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Gestational weight gain and obstetric outcomes in women with obesity in an inner-city population

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Abstract

Objectives: To describe maternal and perinatal outcomes in patients with BMI ≥30 kg/m^2 by BMI class and gestational weight gain.

Methods: Retrospective review of singleton pregnancies with pre-pregnancy BMI ≥30 kg/m^2 who received care at our institution between January 1, 2016 and December 31, 2021. Patients were divided into three categories based on BMI (kg/m^2): Class I (BMI 30.0–34.9), Class II (BMI 35–39.9), and Class III (BMI≥40) obesity. For gestational weight gain analysis, pregnancies were stratified into three groups: <11 pounds, 11–20 pounds, and >20 pounds. Maternal demographics and outcomes were compared using chi-square analysis, analysis of variance, nonparametric tests, and multivariable regression analysis.

Results: Of 641 patients included, 299 (46.6 %) were in Class I, 209 (32.6 %) in Class II, and 133 (20.7 %) in Class III. Readmission within 6 weeks postpartum, the only outcome found to have a significant difference between BMI categories, was higher in the Class III group (p=0.01). One hundred sixty-two (25.3 %) patients gained <11 pounds, 164 (25.6 %) gained 11–20 pounds, and 313 (48.8 %) gained ≥20 pounds. Greater gestational weight gain was associated with increased rates of cesarean delivery (p<0.001), higher quantitative blood loss (p=0.006), longer length of hospitalization (p=0.03), and higher birthweights (p<0.001).

Conclusions: This represents a unique and actionable opportunity for clinicians to counsel and support their patients in adhering to optimal weight gain targets throughout their pregnancy. Future studies are needed to determine the optimal gestational weight gain recommendations for obese patients.

Keywords: blood loss; body mass index; cesarean delivery; gestational weight gain; postpartum readmission; severe obesity

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Introduction

The growing prevalence of obesity in the United States continues to be a major population health concern [1]. According to the most recent National Health and Nutrition Examination Survey (2017–2020), 27.5 % of women were overweight (Body Mass Index [BMI] of 25.0–29.9 kg/m^2), 41.9 % were obese (BMI≥30 kg/m^2), and 11.5 % were severely obese (BMI≥40 kg/m^2), with 56.9 % of non-Hispanic Black women being obese [2]. Additionally, a recent study projected that in 2030 nearly 1 in 2 adults will have obesity, and severe obesity (BMI≥35 kg/m^2) is likely to become the most common BMI category among women in the United States [3]. It has been well established that pre-pregnancy obesity significantly increases both maternal and fetal morbidity and mortality [4–7]. The adverse pregnancy outcomes for patients with obesity include an increased risk of spontaneous abortion, recurrent miscarriage, fetal growth abnormalities, and stillbirth [7–16]. Maternal complications include but are not limited to an increased risk of gestational diabetes mellitus, preeclampsia, thrombotic events, cardiac dysfunction, higher rates of cesarean delivery, and cesarean wound infection [2–12].

Much of the research currently available uses a single category of “obesity” for all women with a BMI ≥30 kg/m^2. The Institute of Medicine (IOM) guidelines state that for people with a singleton pregnancy with a pre-pregnancy BMI ≥30 kg/m^2, total weight gain should equal 11–20 pounds. However, this recommendation does not differ based on class of obesity due to limited data on weight gain and associated outcomes across BMI severities [17].

It has been suggested that weight gain should be personalized based on class of obesity to reduce the risk of having small and large neonates for gestational age, preeclampsia, and cesarean delivery [6]. Marshall et al. showed a “dose-dependent” relationship between degree of obesity and perinatal and maternal outcomes [8]. They found that pregnant people with extreme obesity (BMI≥50 kg/m^2) carry a significantly higher disease burden and tend to have worse perinatal and maternal outcomes when compared to those with “obesity” (BMI 30.0–39.9 kg/m^2), and “morbid obesity” (BMI 40–49.9 kg/m^2) [8]. This suggests that the current classification of “obesity” without further subclassification is an oversimplification. Understanding the relationship between pre-pregnancy BMI and adverse maternal and fetal perinatal outcomes is critical to adequately caring for and providing specific weight gain recommendations for this group of patients. The goal of this study is to evaluate maternal and perinatal outcomes by pre-pregnancy BMI and gestational weight gain in patients with a pre-pregnancy BMI ≥30 kg/m^2 in an inner-city population.

Materials and methods

Patient population

The study included all pregnant patients with a pre-pregnancy BMI ≥30 kg/m^2 who received prenatal care at Saint Francis Hospital and Medical Center (SFHMC) obstetrics and gynecology clinic and affiliated offices between January 1, 2016 and December 31, 2021. All patients delivered at SFHMC in Hartford, CT, and were identified using the electronic medical record system Epic (Verona, WI) using ICD-10 codes for obesity (O99.21-, O99.21-E66.01). Patients with a singleton gestation who presented for their first prenatal visit before 13 weeks’ gestation were included to reduce bias in outcomes that may result from a patient being late to prenatal care. Only patients who delivered at ≥37 weeks’ gestation were included to reliably quantify total weight gain during a typical pregnancy. Pregnancies with multiple gestation, maternal age <18 or >50 years, preterm delivery, and fetal chromosomal or congenital anomalies were excluded. Pre-pregnancy weight was recorded as a known pre-pregnancy weight or weight recorded at the initial prenatal visit. BMI was calculated using weight divided by height in meters squared. Gestational weight gain was calculated based on the difference between weight at initial prenatal visit and weight at delivery.

Study design

We performed a retrospective chart review of the electronic medical record to extract information on patient demographics, pre-pregnancy medical conditions, and obstetric outcomes. Patient information included age, race, insurance, pre-pregnancy BMI, total weight gain in pregnancy, gravidity and parity, history of preterm delivery and self-reported smoking status. Pre-pregnancy medical conditions that were recorded included psychiatric illness, drug abuse, chronic hypertension, diabetes, sleep apnea, cardiac disease, venous thrombosis, and prior bariatric surgery. Maternal outcomes that were recorded included development of hypertensive disorders of pregnancy, gestational diabetes, induction of labor, gestational age at delivery, mode of delivery, quantitative blood loss, and postpartum complications including postoperative wound infection, thromboembolic events, intensive care unit (ICU) admission, and readmission within 6 weeks postpartum. Perinatal outcomes included birth weight, Apgar score <7 at 5 min, stillbirth, macrosomia, shoulder dystocia, and neonatal intensive care unit (NICU) admission. The Institutional Review Board of Trinity Health of New England approved this study, IRB reference no. SFH 22-04.

Statistical analyses

The objective of this study was to assess obstetric and perinatal outcomes in obese women by obesity class and gestational weight gain. For this analysis, patients were divided into three categories based on pre-pregnancy BMI (kg/m^2): Class I (BMI 30.0–34.9), Class II (BMI 35–39.9), and Class III (BMI>40) obesity based on the World Health Organization obesity categorization [18]. For the gestational weight gain analysis, pregnancies were stratified into three groups based on the IOM weight gain recommendations: <11 pounds, 11–20 pounds, and >20 pounds [18]. Maternal demographics, medical history, and obstetric outcomes of the three BMI classes, and of the three weight gain groups, were compared using chi-square analysis, analysis of variance (ANOVA), and nonparametric tests where appropriate. Specifically, maternal age, gestational age at initial visit and birth, and birth weight were compared among the three BMI classes using ANOVA. Total weight change, hospital length of stay and quantitative blood loss were compared using the non-parametric Kruskal–Wallis test. All other variables were compared using chi-square tests. Multivariate models, which included both BMI class and gestational weight gain group, examined the relationship between obstetrical outcomes (cesarean delivery, hospital readmission, and birth weight). Covariates considered were maternal age, gestational age at delivery, any hypertensive disease (gestational hypertension, preeclampsia, severe preeclampsia, and superimposed preeclampsia), gestational diabetes, and birth weight. Final models included only covariates with significance <0.15. Logistic regression models were used for cesarean delivery (Y/N) and readmission to hospital within 6 weeks of giving birth. A linear regression was used for birth weight. All statistical tests were 2-sided and p<0.05 was considered statistically significant. All analyses were performed using SAS statistical software version 9.4 (SAS Institute, Cary, NC).

Results

Baseline characteristics

Of the 3,677 patients that were screened, 1,317 were excluded based on a pre-pregnancy BMI <30 kg/m^2 and 1,719 were excluded for not meeting the inclusion criteria. Six hundred forty-one patients were included in the final analysis (Figure 1). Their average maternal age was 29.5 years. Most of the patients were Black or African American (43.4 %), followed by other (31.4 %), and White (20.7 %). Government insurance was the most common type of insurance in our study, with 493 (76.9 %) of patients on government insurance, 136 (21.2 %) patients on private insurance, and 12 (1.9 %) patients uninsured.

Table 1 presents the baseline characteristics of the population by obesity classes. There were 299 (46.6 %) patients in the Class I obesity group, 209 (32.6 %) in Class II, and 133 (20.7 %) in Class III. There were differences in obesity class by race (p<0.001) and ethnicity (p=0.006). African American patients accounted for 54.1 % of the Class III group compared to 40.2 % of Class I and II groups. In contrast, Latinx women accounted for 45 % of Class II compared to approximately one-third of Class I and III groups. Otherwise, there were no statistically significant differences among obesity classes in maternal age, gravidity, parity, history of spontaneous abortion, medical insurance, or gestational age at initial prenatal visit (Table 1). Mean weight change was highest for the Class I group and least for the Class III group (p<0.001). The prevalence of chronic hypertension (p=0.009), cardiac disease (p=0.01), and sleep apnea (p=0.01) was greater in the higher obesity categories. There were no significant differences in the prevalence of psychiatric illness, drug abuse, diabetes mellitus, prior venous thromboembolism, or history of bariatric surgery among obesity classes (Table 1).

Table 2 presents the baseline characteristics of the population by gestational weight gain. One hundred sixty-two (25.4 %) patients gained <11 pounds, 164 (25.7 %) gained 11–20 pounds, and 313 (49.0 %) gained ≥20 pounds. When groups were compared based on weight gain during pregnancy, patients in the 11–20 pounds group were older (p=0.001), and there were fewer White patients in the <11 pounds group (p=0.03) compared to the other groups. Additionally, amount of weight gain varied by gravidity (p=0.002).

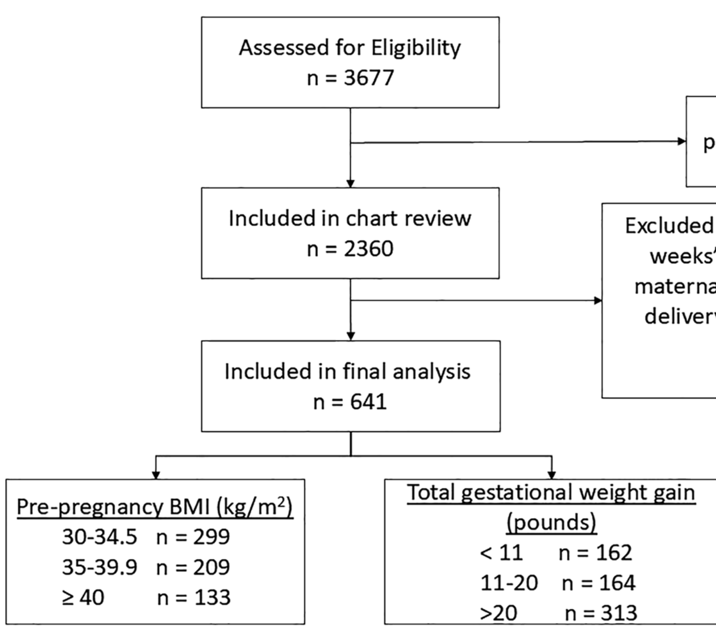

Figure 1: Flow diagram of patient population.

Table 1: Maternal characteristics and medical history by obesity classes.

Body mass index, kg/m^2	30–34.9	35–39.9	≥40	p-Value
Number	299	209	133	
Maternal age, years	29.7 ± 5.9	29.5 ± 5.9	29.3 ± 5.7	0.75
Latinx	94 (31.4)	94 (45)	45 (33.8)	0.006
Race				<0.001
Asian	14 (4.7)	0	0	
African American	124 (41.5)	82 (39.2)	72 (54.1)	
White	70 (23.5)	42 (20.1)	21 (15.8)	
Multi	9 (3.0)	4 (1.9)	1 (0.8)	
Other	81 (27.2)	81 (38.8)	39 (29.3)	
Gravida				0.65
1–2	132 (44.2)	86 (41.2)	53 (39.9)	
3+	167 (55.9)	123 (58.9)	80 (60.2)	
Nulliparous	103 (34.5)	57 (27.3)	34 (25.6)	0.09
Spontaneous abortions				0.24
0	206 (32.1)	134 (20.9)	95 (14.8)	
1	59 (9.2)	57 (8.9)	27 (4.2)	
2+	34 (5.3)	18 (2.8)	11 (1.7)	
Insurance				0.17
None	6 (2.0)	5 (2.4)	1 (0.8)	
Private	75 (25.1)	38 (18.2)	23 (17.3)	
Government	218 (72.9)	166 (79.4)	109 (82.0)	
Initial prenatal visit, weeks	8.4 ± 2.9	8.4 ± 2.3	8.7 ± 2.2	0.62
Weight change, pounds	24.2 ± 15.7	20.1 ± 14.9	15.2 ± 17.2	<0.001
Psychiatric illness	76 (25.4)	53 (25.4)	33 (24.8)	0.99
Drug abuse	31 (10.4)	32 (15.3)	10 (7.5)	0.07
Chronic hypertension	21 (7.0)	25 (12.0)	22 (16.5)	0.009
Diabetes mellitus	9 (3.0)	8 (3.8)	10 (7.5)	0.09
Cardiac disease	3 (1.0)	6 (2.9)	8 (6.0)	0.01
Sleep apnea	2 (0.7)	1 (0.5)	5 (3.8)	0.01
Venous thromboembolism	2 (0.7)	1 (0.5)	1 (0.8)	0.94
Bariatric surgery	9 (3.0)	6 (2.9)	6 (4.5)	0.67

Data are expressed as mean ± standard deviation and number (%) where applicable.

Table 2: Maternal characteristics and medical history by gestational weight gain.

Gestational weight gain, pounds	<11	11–20	>20	p-Value
Number	162	164	313	
Maternal age, years	29.1 ± 5.8	31.0 ± 6.0	29.1 ± 5.7	0.001
Latinx	63 (38.9)	55 (33.5)	114 (36.4)	0.60
Race				0.03
Asian	4 (2.5)	7 (4.3)	3 (1.0)	
African American	73 (45.1)	71 (43.3)	133 (42.6)	
White	22 (13.6)	36 (22.0)	75 (24.0)	
Multi	3 (1.9)	1 (0.6)	10 (3.2)	
Other	60 (37.0)	49 (29.9)	91 (29.2)	
Gravida				0.002
1–2	52 (32.1)	66 (40.2)	152 (48.6)	
3+	110 (67.9)	98 (59.8)	161 (51.4)	
Nulliparous	30 (18.5)	40 (24.4)	123 (39.3)	<0.001
Spontaneous abortions				0.34
0	107 (16.7)	108 (16.9)	218 (34.1)	
1	43 (6.7)	35 (5.5)	65 (10.2)	
2+	12 (1.9)	21 (3.3)	30 (4.7)	
Insurance				0.25
None	5 (3.1)	2 (1.2)	5 (1.6)	
Private	27 (16.7)	33 (20.1)	76 (24.3)	
Government	130 (80.3)	129 (78.7)	232 (74.1)	
Initial prenatal visit, weeks	8.6 ± 2.3	8.4 ± 2.9	8.4 ± 2.5	0.71
Weight change, pounds	2.0 ± 7.9	15.4 ± 2.8	33.7 ± 11.3	
Psychiatric illness	44 (27.2)	39 (23.8)	79 (25.2)	0.78
Drug abuse	16 (9.9)	15 (9.2)	42 (13.4)	0.30
Chronic hypertension	20 (12.4)	16 (9.8)	32 (10.2)	0.71
Diabetes mellitus	5 (3.1)	10 (6.1)	12 (3.8)	0.36
Cardiac disease	7 (4.4)	4 (2.4)	6 (1.9)	0.29
Sleep apnea	4 (2.5)	1 (0.6)	3 (1.0)	0.26
Venous thrombo-embolism	2 (1.2)	0	2 (0.6)	0.37
Bariatric surgery	7 (4.3)	6 (3.7)	8 (2.6)	0.56

Data are expressed as mean ± standard deviation and number (%) where applicable.

Two-thirds of patients in the <11 pounds group were in the gravida three or more category compared to about half of the patients who gained 20 pounds or more. Similarly, the proportion of nulliparous patients increased as the weight gain increased (p<0.001) (Table 2). Otherwise, there were no significant differences between weight gain groups when compared for Latinx ethnicity, insurance type, history of spontaneous abortion, gestational age at initial prenatal visit, presence of psychiatric illness, drug abuse, chronic hypertension, diabetes mellitus, cardiac disease, sleep apnea, prior venous thromboembolism, or history of bariatric surgery (Table 2).

Obstetric outcomes by pre-pregnancy BMI class

Readmission within 6 weeks postpartum was the only outcome found to have a statistically significant difference between BMI categories. A larger proportion of patients with Class III obesity (8.3 %) were readmitted in the 6 weeks postpartum period than patients with Class I (2.4 %) or Class II (2.0 %) obesity (p=0.01) (Table 3). There were no significant differences between BMI categories for maternal outcomes including gestational age at delivery, hypertensive disorders of pregnancy, gestational diabetes, induction of labor,

Table 3: Obstetric outcomes by obesity class.

Body mass index, kg/m^2	30–34.9	35–39.9	≥40	p-Value
Number	299	209	133	
Gestational age at delivery, days	274.0 ± 7.5	273.3 ± 7.6	272.8 ± 7.4	0.30
Gestational hypertension	26 (8.7)	30 (14.4)	16 (12.1)	0.13
Preeclampsia	25 (8.4)	22 (10.5)	20 (15.0)	0.11
Severe preeclampsia	15 (5.0)	14 (6.7)	12 (9.1)	0.28
Superimposed preeclampsia	9 (3.0)	15 (7.2)	8 (6.0)	0.09
Gestational diabetes	76 (25.4)	49 (23.4)	45 (33.8)	0.09
Diet	26 (8.7)	17 (8.2)	17 (12.8)	0.32
Insulin	49 (16.4)	33 (15.8)	28 (21.2)	0.39
Labor induction	123 (41.1)	90 (43.1)	68 (51.1)	0.15
Cesarean delivery	124 (41.5)	96 (45.9)	56 (42.1)	0.59
Quantitative blood loss, milliliters	466.9 ± 415.6	505.1 ± 460.1	475.3 ± 388.5	0.67
Birth weight, grams	3,362.7 ± 442.8	3,355.4 ± 433.3	3,364.8 ± 404.1	0.98
5-min Apgar<7	5 (1.7)	1 (0.5)	1 (0.8)	0.41
NICU admission	24 (8.0)	15 (7.2)	12 (9.0)	0.83
Shoulder dystocia	2 (0.7)	2 (1.0)	1 (0.8)	0.94
Postpartum VTE	1 (0.3)	1 (0.5)	0	0.74
Wound infection	3 (1.0)	7 (3.4)	3 (2.3)	0.18
ICU admission	0	0	0	
Hospital length of stay, days	3.0 ± 1.3	3.1 ± 1.5	3.1 ± 1.2	0.59
Readmission to hospital	7 (2.4)	4 (2.0)	11 (8.3)	0.01

Data are expressed as mean ± standard deviation and number (%) where applicable. NICU, neonatal intensive care unit; VTE, venous thromboembolism; ICU, intensive care unit.

cesarean delivery, quantitative blood loss, thrombotic event, wound infection, and length of hospital stay. There were no significant differences between BMI categories for neonatal outcomes including birth weight, 5-min Apgar score <7, shoulder dystocia, and NICU admission (Table 3).

Of the 22 patients that were readmitted among all obesity classes, the most common diagnosis was a hypertensive disorder (preeclampsia with severe features, n=10; preeclampsia, n=3; hypertension, n=1). Other readmission indications included peripartum cardiomyopathy (n=1), post-operative wound infection (n=1), wound dehiscence and seroma (n=1), post-operative intraabdominal abscess (n=1), breast abscess (n=1), urosepsis (n=1), retained products of conception (n=1), and fluid overload (n=1) (Table 4).

Obstetric outcomes by gestational weight gain

Greater weight gain was associated with increased rates of cesarean delivery (p<0.001), higher quantitative blood loss (p=0.006), longer length of hospital stays (p=0.03), and higher birthweights (p<0.001) (Table 5). The overall incidence of gestational diabetes was not statistically different between groups, however, the percentage of patients with diet-controlled gestational diabetes was greater among patients in the lower weight gain group (p=0.02). The proportion of patients with insulin-controlled gestational diabetes did not change based on amount of weight gained. There were no significant differences among groups for maternal outcomes including gestational age at delivery, hypertensive disorders of pregnancy, induction of labor, thrombotic events, wound infection, or readmission within 6 weeks postpartum. There were no significant differences among groups for fetal outcomes including 5-min Apgar score <7, shoulder dystocia, and NICU admission. No patients in this study were admitted to the intensive care unit (ICU).

Multivariable model for obstetric outcomes

We examined the relationship of cesarean delivery, birth weight, and readmission to hospital with gestational weight gain groups and BMI classes including the covariates maternal age, gestational age at delivery, hypertensive disorder, gestational diabetes, and birth weight. Our initial study findings were confirmed. BMI class was found to be related to readmission to hospital. Both lower BMI classes were one third as likely to be readmitted to hospital as the

Table 4: Indications for readmission.

Obesity class, kg/m²		Reason for readmission
Class I (BMI 30.0–34.9)		
	1	Postpartum pre-eclampsia with severe features
	2	Peripartum cardiomyopathy
	3	Postpartum pre-eclampsia with severe features
	4	Postpartum pre-eclampsia with severe features
	5	Post-operative wound infection
	6	Wound dehiscence and seroma
	7	Retained products of conception
Class II (BMI 35–39.9)		
	1	Postpartum pre-eclampsia with severe features
	2	Breast abscess
	3	Postpartum pre-eclampsia with severe features
	4	Post-operative intraabdominal abscess
Class III (BMI>40)		
	1	Postpartum pre-eclampsia with severe features
	2	Postpartum pre-eclampsia
	3	Hypertension
	4	Postpartum pre-eclampsia
	5	Postpartum pre-eclampsia, rectus sheath hematoma
	6	Shortness of breath secondary to fluid overload
	7	Postpartum pre-eclampsia with severe features
	8	Postpartum pre-eclampsia with severe features
	9	Postpartum pre-eclampsia with severe features
	10	Urosepsis
	11	Postpartum pre-eclampsia with severe features

BMI >40 kg/m² group (BMI 30–34.9 kg/m² – Odds ratio (OR) 0.33 [95 % Confidence Interval (CI) 0.12–0.92]; BMI 35–39.9 kg/m² – OR 0.30 [95 % CI 0.10 – 0.90]). However, gestational weight gain was not associated with readmission to hospital. Hypertensive disorders (OR 5.21 [95 % CI 2.19–12.42]) and gestational diabetes (OR 3.99 [95 % CI 1.68–9.49]) were associated with an increased risk of readmission. BMI class was not related to cesarean delivery; however, patients with a gestational weight gain >20 pounds were 1.6 times (OR 1.58 [95 % CI 1.06–2.34] as likely to have a cesarean delivery when compared to patients with a weight gain of 11–20 pounds. Patients with a gestational weight gain <11 pounds (0.80 [95 % CI 0.51–1.27]) were similar to patients with a weight gain of 11–20 pounds. Finally, BMI class was not found to be related to birth weight; however, gestational weight gain groups <11 pounds and 11–20 pounds both had lower birth weights compared to gestational weight gain >20 pounds.

Distribution of weight gain by body mass index

Based on the IOM recommended gestational weight gain of 11–20 pounds, 25 % of each BMI class gained weight within the recommended range, while the higher BMI class (BMI≥40 kg/m²) tended to gain less weight compared to the other groups. As the patients' obesity class increased, fewer of them gained more than 20 pounds. Fifty-five percent of patients in the Class I obesity group gained more than 20

Table 5: Obstetric outcomes by gestational weight gain.

Gestational weight gain, pounds	<11	11–20	>20	p-Value
Number	162	164	313	
Gestational age at delivery, days	274.0 ± 6.9	272.6 ± 7.1	273.8 ± 8.0	0.20
Gestational hypertension	17 (10.5)	21 (13.0)	34 (10.9)	0.74
Preeclampsia	13 (8.0)	16 (9.8)	38 (12.1)	0.36
Severe preeclampsia	5 (3.1)	13 (8.0)	23 (7.4)	0.13
Superimposed preeclampsia	7 (4.3)	10 (6.1)	15 (4.8)	0.74
Gestational diabetes	49 (30.3)	49 (29.9)	72 (23.0)	0.13
Diet	24 (14.8)	14 (8.6)	22 (7.1)	0.02
Insulin	26 (16.2)	35 (21.5)	49 (15.7)	0.26
Labor induction	72 (44.4)	72 (43.9)	136 (43.5)	0.98
Cesarean delivery	53 (32.7)	66 (40.2)	157 (50.2)	< 0.001
Quantitative blood loss, milliliters	420.7 ± 451.1	475.3 ± 410.7	511.6 ± 413.0	0.006
Birth weight, grams	3,252.7 ± 409.3	3,339.7 ± 404.1	3,425.9 ± 445.5	< 0.001
5-min Apgar <7	3 (1.9)	2 (1.2)	2 (0.6)	0.48
NICU admission	16 (9.9)	14 (8.5)	21 (6.7)	0.47
Shoulder dystocia	0	0	5 (1.6)	0.07
Postpartum VTE	0	1 (0.6)	1 (0.3)	0.61
Wound infection	1 (0.6)	5 (3.1)	7 (2.2)	0.28
ICU admission	0	0	0	
Hospital length of stay, days	2.8 ± 1.1	3.1 ± 1.4	3.2 ± 1.4	0.03
Readmission to hospital	6 (3.8)	5 (3.1)	13 (4.2)	0.84

Data are expressed as mean ± standard deviation and number (%) where applicable. NICU, neonatal intensive care unit; VTE, venous thromboembolism; ICU, intensive care unit.

Table 6: Distribution of weight gain by body mass index.

	Body	Mass, kg/m^2	Index
Weight gain, pounds	30–34.9	35–39.9	≥40
<11	56 (18.7)	53 (25.4)	53 (40.5)
11–20	77 (25.8)	54 (25.8)	33 (25.2)
>20	166 (55.5)	102 (48.8)	45 (34.4)

Data are expressed as number (%). p<0.001. Data is missing in two patients with BMI ≥40 kg/m^2.

pounds compared to 49 % of those in Class II and 34 % in Class III groups (Table 6).

Discussion

When the 2009 Institute of Medicine guidelines were published, the authors acknowledged the paucity of data to support more specific recommendations for women of different obesity classes [18]. Since this recommendation was published, several large population-based studies have suggested benefit from establishing stricter weight guidelines during pregnancy for obese women, while other studies have acknowledged the risk of preterm delivery, low birth weight, and perinatal mortality due to insufficient weight gain [5, 19–21].

Principal findings

Our study of a diverse, inner-city population over five years did not find any differences in the rates of obstetric or neonatal complications by severity of pre-pregnancy obesity other than a greater rate of readmission to hospital within 6 weeks postpartum for patients with Class III obesity, compared to those with Class I and II obesity. We found no statistically significant difference in rates of cesarean delivery, birth weight, rates of hypertensive disorders of pregnancy including pre-eclampsia, and gestational diabetes across pre-pregnancy BMI categories.

However, our study found that greater total gestational weight gain was associated with adverse obstetric and neonatal outcomes. Greater weight gain than recommended by the IOM (>20 pounds) during pregnancy was associated with increased rates of cesarean delivery, greater quantitative blood loss, increased birth weight, and greater length of hospital stay, compared to those who gained the recommended gestational weight or less. In fact, our study showed a stepwise increase in weight gain and rates of cesarean delivery, quantitative blood loss, and birth weight.

Our results are consistent with prior studies that have demonstrated that less gestational weight gain is associated with better pregnancy outcomes in obese women [22–26]. In a large population-based cohort study of obese women residing in Missouri, Kiel et al. found that women who had reduced gestational weight gain had lower rates of cesarean delivery and lower rates of large for gestational age (LGA) births, regardless of obesity class [23]. In a meta-analysis of 23 studies assessing maternal and infant outcomes based on gestational weight gain between 1999 and 2017, Goldstein et al. found that weight gain outside of the recommendations was associated with higher rates of adverse maternal and infant outcomes [22]. They also performed a subgroup analysis of studies which stratified obese patients using the WHO obesity class categorization that was used in our study. Four studies were included that assessed large and small for gestational age, macrosomia, and cesarean delivery. They found that gestational weight gain above the recommended guidelines was associated with increased odds of LGA, macrosomia, and cesarean delivery across all obesity classes, while weight gain below the guidelines was associated with lower rates of cesarean delivery, macrosomia, and LGA across all obesity classes [22, 27–30].

Additionally, our study supports a previously well documented association between gestational weight gain and newborn birth weight [21, 26, 31]. A possible causal hypothesis for this association is that excessive maternal weight gain and overnutrition affects the intrauterine environment and produces permanent changes in the systems that regulate body weight such as the hypothalamus, pancreatic islet cells, and adipose tissue in the fetus, leading to increased birth weight and contributing to obesity and related conditions into adulthood [31–33]. While our study and the aforementioned studies have shown an association between gestational weight gain and birth weight, they have not demonstrated a causal relationship and this association has been thought to be confounded by factors such as genetic predisposition to weight gain and environmental factors. However, Ludwig and Currie studied maternal weight gain and birth weight and outcomes in multiple pregnancies of the same mother to reduce confounding by genetic, socioeconomic, and other factors using state-based birth registry data [32]. They found that for every additional kilogram of gestational weight gain, birth weight increases by 7.35 g. Their findings support a causal relationship between gestational weight gain and birth weight, independent of genetic or socioeconomic factors, highlighting the importance of reducing excessive gestational weight gain [32].

Clinical and research implications

As the number of obese people continues to increase, a greater proportion of pregnancies will be in obese patients, and it is imperative to establish evidence-based specific weight gain recommendations to improve obstetric and perinatal outcomes [1, 2]. Gestational weight gain is a modifiable risk factor and the findings of this study suggest that patients should be counseled regarding recommended weight gain to improve obstetric outcomes at our institution. Furthermore, as obesity is an independent risk factor for cesarean delivery, optimizing gestational weight gain may reduce the high rates of cesarean delivery in the United States [4]. Providing support and resources for patients during their pregnancy is a unique and actionable opportunity to help patients adhere to the weight gain targets to support a healthy pregnancy.

To best accomplish this, it is extremely important to address physician perception of obese patients and the stigma associated with higher BMI. Incollingo Rodriguez et al. examined the consequences of weight bias on obese women in pregnancy and found that weight bias was associated with greater gestational weight gain, weight gain above the IOM recommendations, and greater rates of depressive symptoms and weight retention at 1 year postpartum [34]. In the context of our findings, prejudging a patient based on their BMI may be a threat to maternal health as pre-pregnancy BMI was largely not predictive of maternal and neonatal health outcomes in our study population. Understanding how physicians can best discuss weight gain during this time while fostering inclusivity and patient comfort is extremely important to improving the patient-provider relationship, and health outcomes.

Strengths and limitations

The limitations of this study include a sample size which may not have been powered to detect differences in specific outcomes, as well as the retrospective nature of the study. Many patients screened were excluded because they did not present to their first prenatal before 13 weeks' gestation. Additionally, this study used a cohort of women with BMI ≥30 kg/m^2; therefore, it cannot be determined if the rates of complications are different from nonobese patients at our institution. However, to our knowledge, this study is the first to assess outcomes in an inner-city, racially diverse, and predominantly state insured population over multiple years, suggesting that our results are applicable to other community hospitals. Patient data was extremely accurate because all patients received their prenatal care and delivered within the same institution. Patients were not excluded based on prior medical diagnoses to increase generalizability.

Conclusions

This study suggests that increased gestational weight gain in obese women is associated with worse obstetric outcomes, while pre-pregnancy BMI was not associated with worse outcomes in obese women in our institution. Future prospective studies are needed to determine the optimal weight gain recommendations for obese patients based on pre-pregnancy BMI, as well as understanding how women can be best counseled throughout their pregnancy in an inclusive and stigma-free environment.

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