European Journal of Clinical and Biomedical Sciences
2021; 7(6): 138-145
http://www.sciencepublishinggroup.com/j/ejcbs
doi: 10.11648/j.ejcbs.20210706.18
ISSN: 2575-4998 (Print); ISSN: 2575-5005 (Online)

Relationship of Pre-pregnancy BMI, Gestational Anaemia and Weight Gain During Pregnancy with Birth Outcomes of Selected Indian Women

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To cite this article:

Mythili V., Anusuya Devi K., Latha Maheswari S. Relationship of Pre-pregnancy BMI, Gestational Anaemia and Weight Gain During Pregnancy with Birth Outcomes of Selected Indian Women. *European Journal of Clinical and Biomedical Sciences*. Vol. 7, No. 6, 2021, pp. 138-145. doi: 10.11648/j.ejcbs.20210706.18

Received: July 29, 2021; **Accepted**: August 9, 2021; **Published**: November 29, 2021

Abstract: Maternal weight before and throughout pregnancy is clearly tied to maternal and neonatal health outcomes, and excessive gestational weight gain (GWG) is linked to a diversity of short and long term maternal and child complications. The focus of this research is to determine the relationship between pre-pregnancy BMI and gestational weight gain in mothers and birth outcomes, as well as to investigate socio-demographic factors that influence pre-pregnancy BMIs and GWG, as well as the consequences of pre-pregnancy BMI and GWG on maternal and infant complications in Coimbatore. It's a Prospective observational study using random sampling technique to select the 421 pregnant women between the ages of 18 and 35 visiting clinics and super speciality hospitals for pregnancy confirmation tests during August to April, 2021. Regression analysis was employed to evaluate the socio-demographic factors affecting pre-pregnancy BMI and GWG values and their effects on adverse maternal and infant complications. Multivariate logistic regression analysis revealed that age groups 26-30 years (OR: 0.652) and living in rural area (OR: 2.375) were risk factors in maintaining a normal pre-pregnancy BMI. An age range of 26-30 years (OR: 0.478), living in rural area (OR: 2.512) with nuclear family (OR: 0.599) were factors affecting GWG. Overweight pregnant women were lower to suffer anemia (OR: 1.935) and GDM (OR: 1.162) and higher to deliver low birth weight (OR: 1.996) compared to normal weight pregnant women and both inadequate and excessive GWG were not at the risk for low birth weights. Overweight before pregnancy is linked to a higher chance of having low-birth-weight babies, according to the study. Body weight control before and during pregnancy is indicated to reduce unfavorable pregnancy outcomes, particularly in pregnant women aged 21 to 30 years old and those women who reside in rural areas with nuclear families.

Keywords: Pregnancy, Anemia, Gestational Weight Gain, Overweight

1. Introduction

Pregnancy is an important time for women to eat healthy so as to guarantee good birth and growth outcomes, the additional dietary demands of fetal growth and development must be satisfied. A poor maternal diet and insufficient gestational weight growth during pregnancy raise the likelihood of both mother and child suffering from negative health outcomes [1].

Birth weight of a neonate is a key determinant of the newborn's likelihood of survival, and it is strongly linked to mother anthropometry during pregnancy [2].

Still birth, Diabetes mellitus (DM), hypertension and preeclampsia have all been linked to high mother body weight (HBW) during pregnancy whereas Preterm birth and low neonatal birth weight are risks associated with low body weight of the mother's [3]. Abnormal weight gain during pregnancy is often linked with early asphyxia, birth injury and hypoglycemia of neonates [4]. The incidence of anemia is also greatly influenced by variables like genes, socio-demographic factors, and economic freedom of women [5].

Maternal anemia is correlated to negative outcomes for the

newborn, such as preterm birth, low birth weight, and retinopathy of prematurity, as well as higher risks for the mother, such as cesarean section, red blood cell transfusion, or death [6].

Researchers wanted to learn more about the socio-demographic factors that influence pre-pregnancy BMI and GWG values, along with maternal and infant complications.

2. Materials and Method

This prospective observational study was done in a Maternity Clinic and Super Speciality hospital located in the heart of Coimbatore region, during August to April, 2021. The study was carried out using a pretested and validated questionnaire. The present study was approved by the Hospital Ethical committee (No. PSG/IHEC/2021/Appr/Exp/041) and Informed consent was taken from all participants before data collection.

The study comprised of 421 pregnant women (18-35years) in the visiting thee clinic and super speciality hospital selected randomly.

Inclusion criteria: Pregnant women between the age of 18-35 years, express willingness to participate, regular antenatal check-up visits, full term delivery, single gestation.

Exclusion criteria: Teenage or elderly primigravida (<18 years or > 35 years), not willing to participate, multiple gestation and high risk pregnancy.

We collected socio-demographic data from pregnant women surveys including present and marital age, education, residential area, family type, family member and family monthly income. We also measured the heights and weights of the women at their prenatal examination, including their weights recorded at the last prenatal examination. Maternal outcomes including gestational weeks, delivery mode, maternal complications (e.g., anemia, gestational diabetes mellitus and gestational hypertension) and Neonatal outcomes including low and normal birth weights, macrosomia and small, normal or large size for gestational age (GA) were collected.

Standard measurements:

Mother's weights and heights were measured in light clothing but with no shoes on. Height was measured to the nearest 0.01 kg using calibrated electronic scales. Blood pressure was measured using a standard sphygmomanometer.

BMI (kg/m^2) values before pregnancy were calculated by measuring the height and weight of pregnant women at their first prenatal examination. Gestational weight gain (GWG) refers to the difference between the weight measured at the last prenatal examination before delivery and the weight measured at the initial prenatal examination [7].

Gestational Diabetes Mellitus (GDM) was diagnosed if one or more of the following criteria were met during pregnancy; fasting plasma glucose ≥ 5.1 mmol/L, 1 h plasma glucose levels ≥ 10.0 mmol/L, 2 h glucose levels ≥ 8.5 mmol/L after overnight fasting with a 75 g glucose load according to the WHO 2013 diagnosed criteria [8]. Anemia in pregnancy was diagnosed as a hemoglobin (Hb) concentration < 110 g/L (11 g/dL) according to the WHO criteria [9].

3. Statistical Methods

The information was coded and analyzed using Statistical Package for the Social Sciences version 20 (SPSS v.20). The classification index was used to define the quantity and percentage of different categories, and comparisons between groups were made using the chi-squared test or the exact probability approach. In order to investigate the socio-demographic factors affecting BMI values before pregnancy and GWG, a cumulative logistic regression model was used to correct the effect of confounding factors. To account for confounding factors, multivariate logistic regression models (including cumulative logistic regression and multinomial logistic regression) were used to identify independent risk factors for unfavorable maternal and neonatal outcomes. A significant finding was defined as one with a P-value of less than 0.05.

4. Results

4.1. Socio-demographic Factors Affecting BMI Values Before Pregnancy and GWG

Pre-pregnancy BMIs were categorized into four types namely: underweight, normal, overweight and obese women (shown in Table 1). Among the 4 pre-pregnancy BMI groups, there were significant difference in residential area (P=0.022), and no significant differences in present age (P=0.097), marital age (P=0.960), education (P=0.876), family type (P=0.265), family member (P=0.149) and family monthly income (P=0.213) (Table 1). Despite that, after rectifying by multivariate logistic regression analysis, it was observed that in view of age, compared with the age groups of 21 to 25 years, pregnant women of the age groups < 21 years old (OR: 1.861, P=0.195), 26-30 years old (OR: 0.652, P=0.047), 31-35 years old (OR: 0.741, P=0.324) but only 26-30 years age group were at risk to maintain normal weight before pregnancy. In sight of education, compared with pregnant women with graduate and above, illiterate (OR: 0.347, P=0.486), secondary school (OR: 0.440, P=0.239) and higher secondary school (OR: 0.820, P=0.497) were not risk factors to maintain normal pre-pregnancy BMI. In sight of residential area, compared with pregnant women with urban area, rural area (OR: 2.375, P=0.009) than living in semi-urban area (OR: 1.130, P=0.594) were risk factors to maintain normal pre-pregnancy BMI. In view of type of family, joint family were more likely to adjust pre-pregnancy BMIs within the normal range than pregnant women in nuclear family (OR: 1.323, P=0.162, shown in Table 3).

According to IOM recommended criteria, GWG was categorized into 3 types namely: inadequate, adequate and excessive as shown in Table 2. Among the 3 GWG groups, there were significant difference in family type (P=0.018) and not significant differences in present age (P=0.058),

marital age (P=0.092), education (P=0.908), residential area (P=0.147), family member (P=0.230) and family monthly income (P=0.528) as shown in Table 2. Despite that, after rectifying by multivariate logistic regression analysis, it was observed that compared with the 21-25 years age group, 26-30 years old (OR: 0.478, P=0.004) was a safeguarding point in increasing adequate weight during pregnancy. On the other side, pregnant women living in rural area (OR: 2.512, P=0.028) and living with nuclear family (OR: 0.599, P=0.036) were risk factors for increasing adequate weight during pregnancy (shown in Table 3).

4.2. Consequence of Pre-pregnancy BMI Values on Maternal and Infant Complications

Among the 4 pre-pregnancy BMI groups, there were significant differences in the delivery mode (P<0.05), anemia (P=0.034) in maternal outcomes and there were significant differences in birth weights (P=0.003) for neonatal outcomes (Table 4). After rectifying for the consequences of confounding factors using a multivariate logistic regression analysis: compared to normal weight pregnant women we observed that odd ratios in overweight pregnant women were 1.935 times and 1.162 times lower to suffer anemia (P=0.139) and GDM (P=0.65) and 1.996 times higher to delivering low birth weight (P=0.005) (Table 6).

4.3. Consequence of GWG on Maternal and Infant Complications

Among the 3 GWG groups, there were significant difference in delivery mode (P=0.008) for maternal outcomes and there were no significant differences in birth weights (P=0.182) and GA (P=0.694) for neonatal outcomes (Table 5). After rectifying for the consequences of confounding factors using a multivariate logistic regression analysis: compared to adequate GWG, both inadequate and excessive GWG were not at the risk to delivering low birth weight babies.

Table 1. *Comparison of socio-demographic factors in the four pre-pregnancy BMI groups.*

	Category of Pre-pregnancy BMI				**P-value**
	Underweight	**Normal weight**	**Overweight**	**Obese**	
N%	25 (5.9)	240 (57)	134 (31.8)	22 (5.3)	
Present Age (years)					
<21	0	08 (3.3)	10 (7.5)	0	0.097
21-25	05 (20)	105 (43.8)	60 (44.8)	12 (54.5)	
26-30	16 (64)	93 (38.8)	46 (34.3)	09 (41)	
31-35	04 (16)	34 (14.1)	18 (13.4)	01 (4.5)	
Marital Age (years)					
<21	03 (12)	39 (16.2)	22 (16.4)	04 (18.2)	0.960
21-25	18 (72)	162 (67.5)	83 (62)	13 (59)	
26-30	04 (16)	35 (14.6)	24 (17.9)	05 (22.7)	
31-35	0	04 (1.7)	05 (3.7)	0	
Education					
Illiterate	0	02 (0.8)	0	0	0.876
Secondary	0	07 (2.9)	02 (1.5)	0	
Higher-secondary	05 (20)	30 (12.5)	19 (14.2)	03 (13.6)	
Graduate & above	20 (80)	201 (83.8)	113 (84.3)	19 (86.4)	
Residential Area					
Urban	14 (56)	160 (66.7)	81 (60.4)	12 (54.5)	0.022
Semi-urban	11 (44)	55 (22.9)	39 (29.1)	04 (18.2)	
Rural	0	25 (10.4)	14 (10.5)	06 (27.3)	
Family type					
Nuclear	15 (60)	125 (52.1)	80 (59.7)	10 (45.5)	0.265
Joint	10 (40)	115 (47.9)	54 (40.3)	12 (54.5)	
Family member					
1-2	09 (36)	69 (28.8)	50 (37.3)	05 (22.7)	0.149
3-4	06 (24)	67 (27.9)	33 (24.6)	05 (22.7)	
5-6	03 (12)	54 (22.5)	17 (12.7)	07 (31.8)	
7-8	06 (24)	39 (16.2)	22 (16.4)	05 (22.7)	
9-10	01 (4)	11 (4.6)	12 (9)	0	
Family Monthly Income					
10-20,000	0	20 (8.3)	12 (9)	02 (9.1)	0.213
21-40,000	05 (20)	61 (25.4)	42 (31.3)	02 (9.1)	
41-60,000	11 (44)	93 (38.8)	54 (40.3)	12 (54.5)	
>60,000	09 (36)	66 (27.5)	26 (19.4)	06 (27.3)	

Table 2. *Comparison of socio-demographic factors in the 3 GWG groups according to IOM recommendations.*

	Category of Gestational weight gain			P-value
	Inadequate	Adequate	Excessive	
N%	73 (17.3)	321 (76.2)	27 (6.4)	
Present Age (years)				
<21	01 (1.4)	16 (5)	02 (7.4)	
21-25	26 (35.6)	139 (43.3)	17 (62.9)	0.058
26-30	38 (52.1)	120 (37.3)	06 (22.2)	
31-35	08 (10.9)	46 (14.3)	02 (7.4)	
Marital Age (years)				
<21	13 (17.8)	51 (15.9)	04 (14.8)	
21-25	47 (64.4)	213 (66.4)	16 (59.3)	.092
26-30	09 (12.3)	55 (17.1)	06 (22.2)	
31-35	04 (5.5)	02 (0.6)	01 (3.7)	
Education				
Illiterate	0	02 (0.6)	0	
Secondary	01 (1.4)	08 (2.5)	0	0.908
Higher-secondary	09 (12.3)	44 (13.7)	02 (7.4)	
Graduate & above	63 (86.3)	267 (83.2)	25 (92.6)	
Residential Area				
Urban	53 (72.6)	200 (62.3)	14 (51.9)	
Semi-urban	15 (20.5)	86 (26.8)	07 (25.9)	0.147
Rural	05 (6.8)	35 (10.9)	06 (22.2)	
Family type				
Nuclear	46 (63)	173 (53.9)	10 (37)	0.018
Joint	27 (37)	148 (46.1)	17 (62.9)	
Family member				
1-2	33 (45.2)	97 (30.2)	04 (14.8)	
3-4	17 (23.3)	87 (27.1)	08 (29.6)	
5-6	11 (15.1)	61 (19)	07 (25.9)	0.230
7-8	09 (12.3)	57 (17.8)	06 (22.2)	
9-10	03 4.1)	19 (5.9)	02 (7.4)	
Family Monthly Income				
10-20,000	09 (12.3)	26 (8.1)	0	
21-40,000	15 (21)	88 (27.4)	06 (22.2)	0.528
41-60,000	30 (41.1)	126 (39.3)	13 (48.1)	
>60,000	19 (26)	81 (25.2)	08 (29.6)	

Table 3. *Multivariate analysis of socio-demographic factors affecting pre-pregnancy BMI values and GWG.*

	OR (95% CI)	P-value
Socio-demographic factors affecting pre-pregnancy BMI values		
< 21 vs 21-25	1.861 (0.727-4.764)	0.195
26-30 vs 21-25	0.652 (0.427-0.995)	0.047
31-35 vs 21-25	0.741 (0.408-1.346)	0.324
Illiterate vs Graduate & above	0.347 (0.018-6.814)	0.486
Secondary vs Graduate & above	0.440 (0.112-1.725)	0.239
Higher secondary vs Graduate & above	0.820 (0.461-1.456)	0.497
Semi-urban vs urban	1.130 (0.722-1.766)	0.594
Rural vs urban	2.375 (1.245-4.527)	0.009
Nuclear vs joint	1.323 (0.893-1.96)	0.162
Socio-demographic factors affecting GWG		
< 21 vs 21-25	2.071 (0.616-6.959)	0.239
26-30 vs 21-25	0.478 (0.287-0.795)	0.004
31-35 vs 21-25	0.716 (0.347-1.477)	0.366
Illiterate vs Graduate & above	3.391 (0.097-118.629)	0.501
Secondary vs Graduate & above	0.640 (0.129-3.184)	0.586
Higher secondary vs Graduate & above	1.033 (0.521-2.044)	0.927
Semi-urban vs urban	1.186 (0.694-2.028)	0.532
Rural vs urban	2.512 (1.105-5.705)	0.028
Nuclear vs joint	0.599 (0.371-0.968)	0.036

Table 4. *Comparison of maternal and neonatal outcomes in the four pre-pregnancy BMI groups.*

	Pre-pregnancy BMI category				P-value
	Underweight (N=25)	Normal weight (N=240)	Overweight (N=134)	Obese (N=22)	
Maternal outcomes Gestational weeks					
≥ 28 and < 37	13 (52)	79 (32.9)	48 (35.8)	08 (36.4)	
≥ 37 and < 42	12 (48)	155 (64.6)	82 (61.2)	13 (59.1)	0.606
≥ 42	0	06 (2.5)	04 (3)	01 (4.5)	
Delivery mode					
NVD	04 (16)	125 (52.1)	55 (41)	04 (18.2)	
Forceps	02 (8)	09 (3.8)	06 (4.5)	0	
VAD	02 (8)	38 (15.8)	16 (11.9)	01 (4.5)	0.002
Elective LSCS	09 (36)	29 (12.1)	29 (21.6)	08 (36.4)	
Emergency LSCS	08 (32)	39 (16.2)	28 (21)	09 (40.9)	
Maternal complications Anemia					
No	21 (84)	212 (88.3)	127 (94.7)	22 (100)	0.034
Yes	04 (16)	28 (11.7)	07 (5.3)	0	
GDM					
No	23 (92)	204 (85)	125 (93.3)	16 (72.7)	0.245
Yes	02 (8)	36 (15)	09 (6.7)	06 (27.3)	
Neonatal outcomes Birth weight					
Low birth weight	02 (8)	49 (20.4)	44 (32.8)	08 (36.4)	
Normal birth weight	23 (92)	191 (79.6)	90 (67.2)	14 (63.6)	0.003
Macrosomia	0	0	0	0	
Gestational age (GA)					
Small for GA	12 (48)	86 (35.8)	46 (34.3)	04 (18.2)	0.121
Normal for GA	10 (40)	130 (54.2)	78 (58.2)	18 (81.8)	
Large for GA	03 (12)	24 (10)	10 (7.5)	0	

Note: NVD Normal vaginal delivery, VAD Vacuum assisted delivery, LSCS Lower segment cesarian section, GDM Gestational diabetes mellitus

Table 5. *Comparison of maternal and neonatal outcomes in the 3 GWG groups according to IOM recommendations.*

	Gestational weight gain category			P-value
	Inadequate (N=73)	Adequate (N=321)	Excessive (N=27)	
Maternal outcomes Gestational weeks				
≥ 28 and < 37	26 (35.6)	113 (35.2)	09 (33.3)	
≥ 37 and < 42	47 (64.4)	198 (61.7)	17 (63)	0.653
≥ 42	0	10 (3.1)	01 (3.7)	
Delivery mode				
NVD	36 (49.3)	147 (45.8)	05 (18.5)	
Forceps	03 (4.1)	14 (4.4)	0	
VAD	05 (6.8)	51 (15.9)	01 (3.7)	0.008
Elective LSCS	15 (20.5)	51 (15.9)	09 (33.3)	
Emergency LSCS	14 (19.2)	58 (18.1)	12 (44.5)	
Maternal complications Anemia				
No	64 (87.7)	293 (91.3)	25 (92.6)	0.677
Yes	09 (12.3)	28 (8.7)	02 (7.4)	
GDM				
No	69 (94.5)	275 (85.7)	22 (81.5)	0.151
Yes	04 (5.5)	46 (14.3)	05 (18.5)	
Neonatal outcomes Birth weight				
Low birth weight	19 (26)	81 (25.2)	03 (11.1)	
Normal birth weight	54 (74)	240 (74.8)	24 (88.9)	0.182
Macrosomia	0	0	0	
Gestational age (GA)				
Small for GA	26 (35.6)	113 (35.2)	09 (33.3)	
Normal for GA	42 (57.5)	177 (55.1)	17 (63)	0.694
Large for GA	05 (6.9)	31 (9.7)	01 (3.7)	

Note: NVD Normal vaginal delivery, VAD Vacuum assisted delivery, LSCS Lower segment cesarian section, GDM Gestational diabetes mellitus

Table 6. *Multivariate analysis of the consequence of pre-pregnancy BMI and GWG on maternal and infant complications (All subjects adjusted for present age, marital age, education, residential area, family type, family member and family monthly income).*

	Pre-pregnancy BMI category			**Gestational weight gain category**	
	Underweight vs normal weight	**Overweight vs normal weight**	**Obese vs normal weight**	**Inadequate vs adequate**	**Excessive vs adequate**
Anemia					
OR	0.798	1.935	6.358	0.64	1.649
(95% CI)	(0.266-2.397)	(0.806-4.643)	(0.321-125.828)	(0.281-1.458)	(0.339-8.026)
P-value	0.688	0.139	0.225	0.288	0.536
Gestational diabetes mellitus					
OR	1.756	1.162	0.534	2.005	0.664
(95% CI)	(0.463-6.655)	(0.606-2.228)	(0.187-1.528)	(0.811-4.954)	(0.243-1.81)
P-value	0.408	0.65	0.242	0.132	0.423
Low birth weight					
OR	0.497	1.996	2.034	1.204	0.325
(95% CI)	(0.158-1.565)	(1.226-3.251)	(0.801-5.165)	(0.677-2.14)	(0.094-1.125)
P-value	0.232	**0.005**	0.135	0.527	0.076
Small for GA					
OR	1.158	1.219	2.018	1.506	2.223
(95% CI)	(0.33-4.064)	(0.514-2.89)	(0.114-35.694)	(0.528-4.298)	(0.258-19.147)
P-value	0.819	0.653	0.632	0.444	0.467
Normal for GA					
OR	0.586	1.481	5.868	1.528	3.323
(95% CI)	(0.166-2.07)	(0.645-3.4)	(0.38-90.714)	(0.554-4.217)	(0.412-26.825)
P-value	0.407	0.354	0.205	0.413	0.26

Note: P-values < 0.05 are highlighted in bold text; GA Gestational age

5. Discussion

Investigators observed that the residential region of selected pregnant women played a key role in pre-pregnancy BMI; family type was the key factor in Gestational Weight Gain, through this survey. In terms of maternal and neonatal complications, being overweight before pregnancy was associated with a lower risk of anemia and GDM, as well as a higher likelihood of delivering low birth weight babies. The researchers also noted that both inadequate and excessive GWG were not associated with low birth weight babies when compared to adequate GWG.

This study also revealed that pregnant women aged 21 to 30 years old were found to have pre-pregnancy BMIs that were out of the standard limits when compared to pregnant women aged 21 to 25 year old. The finding goes on par with various researchers that delivering a baby too soon or too late increases the likelihood of a negative pregnancy outcomes [10-13] along with abnormalities [14, 15]. As a result, women in these age groups should be advised to maintain a healthy weight before becoming pregnant.

When compared to pregnant women in urban areas, living in a rural location rather than a semi-urban area were risk factors for maintaining a normal pre-pregnancy BMI. Pregnant women in joint families were more likely than pregnant women in nuclear families to keep their pre-pregnancy BMIs within the normal range.

For maternal outcomes, there were substantial disparities in delivery style and anemia, and for neonatal outcomes. There were significant differences in birth weights across the four pre-pregnancy BMI groups [16]. There were significant variations in delivery mode among the three GWG groups for maternal outcomes, but no significant differences in birth weights or GA among the three GWG groups for neonatal outcomes.

Energy reserves before pregnancy and dietary acquisition during pregnancy are two sources of energy that mothers provide for fetal development [17]. The neonatal problems discovered in our study strongly showed that being overweight was a risk factor for low birth weight, whereas insufficient and excessive GWG were not risk [18-20]. Being overweight or obese before pregnancy may result in higher glucose, amino acid, and free fatty acid concentrations in pregnant women, raising the likelihood of an abnormal child weight at birth [21].

Strength and limitations

1) The studies only involve women with a single pregnancy and omit multiple pregnancies and high risk pregnancies because it is impossible to correlate the birth weight of two kids with the mother's weight.
2) One of the study's shortcomings was that we assumed anemia was caused by a lack of iron rather than assessing ferritin or iron storage, despite the fact that iron shortage causes more than half of anemia in pregnant women.
3) Despite the reduced smaller size, we predicted a statistically significant interaction, implying that our findings would be stronger with a larger sample.
4) There were no details concerning possible confounding factors such clinical problems or changes in lifestyle during pregnancy. Finally, there is no way to totally eliminate the recall bias of pregnant women when it comes to socio-demographic data.
5) The prospective observational study with repeated assessments of BMI, GWG and hemoglobin, which

allowed us to capture the influence modification of pre-pregnancy BMI and GWG with the birth weight of neonates, is one of the study's primary strengths.

6. Conclusion

When compared to normal weight pregnant women, overweight pregnant women had a lower risk of anemia and GDM, as well as a higher chance of delivering a baby with a low birth weight, and both inadequate and excessive GWG were not at risk. In clinical practice, physicians advise women to manage and control pre-pregnancy BMI and GWG in order to limit the chance of negative pregnancy outcomes. When planning to become pregnant, women of child bearing age can be instructed on the need of keeping a healthy BMI. Pregnant women between the ages of 21 and 30, who live in rural areas and have a nuclear family, should be given special attention when it comes to perinatal health care. These findings demand the immediate attention of researchers, policymakers, and decision-makers in order to facilitate the development of culturally sensitive interventions to improve the nutritional status and health of mothers and babies in an area known for high maternal and neonatal mortality rates.

Acknowledgements

The authors would like to express their gratitude toward the invaluable contribution to residential people of the selected Coimbatore district pregnant women for sharing their socio-demographic characteristics, maternal and neonatal outcomes and enriching this manuscript.

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