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The Association of Prepregnancy Body Mass Index and Adverse Maternal and Perinatal Outcomes

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Introduction

The prevalence of both overweight and obesity in the U.S. population has increased dramatically in the last few decades creating an important public health issue. The combined prevalence of overweight and obesity among adults increased from 47 percent in 1976-1980 to 66 percent in 2001-2004.[1] The prevalence of obesity alone among adults during the same period doubled from 15 percent to 32 percent. Among adolescents ages 12 to 19, the prevalence of overweight individuals more than tripled from 5 percent to 17 percent. Six and one-half percent of children ages 6 to 11 years were overweight in the 1976-1980 time period and that rate almost tripled to 17.5 percent in 2001-2004.

Several adverse health outcomes have been associated with excessive weight, including increased risks for heart disease, stroke, high blood pressure, type 2 diabetes, and certain cancers. Additionally, studies have shown that women who are obese before pregnancy have an increased risk for pregnancy complications and adverse outcomes, including gestational diabetes and pregnancy induced hypertension, increased cesarean section deliveries, and delivering preterm.[2] Alternatively, women who are underweight prior to pregnancy have an increased risk for delivering an infant preterm, who is of low birth weight, and is small for gestational age (SGA).[3]

More than one-third of women of childbearing age in the U.S. are overweight or obese and this prevalence is increasing. Therefore, it is of public health importance to study the impact of maternal weight on adverse pregnancy and birth outcomes. While gestational weight gain has been studied extensively, the significance of prepregnancy body mass index (BMI), a measure of weight controlling for height, on maternal and infant outcomes has only recently received attention.[4] The purpose of this study is to assess specifically the effect of prepregnancy BMI on adverse maternal and perinatal outcomes among Colorado mothers.

2007 was the first year that Colorado implemented the National Center for Health Statistics' 2003 revision of the U.S. standard certificate of live birth.[5,6] For the first time this revised

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birth certificate collects data on maternal height in addition to prepregnancy weight. Because maternal height is now recorded on the revised birth certificate, prepregnancy body mass index (BMI) can be calculated and classified as underweight, normal weight, overweight, obese, and morbidly obese as per the recommendations from the National Institutes of Health used in this report.[7]

Methods

Study Population

A retrospective cohort study was designed to study the relationship between body mass index (BMI) and adverse pregnancy outcomes. The 2007 Colorado birth certificate data, maintained by the Health Statistics Section at the Colorado Department of Public Health and Environment, was used for the analysis.

Exclusions

In the year 2007, there were 71,546 live births in Colorado. For this study, births were limited to Colorado resident mothers who were pregnant for the first time and had a successful live singleton (non-multiple) birth. Births to women under 18 years of age were also excluded from the analysis as studies have shown that women under 18 years of age have risks for adverse pregnancy outcomes specifically associated with young age. Finally, birth certificates that had missing data needed for the proposed regression analysis were excluded from the analysis. After all the exclusions, there were 19,758 birth records included in this study.

Independent and Dependent Variables

The independent variable, body mass index (BMI) was classified into five categories: underweight (BMI <18.5); normal weight (BMI 18.5-24.9); overweight (BMI 25.0-29.9); obese (BMI 30.0-39.9); and morbidly obese (BMI >=40.0). BMI was calculated using maternal height and prepregnancy weight utilizing the following equation: BMI = 705 x body weight in pounds / (height in inches squared). Additional independent variables, or covariates, include maternal age, race/ethnicity, education, and smoking status.

The dependent (outcome) variables analyzed for this study were gestational diabetes, gestational hypertension (including pregnancy induced hypertension and preeclampsia), cesarean section delivery, induced labor, premature delivery (<36 weeks gestation), small for gestational age (SGA), and large for gestational age (LGA). SGA was defined as the birth weight below the 10th percentile for each gestational week of age. LGA was defined as the birth weight above the 90th percentile for each gestational week of age.

Analysis

SAS v9.2 (Cary, NC) was used for all analyses. Chi-square tests were conducted to test if there were associations between BMI and the outcomes and covariates. Logistic regression was used to test the association between BMI and the outcome variables while controlling for the selected covariates. Significance was accepted at the 0.05 alpha level for all variables.

Results

Maternal and Perinatal characteristics and outcomes

According to mothers' prepregnancy BMI, 1,019 (5.2%) were classified as underweight, 11,417 (57.8%) were normal weight, 4,541 (23.0%) were overweight, 2,382 (12.1%) were obese, and 399 (2.0%) were morbidly obese. The distribution of BMI across selected maternal characteristics is displayed in Table 1. There was a higher percentage of underweight women who were 18 to 25 years old (6.7%) compared to women over 35 years old (2.9%). Among race and ethnicities, Asian women were more likely to be underweight and normal weight among all the race and ethnic groups. Black women had the highest percentage of morbidly obese mothers (3.2%) compared to women of other races and ethnicities. Women who attended college were more likely to be normal weight (60.1%) and less likely to be underweight (3.9%) compared to women who had not attended college.

The percentages of maternal and perinatal outcomes according to BMI are displayed in Table 2. Women classified as underweight had the highest percentage of smokers (14%) compared to women in the other BMI categories. As BMI increased, the percentages of gestational diabetes and gestational hypertension increased. Similarly, increasing BMI was directly proportional to increasing percentages of induced labor, cesarean section delivery

Table 1. Distribution of Maternal Characteristics by Body Mass Index (BMI) Category.

	BMI Category				
	Underweight (<18.5) (n = 1,019) (5.2%)	Normal Weight (18.5-24.9) (n = 11,417) (57.8%)	Overweight (25.0-29.9) (n = 4,541) (23.0%)	Obese (30.0-39.9) (n = 2,382) (12.1%)	Morbidly Obese (>=40.0) (n = 399) (2.0%)
Maternal Characteristics					
Maternal Age (%)					
18-25 years	6.7	55.6	22.9	12.8	2.0
26-35 years	3.8	59.6	23.2	11.3	2.0
Over 35 years	2.9	61.7	22.0	11.6	1.9
Race/Ethnicity (%)					
White Non-Hispanic	4.3	59.9	22.6	11.2	1.9
White Hispanic	6.1	52.3	24.1	15.0	2.5
Black	6.1	48.7	27.3	14.7	3.2
Asian	11.0	64.3	18.2	6.1	0.4
American Indian	5.6	43.8	25.8	22.5	2.3
Maternal Education (%)					
Less than High School	8.6	53.6	23.2	13.1	1.4
Completed High School/GED	6.9	53.4	23.2	13.9	2.5
Attended College	3.9	60.1	22.8	11.2	2.0

Note: Using chi-square tests, BMI and maternal characteristics were all statistically significantly associated at the 0.05 alpha level.
SOURCE: Health Statistics Section, Colorado Department of Public Health and Environment.

and large-for-gestational-age infants. Those in the underweight category had the highest percentage of small-for-gestational-age infants compared to the other BMI categories. Those in the normal weight category had the lowest rates of having a premature delivery.

Multiple logistic regression analysis

While controlling for maternal age, race/ethnicity, education, and smoking status, the odds of developing gestational diabetes and gestational hypertension increased as pre-prepregnancy BMI increased compared to the normal weight category (adjusted odds ratios with 95% confidence intervals are displayed in Table 3.) Overweight women were almost twice as likely to develop

Table 2. Percentages of Maternal and Perinatal Outcomes by Body Mass Index (BMI) Category.

	BMI Category				
	Underweight (<18.5) (n = 1,019) (5.2%)	Normal Weight (18.5-24.9) (n = 11,417) (57.8%)	Overweight (25.0-29.9) (n = 4,541) (23.0%)	Obese (30.0-39.9) (n = 2,382) (12.1%)	Morbidly Obese (>=40.0) (n = 399) (2.0%)
Maternal Outcomes					
Smoker† (%)	14.0	6.6	7.5	9.0	12.0
Gestational Diabetes (%)	1.4	2.1	3.7	6.4	7.5
Gestational Hypertension (%) (PIH, Preeclampsia)	1.8	2.7	4.8	7.7	8.5
Perinatal Outcomes					
Induced Labor (%)	20.5	22.6	26.0	31.7	41.4
Cesarean Section Delivery (%)	17.3	23.2	28.6	34.9	51.4
Small for Gestational Age (%)	18.6	11.5	9.6	9.3	10.5
Large for Gestational Age (%)	3.6	6.0	8.9	12.4	14.0
Premature Delivery (<36 weeks) (%)	4.6	3.9	4.6	5.9	6.5

†Refers to any smoking during pregnancy.
Note: Using chi-square tests, BMI and maternal and perinatal outcomes were all statistically significantly associated at the 0.05 alpha level.
SOURCE: Health Statistics Section, Colorado Department of Public Health and Environment.

gestational diabetes compared to women of normal weight (OR 1.85, 95% CI 1.51-2.27). Obese and morbidly obese women were three and four times more likely, respectively, to develop gestational diabetes compared to women in the normal weight category (obese OR 3.40, 95% CI 2.75-4.20) (morbidly obese OR 4.13, 95% CI 2.77-6.15). Overweight (OR 1.86, 95% CI 1.56-2.22), obese (OR 3.10, 95% CI 2.57-3.75), and morbidly obese (OR 3.47, 95% CI 2.39-5.02) women were also more likely to develop gestational hypertension compared to normal weight women.

The odds of being induced for labor, delivering by cesarean section, and having a large-for-gestational-age infant also increased as BMI increased compared to those women that were normal weight. Morbidly obese women were almost four times more likely to deliver by cesarean section compared to women of normal weight (OR 3.69, 95% CI 3.01-4.53). The odds of delivering a premature infant (<36 weeks) increased in obese and morbidly obese women compared to normal weight women (obese OR 1.50, 95% CI 1.24-1.83) (morbidly obese OR 1.68, 95% CI 1.11-2.53).

Being underweight had an increased risk for having a small-for-gestational-age (SGA) infant (OR 1.58 95% CI 1.33-1.87), whereas the risk for a cesarean section delivery and large-for-gestational-age infant were reduced, compared to women of normal weight. Underweight women did not have a statistically significant increased risk for premature delivery (OR 1.10, 95% CI 0.81-1.50).

Table 3. Adjusted* Odds Ratios (with 95% Confidence Intervals) for Maternal and Perinatal Outcomes by Body Mass Index (BMI) Category.

	BMI Category				
	Underweight (<18.5) (n = 1,019)	Normal Weight (18.5-24.9) (n = 11,417)	Overweight (25.0-29.9) (n = 4,541)	Obese (30.0-39.9) (n = 2,382)	Morbidly Obese (>=40.0) (n = 399)
Maternal Outcomes					
Gestational Diabetes	0.63 (0.37, 1.09)	1.00	**1.85 (1.51, 2.27)**	**3.40 (2.75, 4.20)**	**4.13 (2.77, 6.15)**
Gestational Hypertension (PIH, Preeclampsia)	0.68 (0.42, 1.10)	1.00	**1.86 (1.56, 2.22)**	**3.10 (2.57, 3.75)**	**3.47 (2.39, 5.02)**
Perinatal Outcomes					
Induced Labor	0.92 (0.78, 1.08)	1.00	**1.21 (1.12, 1.32)**	**1.62 (1.47, 1.79)**	**2.44 (1.99, 3.00)**
Cesarean Section Delivery	**0.77 (0.65, 0.91)**	1.00	**1.36 (1.26, 1.47)**	**1.88 (1.70, 2.07)**	**3.69 (3.01, 4.53)**
Small for Gestational Age	**1.58 (1.33, 1.87)**	1.00	**0.80 (0.71, 0.90)**	**0.76 (0.66, 0.89)**	0.86 (0.62, 1.20)
Large for Gestational Age	**0.65 (0.46, 0.91)**	1.00	**1.53 (1.35, 1.74)**	**2.25 (1.95, 2.61)**	**2.64 (1.97, 3.55)**
Premature Delivery (<36 weeks)	1.10 (0.81, 1.50)	1.00	1.16 (0.98, 1.37)	**1.50 (1.24, 1.83)**	**1.68 (1.11, 2.53)**

Note: Statistically significant results are in bold (< 0.05 alpha level).
*Results are adjusted for maternal age, race/ethnicity, education, and smoking status.
SOURCE: Health Statistics Section, Colorado Department of Public Health and Environment.

Discussion

The results of this study show that prepregnancy BMI is associated with adverse maternal and perinatal outcomes. Women who were overweight, obese, or morbidly obese had increased odds for gestational diabetes, gestational hypertension, induced labor, cesarean section delivery, and large-for-gestational-age (LGA) infants. Obese or morbidly obese women were also more likely to deliver prematurely (<36 weeks).

Overweight women and women with gestational diabetes are more likely to have LGA infants and complications with labor and delivery. LGA infants are subsequently at risk for obesity, cardiovascular disease and type 2 diabetes later in life. About 50 percent of women with gestational diabetes will eventually develop type 2 diabetes.[8] Gestational hypertension can impair maternal kidney function and often leads to low birth weight and preterm birth. Preeclampsia is a serious health condition associated with gestational hypertension and increased protein in the urine due to impaired maternal kidney function. Preeclampsia can cause maternal organ damage and is one of the leading causes of low birth weight, premature birth, and stillbirth. Eclampsia results if preeclampsia progresses and causes seizures. These hypertensive disorders of pregnancy are a leading cause of maternal mortality in the United States.[9] Adequate prenatal care is imperative for diagnosis and management of both gestational diabetes and hypertensive disorders related to pregnancy.

Though the percentage of the underweight group was only 5.2 percent of the study population, being underweight carries its own risks for adverse maternal and neonatal outcomes. In this study, we observed that underweight women had a higher risk for small-for-gestational-age (SGA) infants. Our analysis did not demonstrate a higher risk for premature delivery, but other studies have shown there is an increased risk for premature delivery among underweight women.[4] The underweight women in our study also had the highest percentage of smokers (14%). Smoking during pregnancy increases the risk for several adverse perinatal outcomes including prematurity. Being born premature is the leading cause of death in newborns.[10] Those infants that do survive are at increased risk for developmental disabilities, cerebral palsy, vision and hearing loss, respiratory problems, and digestive problems. Small-for-gestational-age infants can be premature or full-term, and SGA infants who are born prior to 37 weeks run the same risks as premature infants. Full-term and post-term SGA infants have different health risks than premature infants, including perinatal asphyxia, hypoglycemia, and meconium aspiration which can cause lung injury and respiratory distress.

The health of women throughout their childbearing years should be addressed to improve perinatal outcomes.[11] Enhancing preconception health can improve pregnancy and birth outcomes. Programs are needed prior to conception to help women identify and modify risk factors associated with adverse birth outcomes. These programs can include weight management to help every woman achieve a healthy weight before becoming pregnant. Smoking cessation programs can also be implemented prior to pregnancy to help improve the health outcomes for the mother and her infant.

In Colorado, the Healthy Women-Healthy Babies Roundtable is working toward implementing the Centers for Disease Control and Prevention (CDC) Preconception Care Guidelines. The CDC Preconception Care Guidelines include 14 specific evidence-based prepregnancy interventions that can improve birth outcomes. Obesity control and smoking cessation are two important interventions included in the preconception care guidelines. In addition, the Women's Health Unit at the Colorado Department of Public Health and Environment (CDPHE) coordinates the Healthy Baby Campaign with a goal to reduce adverse pregnancy outcomes. The Healthy Baby Campaign incorporates a social marketing approach to address risk behaviors related to inappropriate weight gain; inadequate nutrition; and smoking before, during, and after pregnancy. The campaign currently bases pregnancy weight gain recommendations on the Institute of Medicine (IOM) pregnancy weight guidelines.

The Institute of Medicine (IOM) developed pregnancy weight guidelines in 1990 based on maternal prepregnancy BMI.

These guidelines are currently under reexamination in light of the changing patterns of prepregnancy BMI and weight gain.[12] The investigators are reviewing the emerging trends of maternal obesity as well as changes in race/ethnicity and age as it relates to childbirth. They are adopting a life-stage framework to evaluate the association of BMI and weight gain in pregnancy and how it is associated with not only maternal health outcomes, including postpartum weight retention, lactation performance, cardiovascular, metabolic, and other chronic diseases, but also child health outcomes, including consequences of low birth weight, consequences of obesity, and impacts of early development. The IOM plans to publish the new recommendations by June 2009. These new recommendations will help guide those in maternal and child health, including preconception health, with strategies toward optimizing maternal and perinatal outcomes.

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