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Original Research Article

Assessing the Impact of First Trimester Maternal BMI on Pregnancy Outcomes: A Prospective Observational Study

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Abstract:

Background: It is important in its relationships to maternal and neonatal outcomes to examine Maternal Body Mass Index (BMI) in early pregnancy. The extremes of BMI whether underweight or overweight are found to be associated with adverse events in pregnancy.

Aim: To evaluate the association between first trimester maternal BMI and pregnancy outcomes in women with singleton pregnancies.

Method: A prospective observational study recruited 180 women who were attending at Nalanda Medical College & Hospital, Patna, Bihar, India. Participants were grouped into four BMI categories (underweight, normal, overweight, and obese). Maternal complications, mode of delivery, and neonatal outcomes were analyzed utilizing ANOVA and Chi-squared tests ($p<0.05$ significant).

Results: Normal BMI women accounted for 48.9% of the cohort. Higher BMI increased the incidence of pregnancy related hypertension (16.7%) and gestational diabetes (33.3%). Severe anemia (21.4%) and intrauterine growth restriction (35.7%) was more prevalent in underweight women. Rates of Cesarean delivery increased with BMI and postpartum complications (PPH, wound sepsis) were common in obese women. Neonates of underweight mothers tended to be SGA (35.7%) and neonates of obese mothers had an increased incidence of macrosomia (12.5%).

Conclusion: Low and high maternal BMI both have a negative impact on pregnancy outcomes and need assessment along with clinical interventions initiated in early pregnancy based on their BMI.

Keywords: Maternal BMI, Pregnancy Outcomes, Gestational Diabetes, Hypertension, IUGR, Macrosomia, Neonatal Health.

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Introduction

Maternal health throughout a pregnancy is crucial in determining the outcome of both the mother and the newborn. Of all the available estimates of maternal health, early pregnancy Body Mass Index has emerged as one of the most crucial determinants for the course and the outcome of pregnancy. BMI, defined as a person's weight in kilograms divided by the square of their height in meters (BMI = kg/m²), is an easy but powerful tool for assessing nutritional status and possible health risks from both undernutrition and overnutrition. The early pregnancy BMI, calculated from pre-pregnancy values, is a baseline measure of nutrition before pregnancy and can be utilized as an indicator of related complications to pregnancy [1].

A robust body of literature demonstrates that being outside the normal BMI range, either high or low, correlates with adverse outcomes. High BMI individuals are at significantly higher risk of developing gestational diabetes mellitus (GDM), pregnancy-induced hypertension (PIH), preeclampsia (PE), postpartum hemorrhage (PPH), and other obstetrical complications [2]. Additionally, high BMI has been associated with higher rates of cesarean deliveries, shoulder dystocia, instrumental deliveries, and birth trauma (i.e., asphyxia, macrosomia). These complications result in increased maternal morbidity, with long-term health outcomes for the neonate (i.e., metabolic disorders, obesity, etc.).

Conversely, women with low BMI during early pregnancy are also not immune to complications but

rather face other challenges [3]. Underweight pregnant women are at increased risk for preterm labor, LBW infants, IUGR, anemic. Most often these complications result from less-than-optimal nutritional stores and diastatic placental development, which impairs fetal growth and gestation period. Infants born to underweight women have greater risk for neonatal morbidity and mortality, developmental delays, and chronic medical conditions later in life. Thus, both extremes of the BMI spectrum can be serious threats to pregnancy outcomes and emphasize important need for optimal maternal nutrition status before and during pregnancy.

Because of this association, early gestation provides a golden opportunity to assess each woman for risk and take appropriate measures. Considering this importance, the American College of Obstetricians and Gynecologists strongly recommends that BMI be routinely calculated in all pregnant women during the first prenatal visit [4]. Early estimation enables the clinicians to categorize clinical weight change as underweight, normal weight, overweight, and obese and grade the intensity of antenatal care. High-risk individuals can thus be counseled about diet and exercise and the risks of inappropriate gestational weight gain.

Gestational weight gain is another relevant and modifiable agent impacting maternal and fetal outcomes. Weight gain during pregnancy should be according to specific recommendations based on the mother's pre-pregnancy BMI to improve both maternal and fetal health. The Institute of Medicine has proposed recommendations for the optimal range of weight gain for each BMI category of pre-pregnancy weight indicating that too much or too little weight gain, based on these ranges, is related to various complications [5]. Excess weight gain among overweight and obese women increases the risk of various pregnancy-related complications such as GDM, hypertensive disorders, or CS versus women with recommended weight gain. Insufficient weight gain among underweight women can increase the risk of cases such as placental insufficiency, poor fetal growth (IUGR), or preterm birth.

Evaluating and addressing mothers' BMI can have a more significant impact on improving short- and long-term health outcomes for both mother and child. From a public health perspective, rising obesity and undernutrition trends in different parts of the globe present a dual problem. While undernutrition and lower BMI are still major contributors to poor pregnancy outcomes in developing countries, rising obesity in developed and urban contexts has been associated with greater metabolic issues and obstetric interventions. These contradictory trends in nutritional epidemiology highlight the importance of context-specific data and planning antenatal strategies accordingly.

Furthermore, the earlier we recognize risks associated with BMI, the earlier we can facilitate multidisciplinary interventions such as nutritional counseling, increasing physical activity, and ongoing maternal-fetal monitoring. This management not only increases the chances of positive pregnancy outcomes but reduces health costs related to preventable complications of pregnancy. In practice, assessing BMI is a simple, cost-effective screening tool, that can easily be done as a part of routine antenatal care.

Despite there being many studies around the world trying to establish the relationships between both maternal BMI and pregnancy outcomes, results vary because of genetic variation and different sociodemographic and lifestyle differences from one population to another. As a result, obtaining population specificity has been deemed important for better understanding these associations and making guidance for local health care. This prospective observational study was developed therefore to assess first trimester maternal BMI and its impact on pregnancy outcomes. This study is looking at maternal and fetal outcomes in different categories of BMI and evaluating specific risk related to high BMI and low BMI, while reinforcing the importance of monitoring maternal weight during pregnancy both early and continuously. The identified products would be used for developing better assessment of antenatal strategies, onset/Risk stratification, and ultimately maternal and neonatal health.

Materials and Methods

Study Design: This study is a prospective observational study that was undertaken with a goal to evaluate the association of first-trimester maternal BMI with pregnancy outcomes. The study was conducted under standard clinical and ethical research standards.

Study Area: The study was conducted at the Department of Obstetrics and Gynecology, Nalanda Medical College & Hospital, Patna, Bihar, India.

Duration of Study: The study duration was Five months.

Study Population: Study population included women who attended of the Department of Obstetrics and Gynecology, booked during the first trimester of pregnancy, and were Singleton pregnancies (≤13 weeks of gestation).

Sample Size: Based on the inclusion and exclusion criteria, a total sample size of 180 women was enrolled in the study. The sample size was based on the number of eligible women who attended the antenatal clinic during the study.

Inclusion Criteria

- Women with a confirmed singleton pregnancy in the first trimester (≤13 weeks)

- Women who provided written informed consent to participate in the study

Exclusion Criteria

- **Multiple pregnancies**
- Women with pre-existing medical conditions such as:
    - Diabetes mellitus
    - Chronic hypertension
    - Heart disease
    - Hypothyroidism
- Women unwilling to participate or lost to follow-up

Data Collection: We collected data prospectively from all eligible participants during their routine antenatal appointments. At the time of booking in the first trimester, we obtained a full history including demographic information, obstetric history, and other medical details, and conducted a thorough clinical examination including recording maternal height and weight. Maternal BMI was calculated using the standard formula.

$$\text{BMI} = \frac{\text{Weight (Kg)}}{\text{Height (m)}^2}$$

Based on the calculated BMI, participants were categorized into five groups following the World Health Organization (WHO) and National Institutes of Health (NIH) guidelines:

- Group I (underweight)- Less than or equal to 19.9 kg/m2
- Group II (normal)- BMI: 20-24.9kg/m2
- Group III (overweight)- BMI: 25-29.9kg/m2
- Group IV (obese)- BMI: 30-34.9kg/m2
- Group V (morbidly obese)- BMI: >35kg/m2

Subsequently, the participants were followed up at regular intervals throughout their pregnancy in order to document any complications for either the mother or baby. We carefully recorded data regarding weight gain, development of antenatal complications, delivery mode, and neonatal outcomes.

Procedure: After participants were recruited, all women received standard antenatal care and were monitored throughout their pregnancy, according to any institutional protocol. Maternal weight was measured at each follow-up appointment, and routine antenatal assessments were completed by midwives in the antenatal clinic. Any complications experienced by women during pregnancy, such as gestational hypertension or diabetes, pre-eclampsia, preterm labor, etc. were recorded. Labor and delivery information (mode of delivery and intrapartum events) were also recorded during the time of confinement. Maternal and neonatal outcomes were also recorded, including birth weight, Apgar score, NICU admission, etc. Each woman was followed through delivery for complete assessment of maternal and fetal outcomes related to maternal BMI.

Statistical Analysis: The data was compiled and analyzed for this study using either commercially available statistical software (Statistical Package for the Social Sciences (SPSS) software (version 27) or an equivalent statistical program). Maternal age, body mass index (BMI), and weight-gain designed for this study were to be expressed as mean ± standard deviation (SD) and pregnancy complications and mode of delivery were to be expressed as frequency and percentages. Comparison between group means was to be performed with either an analysis of variance (ANOVA) or Mann–Whitney U test for continuous variables and by using Chi-square test for categorical variables. For all analyses, a p-value of less than 0.05 using 95% confidence intervals was used to determine statistical significance."

Result

The distribution of women by body mass index (BMI) is shown in Table 1. Of the 180 women studied, almost half (48.9%) were classified as normal weight (Group II, BMI 20–24.9 kg/m²), representing the largest proportion of women in this sample. Overweight women (Group III, BMI 25–29.9 kg/m²) made up 22.2% of the sample, while underweight women (Group I, BMI ≤19.9 kg/m²) were 15.6% of the study. Obese women (Group IV, BMI 30–34.9 kg/m²) represented 13.3% of the sample, while no woman belonged to the morbidly obese category (BMI ≥35 kg/m²). The BMI distribution shows that the majority of the women in the study were within or near the normal BMI range; very few women were identified as overweight or underweight, or morbidly obese. The absence of morbidly obese women may reflect the characteristics and lifestyles of the study population or have impacted inclusion criteria specific to participants who were morbidly obese. Pooling these data shows that a majority of the sample were normal weight women, which could serve as a "typical" representative sample used for comparisons in pregnancy outcomes in women enrolled varying BMI classifications.

Table 1: Distribution of Patients According to BMI

BMI Group	BMI (kg/m²)	No. of Women (n=180)	Percentage (%)
I – Underweight	≤19.9	28	15.6
II – Normal Weight	20–24.9	88	48.9
III – Overweight	25–29.9	40	22.2
IV – Obese	30–34.9	24	13.3
V – Morbidly Obese	≥35	0	0

Table 2 reveals a robust relationship between maternal BMI and antenatal complications. Specifically, the proportion of pregnancies complicated by pregnancy induced Hypertension (PIH) and gestational diabetes mellitus (GDM) rose sharply as BMI increased, from 3.6% to 16.7% and 3.6% to 33.3%, respectively ($p < 0.01$ for both), suggesting a degree of metabolic risk associated with obesity. Inversely, we similarly observed a decline in anemia within these categories (21.4% in the low BMI group and subsequently declining to 4.2% in the high BMI group ($p < 0.05$)). Intrauterine growth restriction (IUGR) also occurred most often in women with lower BMIs (35.7%); whereas this condition was considerably less present in the higher BMI groups (11.4-16.7%, $p < 0.05$). Macrosomia did not occur in the low BMI group but progressively reached 12.5% in the high BMI group ($p < 0.01$). Our data suggests maternal undernutrition, BMI less than normal, will likely predispose to anemia and IUGR, but being overweight and obese certainly predispose to greater risk for PIH, GDM, and macrosomia. Consequently, addressing unhealthy BMI at both ends is important to improve pregnancy outcomes.

Table 2: Comparison of Antenatal Complications Based on BMI

Complication	Group I (n=28)	Group II (n=88)	Group III (n=40)	Group IV (n=24)	p-value
Pregnancy Induced Hypertension (PIH)	1 (3.6%)	1 (1.1%)	3 (7.5%)	4 (16.7%)	<0.01
Gestational Diabetes Mellitus (GDM)	1 (3.6%)	9 (10.2%)	10 (25.0%)	8 (33.3%)	<0.01
Anemia	6 (21.4%)	8 (9.1%)	4 (10.0%)	1 (4.2%)	<0.05
Intrauterine Growth Restriction (IUGR)	10 (35.7%)	10 (11.4%)	5 (12.5%)	4 (16.7%)	<0.05
Macrosomia	0 (0%)	1 (1.1%)	2 (5.0%)	3 (12.5%)	<0.01

Table 3 details the distribution of method of delivery and postpartum complications among four groups in the study. Normal vaginal delivery was viewed as the most common method overall (Group I 57.1%, Group II 56.8%, Group III 45.0%, Group IV 41.7%). Statistically significant differences were identified in the rate of normal vaginal delivery ($p < 0.05$). The overall instrumental delivery rate was low but did demonstrate variability between groups ($p < 0.01$), with high rates in Group IV 12.5% and low rates in Group II 4.5%. Cesarean section (LSCS) rates were also frequent, particularly in Groups III 47.5% and IV 45.8%, when comparing groups, I 35.7%, and II 38.6% ($p < 0.05$; in other words, statistically significant), pointing to an association with higher rates of operative delivery in later groups. In terms of postpartum complications, PPH was higher in each group compared to group I, with group I, 3.6% and group IV 8.3% ($p < 0.05$). Similarly, wound sepsis was higher in Group IV 8.3%, versus group I, group II, and group III, all with varying rates between 1.1-3.6% and statistically significant rates ($p < 0.05$). In sum, while normal vaginal delivery continued to be the most common delivery method in this study, the rates of operative deliveries and postpartum complications were seen in group were greater in group III and IV, possibly based on clinical and or demographic risk factors for these populations.

Table 3: Mode of Delivery and Postpartum Complications

Parameter	Group I (n=28)	Group II (n=88)	Group III (n=40)	Group IV (n=24)	p-value
Mode of Delivery					
Normal Vaginal Delivery	16 (57.1%)	50 (56.8%)	18 (45.0%)	10 (41.7%)	<0.05
Instrumental Delivery	2 (7.1%)	4 (4.5%)	3 (7.5%)	3 (12.5%)	<0.01
LSCS	10 (35.7%)	34 (38.6%)	19 (47.5%)	11 (45.8%)	<0.05
Postpartum Complications					
Postpartum Hemorrhage (PPH)	1 (3.6%)	2 (2.3%)	2 (5.0%)	2 (8.3%)	<0.05
Wound Sepsis	1 (3.6%)	1 (1.1%)	1 (2.5%)	2 (8.3%)	<0.05

Table 4 outlines the link between maternal body mass index (BMI) and neonatal outcomes. Infants born small for gestational age (SGA) had a significantly higher prevalence among underweight mothers (Group I), affected 35.7%, than other groups where incidence ranged from 10.2% - 16.7% ($p < 0.05$) where maternal undernutrition may be linked with fetal growth restriction. Large for gestational age (LGA) demonstrated a clear positive correlation with increasing BMI, being absent in Group I and slowly increasing to 12.5% in Group IV ($p < 0.01$), suggesting that obese mothers are at risk of having the fetus overgrow. Neonatal intensive care unit (NICU) admission was most likely in Groups I and IV (7.1% and 8.3% respectively) versus Group II being only 1.1% ($p < 0.05$), indicating that both extremes of maternal BMI are associated with adverse neonatal outcomes. Importantly, there were no reported perinatal deaths in any BMI group. In conclusion, this study summarizes the U-shaped

relationship between maternal BMI and neonatal outcomes; both underweight and obese mothers are at risk of adverse neonatal outcomes and emphasizes the importance in achieving optimal maternal weight to achieve optimal perinatal health outcomes.

Table 4: Neonatal Outcomes in Relation to Maternal BMI

Neonatal Outcome	Group I (n=28)	Group II (n=88)	Group III (n=40)	Group IV (n=24)	p-value
Small for Gestational Age (SGA)	10 (35.7%)	9 (10.2%)	5 (12.5%)	4 (16.7%)	<0.05
Large for Gestational Age (LGA)	0 (0%)	1 (1.1%)	2 (5.0%)	3 (12.5%)	<0.01
NICU Admission	2 (7.1%)	1 (1.1%)	3 (7.5%)	2 (8.3%)	<0.05
Perinatal Death	0	0	0	0	—

Discussion

The results of the present study reinforce the significance of maternal body mass index during the first trimester in pregnancy outcomes, with underweight or overweight/obese conditions conferring risk for many different adverse maternal and neonatal outcomes. In our cohort, 48.9% of women were in the normal range for body mass index, and 15.6% and 35.5% were deemed underweight and overweight/obese respectively. This reflects the emerging dual burden of malnutrition and obesity in Indian women of reproductive age, consistent with national data from NFHS-3, which reports rising trends in both undernutrition and overweight among women (IIPS, 2006) [1]."

A clear trend of antenatal complications was observed with respect to BMI. The complications of PIH and GDM rose significantly with increased BMI, while anemia and IUGR were found to be higher among underweight pregnant women. PIH was observed in 16.7% of obese pregnant women, while for underweight pregnant women, it was observed in only 3.6%. These findings have been agreed upon by several studies also (Sahu et al., 2007; Bhattacharya et al., 2007; Fujiwara et al., 2016) [2,6,7]. Similarly, Sahu et al. (2007) [2] found the trend for gestational diabetes and hypertensive disorders to be high among obese pregnant women, whereas lean pregnant women were at risk for anemia and low birth weight babies. Bhattacharya et al. (2007) [6] also observed that risk of preeclampsia and PIH increased progressively with BMI and the morbidly obese had the highest risk. Endothelial dysfunction, along with increased amounts of inflammatory mediators in obese pregnant women, accounts for the association between obesity and hypertensive disorders. A meta-analysis conducted by O'Brien et al. (2003) [8] again demonstrated that the risk of preeclampsia is doubled for every 5–7 kg/m² increase in maternal BMI.

On the contrary, underweight women in our series had a higher incidence of anemia 21.4% and IUGR 35.7%, which corroborates the findings of Verma and Lalit, 2012 [3], who found that anemia and growth restriction of the fetus were significantly higher in women with low BMI. Poor nutritional reserve and micronutrient deficiencies among underweight gravid women affect placental growth and lead to fetal undernutrition, hence SGA infants. Fujiwara et al. 2016 [7]; Takai et al. 2017 [9] also demonstrated similar results and highlighted that both the extremes of BMI- namely, underweight and obese-will have a different adverse effect on pregnancy health, underweight pregnant women are especially at risk for fetal growth compromise while overweight/obese subjects face metabolic or hypertensive complications.

Maternal BMI influenced the mode of delivery in our study. The incidence of LSCS increased from 35.7% in underweight women to almost half (47.5%) in overweight women, indicating that as the BMI increases, there is a predisposition to obstetric intervention. Various studies show similar associations. Verma and Lalit, 2012 [3], reported a significantly higher incidence of cesarean delivery and wound infections in obese women, while Bhattacharya et al., 2007 [6] found a significant incidence of cesarean section and PPH in obese groups. Fujiwara et al., 2016 [7] reported a high incidence of cesarean section among Japanese women with a high pre-pregnancy BMI, contributed to by macrosomia, prolonged labor, and failed induction. In this study, PPH and wound sepsis were predominantly higher in obese women, about 8.3%, a finding that has been seen in the literature to represent increased perioperative morbidity (Sahu et al., 2007; Bainco et al., 1998) [2,10]. Bainco et al., 1998 [10] did not report a significant difference in the incidence of PPH in different categories, however. These could be related to some discrepancies in results because of clinical practice, monitoring, and obstetric protocols followed in various studies

Neonatal outcomes also tended to mirror the same contrasting trend across the BMI categories. The incidence of small-for-date infants was highest in underweight mothers (35.7%), while LGA babies were more common in overweight (5.0%) and obese women (12.5%). These findings are supported by previous reports from Sebire et al. 2001 [11] and Weiss et al. 2004 [12], who documented that maternal obesity increases the risk of delivering LGA infants by 18–26% over those with normal BMI. The reason for this is maternal hyperglycemia and

hyperinsulinemia, which promote excessive fetal growth and obesity. Fetal growth restriction among underweight mothers probably reflects inadequate uteroplacental blood flow and an inadequate supply of nutrients. NICU admission was slightly more common at both ends of the BMI spectrum because of complications from IUGR in underweight mothers and macrosomia and neonatal hypoglycemia among overweight mothers. Takai et al. [9] (2017) also found more neonatal morbidity among low and high BMI groups, and noted that even in low-resource settings, low and high BMIs are an impediment to optimal outcomes.

Overall, our study's results aligned with the overall body of evidence suggesting that maternal BMI at conception and in early pregnancy is a powerful predictor of maternal and fetal outcomes. Underweight women are at increased risk for anemia, IUGR, and SGA infants due to nutritional deprivation, while overweight and obese women are at risk for PIH, GDM, macrosomia, cesarean delivery, and postpartum complications. The coexistence of undernutrition and obesity within the same population, as observed in our study, heightens the urgent need for preconception counseling, nutritional education, and BMI optimization strategies among women of reproductive age.

Conclusion

The study revealed a significant association between maternal BMI in the first trimester and various maternal as well as neonatal outcomes. Antenatal complications, including pregnancy-induced hypertension and gestational diabetes mellitus, were common in women with increased BMI, while anemia and intrauterine growth restriction were more common in women having a low BMI. The mode of delivery also varied with BMI: overweight and obese women showed increased rates of cesarean sections and instrumental deliveries, while normal vaginal deliveries were more common in underweight and normal-weight women. Postpartum hemorrhage and wound sepsis were more common among obese women, indicating greater risk for morbidity in this category. Infants born to underweight mothers were more likely to be small for gestational age, while infants of overweight and obese mothers have a greater likelihood of macrosomia and large-for-gestational-age births. NICU admissions were more common in the underweight and obese categories, pointing out the dual risk due to deviation from normal BMI. Overall, the results show that the extreme values of maternal BMI adversely affect the outcome of pregnancy, emphasizing the need to achieve and maintain optimal BMI before conception and in early pregnancy for improved health outcomes for both mothers and neonates.

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