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Jessica T. Bullard, MD Date

Obesity in Pregnancy and Mode of Delivery

By

Jessica T. Bullard, MD
Degree to be awarded: MPH

Epidemiology

_________________________________ Signature
Carol J. Rowland Hogue, PhD, MPH
Committee Chair

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M.A., The Ohio State University, 1994
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Thesis Committee Chair: Carol J. Rowland Hogue, PhD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Epidemiology
2011

Abstract

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OBJECTIVE: To estimate the effect of obesity on risk of cesarean delivery among pregnant women.

METHODS: Data were collected retrospectively from an electronic database that records antepartum and intrapartum medical information. Deliveries between January 2005 and January 2010 were used for analysis. Body mass index (BMI) was used as a measure of weight classification. Obese (BMI ≥30) pregnant women were compared to normal weight (BMI 20 to 24.9) pregnant women. Odds ratios for risk of cesarean delivery among both groups of pregnant women were estimated using multivariate logistic regression, adjusting for confounding variables.

RESULTS: Compared to women with a normal BMI, cesarean delivery is twice as likely as vaginal delivery in women with a BMI ≥ 30 (OR = 2.03, 95% C.I. 1.38 – 2.98, $p=0.0003$). Adjusting for maternal age, obese women remain at increased risk for cesarean section (OR = 1.91, 95% C.I. 1.30 – 2.82, $p=0.001$). Using multiple logistic regression analysis and controlling for maternal age, infant birth weight, Apgar score at 1 and 5 minutes, gestational age at time of delivery, and infant gender simultaneously, obese women are 1.83 times as likely as normal weight women to have a cesarean delivery (95% C.I. 1.19 – 2.79, $p=0.006$). We also show that as BMI increases, the risk of cesarean section increases in a dose response manner ($p=0.001$). Other factors associated with increased risk of cesarean delivery include maternal age ≥35 years (OR = 1.67, 95% C.I. 1.13 – 2.53, $p=0.01$) and neonatal Apgar score at 1 minute of life of 6 or less (OR = 2.01, 95% C.I. 1.15 – 3.52, $p=0.01$). Women who delivered female infants are less likely to undergo a cesarean section (OR = 0.67, 95% C.I. 0.48 – 0.95, $p=0.03$).

CONCLUSION: Obesity remains a significant risk factor for cesarean delivery. This risk increases as BMI increases.

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Introduction:

According to national data surveillance systems, the prevalence of obesity in the United States increased rapidly over the past three decades. [1] This increase was especially evident over the past 15 years as the number of U.S. adults considered obese increased from 23.2 % to 32.9%. Concomitantly, the prevalence of comorbid conditions, such as hypertension and diabetes, also rose. African American and Mexican American groups have shown the largest increases in the prevalence of obesity. Further, obesity is more common among women than men.

Obesity adversely affects obstetric outcomes in the gravid woman.[2-12] It has been shown that obese pregnant patients are at increased risk for developing gestational diabetes, gestational hypertension, preeclampsia, and cesarean delivery. [2-4,6,7,9-12] Other authors have also demonstrated a possible association between obesity and increased risks for fetal macrosomia, shoulder dystocia, and operative vaginal delivery. [4-6,9,10-11] Perlow further showed that obese women experienced an increased rate of emergency cesarean delivery as well as increased total operative time, increased blood loss, multiple epidural placements, increased infection, and prolonged hospitalization. [13]

The purpose of this study is to examine the effect of obesity on mode of delivery. It is postulated that obese women do not differ from normal weight women in the risk for cesarean delivery, even after controlling for various relevant factors.

Methods:

In a retrospective manner, data were sampled from the Mid Atlantic region of Kaiser Permanente's Health Connect system. This system corroborates relevant antepartum and intrapartum data using patient medical records, as well as patient report. The Kaiser Permanente supervising physician and clinical staff enter such data during antepartum care in the office throughout pregnancy, during the hospital course, and postpartum. The study period includes data from January 2005 through January 2010. The Institutional Review Board of Kaiser Permanente approved this study.

Obesity is defined as a body mass index (BMI) greater than or equal to 30. Overweight includes women whose BMI measures 25 to 29.9. A control group of normal weight individuals, BMI 20 to 24.9, is used for comparison. The main outcome variable of interest is mode of delivery: cesarean birth versus vaginal delivery. Other outcomes of interest include Apgar score at 1 and 5 minutes of life and birth weight. Possible confounders include maternal age, gestational age at time of delivery, and infant gender.

In an effort to optimize the validity of this study, the following exclusion criteria were applied: prior cesarean delivery, placenta previa, fetal malpresentation, multiple gestation, and missing data for variables of interest. All subjects had singleton gestations of at least 20 weeks gestational age and/or a fetus weighing at least 500 grams.

The X^2 or Fisher's exact test was used to compare categorical variables. Continuous variables were categorized for evaluation. Univariate and multivariate logistic regression models were applied to data in order to approximate crude and adjusted odds ratios between obesity and mode of delivery, accounting for various outcomes of interest as well. A *p*-value of $< .05$ represents statistical significance. Likelihood ratio testing was also used to establish a final model that exhibits greater precision and simplicity in predicting the outcome of interest. The Hosmer and Lemeshow Goodness of Fit test was applied to the final model for measurement of statistical significance.

Results:

Characteristics of all women included in the study are listed in Table 1. Data from 677 controls (vaginal deliveries) and 191 cases (cesarean deliveries) were included in the study. In this sample, patients who delivered by cesarean section differ significantly by maternal age, compared to women who delivered vaginally ($p=0.006$). Similarly, women who delivered by cesarean section differ significantly from women who experienced vaginal birth in their BMI ($p=0.0014$), infant birth weight ($p=0.02$), and Apgar score at 1 minute of life ($p=0.008$). Conversely, women who delivered by cesarean section do not differ significantly from women who delivered vaginally in their Apgar score at 5 minutes of life ($p=0.35$), gestational age at time of delivery ($p=0.06$), and infant gender (*p=0.06*). Fischer's exact test was used to calculate statistical significance in the evaluation of Apgar score at 5 minutes due to a single small cell number.

In a crude analysis of the data provided (Table 2), it is shown that women 35 years of age and older are 1.75 times as likely to undergo cesarean section compared to women ages 20 to 34 years of age (95% C.I. 1.20 – 2.54, *p=0.003*). Further, during crude evaluation of the data studied, women with a BMI ≥ 30 are twice as likely to deliver by cesarean section, compared to women with a normal BMI (OR = 2.03, 95% C.I. 1.38 – 2.98, *p=0.0003*). This association between BMI and mode of delivery, while adjusting for maternal age, similarly indicates an increased risk of cesarean section among obese women (OR = 1.91, 95% C.I. 1.30 – 2.82, *p=0.001*). Based on the non-significant Breslow–Day test statistics, maternal age does not appear to be an effect modifier of the crude or age adjusted association between BMI and mode of delivery in this study sample. Further, since the odds ratio for obesity adjusted for age is less than 10% different from the crude odds ratio, age does not seem to confound the BMI/mode of delivery association. While adjusting for maternal age, there is evidence that as a woman's BMI increases, she is more likely to experience a cesarean delivery (*p=0.004*).

The association between the Apgar score assigned at 1 minute of life and mode of delivery demonstrates an increased risk of cesarean delivery among infants with a score of 6 or less. Compared to infants with a score of 7 or greater at 1 minute of life, those with a score of 6 or less are almost twice as likely to be delivered by cesarean birth (OR = 1.93, 95% C.I. 1.15 – 3.23, *p=0.01*). Although there is a suggestion for a similar association for an Apgar score at 5 minutes of life, evaluation of this finding does not yield statistical significance. Similarly, the association between gender and mode of delivery is not statistically significant.

Using a birth weight of ≥2500 grams but less than 4500 grams as a reference, babies measuring low birth weight (<2500 grams) are 1.82 times as likely to be born by cesarean section (95% C.I. 1.03 – 3.23, $p=0.04$). A similar association between women delivering infants who weigh at least 4500 grams is not statistically significant. Age does not appear to be an effect modifier or confounder of this association. While there appears to be a suggestion of an increased risk of cesarean delivery among women who deliver both post dates and/or preterm, there is no statistically significant association established in the data studied. Again, age does not confound or interact with this association.

Table 3 illustrates the association between BMI and mode of delivery while controlling for various characteristics. Controlling for birth weight, obese women are 1.96 times as likely to have a cesarean birth compared to women with a normal BMI (95% C.I. 1.33 – 2.88, $p=0.0006$). The risk of cesarean delivery is greater among obese women when adjusting for Apgar score at 1 minute of life (OR = 1.96, 95% C.I. 1.33 – 2.88, $p=0.0006$) as well as Apgar score at 5 minutes of life (OR = 2.01, 95% C.I. 1.37 – 2.95, $p=0.0003$). While controlling for infant gender, obese women are again at increased risk for cesarean birth (OR = 2.14, 95% C.I. 1.43 – 3.19, $p=0.0002$). Women with a BMI consistent with obesity are almost two times as likely to undergo cesarean birth when adjusting for gestational age (95% C.I. 1.28 – 2.84, $p=0.001$).

Based on uniformly non significant Breslow-Day test for homogeneity p-values, there is no argument for effect modification of any of these variables in the relationship between BMI and mode of delivery. Moreover, the adjusted odds ratios in each instance are within 10% of the crude odds ratio. Therefore, confounding by each variable considered individually is not likely. As well, a single odds ratio is sufficient to describe the studied relationship among each stratum of the controlled variable. There is evidence of a dose response in the relationship between BMI and mode of delivery while controlling for each variable. As body mass index increases from normal to overweight to obese, the risk of cesarean delivery increases.

Since all variables under study were considered *a priori* to be potential confounders, we included them in the multivariate analysis. Using multiple logistic regression analysis and controlling for all variables simultaneously (Table 4), it is shown that obese women are 1.83 times as likely as normal weight women to undergo a cesarean delivery (95% C.I. 1.19 – 2.79, $p=0.006$). With similar adjustment of selected variables, women of advanced maternal age ($\geq$ 35 years of age) experience cesarean birth more often than women between the ages of 20 and 34 years (OR = 1.69, 95% C.I. 1.13 – 2.55, $p=0.001$). When considering the relationship between birth weight and mode of delivery, there is no statistically significant association demonstrated that indicates increased risk of cesarean delivery. Similarly, no statistically significant association exists between gestational age and mode of delivery. While controlling for all factors considered in the study, women who delivered female infants are more likely to complete a vaginal birth

(OR = 0.68, 95% C.I. 0.48 – 0.97, $p=0.03$). Babies with an Apgar score at 1 minute of life of 6 or less are more likely to be born via cesarean compared to those with an Apgar score of at least 7 (OR = 1.99, 95% C.I. 1.08 – 3.68, $p=0.03$).

Data were evaluated for possible interaction with the relationship between BMI and mode of delivery among selected independent variables (Table 5). There is no observable effect modification between BMI and age in predicting the mode of delivery ($p=0.5453$). The relationship between BMI and mode of delivery is not modified by birth weight ($p=0.9665$). Neither is there interaction of gestational age ($p=0.2177$), Apgar score at 1 minute of life ($p=0.6212$), or infant gender ($p=0.3495$) with the association between BMI and mode of delivery.

Likelihood ratio testing was used to eliminate non-significant terms from a fully adjusted model that included all main effect terms. By creating a parsimonious model, simplicity and greater precision of the measurement of effect is achieved. The following main effect terms were removed from the fully adjusted model using backward elimination: Apgar score at 5 minutes of life ($p=0.53$), birth weight ($p=0.28$), and gestational age ($p=0.25$). The remaining most parsimonious model included the main exposure variable (BMI), maternal age, infant gender, and Apgar score at 1 minute of life. Taking these factors into account simultaneously, an obese woman is 1.86 times as likely to undergo a cesarean section compared to women of normal BMI (95% C.I. 1.22 – 2.84, $p=0.004$). In fact, as a woman's weight increases, her risk of a cesarean delivery increases in a dose response manner ($p=0.001$). Older women ($\geq$35 years of age) are 1.67

times as likely to deliver by cesarean section compared to women ages 20 to 34 years (95% C.I. 1.13 – 2.53, *p=0.01*). In this study sample, women who delivered female infants are less likely to have a cesarean delivery compared to their counterparts who delivered male infants (OR = 0.67, 95% C.I. 0.48 – 0.95, *p=0.03*). Babies with Apgar scores at 1 minute of life that are less than or equal to 6 are more likely to be born via cesarean section (OR = 2.01, 95% C.I. 1.15 – 3.52, *p=0.01*). The Goodness of Fit test statistic for the fully adjusted model is 0.9538. The most parsimonious model, as well as the similar final model, has a Goodness of Fit test statistic of 0.8826, indicating statistical significance.

Discussion:

Consistent with much of the literature, obese women in this study population were more likely to undergo cesarean delivery compared to normal weight women. [12, 14-15] While data from this study reflect a two fold increase in cesarean delivery among the obese population, Crane et al demonstrated a 1.5 fold increased risk of cesarean delivery among obese women.[14] Similarly, Kaiser et al showed that women in a low risk population were 2 times more likely to deliver by cesarean section if they were obese compared to women of normal BMI.[15] In a prospective multicenter study, Weiss et al also showed that morbidly obese women, compared to women with a BMI <30, were more likely to deliver by cesarean section.[12] He also showed that both obese and morbidly obese women were more likely to have pregnancies affected by gestational diabetes, gestational hypertension, preeclampsia, and macrosomia.

The process of labor poses stress on the fetus. Fetal heart rate is typically continuously monitored throughout the process of labor using electronic fetal monitoring. Signs of fetal distress are evident as fetal heart rate decelerations, loss of beat to beat variability in the fetal heart rate, as well as changes in the baseline fetal heart rate. [16] When attempts to recover a distressed fetus by intrauterine resuscitation are not successful, expedited delivery is warranted. Sheiner et al demonstrated that abnormal fetal heart rate patterns during the second stage of labor are significantly associated with higher rates of operative delivery compared to patients with normal tracings.[17] In this study, the group of patients with abnormal fetal heart rate patterns also had significantly higher percentages of Apgar scores lower than seven at one minute.

Infants born via cesarean section also often experience a period of transient tachypnea of the newborn.[18] Compared to their counterparts who are delivered vaginally, these infants are not generally subjected to the beneficial compression and recoil of the chest wall during the birthing process. Additionally, babies delivered vaginally expel a moderate amount of amniotic fluid from the trachea after delivery of the fetal head. In contrast, during cesarean delivery, amniotic fluid is more likely retained in the neonate's upper respiratory tract due to lack of vaginal squeeze on the neonate's chest wall.[18] The adjustment period required for initiation of pulmonary function in babies delivered by cesarean section is thus often reflected as respiratory distress in the neonate.[19] It is also plausible that the prolonged operative time from skin incision to delivery of the infant in obese patients further decreases the initial Apgar score.

Although not statistically significant, there is a suggestion that compared to infants who weigh between 2,500 grams and 4,499 grams, infants who weigh more than 4,500 grams are more often delivered by cesarean section. Among women with diabetes, a fetus with an estimated fetal weight of at least 4,500 grams is considered suspicious for macrosomia. However, for women not affected by diabetes, a suspicion for macrosomia occurs at a higher threshold of 5,000 grams. Women exceeding these weights by ultrasound in the antepartum period may be offered elective cesarean delivery in lieu of a trial of labor. Thus, there is likely an interaction between the prevalence of diabetes in pregnancy and the relationship between birth weight and mode of delivery. When adjusting for age alone, women with infants weighing less than 2,500 grams also tend to undergo cesarean delivery. Babies that are smaller for gestational age often experience fetal intolerance to labor. They typically require more expedited delivery, usually via cesarean section. Male infants tend to weigh more than female infants. The increased risk of cesarean section among male infants demonstrated in the study may be indirectly related to their increased weight.

The reported cesarean section rate in this study is 29%. This compares favorably to the average rate of cesarean delivery of at least 35% in most community hospitals. [20] Patients included in this study are part of a managed care organization. Labor management under this specific organization is typically performed by an “in house” physician completing shift work. In this management setting, it is less likely that cesarean sections are performed for physician convenience. This may be reflected as a decreased cesarean section rate but should apply across all BMI categories and therefore not bias these results.

As previously discussed, confounding was evaluated by comparing the crude and adjusted measures of association between obesity and mode of delivery for each variable. None of the variables studied appear to have a confounding effect on this relationship. This is true for both stratified and logistic regression analyses. However, the main limitation of this study is lack of consideration of additional confounding factors. The incidence of cesarean delivery is increased among women with preeclampsia/eclampsia, placental abruption, and both pregestational diabetes and uncontrolled gestational diabetes. [12] Because these factors are also increased among obese women, an analysis of the relationship between obesity and cesarean section should include adjustment for each of these possible confounders. We attempted to control for this by limiting analysis to women without these complications, but some missed diagnoses may have occurred and may have biased the results away from the null hypothesis. Although age is intended to serve as a proxy for parity, the influence of increased adverse obstetric outcomes among women of advanced maternal age, such as cesarean delivery, distorts this function. Finally, BMI was measured during pregnancy. This may lead to misclassification error; women who were really underweight may be classified as normal and women who were really overweight or on the high end of normal may be classified as obese. The prevalence of obesity in this study sample, however, reflected the similar national population prevalence of obesity of about 30%. Because weight gain in pregnancy differs for each woman, perhaps a more appropriate measure for comparison across studies may be pregestational BMI.

Overweight and obesity can lead to increased morbidity and mortality. The primary means of decreasing adverse health outcomes is prevention. Before pregnancy is achieved, overweight and obese women should be counseled regarding weight loss and improvement of other health issues. Too often, obesity is not directly addressed during health care encounters. In fact, weight loss advice is given to obese patients only half the time by physicians who function in a primary care capacity.[21] In the overweight and obese gravid woman, surveillance for known pregnancy complications associated with increased BMI is essential. In addition to discussing optimal weight gain in pregnancy, consideration should be given to early glucose tolerance screening, appropriate screening for comorbid medical conditions, nutrition consult, deferral of anatomy scan to at least 20 weeks gestational age for optimal visualization, anesthesia consult, antithrombotic precautions, and more frequent prenatal visits to monitor for pregnancy related complications.[21-24]

Given the proven increased risk of cesarean delivery among obese women, future studies on this topic should be directed toward consideration of decreasing perioperative complications in this group. Investigation of antibiotic use as well as skin closure techniques, therapeutic interventions for placenta accreta, and coordinated use of multidisciplinary resources must be further performed. Well designed, prospective studies may help identify other risk factors that may be used to implement interventions for improved obstetric outcomes among obese patients.

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Table 1. Characteristics of pregnant women who delivered by cesarean section and pregnant women who delivered by vaginal route. MidAtlantic States, 2005-2010.

Characteristic	Controls^		Cases†			
	n=677	%	n=199	%	X^2 (d.f.)*	p-value
Maternal age						
15 - 19	29	85.3	5	14.7		
20 - 34	530	79	140	20.9		
≥35	117	68.4	54	31.6	10.15 (2)	0.006
Missing	*1*					
BMI						
20 - 24.9	291	82.7	61	17.3		
25 - 29.9	207	77	62	12		
≥30	179	70.2	76	29.8	13.13(2)	0.0014
Birthweight (g = grams)						
≤2500 g	40	66.7	20	33.3		
2501 - 4499 g	629	78.4	173	21.6		
≥4500 g	8	57.1	6	42.9	7.68 (2)	0.02
Apgar score at 1 minute						
Low (≤6)	47	64.4	26	35.6		
Normal (≥7)	630	78.5	173	21.5	7.55 (1)	0.008
Apgar score at 5 minutes						
Low (≤6)	11	68.8	5	31.3		
Normal (≥7)	666	77.4	194	22.6		0.3785 ‡
Gestational age (weeks)						
32 - 36	13	61.9	8	38.1		
37 - 40	566	78.5	155	21.5		
≥41	46	69.7	20	30.3	5.61 (2)	0.06
Missing	52		*16*			
Infant Gender						
Female	317	79.1	84	20.9		
Male	296	73.4	107	26.6		0.06

* Chi-square test, d.f.= degrees of freedom

‡ Fischer's exact test 2 tailed probability

† Case = cesarean delivery

^ Control = vaginal delivery

Table 2. Unadjusted and age-adjusted associations of characteristics of pregnant women who delivered by cesarean section. MidAtlantic States, 2005 - 2010.

Characteristics	Crude			Age Adjusted			
	Odds ratio	95% C.I.*	X^2 p-value†	Odds Ratio	95% C.I.*	heterog. p-value‡	X^2 p-value†
Age (years)							
15-19	0.65	(.25 - 1.72)	0.39				
20-34	1						
≥35	1.75	(1.20-2.54)	0.003				
BMI							
20 - 24.9	1			1			
25 - 29.9	1.43	(0.96-2.12)	0.08	1.4	(0.94-2.08)	0.2476	0.1
≥30	2.03	(1.38-2.98)	0.003	1.91	(1.30-2.82)	0.256	0.001
				Trend p-value 0.004			
Apgar score at 1 minute							
Low (≤6)	2.02	(1.21-3.35)	0.007	1.93	(1.15-3.23)	0.4469	0.01
Normal (≥7)	1			1			
Apgar score at 5 minutes							
Low (≤6)	1.56	(0.54-4.55)	0.41	1.46	(0.49-4.36)	0.2416	0.51
Normal (≥7)	1			1			
Birthweight (g = grams)							
≤2500 g	1.82	(1.04-3.19)	0.04	1.82	(1.03-3.23)	0.2805	0.04
2501 - 4499 g	1			1			
≥4500 g	2.73	(0.93-7.96)	0.07	2.65	(0.91-7.70)	0.4251	0.5
Gestational age (weeks)							
32-36	2.25	(0.92-5.52)	0.08	2.15	(0.85-5.45)	0.4288	0.11
37-40	1			1			
≥41	1.59	(0.91-2.76)	0.1	1.6	(0.91-2.80)	0.6884	0.1
Gender							
Female	0.73	(0.53-1.02)	0.06	0.73	(0.53-1.02)	0.3245	0.06
Male	1			1			

† Chi-square p-value

*C.I. Confidence interval

‡ Breslow-Day test for heterogeneity of odds ratio

Table 3. Association of BMI with cesarean section among pregnant women, controlling for various characteristics. MidAtlantic States, 2005 - 2010.

Adjusted for	BMI[¶]	Odds Ratio	95% C.I. *	X^2 *p-value*	Heterog. p-value[‡]	Trend p-value[†]
Nothing (Crude)	Normal	1				
	Overweight	1.43	(1.43-2.12)	*0.08*	0.077	
	Obese	2.03	(1.38-2.98)	*0.0003*	0.0003	0.0003
Age	Normal	1				
	Overweight	1.4	(0.94-2.08)	*0.1*	0.2476	
	Obese	1.91	(1.30-2.82)	*0.001*	0.256	0.0009
Birth weight	Normal	1				
	Overweight	1.44	(0.97-2.14)	*0.07*	0.9579	
	Obese	1.96	(1.33-2.88)	*0.0006*	0.8585	0.0029
Apgar score at 1 minute	Normal	1				
	Overweight	1.4	(0.94-2.09)	*0.09*	0.9339	
	Obese	1.96	(1.33-2.88)	*0.0006*	0.8573	0.0006
Apgar score at 5 minutes	Normal	1				
	Overweight	1.43	(0.96-2.13)	*0.07*	0.3686	
	Obese	2.01	1.37-2.95)	*0.0003*	0.0696	0.0003
Infant gender	Normal	1				
	Overweight	1.46	(0.97-2.19)	*0.07*	0.2139	
	Obese	2.14	(1.43-3.19)	*0.0002*	0.7573	0.0002
Gestational age	Normal	1				
	Overweight	1.38	(0.91-2.08)	*0.13*	0.2134	
	Obese	1.9	1.28-2.84)	*0.001*	0.0656	0.0057

[¶] Normal (20-24.9), Overweight (25 - 29.9), Obese (≥30)

* Confidence Interval

[‡] Breslow-Day test for homogeneity of odds ratio

[†] Test for trend (Mantel extension)

Table 4. Adjusted logisitic regression analysis of odds ratios of various characteristics among normal weight, overweight, and obese women. MidAtlantic States, 2005-2010.

Characteristic	Logistic regression analysis Adjusted		
	Odds Ratio	95% C.I.†	*p-value* ‡
Body Mass Index			
Normal (20-24.9)	1		
Overweight (25-29.9)	1.36	(0.88 - 2.08)	*0.16*
Obese (≥30)	1.83	(1.19 - 2.79)	*0.006*
Age (years)			
15-19	0.95	(0.34 - 2.60)	*0.91*
20-34	1		
≥35	1.69	(1.13 - 2.55)	*0.001*
Birthweight (g=grams)			
≤2500 g	0.91	(0.33 - 2.54)	*0.86*
2501-4499 g	1		
≥4500 g	2.48	(0.80 - 7.61)	*0.11*
Gestational age (weeks)			
32-36	1.67	(0.47 - 5.95)	*0.43*
37-40	1		
≥41	1.55	(0.86 - 2.77)	*0.14*
Infant gender			
Female	0.68	(0.48 - 0.97)	*0.03*
Male	1		
Apgar at 1 minute			
≤6	1.99	(1.08 - 3.68)	*0.03*
≥7	1		
Apgar at 5 minutes			
≤6	0.65	(0.17 - 2.49)	*0.53*
≥7	1		

ADJUSTED MODEL: logit (P(D=1 | BMI,Age,BW, GA, Gender, A1, A5) = b_0 + (0.6013*BMI1) + (0.3039*BMI2) + (0.5270*Age1) + (-0.0562*Age2) + (0.9062*BW1) + (-0.0894*BW2) + (0.5143*GA1) + (0.4356*GA2) + (-0.3818*Gender) + (0.6888*A1) + (-0.4245*A5)

† Confidence Interval

‡ Wald Chi-square Test

Table 5. Adjusted[¶] odds ratios for BMI and mode of delivery:evaluation of various effect modifiers.MidAtlantic States, 2005 - 2010.

Interaction with	BMI Odds Ratios, Compared to Reference Group			
	Obese:Normal		Overweight:Normal	
	OR	95% C.I.[†]	OR	95% C.I.[†]
No interaction	1.83	(1.19-2.79)	1.36	(0.88-2.08)
Age (years)				
15-19	3.6	(0.16-79.71)	5.95	(0.50-70.95)
20-34	1.54	(0.94-2.53)	1.15	(0.70-1.89)
≥35	2.89	(1.18-7.13)	1.95	(0.76-4.99)
homogeneity p-value = 0.5453[‡]				
Birth weight (g=grams)				
≤2500 g	1.25	(0.21-7.39)	0.69	(0.06-8.23)
2501 - 4499 g	1.83	(1.18-2.86)	1.4	(0.90-2.17)
≥4500 g	2.61	(0.15-44.73)	1	(0.03-29.87)
homogeneity p-value = 0.9665[‡]				
Gestational age (weeks)				
32-36	0.15	(0.01-1.65)	0.24	(0.02-3.65)
37-40	2.08	(1.32-3.28)	1.28	(0.86-2.20)
≥41	1.24	(0.30-5.18)	1.9	(0.52-6.98)
homogeneity p-value = 0.2177[‡]				
Apgar score at 1 minute				
≥6	1.23	(0.34-4.74)	1.61	(0.41-6.31)
≥7	1.93	(1.23-3.02)	1.33	(0.84-2.09)
homogeneity p value = 0.6212[‡]				
Apgar score at 5 minutes				
≥6	NS*		NS*	
≥7	NS*		NS*	
Gender				
Female	1.92	(1.09-3.38)	1.08	(0.61-1.92)
Male	1.77	(0.92-3.40)	1.8	(0.94-3.45)
homogeneity p-value = 0.3495[‡]				

[¶] Models include BMI, maternal age, birth weight, gestational age, Apgar score at 1 minute and 5 minutes, and infant gender.

[‡] Homogeneity p-value is from the Wald chi-square test for the significance of the combined cross-product terms.

* Association statistically nonsignficant

[†] Confidence Interval

Table 6. Logistic regression summary: most parsimonious and final models.
BMI and risk of cesarean delivery. MidAtlantic States, 2005 - 2010.

	Most Parsimonious Model			**Final Model**		
	OR*	95% C.I.^	*Wald p-value* †	OR*	95% C.I.^	*Wald p-value* †
BMI						
20-24.9	1			1		
25-29.9	1.36	(0.89-2.09)	0.16	1.36	(0.89-2.09)	0.16
≥30	1.86	(1.22-2.84)	0.003	1.86	(1.22-2.84)	0.003
	trend ‡	*p=0.0011*		*trend* ‡	*p=0.0011*	
Age (years)						
15-19	0.94	(0.35-2.56)	0.91	0.94	(0.35-2.56)	0.91
20-34	1			1		
≥35	1.69	(1.13-2.53)	0.01	1.69	(1.13-2.53)	0.01
Apgar score at 1 minute						
≤6	2.01	(1.15-3.52)	0.01	2.01	(1.15-3.52)	0.01
≥7	1			1		
Gender						
Female	0.67	(0.48-0.95)	0.03	0.67	(0.48-0.95)	0.03
Male	1			1		
	HL GOF test¶: 0.9538			HL GOF test¶: 0.8826		

* Odds Ratio
^ Confidence Interval
† Wald p-value = chunk test for overall significance
‡ Test for trend: significance of beta for an ordinal variable
¶ Hosmer-Lemeshow Goodness of Fit test