unit increase in BMI was associated with an increase in gestational age at delivery.

Our findings for the association between prepregnancy BMI and total, as well as spontaneous preterm birth are consistent with the majority of the previous literature.[1,9,23] Haeri et al. found that overweight teens had a lower risk of total preterm birth at less than 37 weeks gestation (OR: 0.28, 95% CI:0.19, 0.77) and at less than 34 weeks gestation (OR: 0.11, 95% CI:0.01, 0.80) when compared to normal weight teens. Salihu et al. did not find any significant associations between prepregnancy BMI and total preterm birth, and Baker et al. assessed spontaneous preterm birth, exclusively.[1,23] Our results indicate a protective effect of obesity for overall preterm birth (OR: 0.12, 95% CI: 0.02, 0.61).

Baker et al. assessed the association of prepregnancy BMI and spontaneous preterm birth among a cohort of teens at the Washington Hospital Center.[1] Authors reported that teens who were obese and morbidly obese (10% Hispanic) had a reduced odds of experiencing spontaneous preterm birth when compared to normal weight mothers with ORs of 0.26 (95% CI:0.12, 0.58) and 0.37 (95% CI:0.16, 0.82) respectively.[1] Salihu et al. also found class I and II obese girls (~32% Hispanic) to have

decreased odds of spontaneous preterm birth, with ORs of 0.84 (95%CI:0.71, 0.99) and 0.68 (95%CI:0.51, 0.90) respectively.[23]

Our findings in regard to medically indicated preterm birth, however, are somewhat inconsistent with the previous literature.[23] Salihu et.al. found that women who were classes II and III obese had increased odds of experiencing medically indicated preterm birth when compared to non-obese women, with ORs of 1.13 (95%CI:1.12, 1.14) and 1.11 (95%CI:1.105, 1.121) respectively. In contrast, we found that overweight/obese women had a reduced risk of medically indicated preterm birth (OR: 0.05, 95% CI: 0.004, 0.70). Consistent with our results, however, is Salihu et al.'s finding that class I obese women had a reduced odds of experiencing medically indicated preterm birth when compared to normal weight women (OR:0.91, 95%CI:0.90, 0.91).[23]

Differences in study findings may be due to smaller sample size in our study, and failure of the prior studies to classify teens into obesity categories according to BMI-for-age percentiles. Differences in study findings may also be due to the consideration of covariates important to our study population, including sociodemographic covariates such as acculturation level and perceived stress level. Previous studies also evaluated important risk factors as well, including tobacco use, illicit substance use, race, gestational weight gain, and pregnancy complications.[1,9,23] Study populations also varied widely between studies.

Differences exist between our age-adjusted and multivariable adjusted models, where a stronger effect is observed in the fully adjusted model, largely due to adjustment for acculturation levels. Acculturation level identifies the teen's perception of their change or adjustment to the culture and social constructs in the U.S. Acculturation level

is essentially a proxy for stress variables that are difficult to measure. Normal weight and overweight participants in our study had higher acculturation levels than the obese participants. High acculturation level as a proxy for higher stress level is positively associated with an increased risk of preterm birth. Normal weight teenagers were more highly acculturated than the overweight and obese participants, indicating that they had higher stress. The higher acculturation level among this group increased their risk of preterm birth, and in our models, we see this through the change in the odds ratio when acculturation was added to the models, and obese teens had a more extreme decreased risk of experiencing preterm birth compared to the normal weight teens. The largest change in estimate in our logistic model for medically indicated preterm birth, which is the model with the largest reduction of risk for overweight and obese girls, was caused by the variable of self-reported stress level.

This study has several strengths. It is the first study to evaluate the relation between BMI and preterm birth risk in Hispanic teens, a group with high baseline risks for adverse pregnancy outcomes. In addition, we assessed both medically indicated and spontaneous categories of preterm birth. This is important in order to adequately address confounding by adjusting for covariates specific to each type, and to avoid potential bias that could arise from censoring of medically indicated preterm births.. And additional strength includes having access to information specific to the Latina teen population, such as acculturation and language preference.

Trained interviewers collected baseline information in a clinical setting from study participants, including self-reported prepregnancy BMI. Because study participants were recruited after becoming pregnant, we were not able to measure pre-pregnancy

weight directly. It is possible that participants may have underreported or over reported their prepregnancy weight.

It is possible that women simply could not remember their exact prepregnancy weight. Nondifferential misclassification of the exposure would tend to underestimate the relationship between BMI and pre-term birth, biasing our results toward the null and causing the groups to appear more similar. However, a study conducted in 1999 found that maternal self-report of prepregnancy height and weight is highly accurate. In this study women who were previously enrolled in an epidemiologic study of pregnancy were contacted and asked to report their prepregnancy height and weight from the pregnancy, which was then compared with information collected prospectively in the study.loo-0pp Maternal recall of prepregnancy height and weight was found by authors to accurately represent prospectively collected information, reporting Spearman correlation coefficients of 0.90 and 0.86, respectively.[22] Although these measures have been validated among some populations, it is likely that misreporting of pre-pregnancy body weight occurred in our study.

Gestational age was determined using the "gold-standard" technique in which fetal size and age is determined through ultrasound and where participant's last reported menstrual period will be taken into consideration. It is possible that non-differential misclassification of outcome occurred due to ultrasonic technique error, in which gestational age was not estimated accurately. We can expect that this bias minimally affected our study results because of the accuracy of gestational aging through ultrasound.

All of our study participants received their prenatal care at Baystate Health where they were initially recruited. However, it is possible that some participants may have been lost to follow up, for example, if they delivered their babies at a different hospital. It is unknown if this type of loss to follow-up would have been differential according to exposure and outcome. If women with high prepregnancy BMIs were more likely to deliver at another hospital and they were more likely to experience preterm birth, our results will be biased toward the null because less women in the overweight and obese group would have been observed to have had a preterm birth than the number that actually occurred.

We made an effort to minimize this potential bias by collecting medical records from outside hospitals where participants delivered their babies. In our study, 47 teens were excluded based on missing information on birth outcome. Participants who were excluded based on missing information on birth outcome did not significantly differ in terms of baseline characteristics from those who were not missing data on birth outcomes.

Standard techniques were used to measure BMI, gestational age, and obstetrician determined spontaneous preterm birth. It is possible that information bias may have impacted medically indicated preterm births. Specifically, in medically indicated preterm birth, a physician will determine at which point the pregnancy has become a health risk for either the mother or fetus, and induce a preterm labor. Information bias could affect our study if a physician decided that their patient's weight was a severe enough health risk, without presenting proper symptoms that would be necessary for induction of preterm labor, and made a decision to induce labor when it was not medically necessary.

This bias would overestimate our results because more women who were overweight or obese would have received a medically indicated preterm birth without biological necessity.

As obstetricians understand the importance and protective aspects of a full term pregnancy, it is somewhat unlikely that this type of information bias occurred within our study. In our study, 6 women who experienced medically preterm birth, but did not present with pregnancy complications including preeclampsia, toxemia, and intrauterine infection. Given this small number of participants, the likelihood for this type of bias is low.

Diet and nutritional intake are thought to play an important role in the risk of preterm birth.[3] Poor diet and nutritional consumption are associated with BMI among adolescents. Diets poor in ample fruits, vegetables, oils, and whole grains reduced the risk of preterm birth in one study published in the British Medical Journal, while women with diets high in salt, sugar, white bread, and processed meat tended to have more preterm births.[26] If participants with higher BMI were also more likely to have a poor, nutritionally deprived diet, and this affected their likelihood of having a preterm birth, our results may be underestimates of the true associations.

Information on prepregnancy diet was not collected in our study, and thus, could not be evaluated in our analysis. It is likely that our results were affected by lack of controlling for dietary patterns, as diet among our participants may vary widely. The quality of diet consumed by the participants may depend on socio-economic status of parents, the geographical location in which they reside, and what school they attend if they eat lunch at school daily. Adjusting for total gestational weight gain in our analyses

may have decreased the likelihood of this bias affecting our results, but did not eliminate confounding by diet.

We expect that the physiologic mechanisms in association between prepregnancy BMI and preterm birth may differ across ethic and race groups. There are important stress and acculturation covariates present in our study population that may not exist at or exist in the same context as other racial categories.

We also expect the physiologic mechanisms of the association to differ across age groups. This difference comes in the form of competing nutritional demands, whereas in teens may be competing with the fetus for nutrients during pregnancy because they are still developing, and adults are developed, so they are not completing with the fetus for nutrients. Further, we do not expect that the association would differ by geographical location.

In this prospective cohort study among Hispanic teens, we found a decreased risk of total preterm birth as well as spontaneous and medically indicated preterm births among overweight and obese teens as compared to normal weight teens after adjusting for important preterm birth risk factors. Each one-unit increase in BMI was associated with an increase in gestational age at delivery. Although our findings indicate a protective effect of obesity on the risk of preterm birth, pregnant teenagers should not be advised to become obese before pregnancy. Future studies should be conducted to assess BMI-for-age percentiles and the risk of the multiple types of preterm birth among ethnically diverse populations.

Table 1: Study Sample, Proyecto Buena Salud, 2006-2011

	N	%
Original Study Sample (Book 1)	1,586	100
Excluded		
≥20 years old	1,094	69%
Missing data on prepregnancy BMI	26	5%
Missing data on birth outcome	47	10%
Missing data on Gest. Age at Delivery	0	0%
Final Study Sample	419	26%

Table 2: Distribution of BMI, Proyecto Buena Salud, 2006-2011

Pre-Pregnancy BMI		
Categorical	**N**	**%**
Underweight <5%	11	2.60%
Normal Weight 5%-<85%	274	65.30%
Overweight 85%-<95%	76	18.20%
Obese ≥95%	58	13.90%
Total	419	100%
	Mean	**SD**
Continuous	24.5	5.56

Table 3: Distribution of Preterm Birth, Proyecto Buena Salud, 2006-2011

Preterm Birth	Total	%
Total	49	11.70%
Medically Indicated	**N**	**%**
Yes	13	26.50%
No	36	73.50%
Total	49	100%
Spontaneous	**N**	**%**
Yes	36	73.50%
No	13	26.50%
Total	49	100%
	Mean	**SD**
Gestational Age	39	2.8

Table 4: Preterm Birth by Prepregnancy BMI, Proyecto Buena Salud 2006-2011

	Total Preterm Birth			Medically Indicated Preterm Birth			Spontaneous Preterm Birth		
	N (%)	OR (95% CI)	*P-Value*	N (%)	OR (95%CI)	*P-Value*	N (%)	OR (95% CI)	*P-Value*
Prepregnancy BMI Categorical									
Underweight	2 (4%)	1.5 (0.31, 7.31)	*0.34*	0 (0%)	<0.001 (<0.001, >999.99)	*0.98*	2 (5.5%)	2.21 (0.45, 10.83)	*0.22*
Normal	35 (71%)	1.0 *referent*		11 (84%)	1.0 *referent*		24 (66.6%	1.0 *referent*	
Overweight	9 (18%)	0.91 (0.42, 2.00)	*0.83*	2 (15%)	0.64 (0.14, 2.99)	*0.94*	7 (19.4%)	1.04 (0.43, 2.52)	*0.96*
Obese	3 (6%)	0.37 (0.11, 1.25)	*0.09*	0 (0%)	<0.001 (<0.001, >999.999)	*0.96*	3 (8%)	0.54 (0.15, 1.86)	*0.18*
Continous		23.54 (4.7)			23.68 (5.29)			23.16 (3.10)	

Table 5: Distribution of Covariates According to BMI Category, Proyecto Buena Salud, 2006-2011

	Prepregnancy BMI (kg/m2) (percentiles)				
Characteristic	**Underweight**	**Normal Weight**	**Overweight**	**Obese**	***P-Value***
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age	17.9 (1.13)	17.9 (1.01)	17.82 (1.05)	18.01 (0.99)	0.6148
Parity	0.09 (0.30)	0.25 (0.53)	0.26 (0.57)	0.25 (0.58)	0.9875
Total Gestational Weight G	31.8 (10.22)	34.6 (14.36)	35.1 (17.2)	25.9 (16.7)	0.0003
Hypertension in pregnancy					
No	11 (100%)	259 (95%)	74 (97%)	54 (93%)	0.5798
Yes	0 (0%)	14 (5%)	2 (3%)	4 (7%)	
Prepregnancy Alcohol Consumption					
No	9 (90%)	160 (65%)	47 (69%)	36 (65%)	0.3994
Yes	1 (10%)	86 (35%)	21 (31%)	19 (35%)	
Pregnancy Alcohol Consumption					
No	9 (100%)	224 (99%)	56 (97%)	50 (100%)	0.3244
Yes	0 (0%)	2 (1%)	2 (3%)	0 (0%)	
Prepregnancy Smoking					
<100 cigarettes	8 (80%)	196 (80%)	56 (81%)	35 (62%)	0.0308
>100 cigarettes	2 (20%)	48 (20%)	13 (19%)	21 (38%)	
Pregnancy Smoking					
No	8 (89%)	205 (90%)	52 (90%)	41 (80%)	0.2839
Yes	1 (11%)	23 (10%)	6 (10%)	10 (20%)	
Acculturation Level					

Low	6 (60%)	188 (81%)	58 (92%)	41 (75%)	0.0236
High	4 (40%)	44 (19%)	5 (8%)	14 (25%)	
Generation in US					
Born in PR/DR	7 (64%)	99 (38%)	25 (35%)	22 (39%)	0.6427
Parent born in PR/DR	4 (36%)	141 (53%)	39 (54%)	29 (51%)	
Grandparent born in PR/]	0 (0%)	23 (9%)	8 (11%)	6 (11%)	
Language preference					
English	10 (91%)	211 (82%)	64 (85%)	48 (87%)	0.8018
Spanish	1 (9%)	43 (17%)	11 (15%)	6 (11%)	
Other	0 (0%)	2 (1%)	0 (0%)	1 (2%)	
Probable Minor Depression					
No	6 (75%)	172 (78%)	43 (77%)	33 (66%)	0.3694
Yes	2 (25%)	49 (22%)	13 (23%)	17 (34%)	
Probable Major Depression					
No	6 (75%)	185 (84%)	48 (86%)	44 (88%)	0.7565
Yes	2 (25%)	36 (16%)	8 (14%)	6 (12%)	
Stress Level					
Never or Not Often	2 (22%)	55 (24%)	16 (27%)	12 (24%)	0.2367
Now and Then	1 (11%)	93 (40%)	25 (42%)	14 (28%)	
Often	6 (67%)	82 (36%)	19 (32%)	24 (48%)	
Pregnancy Complications					
No	11 (100%)	261 (96%)	73 (96%)	51 (88%)	0.083
Yes	0 (0%)	12 (4%)	3 (4%)	7 (12%)	
History of Preterm Birth					
No	10 (100%)	257 (96%)	73 (96%)	56 (100%)	0.3881
Yes	0 (0%)	12 (4%)	3 (4%)	0 (0%)	

Table 6: Distribution of Covariates According to Preterm Birth Type, PBS, 2006-2011

	Medically Indicated N (%)	Spontaneous N (%)	*P-Value*	Gestational Age Mean (SD)
Age	17.8 (0.99)	17.9 (0.998)	0.6976	
Parity	0.15 (0.38)	0.37 (0.645)	0.2778	
Total Gestational Weight	28.9 (14.3)	23.7 (12.7)	0.2529	
Hypertension in pregnancy				
No	7 (54%)	35 (100%)	<0.001	37.87 (2.62)
Yes	6 (46%)	0 (0%)		37.8 (2.63)
Prepregnancy Alcohol Consumption				
No	7 (64%)	22 (71%)	0.6514	39.1 (2.64)
Yes	4 (36%)	9 (29%)		39.1 (2.42)
Pregnancy Alcohol Consumption				
No	10 (91%)	31 (100%)	0.0893	39 (2.69)
Yes	1 (9%)	0 (0%)		39.3 (2.80
Prepregnancy Smoking				
<100 cigarettes	9 (82%)	23 (72%)	0.5144	39.1 (2.48)
>100 cigarettes	2 (18%)	9 (28%)		38.9 (2.96)
Pregnancy Smoking				
No	10 (91%)	24 (77%)	0.3276	39.1 (2.54)
Yes	1 (9%)	7 (23%)		38.3 (3.48)
Acculturation Level				
Low	7 (88%)	23 (79%)	0.6006	39.16 (2.34)
High	1 (13%)	6 (21%)		38.87 (3.33)

Generation in US				
Born in PR/DR	4 (31%)	12 (35%)	0.9434	38.9 (2.73)
Parent born in PR/DR	8 (62%)	20 (59%)		39 (3.03)
Grandparent born in PR	1 (8%)	2 (6%)		39.4 (1.62)
Language preference				
English	9 (82%)	30 (86%)	0.7537	39.1 (2.53)
Spanish	2 (18%)	5 (14%)		38.7 (3.40)
Other	0 (0%)	0 (0%)		39.3 (0.61)
Probable Minor Depression				
No	7 (78%)	21 (72%)	0.7495	39.1 (2.67)
Yes	2 (22%)	8 (28%)		38.9 (2.58)
Probable Major Depression				
No	8 (89%)	23 (79%)	0.5173	39.1 (2.62)
Yes	1 (11%)	6 (21%)		38.8 (2.80)
Stress Level				
Never or Not Often	1 (11%)	6 (20%)	0.5705	39.2 (2.9)
Now and Then	2 (22%)	10 (33%)		39.2 (2.3)
Often	6 (67%)	14 (47%)		38.8 (2.7)
Pregnancy Complications				
No	6 (46%)	34 (97%)	<0.001	39.1 (2.6)
Yes	7 (54%)	1 (3%)		37.6 (2.8)
History of Preterm Birth				
No	13 (100%)	31 (86%)	0.1562	39.1 (2.6)
Yes	0 (0%)	5 (14%)		36.5 (5.1)

Table 7: Logistic Regression: BMI and Preterm Birth, Proyecto Buena Salud, 2006-2011

	Age Adjusted		Fully Adjusted	
	OR	95% CI	OR	95% CI
Total Preterm Birth				
Prepregnancy BMI				
Normal Weight	1.0 *referent*		1.0 *referent*	
Overweight	0.9	(0.41, 1.96)	0.82	(0.30, 2.22)*
Obese	0.36	(0.10, 1.22)	0.12	(0.02, 0.61)
p-trend		*0.104*		*0.003*
Continuous BMI	0.95	(0.90, 1.02)	0.87	(0.80, 0.96) **
p-trend		*0.1957*		*0.005*
Spontaneous Preterm Birth				
Prepregnancy BMI				
Normal Weight	1.0 *referent*		1.0 *referent*	
Overweight and Obese	0.78	(0.36, 1.67)	0.36	(0.13, 1.02) ***
p-trend		*0.267*		*0.0183*
Continuous BMI	0.97	(0.90, 1.03)	0.89	(0.81, 0.98) ****
p-trend		*0.3095*		*0.023*
Medically Indicated Preterm Birth				
Prepregnancy BMI				
Normal Weight	1.0 *referent*		1.0 *referent*	
Overweight and Obese	0.37	(0.08, 1.69)	0.054	(0.004, 0.70) *****
p-trend		*0.1734*		*0.005*
Continuous BMI	0.94	(0.83, 1.06)	0.74	(0.58, 0.94) ******
p-trend		*0.354*		*0.015*

*adjusted for pregcomp obh_preterm age acc_status total_gwg
** adjusted for pregcomp obh_preterm age acc_status total_gwg
*** age acc_status total_gwg obh_preterm
**** age acc_status total_gwg obh_preterm
***** bicentile age total_gwg pregcomp stresslevel
******age total_gwg pregcomp stresslevel

Table 8: Linear Regression: BMI and Gestational Age, Proyecto Buena Salud,2006-2011

	Fully Adjusted*			
	β	SE	P-Value	(95% CI)
Prepregnancy BMI				
Normal Weight	1.0 *referent*			
Overweight	-0.45	0.3225	0.1637	(-1.08, 0.18)
Obese	0.88	0.1965	0.0117	(0.19, 1.56)
Continuous BMI	0.045	0.0222	0.0403	(0.002, 0.08)

*Adjusted for age, acculturation level, total gestational weight gain, pregnancy complications, history of preterm birth

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