Original Article

Weight gain in pregnancy and impact of obesity on the obstetric outcome: A retrospective study in a secondary care hospital in South India

Sandhana Inian, Sharon R. Nadar, Sam Marconi, Ashwin Sukumar, Anne G. Cherian

Department of Community Medicine, Christian Medical College, Vellore, Tamil Nadu, India

Abstract

Objective: To evaluate the patterns of weight gain in pregnancy and the outcomes of pregnancy in overweight and obese mothers. **Materials and Methods:** A retrospective cohort study was performed on 1,352 mothers between October 2020 and August 2021. All pregnant women who presented for antenatal checkups from 20 weeks or earlier, with a singleton pregnancy, were included in the study. Details such as comorbidities, total duration of labor, complications during labor, and neonatal complications were included. **Results:** At the first antenatal visit, 16% of mothers were underweight, 51% of mothers were normal weight, and 33% of mothers were overweight or obese. Women with poor weight gain were two times more prone to give birth to a child with low birth weight than those with adequate weight gain. Excess weight gain in pregnancy in women with a normal body mass index (BMI) had an association with the development of pre-eclampsia. The odds of overweight/obese pregnant women developing gestational diabetes mellitus (GDM) were 2.1 times higher than in pregnant women with normal BMI. The odds of pregnant overweight/obese women undergoing cesarean section were 1.6 times higher than in pregnant women with normal BMI. **Conclusion:** Overweight/obese pregnant women had increased odds of developing GDM and undergoing a cesarean section. Excess weight gain was also seen in overweight/obese women. It is therefore important for physicians to educate women on acceptable weight gain during their pregnancy.

Keywords: Obstetric outcome, pregnancy, weight gain

Introduction

Appropriate weight gain during pregnancy is essential for fetal development and to prevent adverse outcomes during labor and delivery. It is considered essential for women to adhere to weight gain goals, which are explained in initial antenatal visits. The weight gained during pregnancy is categorized taking into account the body mass index (BMI) of the patient. BMI is ideally measured in the first antenatal visit, and the required weight gain is determined.[1] As per the World Health Organization (WHO) guidelines, a normal BMI ranges between 18.5 and 24.9 kg/m^2, with a BMI between 25 and 29.9 kg/m^2 being classified as overweight, and a BMI of more than or equal to 30 kg/m^2 being classified as obese.[2] Pregnant women on both ends of the spectrum are subject to various morbidities if weight gain is inadequate or in excess.[2]

The weight gain recommended during pregnancy described in the 2009 Institute of Medicine (IOM) guidelines were 12.5–18 kg if underweight, 11.5–16 kg if normal weight, 7–11.5 kg if overweight, and 5–9 kg if obese.[3]

Address for correspondence: Dr. Anne G. Cherian, Department of Community Medicine, Christian Medical College, Vellore - 632 002, Tamil Nadu, India.
E-mail: annegc97@yahoo.co.in

Received: 03-03-2024 **Revised:** 03-04-2024
Accepted: 19-04-2024 **Published:** 18-10-2024

Access this article online

Quick Response Code:

Website: http://journals.lww.com/JFMPC

DOI: 10.4103/jfmpc.jfmpc_350_24

How to cite this article: Inian S, Nadar SR, Marconi S, Sukumar A, Cherian AG. Weight gain in pregnancy and impact of obesity on the obstetric outcome: A retrospective study in a secondary care hospital in South India. J Family Med Prim Care 2024;13:4293-8.

Antenatally, mothers with low BMI are prone to develop anemia.[2] The outcomes of pregnancy in mothers with low BMI include preterm labor, intrauterine growth restriction (IUGR), and low birth weight (LBW).[1,3] There is also an increased risk of perineal tears and complex episiotomy.[3]

Mothers with high BMI are likely to develop morbid obesity, which is a recognized risk factor in pregnancy.[4] Pregnancy is considered a high cholesterol state, which is further accentuated in pregnant women with high BMI.[5] The outcomes in these women include failure of induction, hypertension, pre-eclampsia, gestational diabetes mellitus (GDM), thrombophlebitis, the prolonged second stage of labor, and shoulder dystocia.[1,4] Among obese pregnant women who undergo lower segment cesarean section (LSCS), excessive blood loss, prolonged operative time, and postoperative wound infections are common.[4] The fetus is more likely to develop fetal macrosomia, birth defects, and low APGAR scores.[2] There is also an association with cerebral palsy in these newborns.[6]

This study aims to describe the patterns of pregnancy-related weight gain among women visiting a secondary care hospital in Tamil Nadu and to study the effect of being overweight/obese at the time of registration and the outcomes of pregnancy due to weight gain in these women.

Materials and Methods

The study took place in the secondary level teaching hospital. The hospital caters mainly to the area of Kaniyambadi, which constitutes a population of around 116,454 (2020) in 80 villages, which is predominantly rural, in Tamil Nadu, South India. In these areas, the primary and secondary healthcare services have been taken care of by the Community Health and Development (CHAD) program.

The study population was retrospectively analyzed. It included all postnatal women with singleton pregnancy, who had their first antenatal checkup at 20 weeks of gestation or earlier. Mothers who had multiple pregnancies were excluded from this study. The study was conducted between October 2020 and August 2021. Approval was obtained from the Institutional Review Board of the Christian Medical College and Hospital, Vellore (IRB Min No. 13300).

After delivery, charts of all postnatal women were reviewed and women fitting the inclusion criteria were chosen for the study. Weight documented at each antenatal visit was noted. The endpoint of weight gain was the weight noted at the time of admission for delivery. Comorbidities including anemia, GDM, gestational hypertension, and pre-eclampsia were recorded. The total duration of labor (including the first and second stage of labor, where applicable), mode of delivery, postpartum complications such as postpartum hemorrhage (PPH) and wound infection, birth weight of the baby, requirement of nursery admission, and complications in the neonate were noted.

The 2009 IOM guidelines were followed to classify the women as having normal, inadequate, or excessive weight gain.[3]

The sample size was calculated as 1,352 to identify 338 pregnant women with high BMI. A difference of 3% in the proportion of LBW babies among overweight/obese pregnant women at registration of pregnancy compared with pregnant women with normal BMI was estimated. The prevalence of overweight/obese pregnant mothers at the time of registration was taken as 25%.

Statistical analysis

The analysis was conducted using the STATA 16 version. Continuous variables including birth weight, gestational age (GA), and BMI were expressed in terms of mean and standard deviation (SD). Numbers and percentages were used to express the categorical variables. To examine the association between two categorical variables, the Chi-square square test was used. After controlling for potential confounders such as the mother's age, her gestational age at delivery, and her parity, an adjusted odds ratio (AOR) with a 95% confidence interval was generated using the multiple logistic regression method. Statistical significance was noted if the *P* value was less than 0.05.

Results

General characteristics

Study participants' characteristics are tabulated in Table 1. Of the 1,352 pregnant women, most of them were between 21 and 30 years old, nulliparous (56%), and educated up to graduate level (35%). During the pregnancy, 5.7% of the women had hypothyroidism, 21.3% of the women developed GDM, and 1.2% of them developed pre-eclampsia. Among the participants at the time of registration, 51% were normal weight, 33% were either overweight or obese, and 16% were underweight. Table 2 shows the outcome of pregnancy of the women with high BMI (overweight/obese) at the time of registration, and its effects.

Effects of being overweight

In overweight/obese pregnant women, the odds of developing GDM during pregnancy were 2.1 times higher than in normal BMI women (OR: 2.12, 95% CI: 1.58–2.84). Similarly, the odds of overweight/obese women undergoing LSCS at the end of pregnancy were 1.6 times higher (OR: 1.6, 95% CI: 1.19–2.15) than in normal BMI women. However, overweight/obese women were 34% less likely to have PROM than women with normal BMI (OR: 0.66, 95% CI: 0.49–0.88) and it was statistically significant. Other factors among overweight/obese women were not significantly different than normal BMI women. With respect to weight gain, there was evidence stating overweight/obese women were 47% more likely to have excess weight gain (*P* value < 0.001) compared to their counterparts with normal BMI.

Table 1: Baseline characteristics of study participants based on BMI at the time of first visit

Variable	Overall (*n*=1352)	Normal (*n*=691)	Underweight (*n*=221)	Overweight/obese (*n*=440)
Age in Years	***n* (C%)**	***n* (R%)**	***n* (R%)**	***n* (R%)**
±20	211 (15.6)	112 (53.1)	61 (28.9)	38 (18.0)
21–30	1,010 (74.7)	521 (51.6)	152 (15.1)	337 (33.4)
31–40	131 (9.7)	58 (44.3)	8 (6.1)	65 (49.6)
Parity	***n* (C%)**	***n* (R%)**	***n* (R%)**	***n* (R%)**
Nulliparous	753 (55.7)	395 (52.5)	153 (20.3)	205 (27.2)
1	488 (36.1)	241 (49.4)	55 (11.3)	192 (39.3)
2	98 (7.3)	49 (50)	10 (10.2)	39 (39.8)
3	13 (1.9)	6 (46.2)	3 (23.1)	4 (30.8)
Mothers' Education	***n* (C%)**	***n* (C%)**	***n* (C%)**	***n* (C%)**
Professional	158 (11.7)	77 (15.2)	60 (9.5)	21 (9.5)
Graduate	472 (34.9)	178 (35.9)	203 (32.0)	91 (40.1)
Diploma	93 (6.9)	32 (6.4)	41 (6.4)	20 (9.0)
High School	335 (24.8)	117 (23.6)	167 (26.3)	51 (23.0)
Middle School	254 (18.7)	81 (16.3)	137 (21.6)	35 (15.8)
Primary School	22 (1.6)	8 (1.6)	11 (1.7)	3 (1.3)
Illiterate	19 (1.4)	3 (0.6)	15 (2.4)	1 (0.4)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
BMI at booking (kg/m^2)	23.3 (4.7)	21.8 (1.8)	17.1 (1.1)	28.7 (3.0)
BMI at delivery (kg/m^2)	27.5 (4.5)	26.3 (2.5)	22.1 (2.1)	32.2 (3.2)
Gestational Age at the time Delivery (weeks)	39.0 (1.3)	39.0 (1.2)	39.0 (1.2)	38.7 (1.4)
Weight at first visit (kg)	55.8 (11.7)	52.5 (6.3)	41.2 (3.6)	68.4 (8.3)
Weight at the time of delivery (kg)	66.0 (11.5)	63.3 (7.8)	53.1 (6.1)	76.9 (9.0)
Weight Gain (kg)	10.2 (4.7)	10.1 (4.4)	11.3 (4.2)	8.0 (4.2)
Duration of labor (h)	9.0 (6.2)	9.1 (6.2)	9.0 (6.3)	8.8 (6.2)
Birth weight of the baby (kg)	2.9 (0.4)	2.9 (0.4)	2.8 (0.4)	3.0 (0.4)

C%: Column percentage. R%: Row percentage

Table 2: Effect of obese/overweight on pregnancy-related factors

Variable	Normal (Ref) *n*=691 *n* (%)	Overweight *n*=440		*P*
		n (%)	AOR (95% CI)	
GDM	118 (17.1)	146 (33.2)	2.12 (1.58–2.84)	<0.001
LSCS	122 (17.7)	125 (28.4)	1.6 (1.19–2.15)	0.002
PPH	13 (1.9)	11 (2.5)	1.50 (0.65–3.40)	0.344
Preterm[a]	26 (3.8)	23 (5.2)	1.42 (0.80–2.54)	0.235
Pre-eclampsia	9 (1.3)	5 (1.1)	0.84 (0.29–2.64)	0.767
LBW	94 (13.6)	55 (12.5)	0.79 (0.53–1.17)	0.234
Macrosomia	4 (0.6)	5 (1.1)	2.05 (0.53–7.87)	0.296
Shoulder dystocia	1 (0.1)	2 (0.5)	2.33 (0.20–27.10)	0.500
PPROM	12 (1.7)	10 (2.3)	0.87 (0.33–2.28)	0.621
PROM	179 (25.9)	84 (19.1)	0.66 (0.49–0.88)	0.006
Hypothyroidism	29 (4.2)	33 (7.5)	1.61 (0.95–2.73)	0.076
Induced labor	301 (43.6)	181 (41.1)	1.12 (0.86–1.45)	0.412
Inadequate weight gain	374 (54.1)	129 (29.3)	0.47 (0.38–0.58)	<0.001
Overweight gain	79 (11.4)	126 (28.6)	1.47 (1.18–1.83)	<0.001

Adjusted OR: (Adjusted for AGE, GA at delivery, Parity), [a]Preterm is only adjusted for Age and Parity

Weight gain

Overall, the average weight gain during pregnancy was 10.2 (4.7) kg. Among women with normal BMI and underweight BMI at the time of registration, the average weight gain was 10.1 (4.4) kg and 11.3 (4.2) kg, respectively. However, among the women with overweight/obese BMI, the average weight gain was 8.0 (4.2) kg. With respect to the adequacy of the weight gain, at the end of pregnancy, 36.7% (496/1352) of them had adequate weight gain, 46.9% (634/1352) of them had inadequate weight gain, and 16% (222/1352) of them had excess weight gain.

Adequate weight gain

Of the women with normal BMI and underweight BMI, adequate weight gain was seen in 34.4% (238/691) and 33% (73/221), respectively. At the end of pregnancy, among overweight/obese women, 42% (185/440) had adequate weight gain.

Inadequate weight gain

At the end of pregnancy, only 29% (129/440) of the women with overweight/obese BMI had inadequate weight gain. Among the women with normal and underweight BMI, 54.1% (374/691) and 59.3% (131/221) of them had inadequate weight gain.

Excess weight gain

Nearly one-third of the women (126/440) who belong to the overweight/obese category had excess weight gain at the end of pregnancy. Only 11.4% of women belong to normal BMI, and 7.7% of the women who belong to underweight BMI had excess weight gain.

Effects of weight gain

Effects of inadequate weight gain

Tables 3a and b show the effects of inadequate and excess weight gain on pregnancy-related factors among women with normal as well as overweight/obese BMI at the first visit. A statistically significant association was seen with inadequate weight gain and GDM. Among the normal BMI women and inadequate weight gain, the odds of developing GDM were 1.6 times higher than women with normal BMI and adequate weight gain. (OR: 1.6, 95% CI: 1.0–2.5). Similarly, the odds of developing GDM were 2.18 times higher among obese/overweight women with inadequate weight gain than with adequate weight gain.

Women with poor weight gain were two times more prone to give birth to a baby with LBW than those with adequate weight gain. This finding was consistent in both groups of women i.e., normal BMI and overweight/obese, at the time of registration.

Effects of excess weight gain

Excess weight gain did not have any significant association with pregnancy-related factors in normal BMI women and overweight/obese women, except for the development of pre-eclampsia in women with normal BMI (*P* value = 0.04).

Discussion

In this retrospective study, the pattern of weight gain was studied and the effect of maternal overweight/obese BMI and excess weight gain on pregnancy-related outcomes was determined.

Table 3a: Effect of inadequate and overweight gain on pregnancy-related factors among women with normal BMI at the first visit

Variable	Adequate wt gain (Ref) *n*=238 *n* (%)	Inadequate Wt gain *n*=374		*P*	Over wt gain *n*=79		*P*
		n (%)	AOR (95% CI)		*n* (%)	AOR (95% CI)	
GDM	32 (13.5)	81 (21.7)	1.6 (1.0–2.5)	0.061	5 (6.3)	0.6 (0.2–1.6)	0.278
Pre-eclampsia	1 (0.4)	5 (1.3)	3.2 (0.4–28.7)	0.297	3 (3.8)	11.8 (1.1–124.7)	0.040
Hypothyroidism	13 (5.5)	14 (3.7)	0.6 (0.3–1.3)	0.160	2 (2.5)	0.6 (0.1–2.8)	0.506
PPROM	2 (0.8)	10 (2.7)	2.6 (0.5–12.5)	0.246	0	1	
PROM	54 (22.7)	105 (28.1)	1.3 (0.9–1.9)	0.203	20 (25.3)	1.2 (0.7–2.2)	0.498
Preterm[a]	8 (3.4)	17 (4.6)	1.4 (0.6–3.4)	0.406	1 (1.3)	0.3 (0.04–2.9)	0.324
Induced labor	118 (49.6)	143 (38.2)	0.8 (0.5–1.1)	0.133	40 (50.6)	0.8 (0.4–1.3)	0.331
LSCS	40 (16.8)	70 (18.7)	1.0 (0.6–1.5)	0.944	12 (15.2)	1.1 (0.6–2.3)	0.728
LBW	23 (9.7)	67 (17.9)	2.2 (1.3–3.9)	0.005	4 (5.1)	0.6 (0.2–2.0)	0.438
Macrosomia	1 (0.4)	1 (0.3)	0.5 (0.03–8.7)	0.658	2 (2.5)	9.1 (0.7–113.8)	0.088
Shoulder dystocia	1 (0.4)	0	NA		0	NA	
PPH	3 (1.3)	7 (1.9)	1.6 (0.4–6.5)	0.489	3 (3.8)	2.7 (0.5–14.3)	0.231

Adjusted OR: (Adjusted for AGE, GA at delivery, Parity), [a]Preterm is only adjusted for Age and Parity

Table 3b: Effect of inadequate and overweight gain on pregnancy-related factors among overweight/obese women at the first visit

Variable	Adequate wt gain (Ref) *n*=185 *n* (%)	Inadequate Wt gain *n*=129		*P*	Over wt gain *n*=126		*P*
		n (%)	AOR (95% CI)		*n* (%)	AOR (95% CI)	
GDM	56 (30.3)	62 (48.1)	2.18 (1.34–3.56)	0.002	28 (22.2)	0.74 (0.43–1.27)	0.278
Pre-eclampsia	1 (0.5)	2 (1.6)	2.76 (0.23–32.68)	0.420	2 (1.6)	3.11 (0.27–35.29)	0.361
Hypothyroidism	16 (8.7)	8 (6.2)	0.73 (0.29–1.80)	0.490	9 (7.1)	0.90 (0.38–2.17)	0.821
PPROM	3 (1.6)	4 (3.1)	0.70 (0.10–4.75)	0.714	3 (2.4)	1.82 (0.34–9.76)	0.484
PROM	32 (17.3)	25 (19.4)	1.18 (0.66–2.12)	0.582	27 (21.4)	1.26 (0.71–2.25)	0.428
Preterm[a]	10 (5.4)	8 (6.2)	1.24 (0.47–3.29)	0.663	5 (4.0)	0.77 (0.25–2.37)	0.654
Induced labor	75 (40.5)	48 (37.2)	1.10 (0.67–1.80)	0.709	58 (46.0)	1.02 (0.63–1.67)	0.927
LSCS	57 (30.8)	38 (29.5)	0.77 (0.48–1.39)	0.451	30 (23.8)	0.81 (0.48–1.39)	0.451
LBW	20 (10.8)	28 (21.7)	2.62 (1.28–5.35)	0.008	7 (5.6)	0.53 (0.21–1.38)	0.194
Macrosomia	3 (1.6)	1 (0.8)	0.38 (0.03–4.63)	0.447	1 (0.8)	0.44 (0.04–4.54)	0.489
Shoulder dystocia	0	0	NA		2 (1.6)	NA	
PPH	4 (2.2)	1 (0.8)	0.44 (0.05–4.03)	0.465	6 (4.8)	2.16 (0.56–8.28)	0.262

Adjusted OR: (Adjusted for AGE, GA at delivery, Parity), [a]Preterm is only adjusted for Age and Parity

It was found that overweight/obese women at the time of registration were at higher risk of developing GDM during pregnancy and undergoing LSCS at the end of pregnancy. Overweight/obese women were at risk of either inadequate or excess weight gain during the pregnancy. Excess weight gain did not show any significant effect on pregnancy-related outcomes. However, in women with inadequate weight gain, there was an increased risk of delivering an LBW baby and developing GDM during pregnancy.

GDM is due to inadequate insulin secretion and resistance.[7] Pregnant women with higher BMI are at a higher risk of developing GDM than women with normal BMI. We also found that overweight pregnant women had twofold increased odds of developing GDM. A similar finding was reported in many studies. For instance, a meta-analysis done by Chu *et al*., concluded that excess maternal weight is linked with a high risk of developing GDM.[8]

Although the reasons were unclear, studies have concluded that obesity increases the risk of LSCS. In this study, we found that the chance of overweight/obese pregnant women undergoing LSCS was 60% higher than pregnant women with normal BMI. This corresponded with the meta-analysis done by Chu *et al*.[8] They concluded that the odds of pregnant women undergoing LSCS increase as the BMI of the mother increases. The average primary LSCS rate in the hospital where the study was conducted is between 10% and 15%.

The odds of a few outcomes such as PPH,[9-11] fetal macrosomia,[9,12] and shoulder dystocia[11,13] were anticipated to be higher among pregnant women who are overweight/obese than in women with normal BMI in this study. In contrast, the association between the overweight/obese and anticipated outcome was not significant. The probable reason could be the effective management of GDM antenatally, and effective management and active intervention in the second and third stages of labor, which reduced the number of bad outcomes. Though our hospital provides secondary healthcare, the antenatal care and delivery services were provided by community health physicians and medical interns under the supervision of qualified obstetricians.

The average weight gain during pregnancy was 10.1 kg, 11.3 kg, and 8 kg in women with normal, underweight, and overweight/obese BMI, respectively. However, except for the overweight/obese pregnant women, other groups did not reach the minimum expected weight gain as per IOM 2009 guidelines.[14] Based on the Sankey diagram [Figure 1], women who were overweight/obese gained more weight than normal and underweight pregnant women. An almost similar finding was observed in the Chennai, Tamil Nadu study, where obese women gained more weight than their counterparts.[15] Inadequate weight gain during pregnancy is considered a risk factor for LBW.[16] In this study, inadequate weight gain among pregnant women who had normal BMI at the time of registration increased the odds of having LBW by twofold than pregnant women who had adequate weight gain.

The important strength of this study was that all pregnant women who consented to be part of the study received antenatal care in the same hospital where they had delivered. Pregnant women had a minimum of four visits and a maximum of 10 visits, depending on the pregnancy complication. Though data regarding the outcomes was obtained from the hospital records, no missing data was noted. The probable reason could be that entries were entered and checked by different health workers. However, regarding the exposure variables, to minimize the measurement error, the data quality was checked for wrong entries and outliers in a random sample by another individual who was not part of the data collection team. Reverse causality needs to be considered and checked before accepting the study findings. For example, in this study, we found an association between overweight/obese and hypothyroidism: overweight/obese increased the chance of hypothyroidism by 60%. However, hypothyroidism is associated with overweight and obesity due to decreased basal metabolic rate (BMR).[17]

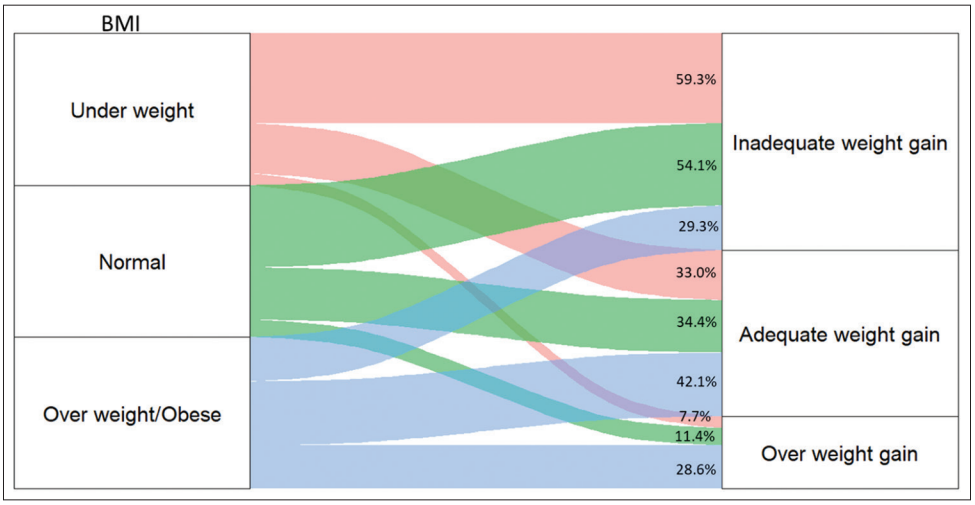

Figure 1: Sankey diagram illustrating the pattern of weight gain in different categories of BMI

Though the sample size was large, the proportion of pregnant women who were overweight and obese (n = 440) during the time of registration was less. Hence, this number might not be powered enough to identify the actual effects, i.e., underestimated or overestimated in this study. Since this was a historical cohort study, potential confounding variables such as dietary habits before and during the pregnancy and physical activity before and during pregnancy were not assessed, which could have altered the actual effects in this study.

Ideally, prepregnancy weight and height should have been used for BMI classification, but in our study, we considered the height and weight at the time of registration. This could have led to a misclassification bias in this study. Although these pregnant women do not belong to a defined geographical location or area, most were below upper-middle socioeconomic status. Hence, these study findings can be generalizable to a similar group of populations elsewhere.

For physicians practicing family medicine, it is important to recognize and identify women prepregnancy who are overweight/obese and give them the necessary counseling on weight reduction, and once pregnant, to advise on what is adequate weight gain and the complications associated with excessive weight gain.

Conclusion

In this study, in overweight/obese pregnant women, the odds of developing GDM during pregnancy were 2.1 times higher than in normal BMI women (OR: 2.12, 95% CI: 1.58–2.84). Similarly, the odds of overweight/obese women undergoing LSCS at the end of pregnancy were 1.6 times higher (OR: 1.6, 95% CI: 1.19–2.15) than in normal BMI women. Excess weight gain was observed more in pregnant women who were overweight and obese at the time of registration. Excess weight gain in pregnant women who were obese/overweight did not have any effect on pregnancy-related outcomes in this study, hence, further research needs to be done to assess the pregnancy-related outcomes with a larger sample size of overweight and obese women. Policies need to be implemented at the various levels of healthcare and individual levels to reduce the overweight/obesity burden in the community and improve the weight during pregnancy. Furthermore, these children born to overweight/obese women need to be followed up over time to look for long-term risks due to overweight and obesity.

Financial support and sponsorship

The Department of Community Medicine, Christian Medical College, Vellore.

Conflicts of interest

There are no conflicts of interest.

References

1. Seshadri L, Arjun G. Essentials of Obstetrics. New Delhi: Wolters Kluwer (India) Pvt. Ltd.; 2015. p. 104.
2. Sahu M T, Agarwal A, Das V, Pandey A. Impact of maternal body mass index on obstetric outcome. J Obstet Gynaecol Res 2007;33:655–9.
3. Goldstein RF, Abell SK, Ranasinha S, Misso ML, Boyle JA, Harrison CL, *et al.* Gestational weight gain across continents and ethnicity: Systematic review and meta-analysis of maternal and infant outcomes in more than one million women. BMC Med 2018;16:153.
4. Ehrenberg HM, Dierker LRN, Milluzzi C, Mercer BM. Low maternal weight failure to thrive in pregnancy and adverse prenatal outcomes. Am J Obstet Gynecol 2003;189:1726–30.
5. Wolfe H. High prepregnancy body mass index: A maternal– fetal risk factor. N Engl J Med 1998;338:191–2.
6. Sadiq G, Mohsin R. The effect of maternal obesity on mode of delivery and duration of labour. J Soc Obstet Gynaecol Pak 2018;8:41-5.
7. Forthun I, Wilcox AJ, Strandberg-Larsen K, Moster D, Nohr EA, Lie RT, *et al.* Maternal prepregnancy BMI and risk of cerebral palsy in offspring. Pediatrics 2016;138:e20160874. doi: 10.1542/peds.2016-0874.
8. Chu SY, Callaghan WM, Kim SY, Schmid CH, Lau J, England LJ, *et al.* Maternal obesity and risk of gestational diabetes mellitus. Diabetes Care 2007;30:2070–6.
9. Chu SY, Kim SY, Schmid CH, Dietz PM, Callaghan WM, Lau J, *et al.* Maternal obesity and risk of cesarean delivery: A meta-analysis. Obes Rev 2007;8:385–94.
10. Sebire NJ, Jolly M, Harris JP, Wadsworth J, Joffe M, Beard RW, *et al.* Maternal obesity and pregnancy outcome: A study of 287,213 pregnancies in London. Int J Obes Relat Metab Disord 2001;25:1175–82.
11. Heslehurst N, Simpson H, Ells LJ, Rankin J, Wilkinson J, Lang R, *et al.* The impact of maternal BMI status on pregnancy outcomes with immediate short-term obstetric resource implications: A meta-analysis. Obes Rev 2008;9:635–83.
12. Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. Obstet Gynecol 2004;103:219–24.
13. Sewell MF, Huston-Presley L, Super DM, Catalano P. Increased neonatal fat mass, not lean body mass, is associated with maternal obesity. Am J Obstet Gynecol 2006;195:1100–3.
14. Usha Kiran TS, Hemmadi S, Bethel J, Evans J. Outcome of pregnancy in a woman with an increased body mass index. BJOG Int J Obstet Gynaecol 2005;112:768–72.
15. Arora P, Tamber Aeri B. Gestational weight gain among healthy pregnant women from Asia in comparison with Institute of Medicine (IOM) Guidelines-2009: A systematic review. J Pregnancy 2019;2019:3849596.
16. Bhavadharini B, Anjana RM, Deepa M, Jayashree G, Nrutya S, Shobana M, *et al.* Gestational weight gain and pregnancy outcomes in relation to body mass index in Asian Indian Women. Indian J Endocrinol Metab 2017;21:588–93.
17. Scholl TO, Hediger ML, Khoo CS, Healey MF, Rawson NL. Maternal weight gain, diet and infant birth weight: Correlations during adolescent pregnancy. J Clin Epidemiol 1991;44:423–8.