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Neonatal morbidities among full-term infants born to obese mothers

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Abstract

Introduction—Impact of maternal obesity on full-term neonates is not known.

Objective—We hypothesized increased incidence of neonatal morbidities requiring NICU admission in full-term neonates of obese women compared to neonates of normal-weight women.

Methods—Data from full-term pregnancies collected in the Consortium of Safe Labor study were analyzed. Maternal BMI was classified using the WHO criteria. Incidence of neonatal outcomes including sepsis, PDA, NEC, respiratory distress, or their combination were compared between newborns of obese and normal-weight women.

Results—Of the 109 488 women included in the study, 17.7% were obese. Maternal co-morbidities (diabetes, gestational diabetes, hypertension, and preeclampsia) increased with increasing maternal BMI. Both maternal obesity and its related co-morbidities were associated with higher incidence of neonatal morbidities. After adjusting for maternal comorbidities, there was a higher incidence of sepsis (AOR 1.91(1.45–2.50)), and combination of any of the neonatal outcomes (AOR 1.66(1.32–2.09)) among newborns of obese women than those of normal-weight women, along with an increased trend for incidence of PDA (Cochran-Armitage Test (CA) =23.1, p<0.0001) and NEC (CA =7.2, p =0.007).

Conclusion—Maternal obesity is independently associated with increased incidence of neonatal sepsis and a combination of neonatal morbidities in full-term newborns with an increased trend for PDA and NEC.

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Declaration of interest

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Keywords

BMI; full-term infants; maternal obesity; outcomes

Introduction

Prevalence of maternal obesity has nearly doubled in the past 15 years and is growing at an accelerated pace [1] such that a large number of women in childbearing age are obese [2]. Maternal obesity is associated with a higher incidence of infertility, increased co-morbidities such as gestational diabetes and preeclampsia, and complications associated with difficult deliveries that require more surgically assisted deliveries along with increased incidence of miscarriages [1,3–6]. In neonates, maternal obesity is associated with increased risk of stillbirths, prematurity [7,8] and associated respiratory distress in near term neonates. While the incidence of common morbidities in full-term neonates are known in general population [9–11], the prevalence of neonatal morbidities in full term neonates born to obese mothers is not known.

We proposed to elucidate the incidence of common morbidities observed among full-term neonates including Sepsis, Patent Ductus Arteriosus (PDA), necrotizing entero-colitis (NEC) or respiratory distress (RD) in full-term neonates born to obese mothers that was associated with a neonatal intensive care unit (NICU) admission in the Consortium of Safe Labor (CSL) study database, a consortium of 19 clinical centers in 12 institutions representing 9 (of 10) American Congress of Obstetricians and Gynecologists districts, designed to reflect all geographic areas of the country [12]. We also investigated the relationship between early pregnancy BMI and weight gain during pregnancy with incidence of sepsis, PDA, NEC, or RD or a combination of these morbidities.

Methods

Secondary data analysis was performed on maternal and neonatal outcomes collected in the Consortium on Safe Labor (CSL) study database between 2002 and 2008. The majority (87%) of births in the consortium occurred between 2005 and 2007, which coincided with the initiation of electronic medical records (EMR) at the individual institutes. A detailed chart review was performed, including data extraction on paper forms for information not available in the EMR, which was manually entered into electronic format. For quality assurance, the overall electronic database was compared with chart review data and was found to be consistent (97.3–99.7%) [12].

Maternal data on demographics (race and ethnicity reported by the mother at initiation of care), maternal medical and obstetrical complications, and delivery details were analyzed. Pertinent neonatal data including birth weight, gestational age, gender and neonatal morbidities were analyzed. For the current study, we restricted the study cohort to live-born singletons between 37 weeks and 0 days to 41 weeks and 6 days gestational age determined by best obstetric estimate, in most cases by last menstrual period, with a confirmatory sonogram. In cases for which last menstrual period was unknown, dating was assigned by earliest sonogram.

Exclusion criterion

To avoid intra-subject correlation, we limited deliveries to the first delivery in the data set irrespective of women's parity. Multiple births were also excluded as they represented a high-risk group. Neonates with major congenital anomalies, chromosomal defects or major birth trauma were excluded. Deliveries with any missing key data like the weight of the mother or of the baby were also excluded. Detailed exclusion criteria are summarized in Figure 1. Out of 228 562 deliveries, the final sample after exclusions consisted of 109 488 deliveries.

Outcomes

Neonatal outcomes included in this analysis were PDA (ICD-9 code 747.0), NEC (ICD-9 code 777.5), RD (ICD-9 code 769), and sepsis (ICD-9 code 771.81) which required a NICU admission. Their occurrence was determined by the ICD-9 code in the EMR, based on the medical record documentation by NICU clinicians, which were confirmed by manual chart extraction. A composite measure denoting a co-occurrence of these outcomes, in any combination, was created. Birth weight was categorized as small for gestational age (<2500 g), large for gestational age (≥4000 g) with normal weight falling within these limits.

The main predictor, maternal BMI, was based on the weight and height collected during a patient's first visit in the first trimester. BMI was categorized using the World Health Organization (WHO) criteria (normal <25.0 kg/m^2, overweight 25.0–29.9 kg/m^2, obese Class I 30.0–34.9 kg/m^2, obese Class II 35.0–39.9 kg/m^2, and obese Class III ≥40 kg/m^2) [13]. Pregnancy weight gain was categorized based on the Institute of Medicine (IOM) recommended guidelines. Normal weight gain was dependent on early pregnancy BMI. If early pregnancy BMI was <18.5 kg/m^2, a gain of 12–18 kg; 18.5–24.9 kg/m^2, a gain of 11–16 kg; 25.0–29.9 kg/m^2, a gain 6–11 kg; and ≥30.0 kg/m^2, a gain of 4–9 kg is regarded as normal weight gain [14]. Higher or lower pregnancy weight gain was determined based on these guidelines.

Statistical methods

Logistic regression analyses were performed to identify the association of maternal BMI with incidence of neonatal outcomes including PDA, NEC, respiratory distress, sepsis or their co-existence leading to a NICU admission. Since other maternal conditions including age, parity, race, and medical conditions including chronic hypertension, pregnancy-related hypertension (preeclampsia, eclampsia, gestational hypertension, or chronic hypertension with superimposed preeclampsia), diabetes, and gestational diabetes significantly influenced the incidence of neonatal outcomes of interest, we conducted multivariate logistic regression models, adjusting for these variables. Adjusted odds ratios (OR) and 95% confidence intervals (CI) comparing outcomes for neonates born to mothers in overweight and obese classes (BMI ≥25 kg/m^2) with those born to mothers with normal weight were estimated from the regression models. The incidences of the outcomes were less than 10%; thus, the OR can approximate the risk ratio or relative risk in the current study. Continuous data were analyzed using Analyses of variance (ANOVA), or its non-parametric counterpart Kruskal–Wallis test while categorical data were analyzed by Chi-square, and the incidence of

measured outcomes with Cochran–Armitage (CA) test of trend. Statistical analyses were performed using SPSS Statistical Software (Version 19, Chicago, IL).

Results

Participant characteristics

Of the 109 488 women in the study sample, 19 425 (17.7%) had early pregnancy BMIs of ≥30, of which 3378 (17.3%) had BMI of ≥40 (Table 1). The sample comprised of 53% White non-Hispanic, 18.4% Black-non Hispanic, and 19.4% Hispanic women. Black women were nearly three times as likely to be morbidly obese (BMI ≥40) as compared to whites (OR =2.98, 95% CI 2.76–3.22) (Table 1). The rates of diabetes, gestational diabetes, hypertension, and pre-eclampsia during pregnancy among the pregnant women increased with increase in BMI but did not differ by ethnic groups. The incidence of weight gain above the IOM recommendations was the higher among obese mothers than normal-weight mothers.

Association of neonatal morbidities with maternal BMI and pregnancy weight gain

The mean gestational age of the neonates was 39.2 ± 1.1 weeks. Increase in maternal BMI was associated with increase in the percentage of LGA neonates (Table 2). The incidence of adverse neonatal outcomes also increased with increasing maternal BMI (Table 2). The occurrence of any of the neonatal outcomes of interest was observed in 2.6% of neonates delivered to mothers with BMIs of ≥40 kg/m^2 as compared to 1.4% of neonates born to mothers with BMI <25 kg/m^2 (p<0.0001). The most common adverse individual neonatal outcome was sepsis, in 1.1% of all neonates, followed by respiratory distress, which occurred in 0.5% of all neonates. However, while the likelihood of sepsis was 1.91 times (p<0.001) higher among neonates born to obese mothers compared to normal-weight mothers, the odds of respiratory distress (RD) (OR =0.96, p =0.1) did not differ between neonates of obese mothers and normal weight mothers.

The odds of all neonatal morbidities increased with increase in maternal BMI except for RD (Table 3). There was significant increase in trend for sepsis (CA =48.2, p<0.0001), PDA (CA =48.8, p<0.0001), NEC (CA =7.2, p<0.0001), LGA (CA =23.1, p<0.0001), and the occurrence of a combination of neonatal morbidities (CA =48.2, p<0.0001) with increase in maternal BMI category. There was also a higher incidence of sepsis (p<0.001) and incidence of any combination of neonatal morbidities (p<0.001) between the normal weight mothers and each incremental increase in category of maternal obesity. Further, there was a significant increase in incidence of sepsis and PDA among neonates born to mothers with weight gain above IOM recommendations than those with normal weight gain during the pregnancy (Table 3).

Association of neonatal morbidities with maternal co-morbidities

Since increase in maternal BMI was associated with higher prevalence of maternal co-morbidities, which independently affect neonatal outcomes, we also investigated their influence on neonatal outcomes. We found that obesity-associated morbidities were also associated with increased incidence of neonatal morbidities (Table 4). Both diabetes and

gestational diabetes increased the risk of adverse neonatal outcomes by 1.5–8 fold. The risk increased by 1.34–3.07 fold with preeclampsia and hypertension in all outcomes, except the incidence of PDA and sepsis, which were not higher in those with preeclampsia compared to those without preeclampsia.

We further investigated whether the effect of maternal BMI on neonatal outcomes was independent of maternal obesity-associated co-morbidities (Table 5). After adjusting for obesity-related co-morbidities, the incidence of neonatal sepsis and a combination of neonatal morbidities increased with increasing maternal obesity and there was a significant increase in trend for incidence of PDA and NEC with incremental increase in maternal BMI category. However, the increase in odds of PDA and sepsis observed among women whose pregnancy weight gain was higher than that recommended by the IOM was rendered non-significant after adjusting for maternal obesity and obesity associated co-morbidities.

Discussion

In our study sample, where 18% mothers were obese early in their pregnancies, we found that maternal obesity was a risk factor for incidence of PDA, NEC, sepsis or a combination of these morbidities, but not for respiratory distress, among full-term neonates. After adjusting for obesity-associated maternal co-morbidities, we found an independent association between maternal obesity with incidence of neonatal sepsis and a combination of neonatal morbidities of interest with a significant trend for increase in incidence for PDA and NEC with increasing maternal BMI. These findings suggest that increase in maternal BMI is associated with an increase in neonatal morbidities among full-term neonates, independent of co-existing obesity-mediated maternal morbidities.

The incidence of all the morbidities increased with increase in maternal BMI and was twice as high among morbidly obese mothers as compared to normal-weight mothers. This increase in neonatal morbidity is of substantial clinical importance since the study population comprised on women with no other co-morbidity other than obesity and its associated medical conditions. By excluding all neonatal causes of NICU admission, including prematurity, as well as birth trauma and congenital malformations from our sample, the population included in the study would be expected to have a very low incidence of neonatal morbidities requiring admission to the NICU. Moreover, we focused on the type of morbidities that led to admission in the NICU only among full-term neonates and thereby differed from prior studies, that included preterm neonates and reported a higher incidence of NICU admissions among neonates born to obese mothers, irrespective of gestational age [15–18] but did not include details on the underlying cause of the NICU admission. The difference in the sample selection also likely contributed to differences in observations. While earlier studies found increased incidence of respiratory distress and sepsis among preterm babies [19,20], we demonstrate that the incidence of sepsis, but not respiratory distress, is higher among full-term neonates born to obese mothers, which increases linearly with maternal BMI, independent of other obesity-mediated maternal comorbidities. We also report a significantly increased trend towards incidence of PDA and NEC among full-term neonates born to obese mothers which require NICU admission, a finding that has not been previously reported. Thus, we extend the findings of earlier reports and additionally identify

potential morbidities that may lead to increased NICU admissions, in full-term neonates, born to obese mothers.

Maternal obesity is also associated with an increased prevalence of maternal co-morbidities including diabetes, gestational diabetes, hypertension, preeclampsia, and neonatal birth size [21], which have been independently associated with higher incidence of adverse outcomes in full-term neonates [22–24]. In keeping with these reports [21], we found increased prevalence of maternal co-morbidities with increasing BMI in obese mothers. Further we found that both obesity and obesity related maternal co-morbidities were independently associated with increased incidence of neonatal morbidities. Increased rates of NICU admissions that have been previously reported among the neonates of all gestation, delivered to obese mothers [15,16], have not been adjusted for obesity-related maternal co-morbidities. Usha Kiran et al. also reported that maternal obesity was independently associated with poor outcomes in newborns of all gestation, after correcting for obesity associated co-morbidities [25]. Together, our findings suggest that maternal obesity as well as its associated co-morbidities were independently associated with increased neonatal complications. These findings are pertinent since, in keeping with prior reports of increased risk for cardiovascular disease among metabolically benign obese individuals as compared to metabolically benign normal weight individuals [26], maternal obesity alone without associated co-morbidities can independently increase the risk of adverse health outcomes in full-term neonates. Moreover, presence of associated co-morbidities further increased the odds of neonatal complications among full-term neonates. Thus, it is important that maternal obesity with or without co-existing morbidities should be identified and addressed early in pregnancy to prevent the occurrence of adverse neonatal outcomes.

While earlier studies found an association between weight gain during pregnancy and adverse neonatal outcomes [27], this association was not observed in our study, after adjusting for maternal obesity and other co-morbidities. These differences may be due to differences in amount and rapidity of weight gain among women. Further, while we analyzed weight gain though the entire pregnancy, it may be possible that weight gain during certain periods in pregnancy may have a greater influence on neonatal outcomes. Thus, further investigations are needed to better define not only the role of cumulative maternal weight gain but that of the timing and rapidity of maternal weight gain and its associated mechanisms that influence neonatal outcomes.

The observed independent association of maternal obesity with adverse neonatal outcomes in full-term neonates born to obese women with no other pregnancy-related complications suggest the role of obesity-associated inflammation. Incidence of neonatal PDA, NEC and sepsis in full-term neonates has been reported to be higher among mothers with perinatal pro-inflammatory conditions like preeclampsia [28]. Further, obesity is a low-grade inflammatory state mediated primarily by leptin, a pro-inflammatory adipokine released by adipocytes [29], which is associated with increase in circulating inflammatory markers that are well characterized in the context of preeclampsia and maternal intrauterine infections. Prior studies have demonstrated that increased levels of these inflammatory markers in the neonatal systemic circulation as well as their direct transmission through the placental barrier may affect the neonate [30]. Since incremental weight gain has been associated with

higher leptin levels [31] and systemic inflammation, and we observed a linear trend between maternal BMI and neonatal outcomes observed in our study, we speculate that increasing systemic inflammation with increasing maternal BMI may play a role in the higher incidence and trends of neonatal morbidities observed in our study. Further studies are needed to investigate this potential mechanism.

While we acknowledge that maternal obesity-related neonatal morbidities also includes neonatal injuries associated with increased instrumentation required at delivery [32], we excluded all major birth trauma that was the primary diagnosis for a NICU admission from our analysis since the primary focus for the current report was the investigation of the association of maternal obesity with incidence of neonatal morbidities that are known to occur among full-term babies.

There are limitations to our study, primarily inherent to retrospective chart review and secondary data analysis. We relied on ICD-9 codes for the neonatal diagnoses that were based on the clinical evaluation of the neonatal physicians providing care to theneonates. To minimize these limitations, we included those mother neonate dyads that had complete data and those with missing data or outliers were excluded. The ICD codes, however, did not specify details of the investigated outcomes, such as the culture status for neonates diagnosed with sepsis, staging of NEC or the intervention made for PDA. Therefore, while we elucidated the incidence of neonatal morbidity among neonates born to obese mothers, clinical details of these illnesses were not available. Nevertheless, the advantage of this data set is the inclusion of a large number of women from a set of hospitals that were representative of the national population characteristics of the delivering mothers and their neonates. Moreover, the data was collected over a short period with likely no change in clinical practices. We also intentionally excluded neonates at increased risk of poor outcomes such as multiple births, major birth injury, and congenital anomalies, which could have confounded the effect of maternal obesity on neonatal outcomes. For similar reasons, we only included one birth, the first one in the dataset, to minimize intra-subject correlation of adverse neonatal outcomes. In conclusion, our findings illustrate that maternal obesity and its associated co-morbidities were independently associated with adverse outcomes in full-term neonates including PDA, NEC and sepsis. These outcomes were associated with a NICU hospitalization, known to contribute to increased length of hospital stay and associated long term morbidities. The incidence of these outcomes increases linearly with increase in maternal early pregnancy weight as well as maternal obesity-related complications during pregnancy including gestation diabetes, and preeclampsia, which place the health of both the mother and the neonate at risk. Although the IOM recommends appropriate maternal weight gain during pregnancy based on early pregnancy BMI, these recommendations may not be enough to reduce the complications observed in the newborns of obese mothers since pre-pregnancy obesity itself may be associated with neonatal morbidities as observed in our study. Thus, obese women, even without any obesity associated medical problems, planning a pregnancy should be strongly encouraged to reduce their weight prior to becoming pregnant and maintain weight gain within recommended guidelines during pregnancy to prevent adverse neonatal outcomes. Future studies are needed to further define both the underlying mechanisms and the clinical severity of these outcomes.

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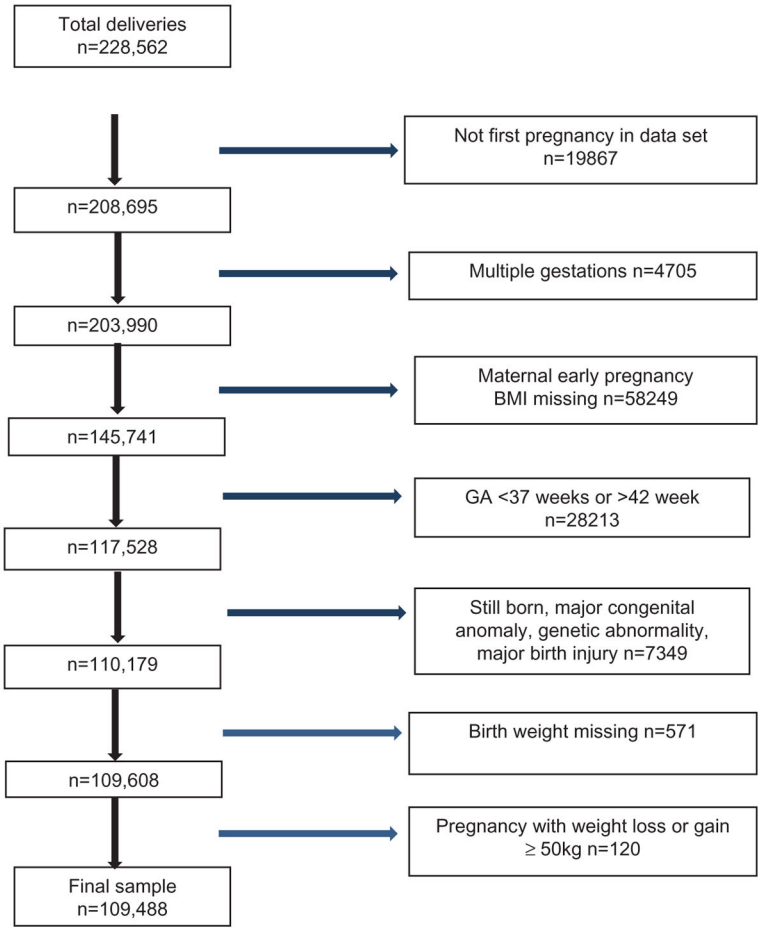

Figure 1.
Mother neonate pairs included in this cohort.

Table 1

Demographic and clinical characteristics of the women by BMI group.

	BMI					
Demographic and clinical characteristics	**<25 *n*(%) 65 656(60)**	**25–29.9 *n*(%) 24 407(22.3)**	**30–34.9 *n*(%) 11 136(10.2)**	**35–39.9 *n*(%) 4911(4.5)**	**≥40 *n*(%) 3378(3.1)**	***p* value**
Age in years mean (SD)	27.4 (6.1)	27.8 (6.0)	28.0 (5.9)	28.0 (5.8)	28.2 (5.7)	<0.0001
Gravidity Median (25th, 75th quartile)	2.0 (1.3)	2.0 (1.4)	3.0 (2.4)	3.0 (2.4)	3.0 (2.4)	<0.0001
Parity Median (25th, 75th quartile)	1.0 (0.1)	1.0 (0.2)	1.0 (0.2)	1.0 (0.2)	1.0 (0.2)	<0.0001
Ethnicity						
White/non-Hispanic (*n* =57 973)	37 822 (65.2)	11 529 (19.9)	5022 (8.7)	2240 (3.9)	1380 (2.3)	<0.0001
Black/non-Hispanic (*n* =20 120)	9251 (46.0)	5202 (25.9)	2867 (14.2)	1455 (7.2)	1345 (6.7)	
Hispanic (*n* =21 290)	11 734 (55.1)	5718 (26.9)	2452 (11.5)	909 (4.3)	477 (2.2)	
Asian/Pacific Islander (*n* =3973)	3119 (78.5)	550 (2.3)	186 (1.7)	77 (1.6)	41 (1.2)	
Other (*n* =6016)	3.98 (61.0)	1.377 (22.9)	593 (9.9)	224 (3.7)	151 (2.5)	
Diabetes (*n* =1750)	548 (0.8)	432 (1.8)	332 (3.0)	222 (4.5)	216 (6.4)	<0.0001 *
Hypertension (*n* =2348)	680 (1.0)	600 (2.5)	448 (4.0)	286 (5.8)	334 (9.9)	<0.0001 *
Preeclampsia (*n* =998)	194 (0.3)	222 (0.9)	218 (2.0)	146 (3.0)	218 (6.5)	<0.0001 *
Gestational diabetes (*n* =3369)	1114 (1.7)	938 (3.8)	659 (5.9)	366 (7.5)	292 (8.6)	<0.0001 *
Gestational weight gain						
Below IOM recommendations (*n* =18 233)	13 076 (19.9)	2199 (9.0)	1153 (10.4)	908 (18.5)	897 (26.6)	<0.0001 *
Above IOM recommendations (*n* =55 433)	26 389 (40.2)	16 883 (69.2)	7722 (69.3)	2782 (56.6)	1657 (49.1)	<0.0001 *

SD =standard deviation, IOM =Institute of Medicine.

*Cochran–Armitage test of trend.

Table 2

Association of maternal BMI with incidence of neonatal outcomes.

		BMI					
		<25	**25–29.9**	**30–34.9**	**35–39.9**	**≥40**	
Neonatal outcomes	*n*	65 656	24 407	11 136	4911	3378	*p* value *
Mean Gestational age [weeks (SD)]	109 488	39.2 (1.1)	39.2 (1.1)	39.2 (1.1)	39.2 (1.1)	39.1 (1.1)	<0.0001
Gestational size							
SGA	2224	1422 (2.2)	427 (1.7)	201 (1.8)	107 (2.2)	67 (2.0)	0.03
LGA	9034	4228 (6.4)	2492 (10.2)	1259 (11.3)	589 (12.0)	466 (13.8)	<0.0001
NEC	17	5 (0.0)	6 (0.0)	3 (0.0)	1 (0.0)	2 (0.1)	<0.0001
PDA	198	89 (0.1)	56 (0.2)	27 (0.2)	9 (0.2)	17 (0.5)	<0.0001
Respiratory distress	551	320 (0.5)	121 (0.5)	62 (0.6)	28 (0.6)	20 (0.6)	0.18
Sepsis	1161	579 (0.9)	314 (1.3)	141 (1.3)	66 (1.3)	61 (1.8)	<0.0001
Combination of morbidities	1711	893 (1.4)	437 (1.8)	203 (1.8)	91 (1.9)	87 (2.6)	<0.0001

SD =standard deviation, SGA =small for gestational age, LGA =large for gesatational age, NEC =necrotizing enterocolitis, PDA =patent ductus arteriosus.

Within parentheses are the SD or %.

*Cochran–Armitage test of trend.

J Matern Fetal Neonatal Med. Author manuscript; available in PMC 2017 April 28.

J Matern Fetal Neonatal Med. Author manuscript; available in PMC 2017 April 28.

Table 3

Odds ratio (OR) of incidence of neonatal morbidities stratified by maternal BMI and weight gain during pregnancy[*].

	PDA[#] OR (95% CI)	NEC[#] OR (95% CI)	Respiratory distress OR (95% CI)	Sepsis[#] OR (95% CI)	Combination of morbidities[#] OR (95% CI)
n	**198**	**17**	**551**	**1161**	**1711**
BMI 25–29.9	1.69 (1.21–2.37)	3.23 (0.99–10.58)	1.02 (0.82–1.25)	1.46 (1.28–1.68)	1.32 (1.18–1.48)
BMI 30–34.9	1.79 (1.16–2.76)	3.54 (0.85–14.81)	1.14 (0.87–1.50)	1.44 (1.20–1.73)	1.35 (1.15–1.57)
BMI 35–39.9	1.35 (0.68–2.69)	2.67 (0.31–22.89)	1.17 (0.79–1.72)	1.53 (1.18–1.98)	1.37 (1.10–1.70)
BMI ≥40	3.73 (2.22–6.27)	7.78 (1.51–40.11)	1.22 (0.77–1.91)	2.07 (1.58–2.70)	1.92 (1.53–2.40)
Weight gain					
Below[&]	1.04 (0.66–1.64)	2.46 (0.66–9.15)	1.04 (0.80–1.35)	0.99 (0.82–1.19)	1.04 (0.80–1.35)
Above[&]	1.43 (1.03–1.98)[#]	1.29 (0.39–4.29)	1.18 (0.98–1.43)	1.30 (1.10–1.44)[#]	1.18 (0.98–1.43)

PDA =patent ductus arteriosus, NEC =necrotizing enterocolitis.

[*]Reference group: BMI 20–24.9.

[#]$p<0.01$ using Cochran–Armitage test of trend.

[&]Reference group: normal weight gain for BMI as per IOM.

Table 4

Odds ratio (OR) of incidence of neonatal morbidities stratified by maternal co-morbidities.

	PDA OR (95% CI)	NEC OR (95% CI)	Respiratory distress OR (95% CI)	Sepsis OR (95% CI)	Combination of morbidities OR (95% CI)
n	**198**	**17**	**551**	**1161**	**1711**
Diabetes	5.08 (3.00–8.62)	8.22 (1.88–35.96)	1.97 (1.21–3.20)	1.76 (1.23–2.51)	2.08 (1.58–2.73)
Chronic hypertension	2.95 (1.65–5.30)	0.00	1.91 (1.24–2.93)	1.34 (0.95–1.90)	1.56 (1.19–2.04)
Preeclampsia	0.55 (0.08–0.94)	0.00	3.07 (1.83–5.15)	0.94 (0.50–1.76)	1.58 (1.26–1.98)
Gestational diabetes	3.36 (2.09–5.39)	6.75 (1.94–23.52)	1.69 (1.16–2.48)	1.55 (1.17–2.04)	1.52 (1.29–1.79)

PDA =patent ductus arteriosus, NEC =necrotizing enterocolitis.

Table 5

Adjusted odds ratios (AOR) of incidence of neonatal morbidities stratified by maternal BMI and weight gain during pregnancy*.

	PDA AOR (95% CI)	NEC AOR (95% CI)	Respiratory distress AOR (95% CI)	Sepsis# AOR (95% CI)	Combination of morbidities# AOR (95% CI)
n	**198**	**17**	**551**	**1161**	**1711**
BMI 25–29.9	1.43 (1.01–2.02)	3.25 (0.95–11.13)	0.93 (0.75–1.15)	1.37 (1.19–1.58)	1.22 (1.08–1.37)
BMI 30–34.9	1.37 (0.88–2.14)	3.07 (0.69–13.60)	0.98 (0.74–1.30)	1.32 (1.10–1.60)	1.20 (1.02–1.40)
BMI 35–39.9	0.97 (0.48–1.96)	1.95 (0.22–17.38)	0.98 (0.66–1.46)	1.40 (1.08–1.82)	1.20 (0.97–1.50)
BMI ≥40	2.56 (1.49–4.41)	4.90 (0.87–27.58)	0.95 (0.60–1.52)	1.91 (1.45–2.50)	1.66 (1.32–2.09)
Weight gain					
Below&	0.96 (0.60–1.62)	2.02 (0.54–7.62)	0.96 (0.73–1.25)	0.94 (0.78–1.14)	0.95 (0.82–1.11)
Above&	1.23 (0.88–1.72)	0.95 (0.27–3.26)	1.20 (0.99–1.47)	1.13 (0.99–1.20)	1.20 (1.07–1.34)

PDA =patent ductus arteriosus, NEC =necrotizing enterocolitis.

Adjusted for: diabetes, chronic hypertension, preeclampsia, gestational diabetes, gestational age, small and large for gestational age with *reference group: BMI 20–24.9.

#$p<0.01$ using Cochran–Armitage test of trend.

&Reference group: normal weight gain for BMI as per IOM.

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