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Effect of Early Gestational Body Mass Index and Gestational Weight Gain on Pregnancy Outcome

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ABSTRACT

Background & Objective: The maintenance of an appropriate weight before and during pregnancy has a significant effect on pregnancy outcomes. Therefore, this study attempts to explore the relationship between pre-pregnancy body mass index (BMI) and gestational weight gain (GWG) in the Indian antenatal population. This was a prospective study.

Materials & Methods: This study was conducted on a total of 301 pregnant women who fulfilled the inclusion criteria booked from the first trimester till delivery in the department of Obstetrics and Gynecology, SGRRIM & HS, from January 2020 to June 2021. The weight and height of the participants were recorded at their first visit to the antenatal clinic using standard protocol. BMI was recorded and GWG was calculated at each antenatal clinic visit. BMI and GWG were correlated with antepartum, intrapartum and postpartum complications with the application of appropriate statistical tests.

Results: In our study, higher pre-pregnancy BMI and GWG significantly increased the risk of perinatal adverse outcomes. Increased rates of cesarean section (57.1%), operative vaginal delivery (9.5%), gestational diabetes mellitus (9.5%), and pre-eclampsia (28.6%) were observed in obese women as compared to women with normal pre-pregnancy BMI and gestational weight gain. These were found to be statistically significant (p-value <0.001).

Conclusion: Appropriate nutrition prior to and throughout the pregnancy plays an important role in determining the health of both mother and fetus. There is a positive correlation between early pregnancy BMI and GWG, and the course of pregnancy, and its outcome.

Keywords: Body Mass Index (BMI), Gestational Weight Gain (GWG), Neonatal Intensive Care Unit (NICU)

Introduction

The prevalence of obesity is rising globally **(1)**. Among women of the reproductive age group, more than fifty percent are either overweight or obese **(2-4)**. Obesity in children is linked to maternal obesity in the first trimester **(5)**. "Fetal programming" in utero due to nutritional supply may lead to permanent changes in physiology and metabolism and may serve as the origin of a diverse array of metabolic diseases that arise in later life, such as heart disease, hypertension and type 2 diabetes **(6)**. Both a higher maternal BMI in the first trimester and a greater GWG are associated with an increased rate of pregnancy complications **(7)**.

The effect of low maternal weight on obstetric performance, such as increased incidence of preterm delivery, low birth weight in offspring, and increased perinatal loss, is less clear **(8, 9)**.

In order to provide consistency in the care of pregnant women, the Institute of Medicine (IOM-2009) has provided evidence-based guidelines to help maternity care providers manage their patients with regard to pre-pregnancy BMI and GWG recommendations. A specific range of weight gain for women with a higher BMI (overweight and obese women) is simultaneously recommended **(10, 11)**. The present study was aimed at comparing weight gain during pregnancy (using IOM weight gain guidelines) in an urban Indian population across different BMI categories, as well as comparing pregnancy outcomes in each of those different BMI categories. Several studies have shown a significant contribution of excessive GWG to short- and long-term adverse health outcomes for the mother, the infant and future pregnancies **(12, 13)**.

The present study focuses on pregnancy outcome and other pregnancy-related complications for singleton pregnancies among an urban Indian population according to IOM 2009 weight gain recommendations. This study attempts to explore the relationship between pre-pregnancy BMI and IOM 2009 GWG limits in an Indian setting to stimulate local protocols for weight gain/control in order to optimize pregnancy outcomes.

Methods

This prospective study was conducted in the Department of Obstetrics and Gynecology, Shri Mahant Indiresh Hospital, SSGRRIM & HS, Patelnagar, Dehradun between January 2020 and June 2021. Before initiation, the study was approved by the institutional ethical committee. Pregnant women who were willing to participate and fulfilled the inclusion criteria (those who booked in the first trimester for antenatal care and could be followed through the entire pregnancy) were enrolled in this study. All participants were introduced to the study's objectives and protocol. An informed written consent was obtained from each participant.

Inclusion criteria:

1. All women carrying a singleton pregnancy who enrolled in the first trimester for antenatal check-ups and remained under care until delivery in this institute.

Exclusion criteria:

1. Pregnant women with multiple pregnancies.

2. Pregnancy with congenital malformations.

3. Those not willing to continue care until delivery.

4. Women with pre-existing hypertension and overt diabetes mellitus.

Women with multifetal pregnancies, those with fetal congenital malformations, and those not willing to continue care until delivery were excluded from the study. A detailed history and examination of the participants were taken. The socioeconomic status of the patients was obtained to classify them utilizing a modified Kuppuswamy score.

Maternal weight was recorded at the first antenatal visit in the first trimester. Maternal height was measured to the nearest 0.1cm using standard protocol with a Seca 213 stadiometer (Germany). BMI was calculated as per the formula: weight (kilograms)/height (m^2). Gestational weight gain (GWG) was calculated as the difference between the weight before labor and the early pregnancy weight. It was classified as inadequate, adequate or excessive as per IOM 2009 Guidelines, Washington DC, National Academy Press 2009.

Antepartum complications like gestational diabetes mellitus, pre-eclampsia, and preterm labor were recorded. Intrapartum outcome was recorded in terms of gestational age at delivery, mode of delivery (normal, operative vaginal delivery, or cesarean) and duration of labor.

In the postpartum period, the number of patients who had hemorrhages (atonic or traumatic) was recorded in each BMI group. Neonatal outcome was assessed by the need for admission to the NICU.

Data were described in terms of range, mean ±standard deviation (± SD), frequency (number of cases), and relative frequency (percentages) as appropriate. To compare data belonging to different categories, the Chi square ($\chi 2$) test was applied, and the exact test was used when the expected frequency was less than 5. A probability value (P. value) less than 0.05 was considered statistically significant. All statistical calculations were done using SPSS (Statistical Package for the Social Sciences) 21 version (SPSS Inc., Chicago, IL, USA), a statistical program for Microsoft Windows.

Results

Of a total of 354 women recruited for the study, only 301 could be followed through the pregnancy. Some of these women were lost to follow-up, while others did not deliver at this institution.

35.9% belonged to the upper middle class socioeconomic status, whereas 34.9% were from the lower middle class (according to the Modified Kuppuswami Scale). The data (Table-1) suggests that socioeconomic status, which takes into account, a person's occupation, income and education, greatly affects lifestyle, indirectly affecting the person's BMI. An increased BMI (both overweight and obese) was observed as a direct correlate of higher socioeconomic status.

Table 1. Relationship between bmi and socio economic status:

Socio economic status	BMI GROUP				Total	Chi-square value	p-value
	Underweight	Normal	Overweight	Obese			
Lower class	19	12	11	6	48		
	39.58%	25.00%	22.92%	12.50%	100.00%	70.316	0.0001
	0	0	0	0	0		

Socio economic status	BMI GROUP				Total	Chi-square value	p-value
	Underweight	Normal	Overweight	Obese			
Upper lower class	0%	0%	0%	0%	0%		
Lower middle class	16	52	35	2	105		
	15.24%	49.52%	33.33%	1.90%	100.00%		
Upper middle class	6	42	54	6	108		
	5.56%	38.89%	50.00%	5.56%	100.00%		
Upper class	0	7	26	7	40		
	0.00%	17.50%	65.00%	17.50%	100.00%		
Total	41	113	126	21	301		

During pregnancy, insufficient weight gain was generally seen in women who began the pregnancy with a lower BMI, while adequate or excessive weight gain was observed in those in the overweight and obese category (Table-2). The difference between each group was statistically significant.

Table 2. Relationship between bmi and gestational weight gain:

BMI GROUP	GWG			Total	Chi-square value	p-value
	Inadequate	Adequate	Excessive			
Underweight	37	4	0	41		
	90.2	9.8%	0.00%	100.00%		
Normal	88	22	3	113		
	77.8%	19.5%	2.70%	100.00%		
Overweight	65	35	26	126	60.949	0.0001
	51.6%	27.8%	20.60%	100.00%		
Obese	3	13	5	21		
	14.3%	61.90%	23.80%	100.00%		
Total	193	74	34	301		

More overweight or obese women were delivered by cesarean section compared to women of normal weight or those in the underweight category. (Table-3). The difference between each group was also significant statistically.

Table 3. Relationship between BMI and mode of delivery

BMI Group	Mode of delivery			Total	Chi-square value	P-value
	Caesarean	Instrumental	Vaginal			
Underweight	9	0	32	41		
	22.00%	0.00%	78.00%	100.00%		
Normal	20	5	88	113		
	17.70%	4.40%	77.90%	100.00%		
Overweight	69	14	43	126	60.125	0.0001
	54.80%	11.10%	34.10%	100.00%		
Obese	12	2	7	21		
	57.10%	9.50%	33.30%	100.00%		
Total	110	21	170	301		

The maternal complications observed in this study were Gestational diabetes mellitus (GDM), pre-eclampsia, and preterm labor (Table-4). The incidence of GDM, pre-eclampsia, and preterm labor emerged to be significantly higher, as has been shown in the subsequent tables (P. value <0.05).

Table 4. Relationship between bmi and maternal complications:

BMI Group	Gestational diabetes mellitus		Pre-eclampsia		Preterm labor	
	NO	Yes	NO	Yes	NO	Yes
Underweight	41	0	38	3	18	23
	100.00%	0.00%	92.70%	7.30%	43.90%	56.10%
Normal	111	2	107	6	99	14
	98.20%	1.80%	94.70%	5.30%	87.60%	12.40%
Overweight	106	20	110	16	121	5
	84.10%	15.90%	87.30%	12.70%	96.00%	4.00%
Obese	19	2	15	6	17	4
	90.50%	9.50%	71.40%	28.60%	81.00%	19.00%
Total	277	24	270	31	255	46
Chi-square value	20.263		11.814		66.173	
P-value	0.0001		0.008		0.0001	

A higher incidence of primary post-partum hemorrhage (PPH) (women with blood loss>500ml), was observed among overweight and obese women, and this included both varieties (atonic and traumatic), but the difference between each group did not attain statistical significance (Table-5).

Table.5. postpartum complications

Post-partum complications	BMI Group								Total	Chi-square value	P-value
		Underweight		Normal		Overweight		Obese			
Primary PPH	No	37	90.2%	109	96.5%	119	94.4%	18	85.7%	283	10.254	0.330
	Atonic PPH	4	9.8%	4	3.5%	5	4.0%	3	14.3%	16		
	Traumatic PPH	0	0.0%	0	0.0%	2	1.6%	0	0.0%	2		

Infants born to women at both extremes of the BMI spectrum are at risk of requiring neonatal care, as evidenced by increased admissions due to conditions like prematurity, low birth weight, perinatal asphyxia, and neonatal jaundice, among others (Table-6).

Table 6. Relationship between bmi and nicu admission:

BMI Group	Nicu admission		Total	Chi-square value	p-value
	No	Yes			
Underweight	9	32	41	31.568	0.0001
	22.00%	78.00%	100.00%		
Normal	80	33	113		
	70.80%	29.20%	100.00%		

Overweight	63	63	126
	50.00%	50.00%	100.00%
Obese	9	12	21
	42.90%	57.10%	100.00%
Total	161	140	301

Discussion

The body habits as well as the state of nutrition and medical health in which a woman embarks on a new pregnancy have immense potential to affect the course of the pregnancy and the overall outcome. The present study was undertaken to examine the effects of early gestational BMI and gestational weight gain on obstetric outcomes, both maternal and perinatal. This was a prospective hospital-based study that included 301 women who were observed during their entire gestation period and birth.

Low socioeconomic status may lead to various adverse outcomes, probably attributable to a lack of optimal nutrition and inadequate access to healthcare **(14)**. Slightly more than half the women in the study were either from the lower or lower middle classes, while the upper middle- and upper-class women contributed the remainder. This makes for an interesting comparison of obstetric behavior across all socioeconomic classes. Inadequate prenatal care is associated with poor obstetric outcomes, which may include preterm birth, preeclampsia, and stillbirth **(15)**.

Conversely, women from higher social classes with access to high-calorie diets may begin their pregnancies with a higher BMI **(16)**. This may also impact optimal obstetric outcomes. An analysis of the distribution of women in different socioeconomic classes according to early pregnancy BMI revealed that most of the overweight and obese women were from the upper middle and upper socioeconomic classes. 33 out of 40 women from the upper socioeconomic class and 60 out of 108 women from the upper middle class were overweight or obese at the beginning of their gestation.

Both extremes of BMI have an unfavourable outcome for mothers and their neonates. At the first prenatal assessment, more women were overweight at the beginning of the pregnancy. Among the women under study, BMI ranged from 15.4 kg/m2 to 33.8kg/m^2.

In a study similar to this, Simko et al. observed the effects of maternal BMI and GWG on pregnancy outcome in a retrospective analysis of 7122 women. They found 17.7% of women to be underweight, 21.2% had normal weight, 26.6% were overweight, and 34.9% were obese, observations similar to those in this study **(17)**. They observed that obese women gained less weight than those of normal weight during pregnancy. This finding is in consonance with this study's results, although it was observed that most women, irrespective of early gestational BMI, gained insufficient weight when IOM 2009 guidelines were utilized. This may be attributable to the fact that overweight and obese women were advised to adhere to stricter gestational weight gain in order to achieve a more optimal outcome. Also, it should be noted that this study uses the IOM 2009 guidelines as a reference for classifying BMI and the adequacy of GWG. The IOM 2009 guidelines are largely formed on the basis of studies conducted on American women, which may not accurately represent optimal weight gain for their Indian counterparts. The mean pregnancy weight gain in our study was 8.2 kg± 3.4, which seems lower than the western norm.

Dinatale et al. analyzed the impact of obesity and considered obesity in mothers a high-risk factor, and the positive correlation of the risk of associated complications is also associated with an increasing degree of obesity. The severity of complications is also positively correlated with increased levels of obesity **(18)**. In a study of the effect of obesity on obstetric complications, Weiss et al. also observed that obesity is an independent risk factor for adverse obstetric outcomes and is significantly associated with an increased cesarean delivery rate **(19)**. The results have been proven to be similar in this study as well, with a higher cesarean section rate and a higher rate of operative vaginal delivery (outlet forceps and ventouse) in overweight and obese women as compared to underweight women and those who had a normal BMI.

Out of 24 women who developed gestational diabetes in this study, 20 were overweight and 2 were obese, with only 2 normal-weight gravidee developing GDM. Preeclampsia was observed in 31 women, of whom 16 were overweight and 6 were obese. A total of 22 out of 31 were either overweight or obese.

The genesis of preeclampsia has been linked to not only nutritional deficiency but also to high pre-pregnancy BMI and excessive gestational weight gain **(20)**. A state of obesity and overweight is associated with hyperinsulinemia, insulin resistance, and maternal systemic inflammation, which are again proposed as mechanisms that mediate endothelial damage leading to the development of preeclampsia, hypertension, and thrombotic phenomena resulting in higher maternal morbidity and mortality **(21-23)**. Lopez-Jaramillo and

co-workers support the idea that obesity and preeclampsia may share a common mechanism **(20)**. In this study, we saw the development of preeclampsia in 28% of obese women. Of the 31 women who developed preeclampsia in this study, 22 were either overweight or obese. Only 3 underweight and 6 normal-weight women developed preeclampsia in this study.

In the present study, GDM was not observed in underweight women, in contrast to overweight and obese women. This difference in the development of glucose intolerance among pregnant women of different BMI categories was statistically significant (p-value-0.0001).

Preterm labor is a complication often associated with poor maternal nutrition, and a low BMI may be a surrogate marker for it. Of the 46 women who experienced preterm labor in our study, 23 were underweight, and this observation was also statistically significant. In addition, most of these women gained suboptimal weight during pregnancy.

Tang et al. investigated the association between pre-pregnancy body mass index (BMI) and adverse pregnancy outcomes among women participating in the National Free Preconception Health Examination Project in Guangdong Province, China, and explored these associations according to maternal age. They observed that, as compared to women with normal weight, underweight women had an increased risk of preterm birth and giving birth to SGA infants. Inversely, they observed an association with primary cesarean delivery due to large infants **(24)**. This study concluded that women with a low BMI also had a significant risk of adverse pregnancy outcomes.

When we shift attention to the mode of delivery, this study found that of 301 women, 170 delivered normally, 110 had a cesarean birth, and 21 had an instrumental delivery. The main indication for instrumental delivery was prolonged labor during the second stage of labor, and the commonest indication for cesarean section was secondary arrest in the descent of the head during the second stage of labor.

Al-Kubaisy, in an Iraqi study, studied maternal obesity and the risk of cesarean section in 404 women and found that they had a 38% section rate. This study observed that a greater number of sections were needed for obese primigravidae than for multiparae. More obese women with previous sections were delivered by repeat cesarean compared to those with normal weight **(25)**. The results of this Iraqi study are comparable to the present study.

Another observation in this study was the increased incidence of postpartum complications viz primary postpartum hemorrhages and wound infection, in women with a high early pregnancy BMI compared to those with a normal BMI. The incidence of primary PPH was found to be higher at the extremes of BMI. The results were found to be similar to those in a study conducted by Deshmukh et al., in which they studied the impact of high BMI on pregnancy outcome. They noted that PPH, pyrexia, prolonged hospital stays, and lactation dysfunction were more frequent in women with a high BMI **(26, 27)**.

Maternal obesity is an independent risk factor for the development of fetal macrosomia and the need for intensive neonatal care. In our study, there were 140 NICU admissions for a variety of reasons, which included neonatal jaundice, low birth weight, prematurity, birth asphyxia, respiratory distress, et cetera, of which 63 babies were born to overweight mothers and 12 babies were born to obese women (the majority of all admissions to the NICU were infants of heavier mothers).

In a cohort study of 2049 women, Kalk and colleagues aimed to study the impact of maternal BMI on neonatal outcome. They observed that 500 babies required NICU admissions in their study: infants from overweight/obese mothers exhibited a significantly increased risk of being admitted to a neonatal ward. In their study, these NICU admissions were needed more for surveillance than actual illness **(28)**. A few other studies demonstrated similar results **(29, 30)**.

Conclusion

Maternal nutrition plays a critical role in fetal growth and development. This study yielded many positive correlations between the effects of early-pregnancy BMI and gestational weight gain on the course of pregnancy and the pregnancy outcome. This study may display avenues for many other higher-powered studies to study the overall effect of obesity as well as low BMI on maternal and perinatal health.

Author's Contributions

Conceived and designed the analysis- Dr.Rajive Acharya, Dr. Aditi Agarwal, Dr.Shikha Agarwal. Collected the data- Dr. Aditi Agarwal, Dr.Shikha Agarwal. Contributed data and analysis tools- Dr. Rajive Acharya, Dr. Vineeta Gupta, Dr. Shikha Agarwal. Performed the analysis- Dr. Aditi Agarwal, Dr.Shikha Agarwal. Wrote the paper- Dr. Shikha Agarwal.

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None.

Conflict of Interest

The authors declare no conflict of interest.

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