RESEARCH ARTICLE

Effect of Pregestational Body Mass Index, Trimester-specific Weight Gain, and Total Gestational Weight Gain on Pregnancy Outcomes: A Retrospective Observational Study

Esther Issac[1], Anuradha M[2], Shanmugapriya C[3], Gowthaman Sankar[4]

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Abstract

Background: Overweight women with higher BMI present with an increased risk of complications in gestation, especially the hypertensive disorders of pregnancy (HDP) and gestational diabetes mellitus (GDM). In addition to the increased risk of antenatal complications, there is an increased risk of cesarean delivery and associated morbidities in pregestational overweight or obese women. For the neonate, there is an increased risk of macrosomia, neonatal hypoglycemia or hyperbilirubinemia, in addition to a higher risk of childhood obesity.

Materials and methods: This retrospective observational study aimed to investigate the effect of pre-gestational and trimester-specific weight gain on maternal and neonatal outcomes among pregnant women. Using the universe sampling method, we collected obstetric and postnatal details from previous records in the Department of Obstetrics and Gynecology at a tertiary care hospital in Tamil Nadu.

Results: The receiver operating characteristics probability curve showed that the model had moderate discrimination capacity for GDM [area under the curve (AUC) = 0.591], gestational hypertension (GHTN) (AUC = 0.531), and pre-labor rupture of membranes (PROM) (AUC = 0.553), but no discriminating ability for large for gestational age (LGA) (AUC = 0.509). Additionally, the model demonstrated moderate discriminating capacity of pre-gestational BMI (AUC = 0.522) and trimester-specific weight gain (AUC for first trimester = 0.533; AUC for second and third trimester = 0.525) in predicting GHTN.

Conclusion: First-trimester weight gain and total gestational weight gain (GWG) are positively associated with GDM. Second-trimester weight gain had a positive association with PROM. Third-trimester weight gain was associated with a higher risk for large for gestation babies.

Keywords: Fetomaternal outcomes, Gestational weight gain, Pregnancy, Trimester-specific weight gain.

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Introduction

Globally, the prevalence of obesity and overweight is rising, impacting more than one-third of the worldwide population. In the past two decades, obesity prevalence has doubled, and more people are obese than underweight in every region except sub-Saharan Africa and Asia.[1] Overweight and obesity are not only a problem in high-income nations, but they are also sharply rising in poor-income nations, specifically in urban areas. Experts have attributed rising obesity rates to factors related to globalization, which are believed to contribute to obesity by introducing low-income country markets with inexpensive but obesogenic foods.[2] The rising prevalence of obesity in sexually active women will significantly affect obstetric and neonatal outcomes. Nearly half of pregnant women gain more weight than the actual endorsed range calculated according to their body mass index (BMI), which can have a significant impact on obstetric and neonatal outcomes.[3,4] According to the guidelines of the Institute of Medicine, women with a normal pre-gestational BMI should gain 0.42 kg per week, while those in the overweight BMI category should gain 0.28 kg per week.[5]

Therefore, maintaining a healthy BMI and lifestyle before pregnancy and monitoring weight gain throughout gestation is essential for improving maternal and fetal outcomes.[5] According to certain studies, starting the pregnancy with average weight and gaining adequate weight throughout the pregnancy yields better results for both the baby and the mother.[6] Pregnant women with a higher BMI are at greater risk of developing complications such as hypertensive syndromes and gestational diabetes mellitus (GDM), as well as an increased risk of cesarean delivery and related complications.[7,8]

The mother's weight can impact the health of the newborn as well. When the mother is overweight, the baby has more chances of developing hypoglycemia, childhood obesity, and hyperbilirubinemia,[9,10] which can be concerning. Similarly, when the mother is underweight, there is a chance of fetal growth defect,

[1–3]Department of Obstetrics and Gynecology, SRM Institute of Science and Technology, Chengalpattu, Tamil Nadu, India

[4]Department of Community Medicine, Sri Muthukumaran Medical College Hospital and Research Institute, Chennai, Tamil Nadu, India

Corresponding Author: Esther Issac, Department of Obstetrics and Gynecology, SRM Institute of Science and Technology, Chengalpattu, Tamil Nadu, India, Phone: +91 9080326829, e-mail: drestherissac@gmail.com

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resulting in low birth weight and small for gestational age (SGA).[11] Even though these risks are well-known, very few studies have been conducted in Indian settings. It is essential to address this issue, and that is why this study has been initiated to evaluate the effect of pregestational BMI, trimester-specific, and total gestational weight gain (TGWG) on pregnancy outcomes. Our study aims to establish the relationship between the above factors and perinatal and maternal outcomes. This will help raise awareness among antenatal women and encourage them to take appropriate measures to ensure a healthy pregnancy.

Materials and Methods

This retrospective observational study was carried out over a year, from December 2022 to November 2023. The necessary data for conducting this study was obtained from previous medical records retrieved from the OBG department (Obstetrics and Gynecology) of the tertiary care hospital located in Chengalpattu district of Tamil Nadu.

Study Inclusion and Exclusion Criteria

The study included singleton pregnant women who had regular antenatal follow-ups from the time of conception and gave birth at 37 weeks of gestation. However, women with multiple pregnancies, chronic hypertension, pre-gestational diabetes, and gestational age at delivery more significant than 40 weeks were excluded from this study.

Sample Size Calculation

To determine the sample size for our study, we conducted a thorough review of previous literature and used the sample size formula for odds ratio. We set the proportion at 83% and the odds ratio at 8.42, with an accuracy limit of 5 and 80% power. The calculated sample size for this study is 144.[12] To collect obstetric and postnatal details from previous records, we used the universe sampling method. We also obtained consent from the patients to access the details through a phone call.

Data Collection Process

Data from previous medical records of pregnant women were gathered for this study. The data were then analyzed to determine the prepregnancy BMI of each patient using their weight and height information (before pregnancy). Deducting the weight at the beginning from the weight gained at the end of each trimester will give the weight gain achieved during each trimester. Based on the patient's BMI before pregnancy, the study employed the guidelines suggested by the Institute of Medicine to evaluate whether the patient had gained excessive weight. This study defines maternal outcomes as those developing GDM, gestational hypertension (GHTN), postpartum hemorrhage (PPH), preeclampsia, and pre-labor rupture of membranes (PROM), and neonatal outcomes as babies born with shoulder dystocia, small or large for gestation, an APGAR score of 7 or less at 5 min duration, and NICU admission.

Data Compilation and Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 20 was used to enter and analyze the data. Both continuous variables (mean ± SD) and categorical variables (frequency and percentages) were subjected to descriptive statistics calculations. The association between predictors and the predicted variables was ascertained using a binary logistic regression model, which took potential

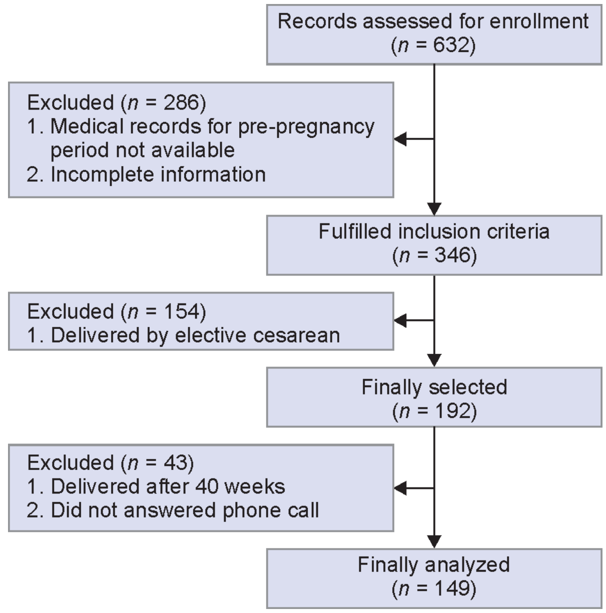

Fig. 1: Flowchart of the included case records

confounders into consideration. The adjusted odds ratio was calculated along with a 95% confidence interval. A statistically significant result was considered when *p*-value was less than 0.05. The area under the curve (AUC) was computed using the receiver operating characteristic curve (ROC) to assess the predictors discriminative power.

Results

This retrospective observational study analyzed 632 medical records of patients who gave birth at a tertiary care hospital in Chengalpattu. After multiple exclusion steps, 149 pregnant women who delivered at 37 weeks gestation were included in the study. The recruitment flowchart of the study participants is depicted in Figure 1. The study included demographic, maternal, and outcome variables, with descriptive data in Tables 1 and 2. The patient's mean (± SD) age was 27.2 years (SD ± 4.3 years), and most were homemakers. Of the participants, 97 (65.1%) were multiparous, and 17 (11.4%) had previously delivered via C-section. Only 3 (2%) reported smoking, and 40 (26.8%) had a history of previous abortions. The mean (±SD) pre-gestational weight and height were 62.9 (±7.7) kg and 155.7 (±8.1) cm, respectively. The mean (±SD) trimester-specific weight gain was as follows: first trimester 2.1 ± 0.7 kg, second trimester 5.3 ± 1.2 kg, third trimester 4.8 ± 1.3 kg, and TGWG of 10.1 ± 1.3 kg. The patient's mean gestational age during delivery was 38.3 ± 0.8 weeks.

Maternal-related complications observed in this study were GDM [22 (14.8%)], PROM [14 (9.4%)], and GHTN [13 (8.7%)]. Regarding neonatal complications, 12 (8.1%) newborns required care NICU admission, and 9 (6%) newborns had an APGAR score calculated to be less than seven at 5 min.

Table 3 exhibits the predictive power of pre-gestational, trimester-specific, and TGWG on adverse perinatal outcomes through binary logistic regression model analysis. Prepregnancy BMI did not show any association with any of the perinatal outcome variables. However, excessive weight during first trimester demonstrated a high risk of developing maternal and neonatal

Table 1: Baseline demographic, maternal characteristics of the study population

Characteristics	*n = 149*
Age in years (mean ± SD)	27.2 ± 4.27
Occupation *n* (%)	
Homemaker	137 (91.9)
Employed	12 (8.1%)
Smoking habits *n* (%)	
Yes	3 (2%)
No	146 (98%)
Parity *n* (%)	
Primi	52 (34.9%)
Multiparous	97 (65.1%)
Previous cesarean *n* (%)	
Yes	17 (11.4%)
No	132 (8.6%)
Previous abortions *n* (%)	
Yes	40 (26.8%)
No	109 (73.2%)
Pre-gestational weight in kg (mean ± SD)	62.9 ± 7.7
Pre-gestational height in cm (mean ± SD)	155.7 ± 8.1
Pre-gestational BMI in kg/m^2 (mean ± SD)	25.8 ± 3.2
Trimester-specific weight gain in kg (mean ± SD)	
1st trimester	2.1 ± 0.7
2nd trimester	5.3 ± 1.2
3rd trimester	4.8 ± 1.3
Total gestational weight gain in kg (mean ± SD)	10.1 ± 1.3
Gestational age at birth in weeks (mean ± SD)	38.3 ± 0.8
Newborn weight (mean ± SD)	3.0 ± 0.4
Newborn gender *n* (%)	
Male	72 (48.3%)
Female	77 (51.7%)

Table 2: Frequency distribution of the variable of interest

Outcome variables	*n (%)*
Cesarean	59 (39.6%)
Instrumental delivery	20 (13.4%)
Gestational diabetes mellitus *n* (%)	22 (14.8%)
Gestational hypertension *n* (%)	13 (8.7%)
Preeclampsia *n* (%)	6 (4%)
PPH *n* (%)	4 (2.7%)
PROM *n* (%)	14 (9.4%)
Shoulder dystocia *n* (%)	2 (1.3%)
SGA *n* (%)	12 (8.1%)
LGA *n* (%)	8 (5.4%)
APGAR score at 5 min (<7) *n* (%)	9 (6%)
NICU admission *n* (%)	12 (8.1%)

LGA, large for gestational age; PPH, postpartum hemorrhage; PROM, pre-labor rupture of membranes; SGA, small for gestational age

outcomes like GDM [aOR = 2.98; *p*-value = 0.02*], GHTN [aOR = 5.69; *p*-value < 0.05*], and PPH [aOR = 14.04; *p*-value <0.05*], and a low risk for SGA [aOR = 0.30; p-value < 0.05*] and large for gestational age (LGA) [aOR = 0.33; *p*-value < 0.05*], and this association was statistically significant. Conversely, the second trimester-specific weight gain indicated a lower risk for outcome variables such as GDM [aOR = 0.10; *p*-value < 0.05*] and GHTN [aOR = 0.07; *p*-value <0.05*] but revealed high for PROM [aOR = 1.99; *p*-value <0.05*], SGA [aOR = 3.65; *p*-value < 0.05*], and less APGAR score [aOR = 2.08; *p*-value < 0.05*]. The third-trimester-specific weight gain showed a low risk of preeclampsia [aOR = 0.37; *p*-value < 0.05*], PPH [aOR = 0.32; *p*-value < 0.05*], and shoulder dystocia [aOR = 0.28; *p*-value = 0.05*], but a high risk for LGA [aOR = 2.06; *p*-value < 0.05*] and admission in the NICU [aOR = 2.29; *p*-value < 0.05*]. Lastly, the total weight gain throughout the pregnancy [aOR = 3.16; *p*-value = 0.04*] had a high risk of developing GDM, and this association was found to be statistically significant.

The model used the receiver operating characteristics curve (ROC) to determine the predictive power of risk factors for perinatal outcomes. The results showed that the model had moderate discrimination capacity for GDM (AUC = 0.591), GHTN (AUC = 0.531), and PROM (AUC = 0.553) but no discriminating ability for LGA (AUC = 0.509). Additionally, the model demonstrated moderate discriminating capacity of pre-gestational BMI (AUC = 0.522) and trimester-specific weight gain (AUC for first trimester = 0.533; AUC for 2nd and third trimester = 0.525) in predicting GHTN. Table 4 displays the AUC values for predicting outcome variables related to pre-gestational, trimester-specific, and TGWG. Furthermore, (Figs 2 to 5) exhibit the ROC curve for predicting GDM, GHTN, PROM, and APGAR scores.

Discussion

Excessive weight during pregnancy can be easily identified and modified to prevent potential risks to both the mother and baby. Having a healthy weight during pregnancy and maintaining an adequate BMI before pregnancy is crucial. According to this study, the overall mean (±SD) pre-gestational weight and height were 62.9 (±7.7) kg and 155.7 (±8.1) cm, respectively. The mean weight gain for each trimester was: 2.1 (±0.7) kg during the first trimester, 5.3 (±1.2) kg during the second trimester, and 4.8 (±1.3) kg during the third trimester, resulting in a TGWG of 10.1 (±1.3 kg). Sekiya et al., also demonstrated that the mean (±SD) weight during first trimester was 2.3 (±2.1) kg, second trimester was 7.0 (±2.0) kg, and third trimester was 6.3 (±2.4) kg.[13] In this study, the patient's mean gestational age was 38.3 (±0.8) weeks. Maternal complications observed in this study were GDM [22 (14.8%)], PROM [14 (9.4%)], and GHTN [13 (8.7%)]. As for neonatal complications, 12 (8.1%) newborns required care in the NICU, and 9 (6%) newborns had an APGAR of seven or less at 5 min duration.

Gestational Diabetes Mellitus

According to this study, GDM is positively associated with first-trimester weight gain and TGWG, and this association was found to be statistically significant. However, 2nd-trimester weight gain has a negative association with GDM. Studies have also indicated that women who experience excessive GWG were at more risk of GDM.[13,14]

Gestational Hypertension and Preeclampsia

Total gestational weight gain, first-trimester weight gain, and pre-gestational BMI are all strongly associated with preeclampsia and GHTN. However, only 1st-trimester weight gain showed a statistically significant association with GHTN. Gonzalez et al., in

Table 3: Binary logistic regression model of predictive ability of pre-gestational body mass index, trimester-specific weight gain, and total weight gain for outcome variables

Outcome of interest	*Pregestational BMI*	*First trimester weight gain*	*Second-trimester weight gain*	*Third-trimester weight gain*	*Total gestational weight gain*
GDM					
aOR (95% CI)	0.58 (0.27–1.20)	2.98 (1.14–7.78)	0.10 (0.01–0.61)	2.12 (0.91–4.93)	3.16 (1.01–9.86)
p-value	0.41	0.02*	0.01*	0.07	0.04*
GHTN					
aOR (95% CI)	1.98 (0.90–4.35)	5.69 (1.81–17.85)	0.07 (0.01–0.62)	0.88 (0.39–2.00)	1.39 (0.45–4.33)
p-value	0.08	<0.01*	0.01*	0.76	0.56
Preeclampsia					
aOR (95% CI)	1.43 (0.57–3.58)	2.71 (0.78–10.01)	0.12 (0.01–1.06)	0.37 (0.14–0.98)	1.43 (0.57–3.58)
p-value	0.43	0.13	0.06	<0.05*	0.43
PPH					
aOR (95% CI)	1.28 (0.54–3.08)	14.04 (1.81–68.76)	0.20 (0.03–1.10)	0.31 (0.12–0.76)	2.06 (0.06–7.03)
p-value	0.56	0.01*	0.06	0.01*	0.24
PROM					
aOR (95% CI)	0.78 (0.52–1.19)	0.31 (0.09–1.02)	1.99 (1.02–3.86)	0.68 (0.25–1.84)	1.15 (0.43–3.05)
p-value	0.25	0.05	0.04*	0.44	0.77
Shoulder dystocia					
aOR (95% CI)	1.22 (0.41–3.61)	5.17 (0.64–41.67)	0.32 (0.35–3.03)	0.27 (0.08–0.86)	0.84 (0.21–6.87)
p-value	0.70	0.12	0.32	0.02*	0.84
SGA					
aOR (95% CI)	1.09 (0.71–1.66)	0.30 (0.11–0.86)	3.65 (1.72–7.74)	0.83 (0.38–1.81)	0.99 (0.45–2.16)
p-value	0.68	0.02*	0.01*	0.65	0.98
LGA					
aOR (95% CI)	1.13 (0.77–166)	0.33 (0.13–0.80)	1.41 (0.75–2.65)	2.06 (1.06–4.00)	0.56 (0.30–1.04)
p-value	0.50	0.01*	0.27	0.03*	0.06
Cesarean					
aOR (95% CI)	1.13 (0.87–1.47)	1.00 (0.60–1.65)	1.01 (0.67–1.50)	0.95 (0.62–1.46)	1.15 (0.77–1.75)
p-value	0.34	0.99	0.98	0.82	0.48
Instrumental delivery					
aOR (95% CI)	1.07 (0.73–1.57)	1.73 (0.76–3.91)	0.78 (0.42–1.44)	0.73 (0.37–1.42)	1.01 (0.54–1.89)
p-value	0.71	0.19	0.43	0.35	0.97
APGAR at 5 minutes (<7)					
aOR (95% CI)	0.98 (0.72–1.33)	0.35 (0.17–0.73)	2.08 (1.24–3.48)	1.32 (0.77–2.26)	0.73 (0.43–1.23)
p-value	0.91	0.01*	<0.01*	0.31	0.24
NICU admission					
aOR (95% CI)	0.90 (0.64–1.25)	0.57 (0.28–1.13)	0.77 (0.45–1.33)	2.29 (1.26–4.16)	0.62 (0.37–1.06)
p-value	0.53	0.10	0.36	<0.01*	0.08

**p*-value of <0.05 is considered statistically significant

Table 4: This table displays a predictive model evaluating the discriminating capacity of pre-gestational body mass index, trimester-specific weight gain, and total weight gain for outcome variables by AUC

Outcome variables	*Pregestational BMI (AUC)*	*First trimester (AUC)*	*Second trimester (AUC)*	*Third trimester (AUC)*	*Total gestational weight gain (AUC)*
Gestational diabetes mellitus	0.452	0.449	0.428	0.457	0.591
Gestational hypertension	0.522	0.533	0.525	0.525	0.531
Preeclampsia	0.484	0.501	0.493	0.488	0.462
PPH	0.514	0.526	0.528	0.510	0.427
PROM	0.526	0.536	0.518	0.535	0.553
Shoulder dystocia	0.475	0.485	0.484	0.459	0.377
SGA	0.543	0.543	0.508	0.533	0.497
LGA	0.444	0.463	0.450	0.441	0.509
APGAR score at 5 minutes (<7)	0.555	0.562	0.538	0.549	0.475
NICU admission	0.538	0.551	0.552	0.534	0.466

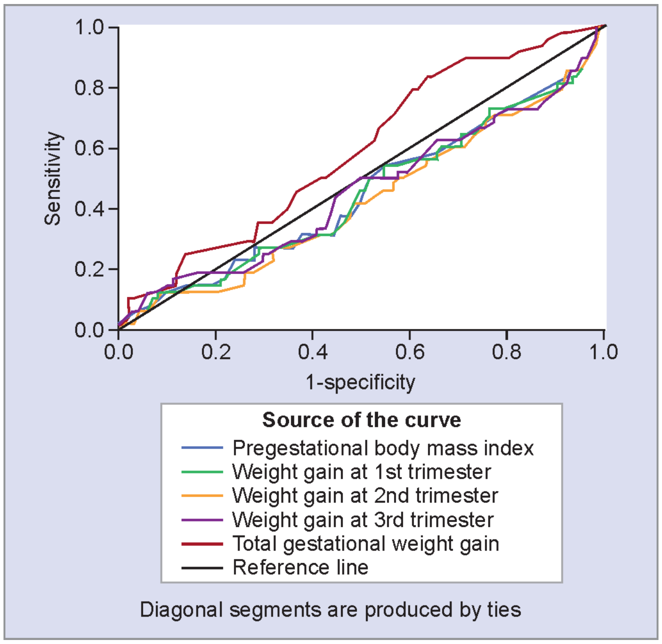

Fig. 2: Receiver operating characteristic curve for predicting GDM using pregestational BMI, trimester-specific weight gain and total weight gain

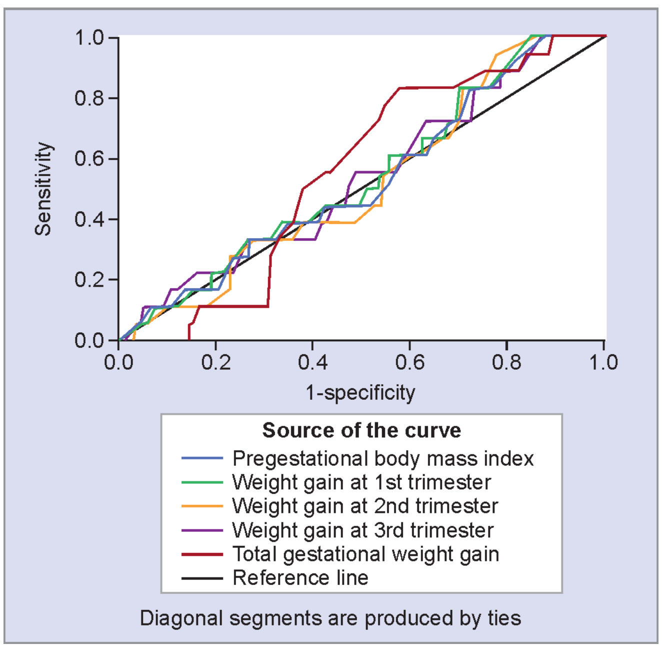

Fig. 3: Receiver operating characteristic curve for predicting HDP using pregestational BMI, trimester-specific weight gain and total weight gain

their research, demonstrated a substantial correlation between the onset of preeclampsia and a high prepregnancy BMI.[15] According to Scott-Pillai et al., obese women had ORs ranging between 1.19 (95% CI: 1.1–2.3) and 6.6 (95% CI: 4.9–8.9) for GHTN.[16] Gaillard et al. found a correlation between excessive weight in all trimesters and HDP, with the highest risk exists during the third trimester.[4] This highlights the consequence of gaining excessive weight in pregnancy.

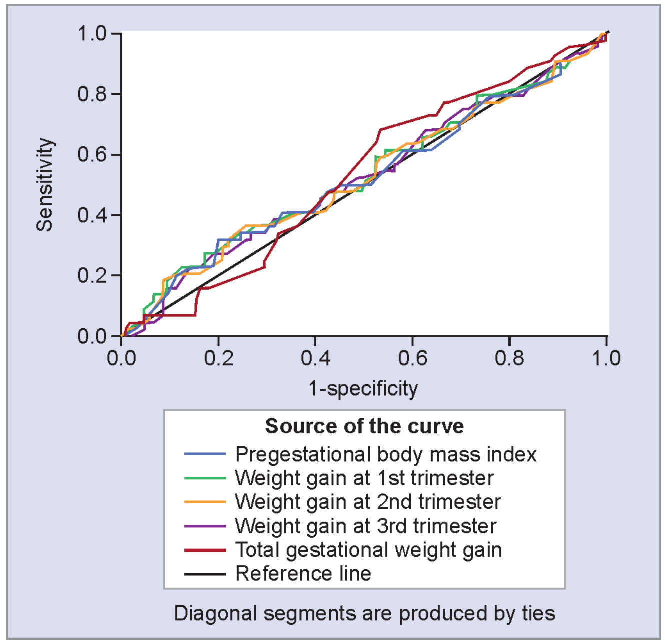

Fig. 4: Receiver operating characteristic curve for predicting PROM using pregestational BMI, trimester-specific weight gain and total weight gain

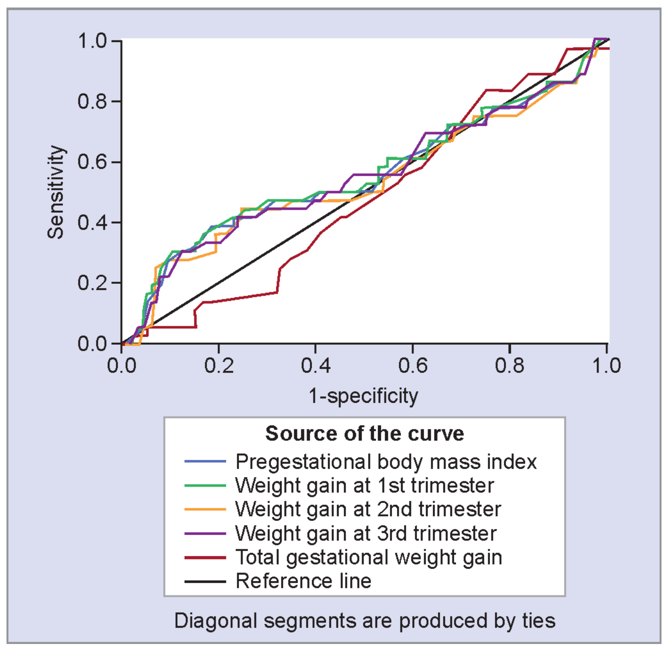

Fig. 5: Receiver operating characteristic curve for predicting APGAR score using pregestational BMI, trimester-specific weight gain and total weight gain

Neonatal Birth Weight

According to this study, gaining excessive weight during first and third trimesters have less risk for SGA babies. However, only the excessive gaining of weight during the first trimester showed a significant association with SGA. On the other hand, higher risks for LGA babies were found in patients with high prepregnancy BMI and those who gained weight in the second and third trimesters. However, only the association between excessive gaining of weight during third trimester and LGA was statistically significant. Based on their study, Young et al. concluded gaining excessive weight at the first 20 weeks of pregnancy has the most significant effect on fetal development, leading to SGA.[17] Similarly, Sekiya et al. found a strong link between second-trimester maternal weight and birth weight.[13]

In this study, it was observed that prepregnancy BMI demonstrated no correlation with any of the perinatal outcome variables. However, weight gain during specific trimesters had a significant impact on the development of maternal and neonatal outcomes. During the gaining of excessive weight during the first trimester, there is a high risk of developing GDM, GHTN, and PPH. It had a low risk for SGA and LGA. Conversely, the second trimester-specific weight gain indicated a lower risk for outcome variables such as GDM and GHTN but a higher risk for PROM and a lower APGAR score. The third-trimester-specific weight gain showed a low risk of preeclampsia, PPH, and shoulder dystocia but had a significant risk for LGA and NICU stay. Finally, the TGWG demonstrated the elevated risk for GDM, and the association came out statistically significant.

Conclusion

The study found that pregestational, trimester-specific, and overall TGWG all impact pregnancy outcomes, resulting in HDP, GDM, LGA, and SGA. Specifically, 1st-trimester and TGWG are linked to gestational diabetes, 2nd-trimester weight gain is associated with PROM, and 3rd-trimester excessive weight has consequences for LGA babies. Therefore, it's essential for women to receive high-quality preconception care, manage their excessive weight gain, and avoid complications during pregnancy.

Ethical Approval

The study was conducted in accordance with the guidelines of the Declaration of Helsinki. The institutional ethics committee granted ethical clearance for conducting the study [SRMIEC-ST0224-938] on 03/04/2024.

Orcid

Esther Issac https://orcid.org/0009-0008-4924-7852
Anuradha M https://orcid.org/0000-0003-3569-9854
Shanmugapriya C https://orcid.org/0000-0001-5021-1920
Gowthaman Sankar https://orcid.org/0000-0002-1754-4843

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