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Original Research Article

Association of maternal body mass index with maternal comorbidities and perinatal outcomes: a prospective observational study

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ABSTRACT

Background: Evidence across the maternal body mass index (BMI) spectrum is limited in Central India. We assessed associations between third-trimester maternal BMI and maternal and perinatal outcomes.
Methods: This prospective observational study enrolled 369 women in the third trimester at a tertiary centre in Ujjain and followed them through delivery. Enrolment BMI was classified as underweight, normal, overweight, or obese using prespecified categories. Maternal and perinatal outcomes were compared using chi-square or exact tests.
Results: Among 369 women, 13.3% were underweight, 48.2% had normal BMI, 25.7% were overweight, and 12.7% were obese. Gestational diabetes mellitus increased from 0.0% in underweight and normal groups to 22.1% in overweight and 51.1% in obese women ($p<0.001$); hypertensive disorders reached 34.0% in obese women ($p=0.003$). Moderate and severe anaemia were most frequent in underweight women (40.8% and 10.2%; $p<0.001$). Caesarean delivery increased from 18.4% in underweight to 68.1% in obese women ($p<0.001$). Low birth weight occurred in 34.7% of neonates born to underweight women; Apgar score <8 and neonatal intensive care admission were most frequent in obese women (17.0% each; $p=0.001$).
Conclusions: Third-trimester BMI was associated with distinct maternal and perinatal outcome patterns. Higher BMI groups had greater metabolic, hypertensive, operative, and postpartum morbidity, whereas underweight women had more anaemia and low-birth-weight neonates. Antenatal nutritional assessment may help guide targeted maternal and neonatal surveillance.

Keywords: Body mass index, Caesarean section, Gestational diabetes mellitus, Hypertensive disorders of pregnancy, Perinatal outcomes, Pregnancy

INTRODUCTION

Maternal body mass index (BMI) is a simple anthropometric measure used in obstetric risk assessment. It reflects maternal nutritional status and is associated with antenatal comorbidities, intrapartum complications, postpartum morbidity, and neonatal adaptation. Systematic reviews have shown that both elevated and low maternal BMI are associated with pregnancy outcomes, although the pattern differs across BMI categories.[1,2]

The global burden of maternal overweight and obesity has increased substantially. A recent systematic review estimated that maternal obesity affected approximately one in six pregnancies during 2010-2019, while combined overweight and obesity affected nearly half of pregnancies globally.[3] India faces a dual nutritional burden, with undernutrition persisting alongside rising overweight and obesity among women of reproductive age and pregnant women.[4]

Elevated maternal BMI is biologically linked to insulin resistance, chronic low-grade inflammation, endothelial dysfunction, and altered placental function. These mechanisms are associated with gestational diabetes mellitus (GDM), hypertensive disorders of pregnancy

(HDP), caesarean delivery, postpartum haemorrhage, and wound complications.[5-8] Conversely, low BMI may reflect limited nutritional reserve and has been associated with fetal growth restriction and low birth weight.[1,2]

Region-specific prospective evidence encompassing underweight, normal-weight, overweight, and obese women within the same antenatal population remains limited in Central India. This study evaluated the association of third-trimester maternal BMI with maternal comorbidities, delivery and postpartum outcomes, and perinatal outcomes.

METHODS

Study design and setting

This prospective observational study was conducted over one calendar year in the Department of Obstetrics and Gynaecology, R. D. Gardi Medical College and its affiliated C. R. Gardi Hospital, Surasa, Ujjain, Madhya Pradesh. Women were enrolled during the third trimester and followed through delivery.

Study population and eligibility

Consecutive pregnant women attending the antenatal clinic in the third trimester were screened for eligibility. Women who declined written informed consent and those presenting in the first or second trimester were excluded. All 369 enrolled women completed follow-up through delivery.

Sample size and sampling

The sample size was calculated for estimation of a single proportion using an anticipated 40% prevalence of overweight, a 95% confidence level, and 5% absolute precision. The minimum required sample size was 369 participants. Consecutive eligible women were enrolled until the target sample size was reached.

BMI measurement and classification

Height and weight were measured at enrolment, and BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m²). For analysis, prespecified study categories were used: underweight (<20.0 kg/m²), normal weight (20.0-24.9 kg/m²), overweight (25.0-29.9 kg/m²), and obese (≥30.0 kg/m²). These measurements represented third-trimester enrolment BMI rather than pre-pregnancy BMI.

Study variables and outcomes

Maternal clinical diagnoses recorded during antenatal care included GDM, HDP, thyroid disorder, and anaemia grade. BMI-stratified comparisons focused on GDM, HDP, and anaemia severity. Maternal outcomes included mode of delivery, primary indication for caesarean section, postpartum haemorrhage (PPH), and surgical site infection (SSI). Perinatal outcomes included birth weight (<2500 g, 2500-3500 g, or 3501-4000 g), 5-minute Apgar score (<8 or ≥8), and neonatal intensive care unit (NICU) admission.

Data collection and statistical analysis

Baseline demographic, clinical, and obstetric details were recorded on a pre-tested proforma. Participants were followed through delivery, and diagnoses, obstetric interventions, postpartum complications, and neonatal outcomes were verified against case files and ward records. Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics version 23. Categorical variables were summarised as frequencies and percentages. Associations between BMI categories and outcomes were assessed using Pearson chi-square, Fisher exact, or Fisher-Freeman-Halton exact tests, as appropriate. All analyses used the full cohort. A two-sided p value <0.05 was considered statistically significant; p values were reported to three decimal places, with values below 0.001 shown as p<0.001.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of R. D. Gardi Medical College. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study.

RESULTS

A total of 369 pregnant women were analysed. Women aged 25-29 years comprised the largest group (55.3%), and 52.3% resided in rural areas. The BMI distribution was 13.3% underweight, 48.2% normal weight, 25.7% overweight, and 12.7% obese. GDM, HDP, thyroid disorder, and anaemia were recorded in 12.2%, 16.5%, 8.9%, and 63.4% of women, respectively (Table 1).

Gestational age at delivery was 37 weeks or later for all participants, with 37.4% delivering at 39 to 39±6 weeks. Normal vaginal delivery was the most frequent mode of delivery (59.3%), while caesarean section was performed in 38.2%. Among the 141 caesarean deliveries, fetal distress was the most frequent indication (31.2%), followed by non-progress of labour (22.0%), cephalopelvic disproportion (20.6%), breech presentation (16.3%), and previous lower-segment caesarean section with scar tenderness (9.9%). Overall, PPH occurred in 3.8% and SSI in 5.7%. Most neonates weighed 2500-3500 g; 5.7% had a 5- minute Apgar score <8 and 5.7% required NICU admission (Table 2).

Maternal BMI was associated with GDM, HDP, and anaemia severity (Table 3; Figure 1).

GDM was not recorded among underweight or normal-BMI women but occurred in 21 (22.1%) overweight and 24 (51.1%) obese women (p<0.001). HDP increased from

4 (8.2%) among underweight women to 16 (34.0%) among obese women (p=0.003). Moderate and severe anaemia were most frequent among underweight women (40.8% and 10.2%, respectively; p<0.001).

Table 1: Demographic and baseline clinical profile of participants (n=369).

Variables	Category	Number	Percent
Socio-demographic characteristics			
Age group	≤24 years	105	28.5
	25-29 years	204	55.3
	≥30 years	60	16.3
Residence	Rural	193	52.3
	Semi-urban	90	24.4
	Urban	86	23.3
Socioeconomic status	Lower	94	25.5
	Lower-middle	91	24.7
	Middle	96	26.0
	Upper-middle	53	14.4
	Upper	35	9.5
Education	Illiterate	44	11.9
	Primary	78	21.1
	Secondary	128	34.7
	Graduate	98	26.6
	Postgraduate	21	5.7
Occupation	Housewife	209	56.6
	Farmer	24	6.5
	Daily-wage labour	32	8.7
	Small business	37	10.0
	Government service	67	18.2
Nutritional and clinical profile			
BMI category	Underweight (<20.0 kg/m²)	49	13.3
	Normal (20.0-24.9 kg/m²)	178	48.2
	Overweight (25.0-29.9 kg/m²)	95	25.7
	Obese (≥30.0 kg/m²)	47	12.7
GDM	Present	45	12.2
Hypertensive disorders of pregnancy	Present	61	16.5
Thyroid disorder	Present	33	8.9
Anaemia severity	No anaemia	135	36.6
	Mild	131	35.5
	Moderate	86	23.3
	Severe	17	4.6

Values are n (%) of N=369. Only present categories are shown for GDM, HDP, and thyroid disorder. BMI=Body mass index; GDM=Gestational diabetes mellitus; HDP=Hypertensive disorders of pregnancy

Mode of delivery and postpartum complications also differed across BMI categories (Table 3; Figure 1). Normal vaginal delivery declined from 73.5% among underweight women to 27.7% among obese women, whereas caesarean delivery increased from 18.4% to 68.1% across the same groups (p<0.001). PPH was recorded in 4.2% of overweight and 21.3% of obese women but not in the underweight or normal-BMI groups (p<0.001). SSI was recorded in 21 (44.7%) obese women and in none of the other BMI groups (p<0.001). Percentages for these postpartum outcomes were calculated using the full BMI-group denominators.

Table 2: Overall obstetric, postpartum, and neonatal outcomes.

Outcome domains	Variable	Category	Number	Percent
Obstetric	Gestational age at delivery in weeks	37 to 37+6	37	10.0
		38 to 38+6	116	31.4
		39 to 39+6	138	37.4
		≥40	78	21.1
	Mode of delivery	Normal vaginal delivery	219	59.3
		Instrumental delivery	9	2.4
		Caesarean section	141	38.2
	Primary indication for caesarean section*	Fetal distress	44	31.2
		Non-progress of labour	31	22.0
		Cephalo-pelvic disproportion	29	20.6
		Breech presentation	23	16.3
		Previous LSCS with scar tenderness	14	9.9
Post-partum	Postpartum haemo-rrhage	Present	14	3.8
	Surgical site infection	Present	21	5.7
Neonatal	Birth weight in gm	<2500	17	4.6
		2500-3500	303	82.1
		3501-4000	49	13.3
	5-minute Apgar score	<8	21	5.7
	NICU admission	Yes	21	5.7

*Percentages for caesarean indications are calculated among women who underwent caesarean section (n=141); all other percentages use N=369. LSCS=Lower-segment caesarean section; NICU=Neonatal intensive care unit

Table 3: Maternal outcomes according to maternal BMI category.

Outcomes	Underweight (n=49), N (%)	Normal (n=178), N (%)	Overweight (n=95), N (%)	Obese (n=47), N (%)	P value
Antenatal comorbidities					
GDM: present	0 (0.0)	0 (0.0)	21 (22.1)	24 (51.1)	<0.001
HDP: present	4 (8.2)	24 (13.5)	17 (17.9)	16 (34.0)	0.003
Anaemia severity					<0.001
No anaemia	4 (8.2)	79 (44.4)	33 (34.7)	19 (40.4)	
Mild	20 (40.8)	58 (32.6)	37 (38.9)	16 (34.0)	
Moderate	20 (40.8)	37 (20.8)	21 (22.1)	8 (17.0)	
Severe	5 (10.2)	4 (2.2)	4 (4.2)	4 (8.5)	
Delivery outcomes					
Mode of delivery					<0.001
Normal vaginal	36 (73.5)	115 (64.6)	55 (57.9)	13 (27.7)	
Instrumental	4 (8.2)	1 (0.6)	2 (2.1)	2 (4.3)	
Caesarean section	9 (18.4)	62 (34.8)	38 (40.0)	32 (68.1)	
Postpartum complications					
Postpartum haemorrhage: present	0 (0.0)	0 (0.0)	4 (4.2)	10 (21.3)	<0.001
Surgical site infection: present	0 (0.0)	0 (0.0)	0 (0.0)	21 (44.7)	<0.001

For binary outcomes, the clinically relevant event category is shown; PPH and SSI percentages use the full BMI-group denominators; Tests: Pearson chi-square for GDM and HDP; Fisher-Freeman-Halton exact test for anaemia severity and mode of delivery; Fisher exact test for PPH and SSI; BMI=Body mass index; GDM=Gestational diabetes mellitus; HDP=Hypertensive disorders of pregnancy; PPH=Postpartum haemorrhage; SSI-Surgical site infection

Birth-weight distribution differed significantly across maternal BMI categories (Table 4; Figure 2). Low birth weight (<2500 g) occurred in 17 (34.7%) neonates born to underweight women and in none of the other BMI groups, whereas 32 (68.1%) neonates born to obese women weighed 3501-4000 g (p<0.001). A 5-minute Apgar score <8 and NICU admission were most frequent among obese women (17.0% each), followed by underweight women (10.2% each), and were least frequent among normal-BMI women (2.2% each; both p=0.001).

Table 4: Perinatal outcomes according to maternal BMI category.

Outcomes	Underweight (n=49), N (%)	Normal (n=178), N (%)	Overweight (n=95), N (%)	Obese (n=47), N (%)	P value
Birth weight in gm					<0.001
<2500	17 (34.7)	0 (0.0)	0 (0.0)	0 (0.0)	
2500-3500	32 (65.3)	178 (100.0)	78 (82.1)	15 (31.9)	
3501-4000	0 (0.0)	0 (0.0)	17 (17.9)	32 (68.1)	
5-minute Apgar score <8	5 (10.2)	4 (2.2)	4 (4.2)	8 (17.0)	0.001
NICU admission: yes	5 (10.2)	4 (2.2)	4 (4.2)	8 (17.0)	0.001

Fisher-Freeman-Halton exact test was used; BMI=Body mass index; NICU=Neonatal intensive care unit

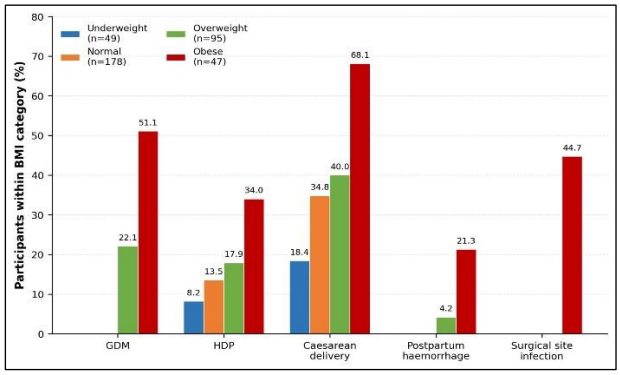

Figure 1: Selected maternal comorbidities and delivery/postpartum outcomes across maternal BMI categories.

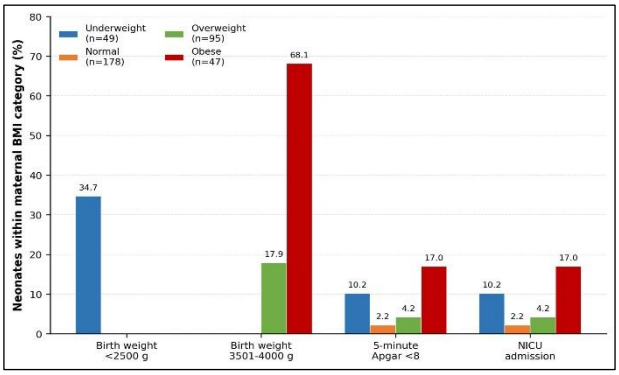

Figure 2: Birth-weight and neonatal outcomes across maternal BMI categories.

DISCUSSION

This prospective observational study identified distinct BMI-stratified patterns across maternal and perinatal outcomes. Third-trimester BMI was associated with GDM, HDP, anaemia severity, mode of delivery, PPH, SSI, birth-weight category, 5-minute Apgar score, and NICU admission. Higher BMI groups had greater metabolic, hypertensive, operative, and postpartum morbidity, whereas underweight women had more anaemia and low-birth-weight neonates. Because BMI was assessed in the third trimester and the analyses were unadjusted, these findings represent observed associations rather than independent predictive or causal effects.

The strong association between elevated BMI and GDM is consistent with meta-analytic and cohort evidence. Zhang et al reported that overweight and obesity were associated with GDM, gestational hypertension, pre-eclampsia, caesarean delivery, and postpartum haemorrhage.[5] Simko et al. and Almutairi et al. similarly identified associations between higher BMI, GDM, hypertensive disorders, and adverse perinatal conditions.[9,10] The 51.1% prevalence of GDM among obese women in this study is directionally consistent with reports by Patel and Mehta, Dogra et al, Surendra and Choudhary, and Saini et al.[11-14]

HDP also increased across BMI categories and was most frequent among obese women. This pattern is biologically plausible because adiposity, insulin resistance, inflammation, and endothelial dysfunction can amplify hypertensive pathways during pregnancy. Short et al reported increasing adverse maternal outcomes with higher early-pregnancy BMI among women in rural India and Pakistan.[15] Ballesta-Castillejos et al observed a dose-response association between maternal BMI and pre-eclampsia, labour induction, emergency caesarean section, and macrosomia.[16] Although the present study did not assess macrosomia, the observed BMI gradient in hypertensive and delivery outcomes is concordant with this broader literature.

In contrast to the metabolic and hypertensive patterns at higher BMI, moderate and severe anaemia were most frequent among underweight women. This is clinically relevant in Central India, where undernutrition and anaemia coexist with increasing overweight and obesity.

Ramya et al reported associations of low BMI with maternal anaemia and NICU admission, while Chen et al found that maternal anaemia was associated with low birth weight and other adverse neonatal outcomes.[17,18] These findings underscore the need to address both ends of the maternal nutritional spectrum.

Caesarean delivery increased progressively across BMI categories. Pettersen-Dahl et al also found maternal BMI to be associated with delivery method, with higher BMI increasing the probability of operative delivery.[19] Comparable patterns have been reported by Zhang et al, Simko et al, Short et al, Ballesta-Castillejos et al, and Tharihalli and Thathagari.[5,9,15,16,20] In this cohort, fetal distress was the most frequent caesarean indication overall, but the analysis did not identify a single indication accounting for the BMI-related delivery pattern.

Postpartum complications were concentrated in the obese group. Pooled evidence similarly indicates increased postpartum haemorrhage among overweight and obese women, although effect magnitude varies across studies.[5,21] SSI in obesity is biologically plausible because of greater tissue depth, reduced wound perfusion, impaired immune response, and the higher frequency of caesarean delivery. Axelsson et al and Shacho et al identified obesity or high BMI as important correlates of postpartum or post-caesarean infection.[22,23] Because SSI percentages in this study used the full BMI-group denominators and caesarean rates varied markedly by BMI, an independent association with BMI cannot be inferred.

Perinatal outcomes also differed across BMI categories. Low-birth-weight neonates occurred only among underweight women, whereas the 3501-4000 g category was most frequent among obese women. A 5-minute Apgar score <8 and NICU admission were most frequent in obese women and next most frequent in underweight women. Mohamed et al, Ballesta-Castillejos et al, Tharihalli and Thathagari, and Addicott et al have reported BMI- related differences in neonatal outcomes, including birth weight, Apgar score, and NICU admission.[16,20,24,25] Azher et al also reported greater NICU-related morbidity among infants of obese mothers.[26]

These findings support careful attention to maternal nutritional status during antenatal assessment. Women with higher third-trimester BMI may merit focused evaluation for metabolic and hypertensive comorbidity, together with delivery and postpartum planning. Women with low BMI may benefit from nutritional assessment, anaemia management, and fetal-growth surveillance. International guidance from FIGO and other professional bodies supports life-course and pregnancy-specific strategies for weight optimisation, gestational weight-gain counselling, and postpartum risk reduction.[27-29]

This study has few strengths and limitations. The study's strengths include its prospective design, consecutive enrolment of 369 women, complete follow-up through delivery, and assessment of maternal comorbidities, delivery outcomes, postpartum complications, and neonatal outcomes within the same cohort. Several limitations should be considered. BMI was measured in the third trimester rather than before pregnancy or during early gestation and therefore reflects gestational weight gain as well as baseline nutritional status. The single-centre design limits generalisability. Potential confounders, including dietary intake, physical activity, gestational weight-gain trajectory, and socioeconomic determinants of nutrition, were not examined in multivariable models. Clinical outcomes were analysed

using documented diagnoses and categorical measures. SSI proportions used the full BMI-group denominators despite substantial differences in caesarean delivery rates. Accordingly, the findings should be interpreted as unadjusted associations rather than independent effects.

CONCLUSION

Third-trimester maternal BMI was associated with maternal and perinatal outcome patterns in this cohort. Obese women had higher proportions of GDM, HDP, caesarean delivery, PPH, SSI, 5-minute Apgar score <8, and NICU admission, while underweight women had more moderate or severe anaemia and low-birth-weight neonates. These findings support antenatal nutritional assessment and targeted maternal and neonatal surveillance across the BMI spectrum. Prospective studies incorporating pre-pregnancy or early- pregnancy BMI and multivariable adjustment are required to establish independent predictive relationships.

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Ethical approval: The study was approved by the Institutional Ethics Committee, R. D. Gardi Medical College and its affiliated C. R. Gardi Hospital, Surasa, Ujjain, Madhya Pradesh (IEC/RDGMC/2024/49/2024: dated 09 May 2024)

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