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Correlation of pre pregnancy BMI and gestational weight gain with fetomaternal outcome: An observational study

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Abstract

Background: Gestational weight gain (GWG) is a crucial determinant of maternal and neonatal health. Both inadequate and excessive GWG are associated with adverse outcomes. The Institute of Medicine (IOM) guidelines recommend weight gain ranges based on pre-pregnancy body mass index (BMI). This study aimed to evaluate the correlation between GWG and fetomaternal outcomes across different BMI categories among women delivering at a tertiary care hospital in North India.

Methods: A retrospective observational study was conducted in the Department of Obstetrics and Gynaecology, Rohilkhand Medical Research Institute (RMCH), Bareilly, from March 2024 to March 2025. Medical records of 350 pregnant women were reviewed. Data regarding age, parity, BMI, GWG, obstetric complications, labour, and neonatal outcomes were collected. GWG was classified according to IOM recommendations as poor, normal, or excessive. Associations between GWG, BMI, and outcomes were analyzed using the chi-square test, with $p < 0.05$ considered statistically significant.

Results: The majority of women (97%) were aged 19-35 years; 40.6% were primipara. Based on BMI, 26.3% were underweight, 52.6% normal, 14.6% overweight, and 6.6% obese. Inadequate GWG occurred in 56%, normal GWG in 31%, and excessive GWG in 13%. Poor GWG was linked with preterm labour (10.5%), low birth weight (39%), and anaemia (43%), while excessive GWG was associated with GDM (5%), hypertensive disorders (6%), and increased LSCS rate (36%). Most deliveries occurred at term ($\approx 78\%$).

Conclusions: GWG closely followed pre-pregnancy BMI trends. Excessive GWG and high BMI were linked to metabolic and obstetric complications, whereas below-recommended GWG increased risks of anaemia, preterm delivery, and low birth weight. Integrating BMI assessment and individualized nutritional counselling into antenatal care can improve fetomaternal outcomes.

Keywords: Body mass index, gestational weight gain, fetomaternal outcome, low birth weight, preterm birth

Introduction

Weight gain during pregnancy is a physiological process essential for fetal growth, placental development, and maternal tissue expansion. However, deviations from the optimal range can adversely affect both mother and child ^[1, 2]. The Institute of Medicine (IOM), in its 2009 report, established recommendations for gestational weight gain (GWG) based on pre-pregnancy BMI ^[3].

Excessive GWG has been associated with gestational diabetes mellitus (GDM), hypertensive disorders, macrosomia, obstructed labour, and caesarean delivery ^[4, 5]. Conversely, inadequate GWG leads to intrauterine growth restriction (IUGR), preterm birth, and low birth weight ^[6, 7].

Globally, obesity has reached epidemic proportions, affecting nearly 30% of women of reproductive age ^[8]. The World Health Organization (WHO) identified obesity in pregnancy as a non-communicable disease risk that contributes to maternal and child morbidity ^[9]. Simultaneously, undernutrition continues to plague low-and middle-income countries (LMICs) like India, where malnutrition-related complications such as anaemia and low birth weight remain prevalent ^[10, 11].

According to the National Family Health Survey (NFHS-5), over one-fifth of Indian women of reproductive age are underweight, while another quarter are overweight or obese. This dual nutritional burden underscores the importance of identifying and managing both extremes during pregnancy ^[12].

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Given the regional variation in socioeconomic status and dietary habits, it is important to evaluate local patterns of GWG and their association with pregnancy outcomes. Hence, this study was designed to assess the correlation between maternal BMI, GWG, and fetomaternal outcomes among women admitted to the labour room at Rohilkhand Medical Research Institute, Bareilly.

Methods

Study design and population

This was a retrospective observational study conducted in the Department of Obstetrics and Gynaecology, RMCH, Bareilly, from March 2024 to March 2025. Records of 350 pregnant women registered in the first trimester and delivered at the hospital were analyzed.

Inclusion criteria

- Singleton pregnancy
- Registration in first trimester
- Complete antenatal and delivery records available

Exclusion criteria

- Multifetal gestation
- Pre-existing chronic diseases (diabetes mellitus, hypertension, thyroid dysfunction, renal disease)
- Unbooked or emergency cases

Data collection

Demographic data (age, parity), first-trimester BMI, GWG, antenatal complications, labour details, and neonatal outcomes were extracted from medical records. GWG was calculated as the difference between the booking weight (first trimester) and weight at delivery.

BMI categories were defined as per WHO

- Underweight: ≤ 18.5 kg/m²
- Normal: 18.5-24.9 kg/m²
- Overweight: 25-29.9 kg/m²
- Obese: ≥ 30 kg/m²

IOM recommendations for total GWG were applied

- Underweight: 12.5-18 kg
- Normal: 11.5-16 kg
- Overweight: 7-11.5 kg
- Obese: 5-9 kg
- Women gaining less than, within, or more than these limits were categorized as having poor, normal, or excessive GWG respectively.

Statistical analysis

A total of 350 pregnant women who fulfilled the inclusion criteria were analyzed. Data were summarized using descriptive statistics, and associations were tested using chi-square and ANOVA where appropriate. Significance was set at $p < 0.05$.

Results

Above table shows the age and parity distribution across BMI categories. The mean maternal age was 26.4 ± 3.8 years, and most participants (97%) were between 19 and 35 years, indicating a relatively young obstetric population. Only 1.7% were 18 years, reflecting improved awareness and reduced teenage conception in the study population. Parity-wise, primipara constituted 40.6%, second para 35.7%, and multipara 22%. Underweight women were predominantly primiparous (43%), while higher-parity women tended to fall into overweight and obese categories. The association between BMI and parity was statistically significant ($\chi^2 = 9.32$, $p = 0.025$), indicating that multiparity may contribute to weight retention and higher BMI.

Table 1: Distribution of subjects according to age and parity

Variables	Underweight	Normal	Overweight	Obese	Total	Percentage
Age (in years)						
18	2	2	1	1	6	1.7
19-25	50	110	35	17	212	60.6
26-35	35	68	12	10	125	35.7
>35	5	4	3	2	14	2.0
Parity						
Primipara	40	73	20	9	142	40.6
Second para	30	67	19	9	125	35.7
Multipara	20	41	10	6	77	22.0
Grand multipara	2	3	2	1	8	1.7

Table 2: Correlation of BMI with total gestational weight gain (n=350)

BMI category	Poor GWG	Normal GWG	Excessive GWG	Total (%)
Underweight	54	38	0	92(26.3)
Normal	135	41	8	184(52.6)
Overweight	7	29	15	51(14.6)
Obese	0	17	6	23(6.6)
Total	196(56%)	109(31%)	45(13%)	350(100%)

This table presents the relationship between BMI and total gestational weight gain (GWG). Out of 350 participants, 56% had poor GWG, 31% had normal, and 13% had excessive gain based on IOM guidelines. Underweight women showed the highest prevalence of poor GWG (58%), while excessive GWG was most frequent among overweight (29%) and obese (26%) groups. The association between BMI and GWG was

statistically significant ($\chi^2 = 42.76$, $p < 0.001$). The mean GWG was 9.2 ± 3.8 kg overall, ranging from 11.1 kg in underweight women to 7.4 kg in obese women, following the expected inverse pattern of GWG with increasing BMI. Inadequate GWG was most common among underweight and normal BMI women, while excessive GWG predominated in overweight and obese groups.

Table 3: Gestational age at delivery by BMI category

Gestational age	Underweight (%)	Normal (%)	Overweight/Obese (%)	Total
Preterm (<37 wk)	9(9.8)	13(7.1)	6(8.1)	28
Term (37-41 wk)	75(81.5)	147(79.9)	55(74.3)	277
Post-term (>41 wk)	8(8.7)	24(13.0)	13(17.6)	45

As shown in above table, most deliveries occurred at term (79.1%). Preterm birth was recorded in 8% of normal-weight and 9.8% of underweight women, while post-term deliveries occurred more often among obese women (17.6%). The mean gestational age at delivery was 38.3±1.9 weeks overall. Comparison across BMI categories showed a significant

association ($\chi^2 = 8.12$, $p = 0.044$). Preterm labour was notably higher in underweight women with poor GWG, supporting the hypothesis that inadequate nutrition may predispose to early labour onset. Most deliveries occurred at term (79%). Preterm birth was higher among underweight women, while post-term pregnancy was more common in obese women.

Table 4: Labour and delivery outcomes by GWG (n=350)

Parameter	Poor GWG	Normal GWG	Excessive GWG	Total
Spontaneous labour	146	86	22	254
Induction of labour	50	38	8	96
Vaginal delivery	142(72.4%)	88(80.7)	19(64.4%)	249
LSCS	54(27.6%)	21(19.3%)	10(35.6%)	85

This table describes the pattern of labour onset and delivery modes relative to GWG. Spontaneous onset of labour was observed in 72.6% of women, while 27.4% required induction. The rate of induced labour increased progressively with higher BMI and excessive GWG. The overall caesarean section (LSCS) rate was 24.2%, but this rose significantly with excessive GWG (35.6%) and obesity (39.1%) ($p = 0.031^*$). Among women with

normal BMI and GWG, vaginal delivery was achieved in over 80%, compared to only 64% in the excessive-GWG group. The most common indications for LSCS were fetal distress (8%), non-progress of labour (7%), and previous caesarean (5%). The LSCS rate increased with higher BMI and excessive GWG ($p < 0.05$).

Table 5: Correlation of birth weight with GWG (n=350)

Birth weight (kg)	Poor GWG (%)	Normal GWG (%)	Excessive GWG (%)	Total
<1.5	2(1.0)	0	0	2
1.5-2.5	78(39.8)	29(26.6)	4(8.8)	111
2.5-3.5	114(58.2)	73(67.0)	24(53.3%)	211
>3.5	2(1.0)	7(6.4)	17(37.7)	26

As summarized in Table 5, low birth weight (LBW, <2.5 kg) occurred in 31.7% of neonates overall, but disproportionately affected women with poor GWG (39.8%). In contrast, macrosomia (>3.5 kg) was significantly higher among women with excessive GWG (37.7%). The mean birth weight was 2.78±0.46 kg, ranging from 2.51 kg in poor-GWG to 3.32 kg in excessive-GWG groups (ANOVA = 18.52, $p < 0.001$). This demonstrates a strong positive correlation between GWG and birth weight ($r = 0.41$, $p < 0.001$). Perinatal morbidity, including low Apgar scores and NICU admissions, was also higher among LBW infants, though no neonatal deaths occurred in the study period. Low birth weight (<2.5 kg) was significantly higher among women with inadequate GWG ($p < 0.01$).

Catalano & Shankar [19]. Other complications included oligohydramnios (5.1%), meconium-stained liquor (5.1%), and fetal distress (6.8%), which showed no significant variation across BMI groups.

Discussion

This retrospective study of 350 women delivering at a tertiary care centre in Bareilly examined the relationship between pre-pregnancy body mass index (BMI), gestational weight gain (GWG), and fetomaternal outcomes. The findings highlight a dual burden of malnutrition, with underweight and overweight/obese women both facing distinct yet serious pregnancy-related risks.

Global and regional context

Maternal nutritional status continues to be a cornerstone of safe motherhood. The World Health Organization (WHO) and Institute of Medicine (IOM) have consistently emphasized the role of pre-pregnancy BMI and GWG as key determinants of pregnancy outcome [1-3, 9]. Despite widespread adoption of these recommendations, adherence remains low, especially in low-and middle-income countries (LMICs). Studies from South and Southeast Asia demonstrate that 40-60% of women fail to achieve adequate GWG, primarily because of nutritional deficiencies, dietary restrictions, and low health literacy [4, 5, 10]. Our study supports this trend, with 56% of women showing inadequate GWG. Such prevalence mirrors the data reported by Dangat *et al.* [5] from Western India and Patel *et al.* [6] from Gujarat, suggesting that suboptimal maternal nutrition remains pervasive despite improvements in antenatal coverage. The high rate of poor GWG also underscores the need for preconceptional nutritional interventions.

Relationship between BMI, GWG, and birth weight

A clear correlation emerged between BMI, GWG, and neonatal

Table 6: Maternal morbidity by BMI

Morbidity	Underweight	Normal	Overweight/Obese	Total
Anaemia	66	64	23	153
Hypertensive disorders	4	6	12	22
GDM	1	4	6	11
Oligohydramnios	4	8	6	18
Polyhydramnios	0	2	1	3
IUGR	5	2	0	7
Meconium-stained liquor	4	6	8	18
Fetal distress	9	10	5	24

Table 6 highlights maternal complications by BMI category. Anaemia was the most frequent morbidity, observed in 43.7%, with the majority (66 cases) in underweight women ($p = 0.012^*$). The mean haemoglobin level among anaemic women was 9.8±0.9 g/dL. Among overweight and obese women, the incidence of hypertensive disorders (12/22 cases) and GDM (6/11 cases) was significantly higher ($p < 0.05^*$). These conditions were strongly associated with excessive GWG rather than BMI alone, consistent with findings by Bodnar *et al.* [4] and

birth weight. Underweight women and those with poor GWG had significantly more low birth weight (LBW) infants, while excessive GWG and obesity were associated with macrosomia. Similar patterns were reported by Bodnar *et al.* [4] and Han *et al.* [14] in large meta-analyses, showing that both extremes of GWG are independently associated with adverse neonatal outcomes. In our cohort, 39% of inadequate GWG pregnancies resulted in LBW babies, closely aligning with Goldstein *et al.* [15], who found a 45% higher risk of LBW with insufficient GWG. Conversely, overweight and obese women had a higher frequency of macrosomia and caesarean deliveries. These findings are biologically plausible: inadequate weight gain restricts fetal nutrient supply, while excessive gain leads to insulin resistance, fetal hyperglycaemia, and overgrowth [19, 21].

Maternal morbidity and metabolic outcomes

The present analysis reinforces the link between maternal obesity and pregnancy complications. Women with higher BMI and excessive GWG experienced greater incidences of gestational diabetes mellitus (GDM) and hypertensive disorders. Obesity-related insulin resistance increases hepatic gluconeogenesis and decreases peripheral glucose uptake, explaining the elevated GDM rates [19]. In addition, adipose-derived inflammatory cytokines such as TNF- α and IL-6 impair endothelial function and promote preeclampsia [20, 21]. Crane *et al.* [22] previously reported a 1.5–2-fold increase in hypertensive disorders among women with excessive GWG, findings consistent with this study. Similarly, the LSCS rate in our study rose from 27% among normal-weight women to 36% among obese women, comparable to results from Chinese [23] and Middle Eastern [21] cohorts.

Labour characteristics and delivery outcomes

Our study observed higher rates of induction of labour and failed progression among women with elevated BMI. Excess adiposity has been implicated in abnormal uterine contractility due to altered oxytocin receptor expression and mechanical factors such as soft-tissue dystocia. Subramaniam *et al.* [22] observed that obese women required longer labour induction times and had lower rates of spontaneous vaginal delivery, consistent with our observations. Additionally, obese and overweight mothers were more likely to deliver post-term, whereas underweight mothers had more preterm births. This bimodal distribution parallels the results from Goldstein *et al.* [15] and Han *et al.* [14], confirming that deviation from recommended GWG—whether too low or too high—predisposes to suboptimal gestational age at delivery.

Anaemia and undernutrition in underweight women

Anaemia was the most common maternal morbidity in our study (44%), predominantly among underweight women. This finding resonates with WHO's global estimates, where up to 50% of pregnant women in South Asia are anaemic [20, 24]. Poor iron stores, low dietary intake of heme iron, and repeated pregnancies contribute significantly to this burden. The WHO recommends routine iron-folic acid supplementation during pregnancy [24], yet adherence remains suboptimal. Integrating iron supplementation into community-level programs such as India's Anaemia Mukh Bharat initiative can reduce related risks. Moreover, underweight women frequently presented with oligohydramnios and intrauterine growth restriction (IUGR), likely due to inadequate uteroplacental perfusion and suboptimal nutrient transfer. Studies from Thailand and Indonesia [16, 17] support these findings, reporting increased risks of SGA and IUGR among women with BMI < 18.5 kg/m².

Relevance of IOM guidelines for Asian populations

The IOM 2009 guidelines were originally derived from Western populations, which may limit their applicability to Asian women, who have smaller body frames and different body fat distribution [3]. Several recent studies [25] have suggested recalibrating GWG recommendations for Asian populations. For example, Gong *et al.* [23] proposed slightly lower upper limits of GWG for normal-BMI women in East Asia, citing higher metabolic risks at lower BMI thresholds. Our findings lend support to developing region-specific GWG guidelines for Indian women. While the general pattern of risk holds, the optimal weight gain ranges may differ. For instance, women of South Asian origin have higher visceral adiposity at a given BMI compared with Western counterparts, which could modify risk thresholds for GDM and hypertension.

Implications for antenatal care and public health

Antenatal counseling on balanced nutrition and physical activity should be a routine component of maternal care. Both excessive dietary restriction and overnutrition should be avoided. Weight monitoring every trimester, combined with BMI-specific advice, could substantially improve outcomes. Community-level interventions, including preconceptional nutritional screening, fortified foods, and targeted supplementation programs, could prevent undernutrition-related complications. For overweight and obese women, lifestyle modification emphasizing moderate physical activity and portion control is essential. Moreover, healthcare providers must be sensitized to interpret GWG patterns contextually rather than universally. For instance, a seemingly modest weight gain in an undernourished woman may warrant intervention, whereas similar gain in an overweight woman may be optimal.

Limitations and strengths

The limitations of this study include its retrospective nature, single-centre design, and reliance on first-trimester weight instead of exact pre-pregnancy weight. However, strengths include adequate sample size, comprehensive record review, and consistent application of IOM-based GWG categories. The findings contribute valuable regional data from Northern India, where similar large-scale studies are limited.

Future directions

Future research should aim for multicentre, prospective studies with preconceptional weight records, detailed dietary assessments follow-up of neonatal outcomes beyond birth. Additionally, developing predictive models that combine BMI, GWG, and biochemical markers (such as serum ferritin and fasting glucose) may enable personalized risk prediction.

Conclusion

The analysis confirms the predictive power of maternal BMI and GWG for fetomaternal outcomes. Women achieving GWG within IOM recommendations demonstrated the lowest complication rates. Inadequate GWG is linked to anaemia, preterm birth, and low birth weight, while excessive GWG increases metabolic and obstetric complications. Individualized nutrition counseling, BMI-based risk stratification, and continuous monitoring of weight gain should be standard antenatal practices to optimize fetomaternal health. Optimizing GWG through individualized, evidence-based antenatal care is a key strategy for improving maternal and neonatal health outcomes in India and globally.

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