e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(11); 1658-1665

Original Research Article

Effect of Maternal Body Mass Index on Pregnancy Outcome and Newborn Weight

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Received: 01-08-2025 / Revised: 15-09-2025 / Accepted: 21-10-2025

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Conflict of interest: Nil

Abstract

Background: One important modifiable predictor of pregnancy outcomes is the mother's nutritional state, as measured by her Body Mass Index (BMI). India is currently dealing with a "double burden" of malnutrition, which is defined by the persistence of underweight women and the rising incidence of obesity. Negative maternal-fetal outcomes are linked to both BMI extremes.

Methods: From October 2018 to December 2019, the Department of Obstetrics and Gynecology at Jhalawar Medical College in Rajasthan hosted this prospective hospital-based study. 252 primigravida women with singleton pregnancies who showed up in the first trimester were included in the study. Five BMI categories were used to stratify the participants: underweight, normal, pre-obesity, moderately obese, and severely obese. Up until discharge, maternal and perinatal outcomes were tracked.

Results: Significant correlations between aberrant BMI and negative outcomes were found in the study. Preeclampsia incidence was 66.7% in the very obese group and 6.6% in the normal weight group ($p = 0.001$), indicating a clear correlation between hypertensive disorders of pregnancy and increasing BMI. Obese women had a considerably greater risk of gestational diabetes mellitus (GDM) ($p < 0.0001$). On the other hand, low birth weight (LBW) neonates (62.0%, $p < 0.0001$) and anemia (54.0%, $p = 0.009$) were substantially linked to underweight mothers. With BMI, the rate of cesarean sections rose in a linear fashion. The underweight group had the highest neonatal mortality rate (10.0%, $p = 0.037$).

Conclusion: Maternal BMI extremes are important independent risk factors for obstetric and neonatal problems. To maximize BMI and enhance perinatal survival and health, preconceptional counseling and dietary management are crucial.

Introduction

Pregnancy is a special physiological window during which the mother's nutritional needs are extremely high in order to sustain the growing fetus. As a result, a woman's nutritional state during this time is a critical but changeable element that affects both perinatal survival and maternal health. Maternal depletion and underweight status have always been the main obstetric nutrition concerns in underdeveloped countries. However, a complicated epidemiological environment has been brought about by recent changes in lifestyle and demographics. A complicated health issue known as the "double burden" of sickness is currently plaguing nations like India. This indicates that a sizable portion of women who experience chronic malnutrition coexist with a rapidly increasing number of individuals who suffer from obesity. Experts use the Body Mass Index (BMI), also known as the Quetelet index, to comprehend these developments. It is largely regarded as a trustworthy method of forecasting health outcomes during pregnancy and uses a person's height and weight to assess body fat [1].

The Double Burden of Malnutrition: The nutritional landscape is divided in the particular demographic setting of rural and semi-urban India. Undernutrition ($BMI < 18.5$ kg/m2) is still common on one end of the spectrum and is frequently caused by dietary practices and socioeconomic variables. Low birth weight (LBW), anemia, and preterm births are all closely associated with this condition. Small for gestational age (SGA) is a significant predictor of neonatal mortality, stunted growth, and the emergence of chronic illnesses in adulthood in addition to being an acute worry for newborns [2]. Conversely, the increasing prevalence of obesity (BMI ≥ 30 kg/m2) presents a distinct, but no less hazardous, set of issues. According to the World Health Organization (WHO), obesity is a "killer illness" on par with infectious diseases and hunger, making it one of the most prominent but underappreciated public health issues [3]. Obstetric treatment now faces a new issue due to the rising incidence of maternal obesity, which calls for a change in emphasis to concurrently address excess and shortfall.

Pathophysiological Mechanisms: The endocrine function of adipose tissue is the basis for the biological plausibility linking abnormal BMI to unfavorable pregnancy outcomes. Adipose tissue is a metabolically active organ rather than just an inert place to store energy. Pro-inflammatory cytokines like Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha ($TNF-\alpha$) are secreted by excess adipose tissue in obese individuals. This secretion causes insulin resistance, vascular dysfunction, and a persistent, low-grade inflammatory state [4].

This metabolic state puts the mother at risk for thromboembolism, preeclampsia, and gestational diabetes mellitus (GDM). Additionally, this "perinatal programming" implies that acquired diseases can be epigenetically transmitted to the embryo through the intrauterine environment, possibly locking the baby into a lifelong cycle of metabolic syndrome and cardiovascular disease [5]. On the other hand, underweight mothers are frequently linked to shortages in micronutrients, especially iron and zinc, which impair fetal development and immune system performance. Despite these established hazards, there is a dearth of precise information about how early pregnancy BMI affects outcomes in the particular Southeastern Rajasthani group. In order to close this information gap, this study attempts to assess the impact of maternal BMI measured during the first trimester on antepartum, intrapartum, and neonatal outcomes in a tertiary care context.

Materials and Methods

Study Structure and Setting: A prospective, hospital-based observational research was created to examine the connection between maternal BMI and pregnancy outcomes. With assistance from the Department of Pediatrics, the Department of Obstetrics and Gynecology at Jhalawar Medical College in Rajasthan organized the study. October 2018 to December 2019 was the study period. All procedures were approved by the institutional review board beforehand, and they all adhered to ethical norms.

Study Population: 252 women made up the study cohort. We used strict selection criteria to ensure that BMI classifications were accurate. Only primigravida women with singleton pregnancies who went to their first prenatal checkup in the first trimester were eligible to participate. Because weight swings in the second and third trimesters, which are frequently caused by fluid retention and fetal development, can be unpredictable, this time range was crucial. Thus, the most reliable baseline for pre-pregnancy nutritional status is first-trimester weight. After being fully told about the study's goals, each participant gave signed informed consent.

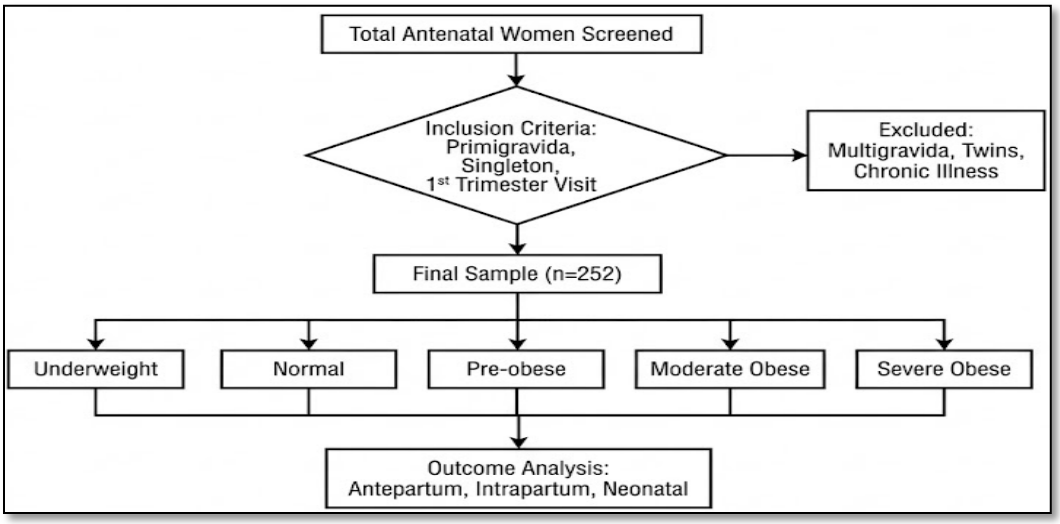

Figure 1: **Study Methodology Flowchart**

On the other hand, in order to preserve the sample's homogeneity, particular exclusion criteria were set. Women who presented for the first time in the second or third trimester, had multiple pregnancies (twins or triplets), or had a history of chronic conditions were not included. These problems included heart disease, endocrine abnormalities, pre-gestational diabetes mellitus, and chronic hypertension because they could independently affect pregnancy outcomes regardless of the patient's BMI.

Data Collection and Methodology: To reduce measurement error, the data collection approach was standardized. Each participant was asked to provide a thorough clinical history at the time of participation, including information about their age, education level, socioeconomic situation, and menstruation history. High-precision equipment was used to take anthropometric measurements. An Equinox electronic personal scale (Model EB 1003) with a sensitivity of 0.1 kg was used to measure weight in kilos. Patients were weighed without shoes and in light indoor attire to guarantee uniformity. A Bio Plus stadiometer (Model 26M/1013522) was used to measure height in meters while patients stood upright in the Frankfort horizontal plane, making sure their shoulders, heels, and buttocks touched the vertical backboard.

The traditional method of dividing weight in kilos by the square of height in meters (kg/m^2) was used to compute body mass index. The study population was divided into five different groups according to modified World Health Organization criteria. Cases with a BMI of less than 18.5 kg/m^2 made up the first group, whereas cases with a BMI between 18.6 and 24.9 kg/m^2 made up the second group, which served as the healthy reference standard. Pre-obese (25–29.9 kg/m2), moderately obese (30–34.9 kg/m2), and severely obese (over 35 kg/m2) were the categories for higher BMI ranges. Preeclampsia, anemia, and gestational diabetes were among the problems that were monitored during the prenatal period. Along with neonatal health indicators including birth weight and APGAR scores, delivery metrics were also documented, such as the mode of delivery and the necessity of labor induction.

Statistical Analysis: Before being processed using SPSS version 16.0 for statistical analysis, raw data was first coded and cleaned within Microsoft Excel spreadsheets. Depending on the type of data, descriptive measures were used; in particular, frequencies and percentages described categorical characteristics like preeclampsia incidence and delivery methods, while means and standard deviations summarized continuous variables like age and birth weight. Inferential statistics, such as the Chi-square test and Fisher's exact test, were used when appropriate to ascertain whether relationships between maternal BMI categories and pregnancy outcomes existed. A p-value threshold of less than 0.05 was used to determine statistical significance throughout the investigation.

Results

Demographic Characteristics: The 252 participants' demographic data showed clear trends that correlated with body mass index. 48.4% (n=122) of the study population, or the majority, were classified as normal weight. With 19.8% (n=50) of women categorized as underweight and a total of 31.7% falling into the overweight or obese categories (pre-obese 21.8%, moderate Obese 8.7%, and severe Obese 1.2%), the burden of malnutrition was apparent at both extremes. Maternal age showed a statistically significant correlation ($p = 0.002$), with the mean age rising linearly with BMI; the mean age of the Underweight group was 24.2 years, while that of the Severe Obese group was 27.6 years. Additionally, there was a significant inverse correlation between BMI and socioeconomic status (SES) ($p < 0.0001$).

Obesity was considerably more common among women from upper-middle SES origins, suggesting the food and lifestyle changes linked to economic progress, while women from lower socioeconomic backgrounds were primarily found in the Underweight and Normal weight groups.

Maternal Antepartum Complications

An obvious difference based on BMI status was observed in maternal problems throughout the antepartum interval. Pregnancy-related hypertensive diseases showed a direct linear relationship with increased body mass.

The incidence of gestational hypertension increased dramatically from 13.1% in the normal weight group to a startling 66.7% in the severe obese group, as seen in Table 1. Similarly, preeclampsia afflicted 22.7% of moderately obese women and 66.7% of severely obese women, whereas it only impacted 6.6% of women of normal weight.

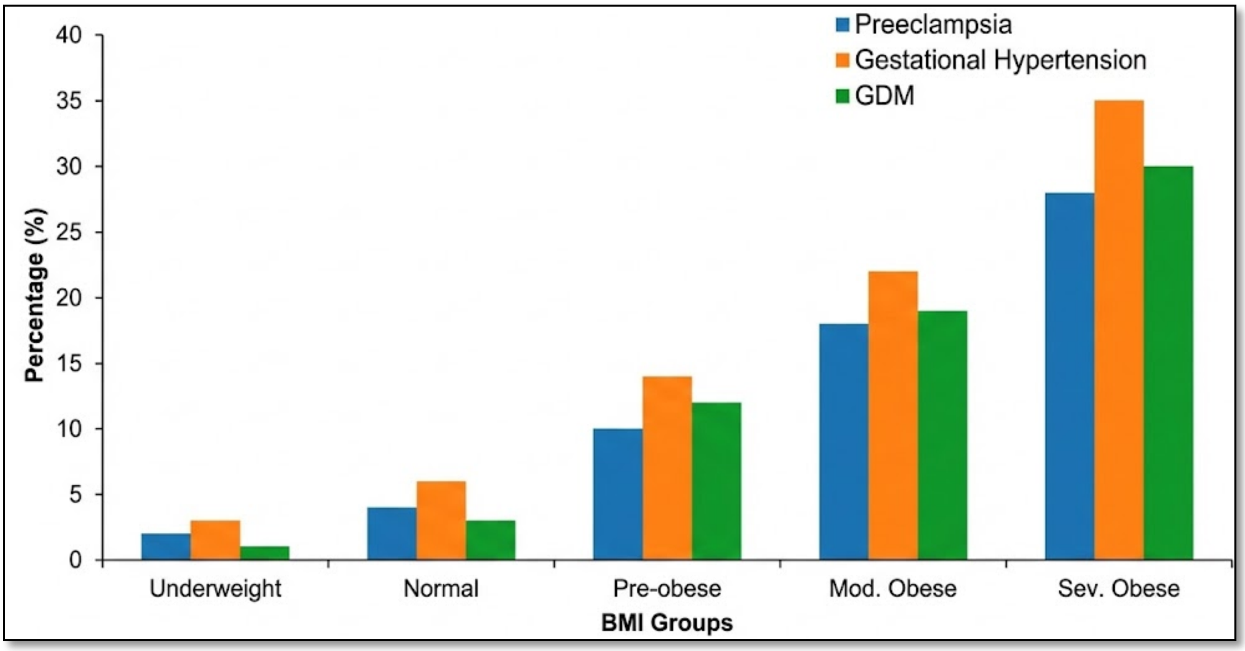

Figure 2: **Incidence of Key Maternal Complications**

The higher BMI groups also showed signs of metabolic dysfunction; 33.3% of women with severe obesity had a diagnosis of gestational diabetes mellitus (GDM), whereas GDM was almost nonexistent in the underweight group. On the other hand, the most common consequence among underweight women was anemia, which affected 54.0% of the group. This rate was substantially greater than that of the normal weight cohort ($p = 0.009$).

Table 1: **Distribution of Maternal Antepartum Complications According to BMI**

Complication	Underweight (n=50)	Normal (n=122)	Pre-obese (n=55)	Mod. Obese (n=22)	Sev. Obese (n=3)	P-value
Preeclampsia	3 (6.0%)	8 (6.6%)	8 (14.5%)	5 (22.7%)	2 (66.7%)	**0.001**
Gestational HTN	7 (14.0%)	16 (13.1%)	21 (38.2%)	12 (54.5%)	2 (66.7%)	**< 0.0001**
GDM	0 (0.0%)	2 (1.6%)	2 (3.6%)	4 (18.2%)	1 (33.3%)	**< 0.0001**
Anemia	27 (54.0%)	32 (26.2%)	18 (32.7%)	5 (22.7%)	1 (33.3%)	**0.009**

Intrapartum and Postpartum Outcomes: Deviations in maternal weight greatly affected the outcomes of labor and delivery. Compared to just 10.7% of women of normal weight, 66.7% of the Severe Obese group and 40.9% of the Moderate Obese group required induction of labor (Table 2). A clinical pattern was apparent: the rate of cesarean sections rose steadily with BMI, from 22.0% in underweight women to 66.7% in the severe obese group, even though the overall p-value for the mode of birth did not reach statistical significance in this sample size. A "U-shaped" curve was observed for postpartum problems, especially infections. Compared to the Normal weight group (9.0%), the Severe Obese group (66.7%) and the Underweight group (18.0%) had significantly higher rates of wound infection or sepsis.

Additionally, the Severe Obese category had a significantly higher frequency of postpartum hemorrhage (PPH) ($p = 0.030$).

Table 2: **Intrapartum and Postpartum Maternal Outcomes**

Outcome	Underweight (n=50)	Normal (n=122)	Pre-obese (n=55)	Mod. Obese (n=22)	Sev. Obese (n=3)	P-value
Induction of Labor	5 (10.0%)	13 (10.7%)	7 (12.7%)	9 (40.9%)	2 (66.7%)	**< 0.0001**
Cesarean Section	11 (22.0%)	35 (28.7%)	17 (30.9%)	9 (40.9%)	2 (66.7%)	0.532
PPH	5 (10.0%)	11 (9.0%)	7 (12.7%)	3 (13.6%)	2 (66.7%)	**0.030**
Infection	9 (18.0%)	11 (9.0%)	3 (5.5%)	4 (18.2%)	2 (66.7%)	**0.005**

Neonatal Outcomes: Table 3 shows that maternal BMI had a significant impact on neonatal outcomes. The newborn's birth weight and the mother's BMI were significantly correlated. The normal weight group had the highest mean birth weight (2923 g), whereas the underweight group had the lowest (2136 g). As a result, the Underweight group had a startlingly high incidence of Low Birth Weight (LBW) babies (62.0%), while the Normal weight group had a far lower incidence (11.5%). On the other hand, mothers who were moderately obese had the highest risk of macrosomia, or large for gestational age (LGA), babies (9.1%). The Severe Obese (33.3%) and Moderate Obese (27.3%) groups as well as the Underweight group (22.0%) had the greatest rates of neonatal morbidity, as measured by NICU admission rates, indicating the elevated risk at both extremes of the nutritional continuum.

Most importantly, the Underweight group had a considerably greater infant death rate (10.0%) than the Normal weight group (4.9%), underscoring the potentially fatal consequences of maternal undernutrition ($p = 0.037$).

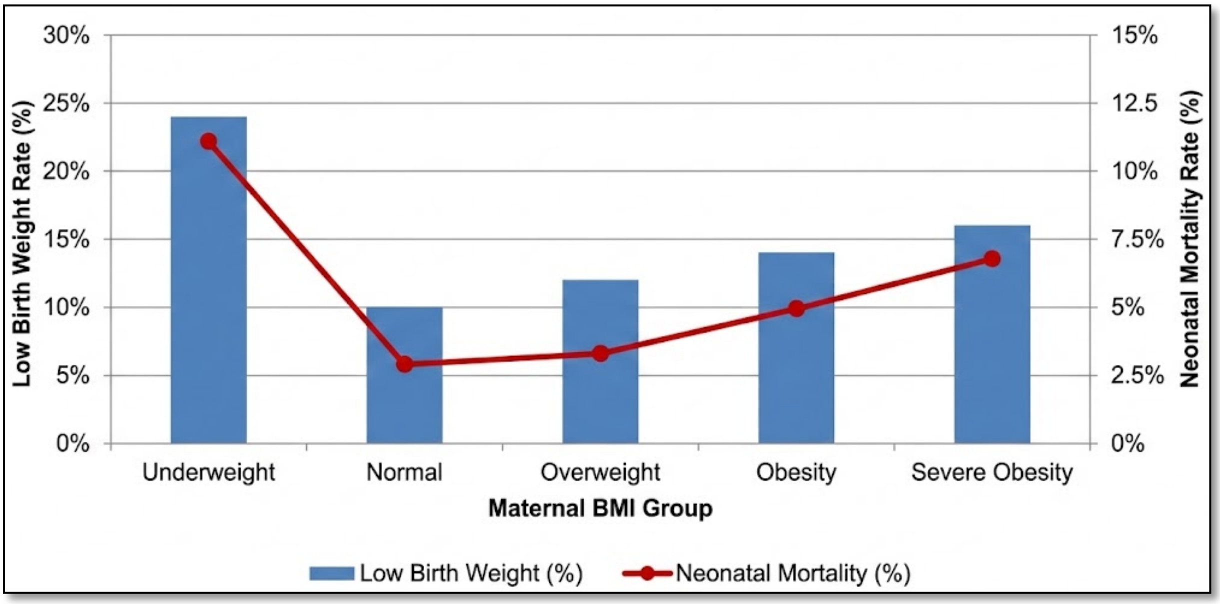

Figure 3: **Neonatal Morbidity and Mortality Trends**

Table 3: **Neonatal Weight and Morbidity Outcomes**

Outcome	Underweight (n=50)	Normal (n=122)	Pre-obese (n=55)	Mod. Obese (n=22)	Sev. Obese (n=3)	P-value
Mean Birth Wt. (g)	2136.0	2923.9	2846.8	2604.5	2466.7	$< \mathbf{0.0001}$
LBW ($<$ 2.5kg)	31 (62.0%)	14 (11.5%)	11 (20.0%)	7 (31.8%)	2 (66.7%)	$< \mathbf{0.0001}$
NICU Admission	11 (22.0%)	23 (18.9%)	14 (25.5%)	6 (27.3%)	1 (33.3%)	**0.040**
Neonatal Mortality	5 (10.0%)	6 (4.9%)	3 (5.5%)	1 (4.5%)	0 (0.0%)	**0.037**

Maternal BMI's Effect on Delivery Method and Intrapartum Treatments:

A mother's Body Mass Index (BMI) and the probability of needing medical assistance during labor are clearly related. Research indicates that the need for labor induction increases in direct proportion to BMI. In particular, compared to women in the normal weight range ($p < 0.05$), those in the overweight and obese groups exhibit a significantly larger demand for induction. This pattern persists over time, with the most obese individuals experiencing the greatest induction rates, demonstrating a direct link between increased body weight and the mode of birth.

Across the range of body mass index categories, a slow change in delivery techniques is evident. While vaginal delivery continues to be the most common method for underweight and normal-weight groups, the frequency of cesarean sections rises steadily with BMI, reaching its greatest rates among the extremely obese category. There is still a clinically significant trend in favor of surgical intervention, even though the specific association between BMI and cesarean section did not reach statistical significance.

Although the prevalence of instrumental delivery was generally low, it was significantly greater in the overweight and moderately obese categories. In the end, our results highlight the influence of nutritional status on intrapartum care, showing that a higher BMI is associated with a higher need for medical and surgical procedures during childbirth.

Table 4: Association of Maternal BMI with Mode of Delivery and Intrapartum Interventions

MI Category	Vaginal Delivery n (%)	Cesarean Section n (%)	Induction of Labor n (%)	Instrumental Delivery n (%)
Underweight (n=50)	39 (78.0)	11 (22.0)	6 (12.0)	3 (6.0)
Normal (n=122)	95 (77.9)	27 (22.1)	13 (10.7)	5 (4.1)
Pre-obese (n=55)	35 (63.6)	20 (36.4)	18 (32.7)	4 (7.3)
Moderately Obese (n=22)	13 (59.1)	9 (40.9)	9 (40.9)	2 (9.1)
Severely Obese (n=3)	1 (33.3)	2 (66.7)	2 (66.7)	0 (0.0)
P-value	—	0.08	**<0.05**	0.21

Discussion

Hypertensive Disorders and Metabolic Complications: Elevated maternal BMI is strongly associated with an increased risk of metabolic dysfunction and hypertensive diseases, according to substantial evidence. As BMI rises, there is a clear, linear increase in the incidence of prenatal hypertension and preeclampsia. The "lipotoxicity" of excess adipose tissue, where adipocytes produce inflammatory mediators that cause endothelial damage a hallmark of preeclampsia is probably the pathophysiology underlying this association. These findings are consistent with Voigt et al.'s finding that preeclampsia is substantially more common in people with a BMI over 30 than in those who are thinner [6]. Additionally, obesity and the risk of gestational diabetes mellitus (GDM) are strongly correlated. This is consistent with research by Bianco et al. showing that obese populations had a significantly greater prevalence of GDM [7]. The risk of GDM increases significantly with each 1 kg/m² increase in BMI, according to systematic reviews by Torloni et al. [8]. According to Roberts et al., this process is fueled by obesity-induced chronic insulin resistance, which overwhelms the pancreatic beta-cells' ability to adapt and causes hyperglycemia when paired with the physiological insulin resistance that comes with pregnancy [9].

The Impact of Maternal Underweight on Fetal Growth: Our study emphasizes the ongoing and serious risks associated with maternal underweight status, even though the worldwide conversation frequently centers on obesity. We discovered a strong correlation between low maternal BMI and unfavorable fetal growth outcomes, particularly anemia and low birth weight (LBW). Our underweight cohort's 54% anemia prevalence is in line with research by Sahu et al., which points to a dietary etiology in which iron deficiency and other macronutrient deficiencies coexist [10]. The "fetal causes of adult disease" theory is further supported by the finding that 62% of newborns born to underweight mothers were LBW. Intrauterine growth limitation results from maternal undernutrition, which significantly limits the fetus's access to substrate. This supports the findings of Han et al.'s comprehensive study, which identified maternal underweight as the main risk factor for preterm delivery and small-for-gestational-age (SGA) infants [11]. This group's higher neonatal mortality rate (10.0%) emphasizes that maternal emaciation is still a deadly hazard for the child, most likely because of a lack of physiological reserve.

Obstetric Interventions and Postpartum Morbidity: Our findings showed that the progress of labor and the likelihood of postpartum problems are strongly influenced by the mother's BMI. According to Jensen et al. [12], the high probability of labor induction among obese women (66.7% in the severe group) raises the possibility that obesity may affect cervical ripening or uterine contractility. Furthermore, maternal obesity has been found by Sheiner et al. to be an independent risk factor for primary cesarean birth, regardless of any obstetric problems; this tendency is seen in our increasing incidence of cesarean sections [13]. In terms of postpartum infections, we similarly saw a "U-shaped" curve, with underweight and severely obese women at greater risk than women of normal weight. The poor vascularity of subcutaneous adipose tissue, which hinders wound healing, and the technical challenges of surgery are probably the causes of this in obese women. This is in line with Satpathy et al.'s findings that obese patients had greater rates of wound disruption after cesarean procedures [14]. Additionally, compared to their non-obese counterparts, enormously obese parturients have a markedly increased risk of wound complications, according to Alanis et al. [15]. Our obese cohort's higher rate of postpartum hemorrhage (PPH) is consistent with research by Liu et al. showing that fat makes delivery and hemostasis more difficult [16]. Lastly, Scott-Pillai et al. confirmed that aberrant maternal BMI is a strong predictor of NICU admission with relation to newborn morbidity [17], which is consistent with our findings of increased admissions at both BMI extremes.

Maternal BMI and Intrapartum Decision-Making: This study's findings about the association between maternal BMI and intrapartum therapies underscore the increasing clinical difficulty associated with abnormal maternal weight. Impaired uterine contractility reduced myometrial reactivity to oxytocin, and greater soft tissue resistance in the pelvis may all contribute to the increased requirement for labor induction and cesarean birth among obese women. Obstetricians frequently adopt a lower threshold for surgical intervention due to the well-known effects of maternal obesity, such as prolonged labor and unsuccessful induction [15, 16].

Obese women may have higher incidence of cesarean sections because of proactive clinical decision-making to minimize difficulties for both mothers and newborns. Delivery planning in this population is often influenced by concerns about shoulder dystocia, fetal macrosomia, and intrapartum fetal impairment. However, there is a complicated risk-benefit analysis because cesarean delivery in obese women is linked to higher postoperative morbidity, such as wound infection and postpartum hemorrhage.

Despite having lower intervention rates, underweight women are more susceptible to anemia and have less physiological reserve, which can make labor more difficult, particularly during lengthy or surgical deliveries. This emphasizes the value of having a balanced nutritional state as opposed to concentrating only on obesity [18].

These results support the necessity of tailored intrapartum planning and early BMI evaluation. Identification of pregnant women at BMI extremes enables focused counseling, maternal health optimization, and readiness for possible labor problems. Maternal BMI can be incorporated into labor risk stratification methods to reduce needless interventions and enhance outcomes for both mothers and newborns.

Limitations of the Study: Despite the noteworthy results, there are a number of limitations to this study that need to be recognized in order to appropriately interpret the findings. First and foremost, the sample size of 252 women is comparatively small for subgroup analysis, even though it is adequate for identifying general trends. With just three competitors in the "Severe Obese" category, this is very clear. The generalizability of results pertaining to huge obesity may be limited by this tiny denominator, which might result in broad confidence intervals and skew statistical significance for this particular cohort. Larger cohorts in future research are required to confirm the high rates of problems seen in this particular population.

Second, the study used weight measurements taken during the first trimester to establish BMI. This is not the same as pre-pregnancy weight, even though it is a common and recognized proxy in obstetric research. By the time of the initial visit, a small proportion of participants might have been incorrectly classified due to some degree of gestational weight increase or loss brought on by hyperemesis gravidarum. In developing countries, where women frequently wait to seek medical attention until pregnancy is confirmed, the lack of pre-pregnancy data is a typical problem.

Lastly, a thorough nutritional evaluation incorporating food memory and adherence to iron-folic acid supplementation was absent from the study design. Without this information, we are unable to conclusively link the increased prevalence of anemia in the underweight group to calorie deficiency as opposed to particular micronutrient deficits or problems with compliance. Designing focused nutritional interventions would require an understanding of the particular eating patterns that contribute to these BMI categories.

Conclusion

In summary, this prospective study conclusively demonstrates that maternal body mass index is a powerful and independent predictor of pregnancy outcomes, with risks exhibiting a unique distribution based on the particular issue.

The information demonstrates that postpartum morbidity, gestational diabetes, hypertensive problems, and surgical procedures are all significantly influenced by maternal fat. On the other hand, high rates of low birth weight and neonatal mortality are caused by maternal underweight status, which continues to be a significant and potentially fatal risk factor for the fetus. A dual-pronged approach to prenatal care is necessary since the "double burden" of malnutrition is a clinical reality seen in the ward and not just a statistical idea.

There are significant ramifications for clinical practice and public health. To quickly stratify patients by risk, BMI screening must be required as a standard part of the initial prenatal appointment. Undernutrition and anemia must be strictly addressed by public health initiatives through proactive supplements and food security measures.

At the same time, a move toward pre-conceptional counseling is required due to the growing obesity epidemic. Weight optimization techniques should be incorporated into standard women's healthcare services, and women of reproductive age should be informed about the dangers of becoming pregnant at an abnormal weight. Following suggested weight gain goals based on pre-pregnancy BMI is crucial for maximizing results, as stressed by the Institute of Medicine guidelines [18]. We can only hope to improve the long-term health and survival of women and their infants by addressing both extremes of the nutritional continuum.

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