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Original Article

Adverse Perinatal Outcomes Associated with Increasing Maternal Obesity

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Abstract

Objective The aim of this study was to determine adverse perinatal outcomes related to maternal preconception body mass index (BMI).

Study Design This is a retrospective observational cohort study at a single institution of 500 consecutive mothers of normal weight with a preconception BMI of 18.5 to less than 25 and 500 additional obese mothers with a preconception BMI more than or equal to 30. Maternal/newborn metrics were stratified by maternal preconception BMI and trend analysis was performed both by simple univariable and multivariable logistic regression analysis.

Results The study included 858 mother/baby dyads after 142 were excluded. Trend analysis demonstrated higher preconception BMI was significantly associated with progressively higher rates of cesarean section ($p < 0.001$), preeclampsia $p < 0.001$), gestational diabetes ($p < 0.001$), preterm birth ($p = 0.001$), lower 1- and 5 minutes Apgar scores ($p < 0.001$), and neonatal intensive care unit admission ($p = 0.002$). These associations remained significant in both simple univariable and multivariable logistic regression models.

Conclusion We demonstrated obese women are more likely to have maternal complications and neonatal morbidity when compared with normal weight mothers. Maternal and fetal complications increase with increasing obesity with superobese mothers (BMI $\geq$ 50) having more perinatal adverse outcomes when compared with other classes of obesity. It is reasonable to counsel weight loss prior to conception of women with BMI more than or equal to 30 in an effort to reduce maternal complications and neonatal morbidity related to pregnancy.

Keywords
- maternal obesity
- adverse perinatal outcomes
- superobesity

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Key Points

- Maternal obesity is associated with adverse outcomes.
- Complications increase with increasing obesity.
- Superobese mothers have the most adverse outcomes.

There is an increasing prevalence of obesity among women in the United States. Notably, 37% of reproductive-age women are obese as defined as a body mass index (BMI) greater than or equal to 30 kg/m^2, and 10% have morbid obesity with a BMI more than or equal to 40 kg/m^2.[1] There is a significant geographic disparity in prepregnancy weight among women. In 2015 for 48 states, New York City, and District of Columbia, the overall incidence of prepregnancy normal weight (BMI 18.5 to < 25) was 45%. West Virginia reported the second lowest prepregnancy normal weight of 40% and the second highest prepregnancy obesity weight (BMI ≥ 30) of 31%.[2]

Obesity in pregnancy is an important public health problem with short-term and long-term implications for maternal and child health. Maternal obesity, when compared with mothers of normal prepregnancy weight, has been linked to adverse pregnancy outcomes including preeclampsia, gestational diabetes, cesarean deliveries, and prolonged postpartum hospital stay as well as perinatal problems including congenital anomalies, birth asphyxia, neonatal hypoglycemia, and stillbirth.[3–9] A previous study demonstrated a "dose-response" relationship between the severity of maternal obesity with adverse perinatal outcomes,[10] supported by two subsequent meta-analyses.[9,11]

The objective of this study was to investigate the relationship between adverse perinatal outcomes and increasing maternal prepregnancy weight in our population. We hypothesized that increasing prepregnancy weight would correlate with an increase in maternal and neonatal complications.

Materials and Methods

This was a retrospective, observational, cohort study from a single tertiary care perinatal center of women giving birth from 1/1/2015 to 12/31/2018. The study was based at Cabell Huntington Hospital in Huntington, West Virginia, the perinatal teaching hospital for the Marshall University School of Medicine. Antepartum and intrapartum patient information were collected following delivery using the Cabell Huntington Hospital Clinical Data Warehouse. As the Warehouse did not include a preconception BMI, a first documented weight of more than or equal to 90 kg was chosen for the search criteria. Individual charts and obstetrical records were then manually reviewed for self-reported maternal prepregnancy body weight and measured height to calculate BMI. Five hundred consecutive mothers with a prepregnancy BMI of 18.5 to less than 25, and their offspring, and 500 additional mothers with a BMI more than or equal to 30, and their offspring, were identified. For this study, prepregnancy BMI was categorized as normal weight (18.5 to < 25), class I obesity (30.0 to < 35), class II obesity (35.0 to < 40), class III obesity (40.0 to < 50), and superobesity (≥ 50). Mother/baby dyads were excluded from the study for missing medical record data, neonatal abstinence syndrome, maternal substance use disorder, genetic/congenital anomalies, or miscarriages/stillbirths. The institutional review board of Marshall University School of Medicine approved this human subject research prior to its initiation.

Statistical analysis was planned a priori. The primary outcomes considered were preeclampsia, gestational diabetes mellitus, mode of delivery, 1- and 5-minute Apgar scores, neonatal intensive care unit (NICU) admission, and neonatal death.

Maternal/newborn metrics were stratified by maternal preconception BMI and trend analysis was performed using Jonckheere-Terpstra and Cochrane-Armitage tests for continuous and binary data, respectively. We performed a subsequent simple univariable and multivariable logistic regression analysis adjusted for advanced maternal age (> 35 years), preexisting maternal diabetes, preexisting maternal hypertension, and infant gestational age. Regression model covariates were selected based on their clinical relevance to the selected outcomes. Regression model residuals were evaluated for any gross deviations from test assumptions. Regression model results were reported as odds ratios with 95% confidence intervals and *p*-values for our effect measure. Wald test was used to assess for evidence of a linear trend within the regression models. Statistical analysis was performed using STATA (StataCorp. 2022. Stata Statistical Software: Release 17. College Station. TX: StataCorp LP).

Results

Between January 1, 2015, and December 31, 2018, 500 consecutive mother/baby dyads with maternal prepregnancy BMI of 18.5 to less than 25 and the first 500 consecutive dyads with maternal prepregnancy BMI more than or equal to 30 were selected for this study. Of these dyads, 142 did not meet inclusion criteria. The study population resulted in 858 pairs (386 with prepregnancy BMI 18.5 to less than 25 and 472 with maternal BMI more than or equal to 30 (►Fig. 1).

Maternal and newborn metrics were stratified by maternal preconception BMI as well as trend analysis. Simple univariable logistic regression models demonstrated higher preconceptional BMI was significantly associated with progressively higher rates of cesarean section, preeclampsia, gestational diabetes mellitus, and postdelivery length of stay. Higher preconceptional BMI was significantly associated with adverse neonatal metrics including decreased weeks of gestational age, preterm birth, lower 1- and 5-minute Apgar scores, and postdelivery length of stay (►Table 1).

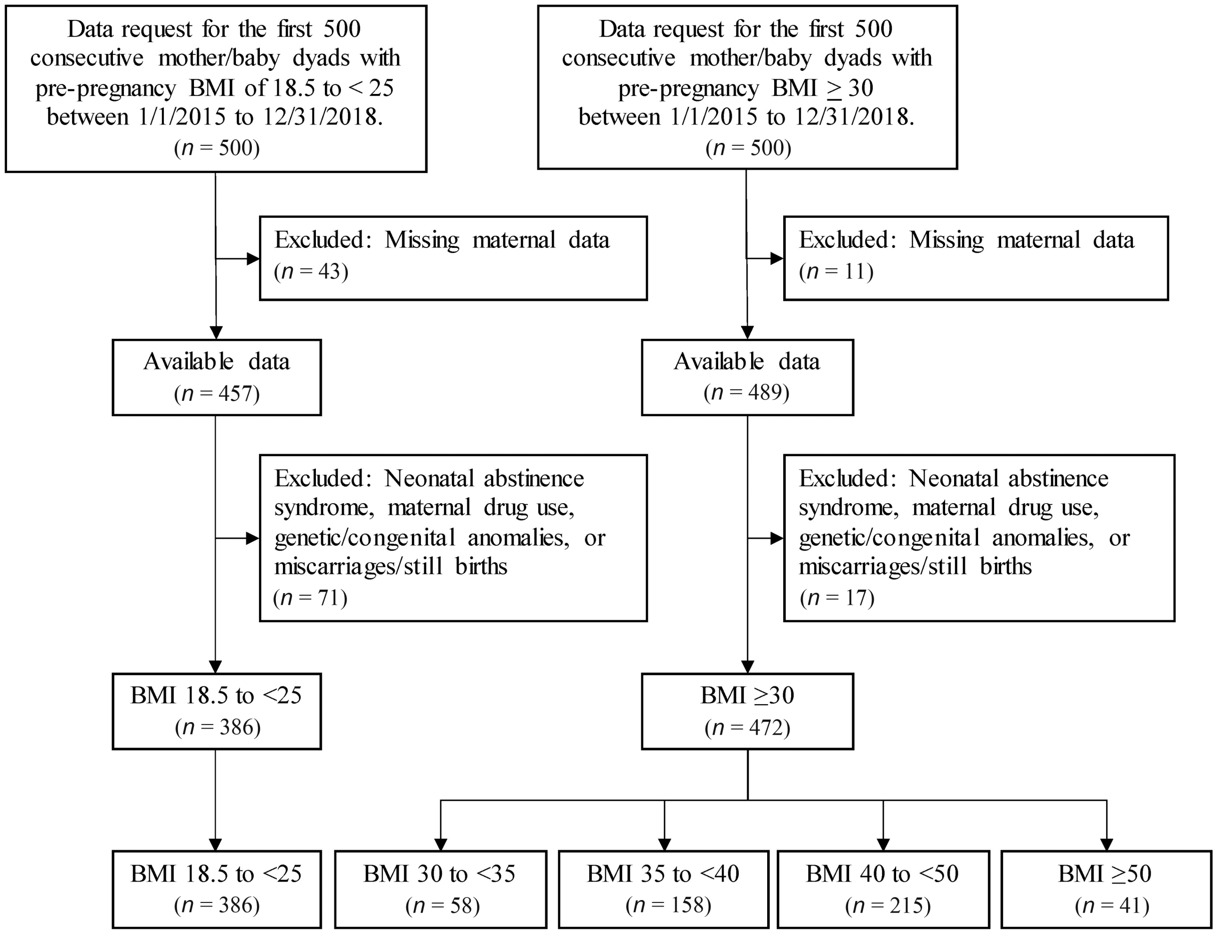

Fig. 1 Flowchart of patient selection. BMI, body mass index.

Associations remained significant in multivariable logistic regression models for gestational diabetes, preeclampsia, cesarean delivery adjusting for advanced maternal age, preexisting maternal hypertension, preexisting maternal diabetes, gestational age, and prior c-section (►Table 2).

All the maternal metrics demonstrated a significant trend except for age at time of delivery and ICU admission. All the neonatal metrics demonstrated a significant trend except emergent cesarean delivery, 5-minute Apgar score less than 7, NICU length of stay, and death. Relative to pregnancies with normal BMI, pregnancies with a pre-conception BMI more than or equal to 30 gained less weight during pregnancy and increasing obesity classes had an incremental decrease in absolute weight gain at time of delivery. Simple univariable logistic regression models demonstrated higher preconception BMI was significantly associated with progressively higher linear rates of gestational diabetes, preeclampsia, cesarean section, and NICU admission (►Table 2). Compared with normal preconception BMI 18.5 to less than 25, cesarean was higher in BMI more than or equal to 30, gestational diabetes was higher in BMI more than or equal to 35, preeclampsia was higher in BMI more than or equal to 40, prematurity, and NICU admission was higher in BMI more than or equal to 50. Associations remained significant in multivariable logistic regression models although compared with normal preconception BMI 18.5 to less than 25, cesarean was higher in BMI more than or equal to 40 and preeclampsia was higher in BMI more than or equal to 40.

Discussion

In this retrospective, case–control study, obese women (preconception BMI $\geq$ 30) were more likely to have maternal complications and neonatal morbidity when compared with women of normal weight (preconception BMI 18.5 to $<$ 25), and perinatal complications increased incrementally with increasing obesity with superobese mothers having more adverse perinatal outcomes when compared with other classes of obesity.

In this study, with increasing maternal prepregnancy BMI, we observed significant increases in trend in maternal adverse metrics including preeclampsia, gestational diabetes mellitus, cesarean delivery, and postdelivery length of hospitalization. In addition, adverse neonatal metrics increased in trend for prematurity, lower 1- and 5-minute Apgar scores, postdelivery length of stay, and NICU admission. Simple univariable logistic regression models demonstrated higher preconception BMI was associated with progressively higher linear rates of gestation diabetes mellitus, preeclampsia, cesarean delivery, and NICU admission.

A previous retrospective study of infants born to 64,272 obese Missouri mothers from 2000 to 2006, utilizing data

Table 1 Descriptive statistics of obstetric/neonatal variables and maternal preconception BMI

		Maternal preconception BMI					*p*-Value
		Normal weight (18.5 to <25)	Obesity class 1 (30 to <35)	Obesity class 2 (35 to <40)	Obesity class 3 (40 to <50)	Super obesity (≥ 50)	
n		386	58	158	215	41	
Maternal metrics							
Age at time of delivery, years	Median (IQR)	26 (22, 31)	27 (24, 34)	27 (23, 32)	27 (24, 31)	28 (25, 31)	0.023
Preexisting diabetes	% (n/N)	1% (3/386)	5% (3/56)	2% (3/154)	7% (15/208)	3% (1/40)	<0.001
Preexisting hypertension	% (n/N)	3% (11/383)	16% (9/56)	16% (25/154)	24% (51/211)	40% (16/40)	<0.001
Preeclampsia	% (n/N)	8% (31/385)	16% (9/57)	15% (23/156)	20% (42/207)	32% (13/41)	<0.001
Gestational diabetes	% (n/N)	2% (8/386)	5% (3/56)	11% (17/153)	15% (32/209)	18% (7/40)	<0.001
Preconception weight, kg	Median (IQR)	59 (55, 63.5)	105 (100, 105)	105 (101, 111)	118 (112, 125)	150 (140, 159)	<0.001
Weight at delivery, kg	Median (IQR)	74 (67, 80)	118 (109, 123)	116 (110, 124)	127 (118, 133)	149 (138, 165)	<0.001
Weight change, kg	Median (IQR)	15 (11, 19)	14 (7, 18)	10 (5, 17)	8 (2, 13)	3 (-4, 10)	<0.001
Preconception BMI	Median (IQR)	22 (21, 23)	34 (33, 35)	37 (37, 39)	43 (41, 45)	52 (51, 56)	<0.001
BMI at delivery	Median (IQR)	28 (26, 29)	37 (36, 40)	41 (39, 44)	46 (44, 49)	54 (51, 58)	<0.001
Postdelivery length of stay, days	Median (IQR)	2 (2, 2)	2 (2, 3)	2 (2, 3)	2 (2, 3)	2 (2, 3)	<0.001
ICU admission	% (n/N)	4% (14/386)	5% (3/56)	3% (4/155)	3% (6/207)	5% (2/41)	0.733
Neonatal metrics							
Delivery type							
Vaginal	% (n/N)	76% (292/386)	62% (36/58)	56% (89/158)	47% (102/215)	34% (14/41)	<0.001
Spontaneous	% (n/N)	33% (128/386)	22% (13/58)	28% (44/158)	19% (41/215)	20% (8/41)	<0.001
Induced	% (n/N)	43% (164/386)	40% (23/58)	29% (45/158)	28% (61/215)	15% (6/41)	<0.001
Cesarean	% (n/N)	24% (94/386)	38% (22/58)	44% (69/158)	53% (113/215)	66% (27/41)	<0.001
Primary	% (n/N)	13% (51/386)	21% (12/58)	28% (44/158)	33% (70/215)	32% (13/41)	<0.001
Repeat	% (n/N)	11% (43/386)	17% (10/58)	16% (25/158)	20% (43/215)	34% (14/41)	<0.001
Nonemergent	% (n/N)	16% (61/386)	35% (20/58)	39% (61/158)	46% (99/215)	56% (23/41)	<0.001
Emergent	% (n/N)	9% (33/386)	3% (2/58)	5% (8/158)	7% (14/215)	10% (4/41)	0.438
Gestational age, weeks	Median (IQR)	39.0 (38.3, 39.6)	39.0 (37.9, 39.0)	39.0 (37.3, 39.1)	39.0 (37.0, 39.0)	38.0 (35.0, 39.0)	<0.001
Preterm	% (n/N)	11% (42/385)	16% (9/58)	17% (27/158)	15% (32/215)	37% (15/41)	0.001
1-minute Apgar	Median (IQR)	9 (8, 9)	8 (8, 9)	8 (8, 9)	8 (8, 9)	8 (7, 9)	<0.001
5-minute Apgar	Median (IQR)	9 (9, 9)	9 (9, 9)	9 (9, 9)	9 (9, 9)	9 (8, 9)	<0.001
5-minute Apgar < 7	% (n/N)	0% (1/386)	0% (0/58)	2% (3/158)	1% (3/213)	0% (0/41)	0.141
Postdelivery length of stay, days	Median (IQR)	2 (2, 3)	2 (2, 3)	2 (2, 3)	2 (2, 3)	3 (2, 7)	<0.001
NICU admission	% (n/N)	15% (59/385)	18% (10/57)	21% (33/157)	20% (43/214)	42% (17/41)	0.002
NICU length of stay, days	Median (IQR)	9 (6, 20)	12 (2, 17)	8 (4, 15)	7 (4, 17)	9 (6, 15)	0.426
Death	% (n/N)	0% (0/385)	0% (0/58)	1% (2/157)	1% (2/213)	0% (0/41)	0.104

Abbreviations: BMI, body mass index; IQR, interquartile range; NICU, neonatal intensive care unit.
Note. p-Values were calculated using Jonckheere-Terpstra and Cochran-Armitage trend analysis tests for continuous and binary data, respectively.

Table 2 Descriptive statistics and logistic regression analysis of obstetric/neonatal variables and maternal preconception BMI, $n = 861$

	Maternal preconception BMI (kg/m^2)	% (n/N)	Nonadjusted odds ratio	95% CI	*p*-Value	Adjusted[a] odds ratio	95% CI	*p*-Value
Gestational diabetes	18.5 to <25	2% (8/386)						
	30 to <35	5% (3/56)	2.67	[0.69, 10.40]	0.156	1.56	[0.32, 7.75]	0.584
	35 to <40	11% (17/153)	5.91	[2.49, 14.00]	<0.001	5.72	[2.36, 13.89]	<0.001
	40 to <50	15% (32/209)	8.54	[3.86, 18.92]	<0.001	9.21	[4.01, 21.14]	<0.001
	≥50	18% (7/40)	10.02	[3.42, 29.37]	<0.001	9.82	[3.11, 30.95]	<0.001
Preeclampsia	18.5 to <25	8% (31/385)						
	30 to <35	16% (9/57)	2.14	[0.96, 4.77]	0.062	1.20	[0.45, 3.16]	0.714
	35 to <40	15% (23/156)	1.97	[1.11, 3.51]	0.020	1.17	[0.60, 2.29]	0.642
	40 to <50	20% (42/207)	2.91	[1.76, 4.79]	<0.001	2.14	[1.21, 3.78]	0.009
	≥50	32% (13/41)	5.30	[2.50, 11.26]	<0.001	2.64	[1.10, 6.30]	0.029
Cesarean [b]	18.5 to <25	16% (61/386)						
	30 to <35	35% (20/58)	1.90	[1.06, 3.39]	0.030	1.52	[0.67, 3.42]	0.316
	35 to <40	39% (61/158)	2.41	[1.63, 3.56]	<0.001	1.74	[0.99, 3.05]	0.053
	40 to <50	46% (99/215)	3.44	[2.41, 4.91]	<0.001	2.67	[1.62, 4.41]	<0.001
	≥50	56% (23/41)	5.99	[3.02, 11.90]	<0.001	4.75	[1.96, 11.46]	0.001
Preterm[c]	18.5 to <25	11% (42/385)						
	30 to <35	16% (9/58)	1.50	[0.69, 3.27]	0.308	0.99	[0.41, 2.39]	0.982
	35 to <40	17% (27/158)	1.68	[1.00, 2.84]	0.051	1.43	[0.83, 2.47]	0.201
	40 to <50	15% (32/215)	1.43	[0.87, 2.34]	0.157	1.07	[0.62, 1.82]	0.818
	≥50	37% (15/41)	4.71	[2.31, 9.60]	<0.001	3.22	[1.49, 6.98]	0.003
NICU admission[c]	18.5 to <25	15% (59/385)						
	30 to <35	18% (10/57)	1.18	[0.56, 2.46]	0.667	0.94	[0.43, 2.07]	0.883
	35 to <40	21% (33/157)	1.47	[0.92, 2.36]	0.111	1.29	[0.79, 2.11]	0.313
	40 to <50	20% (43/214)	1.39	[0.90, 2.15]	0.138	1.01	[0.63, 1.62]	0.974
	≥50	42% (17/41)	3.91	[1.98, 7.73]	<0.001	2.85	[1.37, 5.92]	0.005

Abbreviations: BMI, body mass index; CI, confidence interval; NICU, neonatal intensive care unit.
Note. Descriptive statistics are visually stratified by maternal preconception BMI. Logistic regression derived odds ratios and *p*-values are based on nonstratified maternal preconception BMI.
[a]Adjusted results were based on a multivariable logistic regression analysis adjusting for advanced maternal age, preexisting maternal hypertension, preexisting maternal diabetes, and gestational age.
[b]Cesarean multivariable logistic regression model additionally included previous cesarean section as a covariate.
[c]Prematurity and NICU admission multivariable logistic regression models did not include gestational age as a covariate.

extracted from birth certificate records and hospital discharge information, demonstrated a "dose-response" relationship between worsening obesity and the incidence of cesarean delivery, macrosomia, neonatal hypoglycemia, and preeclampsia. Three classes of obesity (BMI 30 to $<$ 40, 40 to $<$ 50, and $\geq$50) were used for comparisons and no mothers of normal BMI were included in the study.[10]

There have been two meta-analyses examining graded relationships of maternal obesity to pregnancy outcomes. The first combined 59 previous publications and concluded a graded relationship of adverse perinatal outcomes existed with increased severity of obesity including increased incidence of premature birth, macrosomia, preeclampsia, gestational diabetes, cesarean section, maternal bleeding, low umbilical artery pH and Apgar scores, and NICU admission.[9]

The second identified 13 studies with a low risk-of-bias describing 3,722,477 pregnancies. It was concluded that most adverse pregnancy outcomes increased with increasing maternal BMI, including maternal complications of gestational diabetes mellitus, hypertension of pregnancy, cesarean delivery, and neonatal complications including hypoglycemia, macrosomia, birth trauma, respiratory distress, NICU admission, and death.[11]

This study is the first single-center confirmation of a graded "dose-response" to the level of obesity with regard to adverse perinatal outcomes. Unlike previous studies, our data were extracted directly from maternal and neonatal medical records, eliminating possible omissions on reports extracted from birth certificates and hospital discharge data.

In this study, the likelihood of cesarean delivery increased from 24% in women of normal prepregnancy BMI to 66% in superobese women. The rate of emergent cesarean sections, however, remained statistically unchanged with increasing BMI as has been previously reported.[5] Our findings are consistent with previous reports showing that the rate of cesarean delivery and failed labor induction leading to cesarean section increases by maternal prepregnancy BMI category.[5,12–14] In 2020, 31.8% of live births in the United States were to women who had a cesarean delivery. The rate rose steadily from 25.1% of women of normal weight to 52.3% of women in obesity class III.[15]

In this study, parity and failed induction were not analyzed to determine factors involved in the increased rate of cesarean delivery.[16] As previously recommended, future studies are needed to examine what factors are involved in the increased incidence of cesarean delivery related to increasing obesity.[10]

The American College of Obstetricians and Gynecologists has supported the Institute of Medicine (IOM) recommendation for pregnancy weight gain of 5 to 9.1 kg for all obese women without differentiating between classes of obesity.[16] In this study, we have stratified gestational weight gain (GWG) by obesity classes I and II gaining more weight than the recommended GWG, while superobese mothers gained less than the recommended GWG. Studies subsequent to the IOM recommendation have shown benefits of recommended GWG during pregnancy[7] as well as benefits of GWG less than recommended.[7,17,18] While weight loss in obese pregnant women is associated with an increased risk for low-birth-weight neonates, it has also been shown to decrease or maintain risk for other adverse maternal and neonatal morbidities.[19]

Limitations and Strengths

Our study has several limitations. This is a single-center study based on limited numbers and may not be applicable to a larger sample in other centers. This was a retrospective, observational, cohort study with the potential for confounding factors not considered in our analysis including maternal race, smoking status, level of education, and adequacy of prenatal care, all of which can impact perinatal outcome. An additional limitation was the use of self-reported preconception weight, which has been shown to be underestimated by respondants.[20,21] Other studies, however, have shown that although women underestimated weight, 84% of the women remained in the appropriate BMI categories of obesity and self-reporting is a reliable measure of preconception weight.[22]

The findings of this study, as well as previous reports, imply that preconception weight loss might reduce the incidence of adverse perinatal outcomes. A published meta-analysis looked at outcomes following bariatric surgery in 8,364 women who were compared with control subjects matched for presurgery BMI. There were reduced rates of gestational diabetes mellitus, large for gestational age infants, gestational hypertension, all hypertensive disorders, postpartum hemorrhage, and cesarean delivery rates. However, the surgical patients showed an increase in small-for-gestational-age infants, intrauterine growth restriction, and preterm deliveries. There were no differences in rates of preeclampsia, NICU admissions, stillbirths, malformations, and neonatal death.[23] Future prospective studies are needed to examine the risks and benefits of preconception weight loss, including weight reduction surgery, on perinatal outcomes.

Conclusion

We have demonstrated maternal and fetal complications increase with increasing obesity with superobese mothers having more adverse perinatal outcomes when compared with other classes of obesity. It is reasonable to counsel weight loss prior to conception of women with preconception BMI more than or equal to 30 to potentially reduce maternal and neonatal morbidity related to pregnancy. The impact of preconception weight reduction on the incidence of adverse perinatal outcomes and economic implications needs further study.

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Conflict of Interest

None.

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