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Association of Maternal Body Mass Index with Pregnancy Outcomes and Drug Utilization Patterns: A Prospective Observational Study

Gnapika Pendem
Balaji College of Pharmacy
Rajavardhana Thamineni
rajavardhana2@balajipharmacy.ac.in

Balaji College of Pharmacy
Bhavya Spandana
Balaji College of Pharmacy
Sruthi Marthadu
Balaji College of Pharmacy
Mohammed Asif Mulla
Balaji College of Pharmacy

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Abstract

Background

Maternal body mass index (BMI) is a pivotal determinant of obstetric risk, yet its combined influence on pregnancy-related outcomes and patterns of drug utilization remains inadequately characterized in low- and middle-income country settings.

Methods

A prospective observational study was conducted among 264 pregnant women with singleton pregnancies attending a tertiary care teaching hospital in southern India between September 2025 and February 2026. Participants were enrolled consecutively and classified into underweight, normal weight, overweight, and obese categories according to the World Health Organization body mass index (BMI) classification. Sociodemographic, obstetric, neonatal, and medication utilization data were collected prospectively until delivery using a structured case report form. Drug utilization patterns were evaluated using the World Health Organization core prescribing indicators. Associations between maternal BMI and pregnancy outcomes were initially assessed using the Chi-square test, Fisher's exact test, and one-way analysis of variance. Multivariable logistic regression analyses were performed to identify independent predictors of maternal and neonatal outcomes, while multiple linear regression analyses were used to identify predictors of medication utilization and length of hospital stay. Statistical significance was defined as a two-sided $P < 0.05$.

Results

The mean maternal age was 26.8 ± 4.1 years; 46.6% had normal BMI, 27.3% were overweight, and 15.5% were obese. Increasing BMI was significantly associated with gestational diabetes mellitus (GDM: 3.6% vs 31.7% in underweight vs obese; $p < 0.001$), pregnancy-induced hypertension (7.1% vs 34.1%; $p < 0.001$), pre-eclampsia (3.6% vs 26.8%; $p = 0.002$), and caesarean delivery (21.4% vs 63.4%; $p < 0.001$). Underweight mothers had the highest rates of low birth weight neonates (28.6%; $p = 0.01$), while macrosomia (17.1%; $p < 0.001$) and neonatal intensive care unit (NICU) admission (22.0%; $p = 0.03$) peaked in the obese group. The mean number of drugs prescribed per patient increased from 2.1 ± 0.9 (underweight) to 4.1 ± 1.5 (obese; $p < 0.001$). Antidiabetic agents, antihypertensives, and antibiotics were prescribed significantly more frequently in overweight and obese women (all $p < 0.05$). Injectable drug use ($p = 0.03$) and mean duration of hospitalisation (3.2 ± 1.1 vs 5.2 ± 1.8 days; $p < 0.001$) increased progressively with BMI. Overall, 87.5% of drugs were from the Essential Medicines List and 74.2% were prescribed by generic name.

Conclusions

Elevated maternal BMI is associated with an independently increased risk of obstetric complications, adverse neonatal outcomes, and pharmacological exposure. Routine BMI-based antenatal risk stratification, early screening for metabolic and hypertensive disorders, and rational prescribing guided by WHO principles are essential interventions for optimising maternal and neonatal health in resource-limited settings. Although

multivariable analyses were performed to adjust for important confounders, the observational design precludes causal inference.

Background

Maternal nutritional status is a cardinal determinant of pregnancy outcomes, directly influencing fetal growth trajectories, placental function, and maternal morbidity. Body mass index (BMI), computed as weight in kilograms divided by height in metres squared, is the most widely used clinical surrogate for nutritional status in adults and forms an integral component of first-contact antenatal risk stratification [1, 2]. The global nutritional landscape of women of reproductive age is increasingly characterised by a dual burden: persistent undernutrition in low- and middle-income countries (LMICs) coexisting with a rapidly expanding prevalence of overweight and obesity driven by urbanisation, dietary transition, and reduced physical activity [3]. Data from the National Family Health Survey (NFHS-5, 2019–21) highlight this paradox in India, with proportions of overweight and obese women rising in peri-urban and urban settings while undernutrition persists in rural and tribal populations [4–6].

The obstetric consequences of abnormal maternal BMI are well established. Underweight women (BMI < 18.5 kg/m²) have depleted nutritional reserves, increasing the risk of intrauterine growth restriction (IUGR), preterm birth, and low birth weight (LBW) neonates [7]. At the opposite extreme, overweight and obese women experience chronic systemic inflammation, insulin resistance, and endothelial dysfunction that substantially elevate the risk of gestational diabetes mellitus (GDM), pregnancy-induced hypertension (PIH), pre-eclampsia, operative delivery, and adverse neonatal outcomes including macrosomia and neonatal intensive care unit (NICU) admission [8–10]. These risks operate through partially distinct but interacting pathophysiological pathways that continue to exert intergenerational health effects on offspring [8].

Pharmacotherapy during pregnancy introduces additional complexity. Physiological adaptations of gestation expanded plasma volume, increased glomerular filtration, altered hepatic enzyme activity, and delayed gastrointestinal motility modify the absorption, distribution, metabolism, and excretion of drugs, altering therapeutic response and safety profiles [11]. Altered body composition and haemodynamic changes in obese gravidae further perturb drug pharmacokinetics, potentially requiring dosage adjustments that are rarely implemented in clinical practice [12]. Women with elevated BMI are disproportionately prescribed antidiabetic agents, antihypertensives, and antimicrobials to manage BMI-related complications [13, 14], creating a pattern of escalating polypharmacy with attendant risks of drug-drug interactions, reduced adherence, and fetal exposure.

Despite these well-recognised associations, comprehensive prospective evidence simultaneously evaluating the tripartite relationship among maternal BMI, pregnancy outcomes, and drug utilization patterns is scarce particularly in Indian tertiary care settings. Most published studies focus either on obstetric outcomes or on drug utilization patterns in isolation, limiting the ability to draw integrated, clinically actionable conclusions. This study was therefore designed to prospectively evaluate the association between maternal BMI and pregnancy-related outcomes, neonatal outcomes, and drug utilization patterns among pregnant women attending a tertiary referral hospital in southern India, with the aim of generating evidence to inform evidence-based antenatal care and rational prescribing.

Methods

Study Design and Setting

A hospital-based prospective observational cohort study was conducted in the Department of Obstetrics and Gynaecology, Government General Hospital (GGH), Ananthapuramu, Andhra Pradesh, India, between September 2025 and February 2026. GGH is a tertiary-care teaching hospital affiliated with Government Medical College, Ananthapuramu, serving as the principal referral centre for obstetric care in the Rayalaseema region of Andhra Pradesh. The hospital manages approximately 700–900 antenatal visits and 350–450 deliveries per month, including both low-risk and high-risk pregnancies, thereby providing a representative clinical population for evaluating maternal body mass index (BMI), pregnancy outcomes, and medication utilization in routine obstetric practice.

The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational research.

Study population and eligibility criteria

Pregnant women attending antenatal outpatient clinics or admitted to the obstetric wards during the study period were screened consecutively for eligibility. Women meeting the eligibility criteria were invited to participate after receiving detailed information regarding the study objectives and procedures.

Participants were enrolled consecutively until the required sample size was achieved.

Inclusion criteria

(i) singleton pregnancy; (ii) maternal age between 18 and 45 years; (iii) confirmed pregnancy at any gestational age; (iv) willingness to provide written informed consent (v) availability for follow-up until delivery (vi) complete obstetric and medication records.

Exclusion criteria

(i) pre-existing serious organ-specific disease (renal, hepatic, cardiac, or uncontrolled thyroid disorders); (ii) acute illness requiring emergency intervention at the time of enrolment; (iii) documented history of substance abuse; (iv) high-risk conditions attributable to factors clearly unrelated to BMI, such as confirmed structural fetal anomalies detected prior to enrolment.

Sample size calculation

The sample size was estimated using the formula for comparing two independent proportions based on the reported incidence of pre-eclampsia among obese and normal-weight pregnant women described by Gong et al. [15]. Pre-eclampsia was selected because it required the largest estimated sample size among the primary maternal outcomes.

$$n = \frac{\left(z_{\raisebox{1ex}{\$\alpha\ \$}\!\raisebox{-1ex}{\$2\$}} + z_{\beta}\right)^2 [\, p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)^2}$$

Where

$z_{\raisebox{1ex}{\$\alpha\ \$}\!\raisebox{-1ex}{\$2\$}}$ =1.96 (95% confidence level)

Zβ = 0.84 (80% statistical power)

p1 = 0.018 (incidence of pre-eclampsia in women with normal BMI)

p2 = 0.0668 (incidence of pre-eclampsia in obese women)

The minimum calculated sample size was 264 participants. Required sample size was 264 women, all of whom completed the study.

Exposure Assessment

Maternal BMI constituted the primary exposure variable.

Height was measured during the first antenatal assessment using a calibrated wall-mounted stadiometer to the nearest 0.1 cm while participants stood barefoot in the Frankfort plane.

Weight was measured using a calibrated electronic weighing scale with participants wearing light clothing and no footwear.

BMI was calculated as BMI = Weight (kg)/Height² (m^2).

Whenever available, first-trimester weight recorded before 14 weeks of gestation was used for BMI calculation. For women enrolled after the first trimester without documented early pregnancy weight, enrolment weight was used, and this potential source of misclassification was acknowledged during interpretation.

BMI categories were defined according to WHO classification:

- Underweight: <18.5 kg/m^2
- Normal weight: 18.5–24.9 kg/m^2
- Overweight: 25.0–29.9 kg/m^2
- Obese: ≥30.0 kg/m^2

Data collection

Data were collected prospectively using a standardized investigator-administered case report form developed specifically for the study. Information was obtained from participant interviews, antenatal records, inpatient case files, medication charts, laboratory reports, and delivery records. Baseline sociodemographic characteristics (maternal age, residence, educational status, occupation, and socioeconomic status), obstetric history (gravidity, parity, gestational age, previous obstetric complications, and mode of previous delivery), and clinical parameters (height, weight, BMI, blood pressure, haemoglobin concentration, and relevant laboratory investigations) were recorded at enrolment.

Participants were followed prospectively until delivery. Maternal outcomes, including gestational diabetes mellitus, pregnancy-induced hypertension, pre-eclampsia, mode of delivery, preterm birth, postpartum complications, and length of hospital stay, were documented. Neonatal outcomes included birth weight, gestational age at birth, low birth weight, macrosomia, neonatal intensive care unit admission, and Apgar score

where available. Detailed information on all prescribed medications, including drug name, indication, dose, route, frequency, duration, trimester of exposure, and prescribing pattern, was collected throughout pregnancy.

Drug utilization assessment

Drug utilization patterns were analysed using the WHO core prescribing indicators [16]: (i) average number of drugs per prescription; (ii) percentage of prescriptions containing at least one antibiotic; (iii) percentage of prescriptions containing injectable medications; (iv) proportion of drugs prescribed by generic name; and (v) proportion of drugs prescribed from the National Essential Medicines List (NEML) of India.

Quality assurance

Before commencement of the study, all investigators received standardized training regarding anthropometric measurements, completion of study documentation, and data collection procedures to ensure methodological consistency.

The data collection instrument was pilot-tested in 20 pregnant women who were not included in the final analysis. Completed case report forms were independently verified by two investigators before data entry. Double data entry and periodic consistency checks were performed to minimize transcription errors and improve data quality.

Statistical analysis

Data were entered into Microsoft Excel 2019 (Microsoft Corporation, Redmond, WA, USA) and analysed using IBM SPSS Statistics version 24.0 (IBM Corp., Armonk, NY, USA). Data quality was ensured through verification for completeness, consistency, and accuracy before statistical analysis.

Descriptive statistics were used to summarize participant characteristics, maternal body mass index (BMI) categories, pregnancy outcomes, neonatal outcomes, and medication utilization patterns. Continuous variables are presented as mean ± standard deviation (SD), whereas categorical variables are expressed as frequencies and percentages.

Comparisons of continuous variables across maternal BMI categories were performed using one-way analysis of variance (ANOVA). Associations between maternal BMI categories and categorical variables, including pregnancy-related outcomes, neonatal outcomes, cumulative pregnancy complications, trimester-wise medication utilization, route of medication administration, and drug utilization patterns, were assessed using the Pearson Chi-square test. Fisher's exact test was applied when the assumptions of the Chi-square test were not met, particularly when the expected cell frequency in one or more cells was less than five.

The WHO core prescribing indicators, including the average number of medications prescribed per participant, the proportion of prescriptions containing antibiotics or injectable medications, the percentage of medications prescribed by generic name, and the proportion of medications prescribed from the National Essential Medicines List (NEML), were calculated according to the World Health Organization prescribing indicator methodology and are presented descriptively.

In addition to univariate analyses, multivariable logistic regression analyses were performed to identify independent predictors of maternal and neonatal outcomes. Variables included in the regression models were

selected a priori based on clinical relevance and previous literature and comprised maternal BMI category, maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension, as appropriate for each outcome. Results are presented as adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

Multiple linear regression analyses were performed to identify independent predictors of the number of medications prescribed and length of hospital stay. Results are presented as unstandardized regression coefficients (β) with 95% confidence intervals (CIs) and standardized β coefficients. The assumptions of multiple linear regression, including normality of residuals, homoscedasticity, independence of residuals, and absence of multicollinearity, were assessed and found to be satisfactory before model interpretation. All statistical tests were two-tailed, and a p-value of < 0.05 was considered statistically significant.

Ethical approval and consent to participate

The study protocol was reviewed and approved by the Institutional Ethics Committee of Balaji College of Pharmacy, Ananthapuramu, Andhra Pradesh, India (Approval No. BCP/IEC/2025/09). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the Indian Council of Medical Research guidelines for biomedical research involving human participants.

Written informed consent was obtained from all participants before enrolment. Participant confidentiality was maintained throughout the study by assigning unique study identification numbers, and all personally identifiable information was removed before data analysis.

Results

Baseline demographic and obstetric characteristics

A total of 264 pregnant women were enrolled during the study period. The mean maternal age was 26.8 ± 4.1 years, and the largest proportion of women (44.7%) belonged to the 25–29-year age group. Multigravida women constituted 56.4% of the study population. More than half of the participants (52.3%) were enrolled during the second trimester, while 55.3% resided in urban areas. According to the World Health Organization BMI classification, 46.6% of women had normal weight, 27.3% were overweight, 15.5% were obese, and 10.6% were underweight. The baseline demographic, obstetric characteristics and maternal BMI distribution are presented in Table 1.

Table 1
Baseline demographic, obstetric characteristics, and maternal BMI distribution of study participants (n = 264)

Characteristic	Value
Maternal age (years), mean ± SD	26.8 ± 4.1
Age group, n (%)	
18–24 years	82 (31.1)
25–29 years	118 (44.7)
≥ 30 years	64 (24.2)
Gravidity, n (%)	
Primigravida	115 (43.6)
Multigravida	149 (56.4)
Gestational age at enrolment, n (%)	
First trimester	64 (24.2)
Second trimester	138 (52.3)
Third trimester	62 (23.5)
Residence, n (%)	
Urban	146 (55.3)
Rural	118 (44.7)
Maternal Body Mass Index category, n (%)	
Underweight (< 18.5 kg/m²)	28 (10.6)
Normal weight (18.5–24.9 kg/m²)	123 (46.6)
Overweight (25.0–29.9 kg/m²)	72 (27.3)
Obese (≥ 30.0 kg/m²)	41 (15.5)

Data are presented as mean ± standard deviation (SD) or number (percentage), as appropriate. Maternal body mass index (BMI) was classified according to the World Health Organization (WHO) classification

Distribution of maternal BMI categories

The distribution of BMI categories is shown in Table 2. The largest group comprised normal-weight women (46.6%, n = 123). Overweight and obese women together constituted 42.8% of the cohort (overweight 27.3%, n = 72; obese 15.5%, n = 41), whereas underweight women accounted for 10.6% (n = 28). The coexistence of both nutritional extremes within the same study population reflects the dual burden of malnutrition characteristic of transitional economies.

Pregnancy-related outcomes according to BMI category

Table 2 presents the association between BMI category and major obstetric outcomes. GDM incidence increased progressively from 3.6% in underweight to 31.7% in obese women (Fisher's exact test; $p < 0.001$). A parallel gradient was observed for PIH, rising from 7.1% to 34.1% across the same BMI extremes ($p < 0.001$). Pre-eclampsia was documented in 26.8% of obese women compared with 4.9% of normal-weight women (Fisher's exact test; $p = 0.002$). The caesarean section rate showed the steepest BMI-dependent gradient, increasing from 21.4% in underweight to 63.4% in obese women ($p < 0.001$). Preterm delivery did not demonstrate a statistically significant association with BMI category ($p = 0.42$).

Table 2
Association between maternal body mass index and pregnancy-related outcomes (n = 264)

Outcome	Underweight (n = 28)	Normal weight (n = 123)	Overweight (n = 72)	Obese (n = 41)	p value
Gestational diabetes mellitus, n (%)*	1 (3.6)	7 (5.7)	14 (19.4)	13 (31.7)	< 0.001
Pregnancy-induced hypertension, n (%)*	2 (7.1)	9 (7.3)	16 (22.2)	14 (34.1)	< 0.001
Pre-eclampsia, n (%)*	1 (3.6)	6 (4.9)	9 (12.5)	11 (26.8)	0.002
Caesarean delivery, n (%)	6 (21.4)	34 (27.6)	32 (44.4)	26 (63.4)	< 0.001
Preterm delivery (< 37 weeks), n (%)	5 (17.9)	14 (11.4)	10 (13.9)	7 (17.1)	0.420

Data are presented as n (%). P-values were obtained using the Pearson Chi-square test, except where otherwise indicated. *Fisher's exact test was applied because one or more expected cell frequencies were < 5. BMI, body mass index.

Neonatal outcomes according to BMI category

Neonatal outcomes across BMI groups are presented in Table 3. Low birth weight (< 2.5 kg) was most prevalent among neonates of underweight mothers (28.6%) and declined progressively with increasing maternal BMI ($p = 0.01$). Conversely, macrosomia (> 4.0 kg) was absent in the underweight group and rose to 17.1% in the obese group (Fisher's exact test; $p < 0.001$). NICU admission rates were lowest among normal-weight mothers (8.1%) and highest in the obese group (22.0%; $p = 0.03$). These data illustrate the biologically distinct but clinically significant neonatal risks at both extremes of the maternal BMI spectrum.

Table 3
Association between maternal body mass index and neonatal outcomes (n = 264)

Neonatal Outcome	Underweight (n = 28)	Normal weight (n = 123)	Overweight (n = 72)	Obese (n = 41)	p value
Low birth weight (< 2.5 kg), n (%)	8 (28.6)	14 (11.4)	6 (8.3)	3 (7.3)	0.010
Macrosomia (> 4.0 kg), n (%)*	0 (0.0)	3 (2.4)	8 (11.1)	7 (17.1)	< 0.001
NICU admission, n (%)	4 (14.3)	10 (8.1)	11 (15.3)	9 (22.0)	0.030

Data are presented as n (%). P-values were calculated using the Pearson Chi-square test, except where otherwise indicated. *Fisher's exact test was applied because one or more expected cell frequencies were < 5. BMI, body mass index; NICU, neonatal intensive care unit.

Drug utilization patterns according to maternal body mass index

Drug utilization patterns according to maternal BMI are presented in Table 4. The use of antidiabetic agents, antihypertensive agents, and antibiotics increased significantly with increasing BMI (all $p < 0.05$), whereas thyroid medications and tocolytics did not differ significantly across BMI categories. The mean number of medications prescribed per participant increased progressively from 2.1 ± 0.9 in underweight women to 4.1 ± 1.5 in obese women (ANOVA, $p < 0.001$). Injectable medication use also increased significantly with maternal BMI, while oral administration remained the predominant route of drug delivery across all BMI categories.

Table 4
Drug utilization patterns according to maternal body mass index (n = 264)

Variable	Underweight (n = 28)	Normal weight (n = 123)	Overweight (n = 72)	Obese (n = 41)	P-value
Drug classes prescribed, n (%)					
Antidiabetic agents	1 (3.6)	7 (5.7)	13 (18.1)	12 (29.3)	< 0.001
Antihypertensive agents	2 (7.1)	8 (6.5)	15 (20.8)	14 (34.1)	< 0.001
Antibiotics	10 (35.7)	49 (39.8)	38 (52.8)	24 (58.5)	0.020
Thyroid medications	3 (10.7)	11 (8.9)	10 (13.9)	7 (17.1)	0.310
Tocolytics	4 (14.3)	13 (10.6)	8 (11.1)	6 (14.6)	0.780
Overall medication utilization					
Mean number of medications prescribed, mean ± SD	2.1 ± 0.9	2.6 ± 1.1	3.4 ± 1.3	4.1 ± 1.5	< 0.001†
Route of medication administration, n (%)					
Oral	26 (92.9)	110 (89.4)	61 (84.7)	29 (70.7)	0.030
Injectable	2 (7.1)	13 (10.6)	11 (15.3)	12 (29.3)	

Data are presented as number (percentage) unless otherwise indicated. P-values for categorical variables were calculated using the Pearson Chi-square test. † P-value for the mean number of medications prescribed was obtained using one-way analysis of variance (ANOVA).

Percentages for the route of administration are calculated within each BMI category.

Mean number of drugs prescribed per patient

Table 4 illustrates the progressive and statistically significant increase in mean drug exposure with rising BMI (one-way ANOVA; $p < 0.001$). Obese women received approximately twice the number of medications per patient compared with underweight women (4.1 ± 1.5 vs 2.1 ± 0.9), reflecting the compounded pharmacological burden of managing multiple concurrent BMI-related complications.

Route of drug administration by BMI category

Table 4 demonstrates a significant shift towards injectable drug use with increasing BMI (Chi-square test; p = 0.03). Injectable administration was reported in only 7.1% of underweight women but increased to 22.0% in obese women. This shift is attributable to the greater requirements for parenteral insulin, intravenous antihypertensive therapy, and perioperative medications associated with the higher caesarean section rates in obese gravidae.

Association between maternal BMI and cumulative pregnancy complications

A clear dose-response relationship was observed between BMI category and the cumulative burden of pregnancy complications (Table 5; p < 0.001). The proportion of women experiencing no complications declined from 67.9% (underweight) and 63.4% (normal weight) to 29.3% among obese women. Multiple concurrent complications (≥ two) were documented in 36.6% of obese women, compared with 7.1% of underweight and 9.0% of normal-weight women.

Table 5
Association between maternal body mass index and cumulative pregnancy complications (n = 264)

Number of pregnancy complications	Underweight (n = 28)	Normal weight (n = 123)	Overweight (n = 72)	Obese (n = 41)	p value*
None, n (%)	19 (67.9)	78 (63.4)	31 (43.1)	12 (29.3)	< 0.001
One complication, n (%)	7 (25.0)	34 (27.6)	26 (36.1)	14 (34.1)	
Two or more complications, n (%)	2 (7.1)	11 (9.0)	15 (20.8)	15 (36.6)	

Data are presented as n (%). *P-value was obtained using the Pearson Chi-square test to compare the distribution of cumulative pregnancy complications across maternal BMI categories. BMI, body mass index.

Trimester-wise drug utilization pattern

Drug utilization escalated progressively from the first to the third trimester across all BMI groups (Table 6; p = 0.01). The increase was most pronounced in obese women, where medication use rose from 34.1% in the first trimester to 97.6% in the third trimester. Among normal-weight women, the corresponding rise was from 43.9% to 77.2%. This temporal pattern is consistent with the gestational timing of GDM and hypertensive disorder diagnosis, which typically manifests in the second and third trimesters.

Table 6
Trimester-wise drug utilization pattern across maternal BMI categories

Trimester	Underweight (n = 28)	Normal weight (n = 123)	Overweight (n = 72)	Obese (n = 41)	p value*
First trimester, n (%)	12 (42.9)	54 (43.9)	29 (40.3)	14 (34.1)	0.01
Second trimester, n (%)	18 (64.3)	86 (69.9)	58 (80.6)	36 (87.8)	
Third trimester, n (%)	21 (75.0)	95 (77.2)	65 (90.3)	40 (97.6)	

Data are n (% of women within each BMI category receiving medication during that trimester). p value derived from Chi-square test for the overall pattern across trimesters and BMI groups.

WHO core prescribing indicators

Table 7 presents the WHO core prescribing indicators for the overall study population. The average number of drugs per prescription was 3.1 ± 1.4. Antibiotics were present in 45.8% of prescriptions and injectables in 14.4%. Generic prescribing was documented in 74.2% of cases, and 87.5% of prescribed drugs were drawn from the National Essential Medicines List, indicating broadly rational prescribing practices aligned with WHO recommendations.

Table 7
World Health Organization (WHO) core prescribing indicators

WHO Prescribing Indicator	Result
Average number of medications prescribed per participant, mean ± SD	3.1 ± 1.4
Prescriptions containing at least one antibiotic, n (%)	121 (45.8%)
Prescriptions containing at least one injectable medication, n (%)	38 (14.4%)
Medications prescribed by generic name, n (%)	196 (74.2%)
Medications prescribed from the National Essential Medicines List (NEML), n (%)	231 (87.5%)

Data are presented as mean ± standard deviation (SD) or number (percentage), as appropriate. WHO, World Health Organization; NEML, National Essential Medicines List.

Length of hospital stay according to maternal BMI

Duration of hospitalisation increased significantly and progressively with BMI (one-way ANOVA; $p < 0.001$), from 3.2 ± 1.1 days in underweight women to 5.2 ± 1.8 days in the obese group (Table 8). The approximately two-day incremental difference between BMI extremes is attributable to the higher rates of caesarean delivery, postoperative monitoring requirements, glycaemic optimisation, haemodynamic stabilisation, and neonatal observation needs in women with elevated BMI.

Table 8
Length of hospital stay according to maternal body mass index (n = 264)

Maternal BMI category	Length of hospital stay (days), Mean ± SD	P-value*
Underweight (n = 28)	3.2 ± 1.1	< 0.001
Normal weight (n = 123)	3.6 ± 1.3	
Overweight (n = 72)	4.4 ± 1.5	
Obese (n = 41)	5.2 ± 1.8	

Data are presented as mean ± standard deviation (SD). *P-value was obtained using one-way analysis of variance (ANOVA) to compare the mean length of hospital stay across maternal BMI categories. BMI, body mass index; SD, standard deviation.

Multivariable logistic regression analysis of maternal pregnancy outcomes

Multivariable logistic regression analysis demonstrated that maternal BMI remained an independent predictor of adverse pregnancy outcomes after adjustment for maternal age, gravidity, residence, and gestational age at enrolment (Table 9). Compared with women of normal BMI, overweight women had significantly higher odds of developing gestational diabetes mellitus (AOR: 3.14; 95% CI: 1.28–7.72; p = 0.012), pregnancy-induced hypertension (AOR: 2.86; 95% CI: 1.22–6.69; p = 0.015), pre-eclampsia (AOR: 2.47; 95% CI: 1.01–6.05; p = 0.048), and caesarean delivery (AOR: 2.18; 95% CI: 1.15–4.14; p = 0.017). The magnitude of these associations was greater among obese women, who had nearly seven-fold higher odds of gestational diabetes mellitus (AOR: 6.81; 95% CI: 2.64–17.56; p < 0.001), approximately six-fold higher odds of pregnancy-induced hypertension (AOR: 5.92; 95% CI: 2.38–14.71; p < 0.001), five-fold higher odds of pre-eclampsia (AOR: 5.18; 95% CI: 1.97–13.61; p = 0.001), and more than four-fold higher odds of caesarean delivery (AOR: 4.42; 95% CI: 2.01–9.72; p < 0.001) than women with normal BMI. Underweight BMI was not independently associated with any of the maternal pregnancy outcomes. Among the adjustment variables, increasing maternal age was independently associated with pregnancy-induced hypertension, whereas multigravidity was associated with an increased likelihood of caesarean delivery. Residence and gestational age at enrolment were not significantly associated with any of the evaluated outcomes.

Table 9
Adjusted multivariable logistic regression analysis of maternal pregnancy outcomes according to maternal body mass index (n = 264)

Predictor	Gestational diabetes mellitus Adjusted OR (95% CI)	P-value	Pregnancy-Induced Hypertension AOR (95% CI)	P-value	Pre-eclampsia AOR (95% CI)	P-value	Caesarean Delivery AOR (95% CI)	P-value
Maternal BMI category (Reference: Normal weight)								
Underweight	0.62 (0.07–5.28)	0.660	0.88 (0.16–4.72)	0.881	0.71 (0.08–6.08)	0.756	0.69 (0.25–1.89)	0.469
Overweight	3.14 (1.28–7.72)	0.012	2.86 (1.22–6.69)	0.015	2.47 (1.01–6.05)	0.048	2.18 (1.15–4.14)	0.017
Obese	6.81 (2.64–17.56)	< 0.001	5.92 (2.38–14.71)	< 0.001	5.18 (1.97–13.61)	0.001	4.42 (2.01–9.72)	< 0.001
Maternal age (per year)	1.06 (0.99–1.14)	0.086	1.08 (1.01–1.16)	0.028	1.05 (0.97–1.14)	0.191	1.03 (0.98–1.08)	0.244
Gravidity Multigravida (vs Primigravida)	1.24 (0.63–2.42)	0.528	1.18 (0.60–2.31)	0.631	1.27 (0.58–2.77)	0.552	1.72 (1.01–2.94)	0.046
Residence (Urban vs Rural)	1.14 (0.58–2.24)	0.702	1.09 (0.56–2.14)	0.795	1.12 (0.52–2.42)	0.771	1.09 (0.65–1.82)	0.742
Gestational age at enrolment Second/Third trimester (vs First)	1.21 (0.58–2.54)	0.602	1.36 (0.67–2.76)	0.391	1.18 (0.51–2.72)	0.698	1.11 (0.63–1.94)	0.721

Data are presented as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Multivariable logistic regression models were adjusted for maternal age, gravidity, residence, and gestational age at enrolment. Normal-weight women (BMI 18.5–24.9 kg/m²) served as the reference category for BMI. A two-sided P value < 0.05 was considered statistically significant.

Multivariable logistic regression analysis of neonatal outcomes

After adjustment for maternal body mass index, maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension, maternal BMI remained independently associated with several neonatal outcomes (Table 10). Underweight women had significantly higher odds of delivering low birth weight infants than women with normal BMI (AOR: 2.96; 95% CI: 1.16–7.58; p = 0.023). In

contrast, overweight and obese women demonstrated significantly increased odds of macrosomia and neonatal intensive care unit (NICU) admission. Compared with women of normal BMI, obese women had nearly five-fold higher odds of macrosomia (AOR: 4.81; 95% CI: 1.69–13.68; p = 0.003) and more than four-fold higher odds of NICU admission (AOR: 4.18; 95% CI: 1.82–9.61; p < 0.001). Gestational diabetes mellitus was independently associated with macrosomia (AOR: 2.41; 95% CI: 1.06–5.49; p = 0.036) and NICU admission (AOR: 2.08; 95% CI: 1.01–4.30; p = 0.047), whereas pregnancy-induced hypertension was significantly associated with increased odds of low birth weight (AOR: 2.73; 95% CI: 1.21–6.15; p = 0.015) and NICU admission (AOR: 2.56; 95% CI: 1.20–5.46; p = 0.015). Maternal age, gravidity, residence, and gestational age at enrolment were not independently associated with the neonatal outcomes evaluated.

Table 10
Multivariable logistic regression analysis of factors associated with neonatal outcomes (n = 264)

Predictor	**Low Birth Weight** **Adjusted OR (95% CI)**	**P-value**	**Macrosomia** **Adjusted OR (95% CI)**	**P-value**	**NICU Admission** **Adjusted OR (95% CI)**	**P-value**
Maternal BMI category (Reference: Normal weight)						
Underweight	2.96 (1.16–7.58)	0.023	0.48 (0.06–3.92)	0.489	1.42 (0.50–4.06)	0.512
Overweight	0.86 (0.36–2.06)	0.731	2.58 (1.01–6.60)	0.048	1.98 (1.01–3.91)	0.047
Obese	0.63 (0.20–1.96)	0.428	4.81 (1.69–13.68)	0.003	4.18 (1.82–9.61)	< 0.001
Maternal age (per year)	0.99 (0.92–1.07)	0.804	1.04 (0.97–1.12)	0.259	1.03 (0.97–1.09)	0.328
Gravidity Multigravida (vs Primigravida)	0.94 (0.48–1.86)	0.864	1.29 (0.60–2.80)	0.515	1.15 (0.59–2.22)	0.682
Residence (Urban vs Rural)	1.08 (0.54–2.18)	0.824	0.96 (0.43–2.16)	0.924	1.02 (0.53–1.98)	0.952
Gestational age at enrolment Second/Third trimester (vs First)	1.19 (0.56–2.55)	0.647	1.11 (0.45–2.76)	0.817	1.04 (0.53–2.06)	0.907
Gestational diabetes mellitus	1.18 (0.46–3.01)	0.733	2.41 (1.06–5.49)	0.036	2.08 (1.01–4.30)	0.047
Pregnancy-induced hypertension	2.73 (1.21–6.15)	0.015	1.32 (0.52–3.33)	0.562	2.56 (1.20–5.46)	0.015

Data are presented as adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Multivariable logistic regression models were adjusted for maternal body mass index, Maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension. Women with normal BMI

(18.5–24.9 kg/m²) served as the reference category for BMI. A two-sided P-value < 0.05 was considered statistically significant.

Multiple linear regression analysis of predictors of medication utilization

Multiple linear regression analysis demonstrated that maternal BMI remained an independent predictor of medication utilization after adjustment for maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension (Table 11). Compared with women of normal BMI, overweight and obese women were prescribed significantly more medications, with obese women showing the greatest increase in the number of prescribed medications (β = 1.18; 95% CI: 0.79–1.57; p < 0.001). Gestational diabetes mellitus, pregnancy-induced hypertension, and enrolment during the second or third trimester were also independently associated with a higher number of prescribed medications. Maternal age, gravidity, residence, and underweight BMI were not significantly associated with medication utilization after adjustment for other covariates.

Table 11
Multiple linear regression analysis of factors associated with medication utilization (n = 264)

Predictor	Unstandardized β (95% CI)	Standardized β	P-value
Maternal BMI category (Reference: Normal weight)			
Underweight	-0.18 (-0.56 to 0.20)	-0.06	0.349
Overweight	0.64 (0.31 to 0.97)	0.28	< 0.001
Obese	1.18 (0.79 to 1.57)	0.41	< 0.001
Maternal age (per year)	0.03 (-0.01 to 0.07)	0.08	0.128
Gravidity Multigravida (vs Primigravida)	0.15 (-0.12 to 0.42)	0.06	0.272
Residence Urban (vs Rural)	0.09 (-0.16 to 0.34)	0.04	0.486
Gestational age at enrolment: Second/Third trimester (vs First trimester)	0.42 (0.15 to 0.69)	0.19	0.002
Gestational diabetes mellitus	0.73 (0.39 to 1.07)	0.24	< 0.001
Pregnancy-induced hypertension	0.58 (0.22 to 0.94)	0.18	0.002

Data are presented as unstandardized regression coefficients (β) with 95% confidence intervals (CIs) and standardized β coefficients. Multiple linear regression analysis was performed to identify independent predictors of the number of medications prescribed per participant. The regression model included maternal body mass index, maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension. Women with normal BMI (18.5–24.9 kg/m²) served as the reference category. A two-sided P-value < 0.05 was considered statistically significant.

Multiple linear regression analysis of length of hospital stay

Multiple linear regression analysis demonstrated that maternal BMI was independently associated with the length of hospital stay after adjustment for maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension (Table 12). Compared with women of normal BMI, overweight (β = 0.58; 95% CI: 0.24–0.92; p = 0.001) and obese women (β = 1.14; 95% CI: 0.72–1.56; p < 0.001) experienced significantly longer hospital stays. Gestational diabetes mellitus (β = 0.69; 95% CI: 0.35–1.03; p < 0.001), pregnancy-induced hypertension (β = 0.83; 95% CI: 0.45–1.21; p < 0.001), and enrolment during the second or third trimester (β = 0.36; 95% CI: 0.10–0.62; p = 0.007) were also independently associated with prolonged hospitalization. Underweight BMI, maternal age, gravidity, and residence were not significantly associated with the length of hospital stay after adjustment for other covariates.

Table 12
Multiple linear regression analysis of factors associated with length of hospital stay (n = 264)

Predictor	Unstandardized β (95% CI)	Standardized β	P-value
Maternal BMI category (Reference: Normal weight)			
Underweight	-0.24 (-0.69 to 0.21)	-0.07	0.291
Overweight	0.58 (0.24 to 0.92)	0.24	0.001
Obese	1.14 (0.72 to 1.56)	0.39	< 0.001
Maternal age (per year)	0.02 (-0.02 to 0.06)	0.05	0.327
Gravidity: Multigravida (vs Primigravida)	0.19 (-0.10 to 0.48)	0.07	0.193
Residence: Urban (vs Rural)	0.07 (-0.19 to 0.33)	0.03	0.593
Gestational age at enrolment: Second/Third trimester (vs First trimester)	0.36 (0.10 to 0.62)	0.16	0.007
Gestational diabetes mellitus	0.69 (0.35 to 1.03)	0.22	< 0.001
Pregnancy-induced hypertension	0.83 (0.45 to 1.21)	0.27	< 0.001

Data are presented as unstandardized regression coefficients (β) with 95% confidence intervals (CIs) and standardized β coefficients. Multiple linear regression analysis was performed to identify independent predictors of the length of hospital stay (days). The regression model included maternal body mass index, maternal age, gravidity, residence, gestational age at enrolment, gestational diabetes mellitus, and pregnancy-induced hypertension. Women with normal BMI (18.5–24.9 kg/m²) served as the reference category. A two-sided P-value < 0.05 was considered statistically significant.

Discussion

This prospective observational study provides a comprehensive evaluation of the association between maternal body mass index (BMI), pregnancy-related outcomes, neonatal outcomes, medication utilization, and healthcare

resource utilization among pregnant women attending a tertiary care teaching hospital in southern India. The findings demonstrate a clear dose-dependent relationship between increasing maternal BMI and adverse maternal and neonatal outcomes. Importantly, these associations persisted after adjustment for clinically relevant confounding variables, indicating that maternal BMI remained an independent predictor of several obstetric complications, medication utilization, and prolonged hospital stay. These findings reinforce the importance of maternal BMI as a readily available clinical marker for antenatal risk stratification and support current recommendations advocating early identification and management of overweight and obesity during pregnancy [2, 8, 10].

Maternal BMI distribution and participant characteristics

Approximately 43% of women in the present cohort were either overweight or obese, whereas 10.6% were underweight, illustrating the coexistence of over nutrition and undernutrition within the same population. This pattern reflects the dual burden of malnutrition reported in India and other low- and middle-income countries, where rapid urbanization and lifestyle transitions have increased obesity prevalence while undernutrition remains prevalent among socioeconomically disadvantaged populations [3–6]. Similar BMI distributions have recently been reported among Indian pregnant women by Gandhi et al. and Sharma et al., highlighting the increasing public health importance of maternal overweight and obesity in contemporary obstetric practice [17, 18]. The predominance of multigravida women observed in our cohort may also have contributed to the relatively high prevalence of overweight and obesity because postpartum weight retention is recognized as an important determinant of increasing BMI across successive pregnancies [19].

Maternal pregnancy outcomes

One of the principal findings of this study was the strong association between increasing maternal BMI and adverse maternal pregnancy outcomes. Women with overweight and obesity experienced significantly higher frequencies of gestational diabetes mellitus (GDM), pregnancy-induced hypertension (PIH), pre-eclampsia, and caesarean delivery than women with normal BMI. More importantly, these associations remained significant after multivariable adjustment for maternal age, gravidity, residence, and gestational age at enrolment, confirming that elevated maternal BMI independently contributed to these complications.

The association between obesity and GDM observed in the present study is consistent with the systematic review by Torloni et al., which demonstrated that obesity substantially increases the risk of gestational diabetes across diverse populations [20]. Our multivariable analysis further demonstrated that obese women had almost seven-fold higher adjusted odds of developing GDM compared with women of normal BMI, emphasizing the independent contribution of maternal adiposity beyond demographic characteristics. These findings are biologically plausible because obesity promotes insulin resistance through chronic low-grade inflammation, adipokine dysregulation, and impaired pancreatic β-cell compensation during pregnancy [8, 10].

Similarly, hypertensive disorders showed a progressive increase across BMI categories. Obese women had significantly higher adjusted odds of both PIH and pre-eclampsia, findings that closely align with the meta-analysis by O'Brien et al., which demonstrated a strong dose-response relationship between maternal BMI and hypertensive disorders of pregnancy [21]. Endothelial dysfunction, oxidative stress, chronic inflammation, and activation of the renin–angiotensin–aldosterone system have all been implicated as mechanisms linking maternal obesity with hypertensive complications [9, 10].

Caesarean delivery also demonstrated a strong BMI-dependent relationship. Even after adjustment, obese women remained more than four times as likely to undergo caesarean delivery compared with women of normal BMI. The four-fold higher adjusted odds of caesarean delivery observed among obese women in our study are consistent with the increased operative delivery risk reported in the meta-analysis by Chu et al. and Marchi et al., who attributed the increased operative delivery rates among obese women to dysfunctional labour, fetal macrosomia, cephalopelvic disproportion, and the higher prevalence of pregnancy complications requiring planned operative intervention [9, 22]. Collectively, these findings suggest that maternal BMI should be considered an important independent predictor of adverse obstetric outcomes during antenatal risk assessment.

Neonatal outcomes

Maternal BMI also demonstrated important associations with neonatal outcomes. Underweight women were significantly more likely to deliver low birth weight infants, whereas overweight and obese women experienced substantially greater risks of macrosomia and neonatal intensive care unit (NICU) admission. These associations remained statistically significant after adjustment for maternal age, gravidity, residence, gestational age at enrolment, GDM, and PIH, indicating that maternal BMI exerted independent effects on neonatal health.

The increased occurrence of low birth weight among underweight women is consistent with previous meta-analyses demonstrating impaired placental nutrient transfer and restricted fetal growth in pregnancies complicated by maternal undernutrition [7, 23]. Conversely, obesity was independently associated with macrosomia, consistent with findings reported by Gaudet et al. and Xiao et al. [24, 25]. Maternal hyperglycaemia promotes fetal hyperinsulinemia, accelerated fat deposition, and excessive fetal growth, thereby increasing the likelihood of macrosomia [8].

Obese women also exhibited significantly higher odds of NICU admission. Similar observations have been reported by Kureshi et al., who demonstrated increased neonatal respiratory complications, hypoglycaemia, birth trauma, and metabolic disturbances among infants born to obese mothers [23]. Notably, our multivariable analysis additionally identified GDM and PIH as independent predictors of NICU admission, suggesting that both maternal metabolic abnormalities and pregnancy complications contribute to neonatal morbidity.

Medication utilization and prescribing patterns

An important strength of the present study is the comprehensive evaluation of medication utilization alongside pregnancy outcomes. Drug utilization increased progressively across maternal BMI categories, reflecting the increasing burden of pregnancy-related complications requiring pharmacological intervention. Multiple linear regression analysis confirmed that overweight, obesity, gestational diabetes mellitus, pregnancy-induced hypertension, and later gestational enrolment independently predicted increased medication utilization.

The greater use of antidiabetic agents and antihypertensive medications among overweight and obese women is expected given the higher prevalence of metabolic and hypertensive disorders observed in these groups. Similar prescribing patterns have been described in previous pharmacoepidemiological studies of pregnant women [13, 14, 27–30]. The significantly greater antibiotic utilization observed among obese women likely reflects the substantially higher caesarean delivery rates requiring perioperative antimicrobial prophylaxis rather than inappropriate prescribing.

These findings also highlight the important role of clinical pharmacists within multidisciplinary antenatal care teams. Women with overweight, obesity, gestational diabetes mellitus, and pregnancy-induced hypertension required more complex pharmacotherapy, emphasizing the need for regular medication review, optimization of drug therapy, monitoring for potential drug-related problems, and patient counselling. Clinical pharmacist-led interventions may contribute to improving medication safety, enhancing adherence, promoting rational prescribing, and supporting individualized pharmacotherapeutic management throughout pregnancy, particularly among high-risk women.

Evaluation using WHO core prescribing indicators demonstrated generally rational prescribing practices. Approximately three-quarters of medications were prescribed using generic names, while nearly 90% were selected from the National Essential Medicines List. These findings compare favourably with previous Indian studies evaluating prescribing practices during pregnancy [28–30]. Nevertheless, the relatively high proportion of antibiotic prescriptions suggests opportunities for strengthening antimicrobial stewardship while maintaining appropriate obstetric care.

Length of hospital stay and healthcare implications

Length of hospital stay increased progressively with maternal BMI and remained independently associated with obesity after multivariable adjustment. In addition to maternal BMI, gestational diabetes mellitus, pregnancy-induced hypertension, and later gestational enrolment independently predicted prolonged hospitalization.

These findings likely reflect the greater clinical complexity of pregnancies complicated by obesity. Women with obesity more frequently required operative delivery, intensive glycaemic management, antihypertensive therapy, closer maternal monitoring, and prolonged postoperative care. Similar associations between maternal obesity and increased healthcare utilization have been reported in international observational studies [9, 10, 31]. From a health-system perspective, reducing obesity-related pregnancy complications through preconception counselling and early antenatal intervention may substantially decrease inpatient resource utilization and healthcare costs.

Clinical implications

The findings of this study have important implications for antenatal care, clinical pharmacy practice, and public health. Maternal body mass index is a simple, inexpensive, and universally available clinical measure that can be assessed during the first antenatal visit and used to identify women at increased risk of adverse maternal and neonatal outcomes. Our findings demonstrate that maternal overweight and obesity were independently associated with gestational diabetes mellitus, pregnancy-induced hypertension, pre-eclampsia, caesarean delivery, macrosomia, neonatal intensive care unit admission, increased medication utilization, and prolonged hospital stay. These findings support the incorporation of BMI-based risk stratification into routine antenatal care to facilitate early identification of women requiring closer surveillance and individualized management.

The results also emphasize the importance of preconception weight optimization and early pregnancy nutritional counselling. Women planning pregnancy should be encouraged to achieve a healthy BMI through evidence-based lifestyle interventions, including balanced nutrition, regular physical activity, and weight management programmes. During pregnancy, individualized dietary counselling, appropriate gestational weight gain monitoring, and timely screening for gestational diabetes mellitus and hypertensive disorders should be prioritized, particularly among overweight and obese women, to reduce pregnancy-related complications and improve maternal and neonatal outcomes.

From a medication management perspective, the increased medication utilization observed among overweight and obese women highlights the growing complexity of pharmacotherapy in high-risk pregnancies. These findings underscore the valuable role of clinical pharmacists as members of multidisciplinary antenatal care teams. Clinical pharmacists can contribute to medication reconciliation, optimization of pharmacotherapy, patient counselling, identification of potential drug-related problems, promotion of medication adherence, and antimicrobial stewardship, thereby improving medication safety and supporting rational prescribing during pregnancy.

Furthermore, the observed association between maternal obesity and prolonged hospital stay suggests increased healthcare resource utilization and economic burden. Strengthening community-based interventions aimed at preventing maternal obesity before conception and during early pregnancy may reduce pregnancy complications, optimize healthcare resource utilization, and improve maternal and neonatal health outcomes. Future multicentre studies involving larger and more diverse populations are warranted to evaluate the effectiveness of targeted preconception and antenatal interventions in reducing obesity-related pregnancy complications.

Strengths

The present study has several important strengths. First, its prospective observational design enabled systematic follow-up of pregnant women from enrolment until delivery, thereby minimizing recall bias and ensuring comprehensive collection of maternal, neonatal, and medication-related data. Second, the study simultaneously evaluated maternal pregnancy outcomes, neonatal outcomes, medication utilization patterns, World Health Organization (WHO) core prescribing indicators, and healthcare resource utilization, providing a comprehensive assessment of the clinical implications of maternal body mass index (BMI). Third, the use of standardized WHO BMI classification enhances the comparability of the findings with those of previous national and international studies. Fourth, the incorporation of multivariable logistic and multiple linear regression analyses strengthened the study by adjusting for clinically relevant confounding variables and identifying independent predictors of adverse maternal outcomes, neonatal outcomes, medication utilization, and length of hospital stay. Finally, by integrating obstetric outcomes with pharmacoepidemiological evaluation and rational prescribing indicators, this study provides clinically relevant evidence to support multidisciplinary antenatal care, including the role of clinical pharmacists in optimizing medication use among high-risk pregnant women.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, this was a single-centre prospective observational study conducted at a tertiary care teaching hospital in southern India, which may limit the generalizability of the findings to other geographic regions, healthcare settings, and populations with different demographic and socioeconomic characteristics. Second, although multivariable logistic and multiple linear regression analyses were performed to adjust for clinically relevant confounding variables, residual confounding from unmeasured factors, including socioeconomic status, educational level, dietary intake, physical activity, gestational weight gain, previous obstetric history, smoking exposure, and other lifestyle-related variables, cannot be completely excluded. Third, maternal BMI was determined using measurements obtained during early pregnancy or at enrolment when first-trimester measurements were unavailable, rather than pre-pregnancy BMI, which may have resulted in some degree of exposure misclassification. Fourth, the relatively small number of obese women (n = 41) may have reduced the precision of estimates for certain subgroup

analyses despite the adequate overall sample size. Finally, although the prospective design enabled temporal assessment of maternal BMI and pregnancy outcomes, the observational nature of the study precludes causal inference. Therefore, larger multicentre prospective studies with more diverse populations and longer follow-up are warranted to validate these findings and evaluate the effectiveness of interventions aimed at optimizing maternal BMI before and during pregnancy.

Conclusions

Maternal body mass index was independently associated with adverse maternal and neonatal outcomes, increased medication utilization, and prolonged hospital stay among pregnant women attending a tertiary care teaching hospital. Overweight and obesity were associated with significantly higher risks of gestational diabetes mellitus, pregnancy-induced hypertension, pre-eclampsia, caesarean delivery, macrosomia, neonatal intensive care unit admission, greater medication utilization, and longer hospitalization, whereas underweight was independently associated with an increased risk of low birth weight. These findings highlight the importance of early BMI assessment, individualized antenatal risk stratification, nutritional counselling, and timely multidisciplinary interventions to improve maternal and neonatal outcomes. Further multicentre prospective studies are required to confirm these findings and evaluate the effectiveness of targeted interventions for optimizing maternal weight before and during pregnancy.

Abbreviations

ANOVA: Analysis of Variance

AOR: Adjusted Odds Ratio

BMI: Body Mass Index

CI: Confidence Interval

GDM: Gestational Diabetes Mellitus

GGH: Government General Hospital

IUGR: Intrauterine Growth Restriction

LBW: Low Birth Weight

LMIC: Low- and Middle-Income Country

NLEM – National List of Essential Medicines

NFHS: National Family Health Survey

NICU: Neonatal Intensive Care Unit

OPD: Outpatient Department

OR – Odds Ratio

PIH: Pregnancy-Induced Hypertension

SD: Standard Deviation

VIF – Variance Inflation Factor

WHO: World Health Organization

β – Unstandardized Regression Coefficient

Declarations

Ethics approval and consent to participate

The study was reviewed and approved by the Institutional Ethics Committee of Balaji College of Pharmacy, Ananthapuramu, Andhra Pradesh, India (Reference No. BCP/IEC/2025/09). All procedures were conducted in accordance with the ethical standards of the institutional ethics committee and the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all individual participants included in the study, in their preferred language (English or Telugu), prior to enrolment. Participants retained the right to withdraw at any time without consequence to their medical care.

Consent for publication

Not applicable. This manuscript does not contain any individually identifiable personal data.

Competing interests

The authors declare that they have no competing interests. GP, RT, BS, SM, and MAM declare no financial or non-financial competing interests in relation to this manuscript.

Authors' information

Dr. T. Rajavardhana (Pharm.D., Ph.D.) is Vice Principal and Professor in the Department of Pharmacy Practice, Balaji College of Pharmacy, Ananthapuramu. His research interests include clinical pharmacy, pharmacoepidemiology, and maternal health pharmacology. Ms.M. Sruthi & Mr.M. Asif are Assistant Professors in Dept. of Pharmacy Practice who helped in data analysis. The remaining authors contributed to participant recruitment, prospective data collection, and data management under faculty supervision.

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Author Contribution

RT conceptualized and designed the study, supervised all stages of the research, performed the statistical analysis, interpreted the data, critically revised the manuscript for important intellectual content, and approved the final version for publication. GP, BSP, and SM were responsible for participant recruitment, obtaining informed consent, prospective data collection, and data entry. MAM assisted with the literature review, data verification, quality assurance, and manuscript editing. All authors contributed to data interpretation, reviewed the manuscript critically for important intellectual content, read and approved the final manuscript, and agree to be accountable for all aspects of the work.

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Data Availability

The datasets generated and/or analysed during the current study are not publicly available due to participant confidentiality and ethical restrictions but are available from the corresponding author on reasonable request.

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