Published in final edited form as:

Am J Perinatol. 2018 July ; 35(9): 844–851. doi:10.1055/s-0037-1621733.

The relationship between body mass index in pregnancy and adverse maternal, perinatal, and neonatal outcomes in rural India and Pakistan

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Abstract

Objective: To describe the relationship between early pregnancy body mass index (BMI) and maternal, perinatal, and neonatal outcomes in rural India and Pakistan.

Study Design: In a prospective, population-based pregnancy registry implemented in communities in Thatta, Pakistan and Nagpur and Belagavi, India, we obtained women's BMI prior to 12 weeks gestation (categorized as underweight, normal, overweight, and obese following World Health Organization criteria). Outcomes were assessed 42-days postpartum.

Results: The proportion of women with an adverse maternal outcome increased with increasing maternal BMI. Less than one third of non-overweight/non-obese women, 47.2% of overweight women and 56.0% of obese women experienced an adverse maternal outcome. After controlling

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Conflicts of Interest: The authors declare no conflicts of interest.

for site, maternal age and parity, risks of hypertensive disease/severe preeclampsia/eclampsia, cesarean/assisted delivery, and antibiotic use were higher among women with higher BMIs. Overweight women also had significantly higher risk of perinatal and early neonatal mortality compared to underweight/normal BMI women. Overweight women had a significantly higher perinatal mortality rate.

Conclusions: High BMI in early pregnancy was associated with increased risk of adverse maternal, perinatal, and neonatal outcomes in rural India and Pakistan. These findings present an opportunity to inform efforts for women to optimize weight prior to conception to improve pregnancy outcomes.

INTRODUCTION

According to the World Health Organization (WHO), more than half of the world's adult population is overweight (body mass index [BMI] ≥ 25.0) or obese (BMI ≥ 30.0) [1]. Once considered a problem of high-income countries (HIC), overweight and obesity are now increasing in low- and middle-income countries (LMIC) and have been recognized as a major public health problem [2]. Overall, women are more likely to be overweight or obese in LMICs, as opposed to in HICs where men are more likely to be overweight or obese [3]. Consequently, the incidence of maternal obesity at the start of pregnancy has increased in some LMICs [4, 5], which has critical implications for maternal and child populations.

While studies in HICs show that maternal pre-pregnancy obesity contributes to the risk for adverse pregnancy-related outcomes such as hypertension, preeclampsia, gestational diabetes, more frequent cesarean delivery, delivery of large-for-gestational age infants, and stillbirths [6–11], less is known about the impact of maternal BMI on poor pregnancy outcomes in LMICs.

India and Pakistan are two LMICs that would benefit from more population-level data regarding maternal overweight and obesity and associated maternal, perinatal and neonatal consequences. Both countries have seen a recent increase in the prevalence of obesity in the general female population [12, 13]. More than 20% of females aged 20 years and older in India are overweight or obese while more than one-third of females aged 20 years and older in Pakistan are overweight or obese [3]. Thus, obesity likely impacts a large proportion of the maternal populations in these countries and is therefore an expected key determinant of poor pregnancy outcomes. Having a better understanding of the distribution of obesity risk in specific maternal populations and the impact of obesity on pregnancy outcomes can guide initiatives aimed at improving maternal and newborn health in these countries. The aim of this study, therefore, was to describe the relationship between BMI in early pregnancy and adverse maternal, perinatal, and neonatal outcomes in rural areas of India and Pakistan.

METHODS

The study was conducted within the Global Network for Women's and Children's Health Research (Global Network), a multi-country research network with sites in Asia, Africa and Guatemala, which is funded by the *Eunice Kennedy Shriver* National Institute of Child

Health and Human Development [14, 15]. This study was conducted in three Global Network sites in Thatta, Pakistan, and Nagpur and Belagavi, India

The Maternal Newborn Health Registry (MNHR) is a population-based registry initiated in 2009 which aims to enroll all consenting women who reside within study clusters as early as possible during their pregnancy. Study clusters are defined geographic regions surrounding government health centers that generally include 300–500 deliveries per year. Registry administrators, who are trained study staff, aim to identify, screen, enroll and obtain outcomes for all consented women, regardless of where they deliver (home, health center or hospital). Basic demographic information is collected at the enrollment visit, and women are then visited by a registry study administrator, who is generally a nurse or medical officer, following delivery and at 6-weeks post-partum to obtain birth and neonatal outcomes, including information regarding delivery care (16–18). Women's height and weight were generally obtained from data obtained at the first antenatal care visit. For the purposes of the study analyses, we restricted those studied to women with a maternal weight reported at <12 weeks gestation and whose height was recorded at any time in pregnancy.

All data were collected on hard copy and then entered in the data management systems on study computers at each site, where inter and intra-form edit checks were performed. Data were then transmitted through a secure process to a central data coordinating center (RTI International, Durham, NC, USA), where additional data checks were performed.

Statistical analyses

Women's BMIs were categorized as underweight (<18.5 kg/m²), normal (18.5–25.0 kg/m²), overweight (25.1–30.0 kg/m²) and obese (>30.0 kg/m²) following the WHO BMI criteria (19). Maternal outcome measures of interest were maternal death, obstructed or prolonged labor, evidence of hypertensive disease, breech/transverse or oblique lie, cesarean or assisted delivery, treatment for adverse outcomes, unplanned hospitalizations, referral to hospital for evaluation, and antibiotic use. Neonatal outcomes of interest included stillbirth (death at >20 weeks gestation prior to delivery), early neonatal mortality (live births with death at <7 days), perinatal mortality (stillbirth or neonatal death at < 7 days), 28-day neonatal mortality (live birth with death at <28 days), and hospitalization. Available clinical and demographic data included maternal age, education level, parity, antenatal care visits, delivery location, and oxytocin or misoprostol use. Analyses were restricted to deliveries in the database between January 2013 and June 2016.

Differences in the outcome measures and clinical and demographic characteristics across the three research sites were described using counts and percentages, with differences in BMI classification across sites obtained using Mantel-Haenszel statistics. Estimates of maternal outcomes and 95% confidence intervals for each BMI category were obtained using Log-Binomial models adjusting for continuous maternal age and parity with generalized estimating equations (GEE) used to account for possible correlation within clusters. For maternal outcomes where the Log-Binomial models did not converge, a robust Poisson model GEE extension controlling for maternal age and parity was used. For the continuous outcome of birth weight, we used an analogous generalized linear model with an identity link and normal distribution assumption, controlling for correlation within cluster with a

GEE extension to estimate mean birth weight and 95% confidence interval by BMI category. We also performed a Cochran-Mantel-Haenszel test to compare BMI category distributions across Global Network site BMI using standardized rank scores. All models also adjusted for Global Network site. All data analyses were performed in SAS v.9.4 (Cary, NC, USA).

RESULTS

During the study period, of the 123,607 women screened, 122,512 women consented to participate (Table 1). A total of 41,778 (38.0%) study participants had their BMI obtained prior to 12 weeks gestation and were included in this analysis. The majority of participants had a normal BMI (54.7%, n=22,837). Nearly 40% (n=16,448) were considered underweight, 4.9% (n=2,036) were overweight, and 1.1% (n=457) were obese. The mean BMI across all study sites was 19.7 kg/m² (standard deviation 3.2kg/m²) and the range was 12.1 to 58.3 kg/m² (results not shown). The distribution of women in the maternal BMI categories (underweight, normal, overweight and obese) varied significantly by site ($p < 0.0001$). A greater proportion of women from the Pakistan site were overweight or obese compared to the two India sites.

Overall, the majority of participants were between 20 and 35 years of age (91.3%), had a secondary education (50.6%), received 4 or more antenatal care visits (68.1%), and delivered in a hospital setting (63.6%) (results not shown). The maternal demographic and obstetrical characteristics of the study population, stratified by maternal BMI grouping, are summarized in Table 2. Obese women were generally older and had increased parity as compared to non-obese women. No differences in education, number of antenatal care visits, or delivery location were found by BMI group.

Table 3 describes the maternal outcomes by maternal BMI category. Generally, adverse outcomes increased with increasing maternal BMI. While 27.2% of women who were underweight experienced any adverse maternal outcome, almost half (47.2%) of overweight women and more than half (56.0%) of obese women experienced an adverse maternal outcome. Specifically, obstructed/prolonged labor/failure to progress; evidence of hypertensive disease/severe preeclampsia/eclampsia; breech/transverse or oblique lie; any treatment for adverse outcomes; any other symptoms or signs of life threatening illness; and use of antibiotics increased with increasing maternal BMI. Cesarean or assisted vaginal delivery also increased with increasing maternal BMI; 49.4% of obese women had a cesarean delivery compared with 18.6% of underweight women and 24.8% of women with a normal BMI.

After controlling for maternal age, parity, and site, the rate of any adverse maternal outcome was lowest among underweight women and highest among obese women (Table 4). Rates of hypertensive disease/severe preeclampsia/eclampsia and cesarean or assisted delivery were significantly higher among women who were overweight or obese compared to women who were not overweight or obese, while antibiotic use was significantly higher among obese women compared to women who were underweight or had a normal BMI (Table 4).

Perinatal and neonatal outcomes by maternal BMI for all sites combined are shown in Table 5. Stillbirth rates were approximately 50% higher among obese women compared to underweight and normal BMI women, however rates between BMI groups were not statistically different after controlling for site and maternal age and parity (Table 6). Overweight women had a significantly higher adjusted perinatal mortality rate compared to underweight women or women with a normal BMI, while the adjusted neonatal mortality rate was higher for overweight women compared to normal BMI women (Table 6). Infant birthweights also increased with increasing maternal BMI. No differences in hospitalization rates were found by maternal BMI category.

DISCUSSION

Like other LMICs countries, overweight and obesity are increasing rapidly in India and Pakistan, especially among the female population [12, 13]. To our knowledge, this is the first population-based cross-sectional study in rural India and Pakistan to examine the risk of adverse maternal, perinatal, and neonatal outcomes in connection to maternal BMI in early pregnancy.

As indicated by the results of this study, maternal overweight and obesity are a threat to the health of women and their infants in these regions, as both were associated with increased adverse outcomes. Specifically, rates of cesarean or assisted delivery were significantly higher in overweight and obese women compared to normal and underweight women. Evidence of hypertensive disease/severe preeclampsia/eclampsia was also greater in overweight and obese women compared to normal and underweight women. This has important implications as gestational hypertensive disorders are associated with fetal growth restriction, placental abruption, preterm birth, stillbirth, and neonatal mortality [20, 21]. Indeed, our results show that a high maternal BMI was associated with increased risk of stillbirth as well as perinatal and early neonatal mortality. This could be a result of the higher rate of hypertensive disorders in the overweight/obese women in our study. Antibiotic use, highest among our study participants with high BMIs, could perhaps indicate the presence of an infection would could potentially lead to these subsequent adverse perinatal outcomes as well.

The relationships we found between maternal and neonatal outcomes and maternal BMI are expected given that maternal BMI has been associated with increased rates of adverse maternal [22, 23] and perinatal outcomes [24, 25] previously, including studies in LMICs [26–28]. Still, ours is the first study to show that these outcomes are occurring in women in rural India and Pakistan. Our results suggest that efforts to address the obesity epidemic occurring in these regions are warranted to mitigate the serious and negative effects of high maternal BMI on mothers and infants. Given the rising prevalence of maternal overweight and obesity in these areas, even a modest effect could have a substantial population impact.

Underweight was also prevalent in our study population; nearly 40% of study participants had an early pregnancy BMI considered to be underweight. While a low maternal BMI has been previously identified as a risk factor for adverse pregnancy outcomes [29, 30], in our study, underweight women seemed to generally fare better than women with higher BMIs.

After adjusting for maternal age and parity, underweight women had significantly lower rates of cesarean/assisted delivery and hypertensive disease compared to overweight or obese women. Perinatal and neonatal mortality and stillbirth rates were also lower among underweight women. Similar findings have been reported in other LMICs [26–29]. Despite the lower risks of some outcomes measured in our study, the high prevalence of underweight could represent a burden of other conditions. For example, in our study, almost a quarter of infants born to underweight women had a low birthweight which is associated with a range of morbidities such as inhibited growth and cognitive development and chronic diseases later in life [31].

Moreover, maternal underweight has been associated with an increased risk of maternal anemia [32] and stunting and wasting in children [26], though these outcomes were not measured in the current study. Therefore, while having a lower BMI was “protective” against some major adverse outcomes in our study population, maternal underweight may lead to other important problems and the potential risks associated with suboptimal maternal BMI should not be minimized.

There are potential limitations to consider when interpreting our results. To obtain early pregnancy BMI, we restricted analyses to those with documented weight prior to 12 weeks of pregnancy; nearly 60% of women who had weights taken later in pregnancy were excluded and thus our results may not be reflective of the full cohort. Given the limited time-period of our study, we were unable to examine trends over time. Lastly, our findings are also limited to the results from specific sites within the Global Network countries and are not reflective of each country as a whole.

Despite the limitations there are several major strengths of this study. First, we used a prospective, population-based multi-site dataset to investigate adverse health outcomes related to maternal BMI in LMICs. This large sample size resulted in enough power to detect small differences in morbidity. WHO BMI classifications [19] were also used, increasing the ability to compare of our findings to other studies that use this standard BMI definition. Additionally, the population-based nature of the registry makes the findings more generalizable than facility-based studies. Lastly, we enrolled women who delivered in hospital and clinics as well as women who delivered outside such facilities, and did not rely on the health systems to identify eligible women, therefore representing a cross-sectional cohort of residents within the study regions.

In summary, this study provides evidence that high early pregnancy BMI is associated with poor maternal, perinatal, and neonatal outcomes in rural India and Pakistan. These findings suggest that future research focused on finding effective ways to mitigate the increasing threat of overweight and obesity among pregnant women and their infants in these and other LMICs is needed. Increasing efforts to encourage women to optimize weight prior to conception may be warranted.

Acknowledgments:

This study was funded with grants from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development.

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Table 1.

Information for entire study population by site.

	Total	Belagavi (India)	Nagpur (India)	Pakistan
Screened, N	123,607	47,779	35,207	40,621
Ineligible, N (%)	1,079 (0.9)	0 (0.0)	0 (0.0)	1,079 (2.7)
Eligible, N (%)	122,528 (99.1)	47,779 (100.0)	35,207 (100.0)	39,542 (97.3)
Consented, N (%)	122,512 (100.0)	47,766 (100.0)	35,207 (100.0)	39,539 (100.0)
Loss to follow-up prior to delivery, N (%)	1,099 (0.9)	28 (0.1)	71 (0.2)	1,000 (2.5)
Delivered, N (%)	121,413 (99.1)	47,738 (99.9)	35,136 (99.8)	38,539 (97.5)
Exclusions, N (%)	11,498 (9.5)	5,319 (11.1)	2,163 (6.2)	4,016 (10.4)
Maternal death prior to labor/ delivery, N	54	11	17	26
Miscarriage, N	6,982	3,234	1,089	2,659
Medical Terminated Pregnancy, N	3,437	1,744	773	920
Multiple pregnancy, N	1,025	330	284	411
Deliveries included, N (%)	109,915 (90.5)	42,419 (88.9)	32,973 (93.8)	34,523 (89.6)
BMI measured prior to 12 weeks gestation, N (%)	41,778 (38.0)	17,464 (41.2)	12,878 (39.1)	11,436 (33.1)
BMI measured after 12 weeks gestation or unavailable, N (%)	68,137 (62.0)	24,955 (58.8)	20,095 (60.9)	23,087 (66.9)
BMI Category (kg/m ²), N (%)	41,778	17,464	12,878	11,436
Underweight (<18.5)	16,448 (39.4)	6,670 (38.2)	5,726 (44.5)	4,052 (35.4)
Normal (18.5–25)	22,837 (54.7)	9,925 (56.8)	6,731 (52.3)	6,181 (54.0)
Overweight (25–30)	2,036 (4.9)	759 (4.3)	369 (2.9)	908 (7.9)
Obese (>30)	457 (1.1)	110 (0.6)	52 (0.4)	295 (2.6)

Abbreviations: BMI, body mass index.

Table 2:

Covariates and risk factors by maternal BMI.

Characteristic	BMI Category (kg/m ²)			
	Underweight (< 18.5) N=16,448 n (%)	Normal (18.5–24.9) N=22,837 n (%)	Overweight (25.0–29.9) N=2,036 n (%)	Obese (≥ 30.0) N=457 n (%)
Maternal age (years)				
< 20	1,426 (8.7)	1,684 (7.4)	68 (3.3)	10 (2.2)
20–35	14,906 (90.6)	20,891 (91.5)	1,914 (94.0)	422 (92.3)
> 35	115 (0.7)	259 (1.1)	54 (2.7)	25 (5.5)
Education attainment				
No formal education	4,345 (26.4)	6,273 (27.5)	578 (28.4)	143 (31.3)
Primary	2,091 (12.7)	2,958 (13.0)	268 (13.2)	73 (16.0)
Secondary	8,631 (52.5)	11,386 (49.9)	940 (46.2)	177 (38.7)
University+	1,374 (8.4)	2,207 (9.7)	249 (12.2)	64 (14.0)
Parity				
0	6,286 (39.3)	8,446 (38.1)	533 (27.1)	85 (20.0)
1–2	7,696 (48.1)	10,420 (47.0)	955 (48.6)	195 (46.0)
3–4	1,266 (7.9)	1,861 (8.4)	276 (14.0)	71 (16.7)
5	762 (4.8)	1,441 (6.5)	202 (10.3)	73 (17.2)
Last pregnancy resulted in a live birth				
Yes	9,266 (95.3)	13,092 (95.4)	1,349 (94.1)	310 (91.4)
No	460 (4.7)	630 (4.6)	84 (5.9)	29 (8.6)
Number of antenatal care visits				
0	254 (1.5)	389 (1.7)	32 (1.6)	4 (0.9)
1	614 (3.7)	849 (3.7)	73 (3.6)	16 (3.5)
2	1,192 (7.2)	1,716 (7.5)	150 (7.4)	32 (7.0)
3	3,018 (18.4)	4,588 (20.1)	354 (17.4)	60 (13.1)
4	11,364 (69.1)	15,287 (67.0)	1,426 (70.1)	345 (75.5)
Delivery location				
Hospital	9,890 (60.1)	14,895 (65.2)	1,435 (70.5)	330 (72.2)
Clinic	4,707 (28.6)	5,404 (23.7)	366 (18.0)	84 (18.4)
Home	1,741 (10.6)	2,359 (10.3)	225 (11.1)	41 (9.0)
Other	110 (0.7)	179 (0.8)	10 (0.5)	2 (0.4)
Oxytocin or misoprostol use				
Yes	13,613 (82.9)	18,853 (82.7)	1,699 (83.5)	386 (84.5)
No	2,813 (17.1)	3,953 (17.3)	336 (16.5)	71 (15.5)

Table 3.

Maternal outcomes by maternal BMI.

Outcome	BMI Category (kg/m ²)			
	Underweight (< 18.5)	Normal (18.5–24.9)	Overweight (25.0–29.9)	Obese (≥ 30.0)
Deliveries, N	16,448	22,837	2,036	457
Any maternal adverse outcome ²	4,466/16,448 (27.2)	7,499/22,837 (32.8)	960/2,036 (47.2)	256/457 (56.0)
Maternal death < 42 days ¹	17/16,418 (104)	22/22,780 (97)	3/2,031 (148)	0/454 (0)
Obstructed/prolonged labor/failure to progress ²	1,492/16,442 (9.1)	2,403/22,836 (10.5)	251/2,036 (12.3)	59/457 (12.9)
Evidence of hypertensive disease/severe preeclampsia/eclampsia ²	455/16,439 (2.8)	942/22,835 (4.1)	167/2,036 (8.2)	61/457 (13.3)
Breech/transverse or oblique lie ²	331/16,441 (2.0)	535/22,835 (2.3)	58/2,036 (2.8)	20/457 (4.4)
Cesarean or assisted delivery ²	3,044/16,361 (18.6)	5,626/22,715 (24.8)	781/2,014 (38.8)	224/453 (49.4)
Any treatment for adverse outcomes ²	1,211/16,442 (7.4)	1,793/22,830 (7.9)	178/2,036 (8.7)	51/457 (11.2)
Blood transfusion	496/16,439 (3.0)	823/22,828 (3.6)	121/2,036 (5.9)	43/457 (9.4)
D&C or suction	591/16,442 (3.6)	779/22,830 (3.4)	35/2,036 (1.7)	6/457 (1.3)
Magnesium sulfate/anticonvulsants	94/16,439 (0.6)	181/22,828 (0.8)	22/2,035 (1.1)	4/457 (0.9)
Severe anemia (HB < 7)	60/12,685 (0.5)	71/17,059 (0.4)	6/1,222 (0.5)	0/195 (0.0)
Unplanned hospitalization ²	481/10,789 (4.5)	754/15,232 (5.0)	79/1,499 (5.3)	11/328 (3.4)
Referred to hospital for evaluation ²	715/10,779 (6.6)	1,031/15,229 (6.8)	95/1,499 (6.3)	15/328 (4.6)
Antibiotics ²	13,203/16,432 (80.3)	18,572/22,817 (81.4)	1,654/2,036 (81.2)	376/457 (82.3)

¹ n/N (rate/100,000 deliveries).² n/N (%)

Table 4.

Adjusted* estimates of maternal outcomes by maternal BMI

Outcome	BMI Category (kg/m ²)		
	Underweight (< 18.5)	Normal (18.5–24.9)	Overweight (25.0–29.9)
Any maternal adverse outcome ¹	25.9 (24.1, 27.8)	31.5 (29.7, 33.5)	43.3 (41.0, 45.8)
Obstructed/prolonged labor/failure to progress ¹	8.3 (7.3, 9.4)	9.7 (8.6, 11.0)	10.7 (9.0, 12.7)
Evidence of hypertensive disease/severe preeclampsia/eclampsia ¹	2.6 (2.2, 3.1)	3.9 (3.4, 4.5)	7.6 (6.3, 9.3)
Breech/transverse or oblique lie ¹	2.1 (1.8, 2.4)	2.4 (2.1, 2.7)	2.5 (1.8, 3.6)
Cesarean or assisted delivery ²	16.2 (14.6, 17.9)	21.4 (19.8, 23.3)	31.9 (29.4, 34.8)
Any treatment for adverse outcomes ¹	7.5 (6.0, 9.6)	8.0 (6.5, 10.0)	10.2 (7.5, 14.0)
Blood transfusion ²	3.5 (2.7, 4.5)	3.9 (3.0, 5.0)	5.1 (3.7, 7.0)
D&C or suction ¹	3.3 (1.9, 5.8)	3.4 (2.0, 5.7)	2.5 (1.5, 4.1)
Magnesium sulfate anticonvulsants ¹	0.4 (0.3, 0.6)	0.6 (0.4, 0.8)	0.8 (0.4, 1.7)
Unplanned hospitalization ¹	3.7 (2.7, 5.0)	4.1 (3.0, 5.5)	4.8 (3.3, 6.8)
Referred to hospital for evaluation ¹	6.1 (4.8, 7.7)	6.9 (5.4, 8.8)	7.5 (5.5, 10.2)
Antibiotics ²	76.4 (71.0, 82.3)	77.8 (72.7, 83.3)	82.2 (77.6, 87.1)

* All models adjusted for site, maternal age, and parity. Non-overlapping CIs indicate significant differences between estimates.

¹ Log-Binomial models used.² Poisson models used.

Table 5:

Stillbirth, Perinatal and Neonatal outcomes by maternal BMI category.

Outcome	Underweight (< 18.5)	Normal (18.5–24.9)	Overweight (25.0–29.9)	Obese (≥ 30.0)
Deliveries, N	16,448	22,837	2,036	457
Stillbirth ¹	574/16,447 (34.9)	819/22,837 (35.9)	86/2,036 (42.2)	24/457 (52.5)
Early neonatal mortality ^{1,2}	368/15,845 (23.2)	492/21,962 (22.4)	62/1,945 (31.9)	7/430 (16.3)
Perinatal mortality ^{1,3}	942/16,419 (57.4)	1,311/22,781 (57.5)	148/2,031 (72.9)	31/454 (68.3)
28 day neonatal mortality ¹	458/15,845 (28.9)	598/21,962 (27.2)	74/1,945 (38.0)	11/430 (25.6)
Live births, N	15,873	22,018	1,950	433
Measured birth weight ⁵ (g)				
Mean (std)	2,697 (439)	2,773 (446)	2,876 (501)	2,918 (536)
Median	2,700	2,780	2,910	3,000
Birth weight ^{4,5,6} (g)				
< 1000	32/15,872 (0.2)	41/22,017 (0.2)	7/1,949 (0.4)	1/433 (0.2)
1000–1499	138/15,872 (0.9)	169/22,017 (0.8)	12/1,949 (0.6)	3/433 (0.7)
1500–2499	3,442/15,872 (21.7)	3,825/22,017 (17.4)	282/1,949 (14.5)	65/433 (15.0)
≥ 2500	12,260/15,872 (77.2)	17,982/22,017 (81.7)	1,648/1,949 (84.6)	364/433 (84.1)
Hospitalization ⁴	372/10,611 (3.5)	532/15,000 (3.5)	49/1,450 (3.4)	12/324 (3.7)

¹ n/N (rate/1000).

² Mortality at < 7 days.

³ Includes stillbirth or early neonatal mortality.

⁴ n/N (%).

⁵ Of live births (excludes stillbirths).

⁶ Birthweight measured and estimated.

Table 6.

Adjusted* estimates of stillbirth, perinatal and neonatal outcomes by maternal BMI.

Outcome	BMI Category (kg/m ²)			
	Underweight (< 18.5)	Normal ($18.5\text{--}24.9$)	Overweight ($25.0\text{--}29.9$)	Obese (≥ 30.0)
Stillbirth ^{1,2}	31.3 (28.4, 34.4)	32.4 (29.7, 35.4)	37.7 (32.5, 43.7)	48.7 (34.2, 69.2)
Early neonatal mortality ^{1,2,3}	22.3 (19.8, 25.2)	21.3 (19.4, 23.4)	30.3 (24.1, 38.1)	17.3 (8.9, 33.6)
Perinatal mortality ^{1,2,4}	53.1 (49.6, 56.9)	53.3 (49.8, 57.1)	67.0 (59.1, 76.0)	66.3 (47.6, 92.2)
28 day neonatal mortality ^{1,2}	27.6 (24.7, 30.9)	25.7 (23.6, 28.1)	35.8 (28.6, 44.9)	24.8 (13.1, 47.0)
Birth weight ^{5,6} (g)	2698 (2685, 2711)	2773 (2761, 2786)	2869 (2843, 2895)	2912 (2856, 2968)
Hospitalization ^{1,2}	26.8 (20.7, 34.6)	27.6 (21.9, 34.7)	27.1 (20.2, 36.6)	26.8 (14.2, 50.5)

* All models adjusted for site and maternal age and parity. Non-overlapping CIs indicate significant differences between estimates.

¹ Log-Binomial models used.

² Adjusted rate/1000 (95% CI).

³ Mortality at < 7 days.

⁴ Includes stillbirth or early neonatal mortality.

⁵ Multivariable generalized linear model with identity link used.

⁶ Mean measured birthweight (95% CI).