Chapter

Association of Pre-Pregnancy Body Mass Index and Gestational Weight Gain with Preterm Delivery in Pregnant Women

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Abstract

The perinatal mortality rate, which is one of the important adverse pregnancy outcome and includes stillbirths and infant death within first week of life is estimated to be nearly 40 deaths per 1,000 pregnancies in Gujarat. Also the infant mortality rates have been estimated to be 50 deaths before age of one year per 1,000 pregnancies. It is stated that children whose mothers are illiterate or belong to low socio-economic class have two and half times more chances to die within 1 year of their birth compared to those whose mothers have completed atleast 10 years of education or belong to high socio-economic class. There are nearly 13% of women who does not receive proper antenatal care and facility during pregnancy. In India, there are nearly half of the women (52%) who possess normal BMI range: rest are either underweight or overweight. Approximately 55% of the women of total population in India are anaemic. These maternal parameters directly affect the children causing 48% of the children to be malnourished and 43% to be underweight. Therefore, it is imperative to examine the association of pre-pregnancy Body Mass Index (BMI) as well as Gestational Weight Gain (GWG) with diverse pregnancy outcomes such as gestational diabetes, gestational hypertension and also with preterm delivery, caesarean delivery, etc. The present study was designed to investigate the prevalence, GWG, various pregnancy outcomes of underweight, overweight or obese pregnant women, and to explore the relationship between pre-pregnancy BMI as well as gestational weight gain during pregnancy and adverse pregnancy outcomes. This is a prospective, multi-centric study involving pregnant women with gestation week ≤20 weeks in Ahmedabad in Gujarat region. Our study observed that out of 226 women enrolled, 44 women (19.47%) were underweight, 137 women (60.62%) were normal, 30 women (13.27%) were overweight and 15 women (6.64%) were obese. The incidence of caesarean delivery (56.92%) was found more in nuclear family as compared to joint family (46.92%). It was found that in women taking no junk food at all, the chances of LBW were 16.39%, which was less as compared to mothers who had junk food. It was also observed that amongst women taking 1 glass milk daily (42.92%), about 55.67% of had normal type of delivery. Amongst women taking 1 fruit daily (57.52%), 53% women had normal delivery. Present study spotted decrease in risk of caesarean delivery with increase in maternal haemoglobin level from 9.0 gm/dl till 12.0 gm/dl. Average weight gain observed in underweight was 12.93 ± 1.90, in normal 12.32 ± 1.71, in overweight 10.23 ± 1.28 and in obese 9.6 ± 1.50. A negative correlation was found between GWG and pre-pregnancy BMI, i.e. as pre-pregnancy BMI increase, the GWG decrease. The incidence of pre-term delivery (9.49%) was much less in normal BMI range. The average infant birth weight observed in underweight women was 2.63 ± 0.47, in normal was 2.9 ± 0.49, in overweight was 2.92 ± 0.56 and in obese was 2.95 ± 0.86. It is observed that highest birth weight is obtained in obese women, which decreases as the maternal BMI range decreases. The incidence of LBW in normal and overweight women was 15.33 and 16.67%, which was low as compared to obese and underweight women. Our study reveals that parameters such as GWG, type of family, intake of milk, fruits and junk food, haemoglobin concentration directly affects the pregnancy outcomes such as term of delivery, type of delivery and infant birth weight.

Keywords: preterm birth, prepregnancy, body mass index, weight gain, pregnant women

1. Introduction

The perinatal mortality rate, which is one of the important adverse pregnancy outcome and includes stillbirths and infant death within first week of life is estimated to be nearly 40 deaths per 1,000 pregnancies in Gujarat. Also the infant mortality rates have been estimated to be 50 deaths before age of one year per 1,000 pregnancies. It is stated that children whose mothers are illiterate or belong to low socio-economic class have two and half times more chances to die within 1 year of their birth compared to those whose mothers have completed atleast 10 years of education or belong to high socio-economic class. There are nearly 13% of women who does not receive proper antenatal care and facility during pregnancy [1].

In India, there are nearly half of the women (52%) who possess normal BMI range: rest are either underweight or overweight. Approximately 55% of the women of total population in India are anaemic. These maternal parameters directly affect the children causing 48% of the children to be malnourished and 43% to be underweight [2].

The impact of prepregnancy body mass index (BMI) on maternal as well as neonatal outcomes has attracted wide spread attention these days. Several of the recent studies had reported that the prepregnancy BMI is associated with the child birth weight and it is also reported that mothers' whose weight gain during pregnancy may be excessive or inadequate are more prone to poor maternal and child outcomes. The range of weight gain during pregnancy is constant since last 10 years, although it may differs from one to another according to the maternal BMI [3]. According to the recommendations for weight gain during pregnancy by Institute of Medicine (IOM), both prepregnancy BMI and GWG are associated with the outcomes of pregnancy, either in correlation to mother or neonate or in both. Maternal and neonatal complications associated with BMI and GWG are of public health importance because they add to the disease burden in women and children and also increase the medical costs. Prior to pregnancy, all women should strive for appropriate body weights [4]. Gestational weight gain is a modifiable factor which can be controlled through diet as well as nutritional counselling during pregnancy to modify the inadequate or excessive weight [5].

The antenatal care involves various actions such as prevention and health care promotion of mother as well as neonate, early diagnosis and appropriate treatment of any problem occurring during this period of time. For proper antenatal care, monitoring the nutritional intake and status of pregnant women is important along with examining the gestational weight gain, haemoglobin level which also possesses direct co-relation with maternal and foetal health [6].

Various studies have been conducted which suggests the correlation of different maternal parameters with adverse pregnancy outcomes. A study by Li et al. observed that maternal prepregnancy BMI was positively associated with risks of gestational diabetes mellitus (GDM), pregnancy-induced hypertension, caesarean delivery, preterm delivery, LGA, and macrosomia, and inversely associated with risks of SGA and LBW. They also found that maternal excessive GWG was associated with increased risks of pregnancy-induced hypertension, caesarean delivery, LGA, and macrosomia, and decreased risks of preterm delivery, SGA, and low birth weight [3]. Another study by Steer P.J observed that the minimum incidence of low birth weight (< 2.5 kg) and preterm labor (< 37 completed weeks) occurs in association with a haemoglobin concentration of 95–105 g/L. Thus associating the haemoglobin levels with infant birth weight and term of delivery [7]. Adverse pregnancy outcomes are more common in women who begin the gestation as undernourished or as obese in comparison to pregnant women whose weight is within normal ranges. Maternal malnutrition increases the risks of birth weight, premature birth, foetal growth retardation, SGA infants and is associated with perinatal morbidity and mortality; insufficient intake of certain nutrients is related to some foetal congenital anomalies and birth defects. Gestational underweight has also been linked to infant inclination to certain chronic illnesses (diabetes mellitus type 2, hypertension, coronary disease, and stroke) in adulthood [8].

Low prepregnancy BMI (<19.5) is associated with many adverse pregnancy outcomes. In a country like India, where maternal underweight remains more common than overweight, the influence of maternal underweight BMI can affect mother and neonate adversely in many ways. Low Prepregnancy BMI is said to be associated with pregnancy outcomes such as preterm birth, LBW (i.e. birth weight less than 2500grams) or small SGA [9]. Women with lower than normal maternal body weight are prone to elevated risk for adverse prenatal outcomes such as intrauterine growth restriction (IUGR) as well as increased risk of subsequent obesity and hypertension in the offspring [10]. Also the SGA neonates are at risk for low Apgar scores, meconium aspiration, seizures, respiratory complications, extended hospital stays, and long-term squeal, including metabolic syndrome and neurologic deficits [11].

The prevalence of overweight (BMI 25–29.9 kg/m^2) and obesity (BMI 30–34.9 kg/m^2) is increasing rapidly among obstetric population. Further studies report that complications due to obesity can cause excess health care service use, including increased hospital stay during or after pregnancy [12]. Women with higher BMI during pregnancy are at higher risk of antenatal, intrapartum, postpartum and neonatal complications. Antenatal complications include recurrent miscarriage, congenital malformations, pregnancy induced hypertension (PIH), pre-eclampsia, gestational diabetes mellitus (GDM) and venous thromboembolism. Overweight and obese women are more likely to be induced and require a caesarean. Infants of overweight and obese mothers are often macrosomic and require prolonged hospital admission [13].

The iron concentration is less in females compared to males because of blood loss due to menstruation. Moreover during pregnancy, the foetal demand of iron is increased so more iron intake is required. It is also observed that the absorption of iron from the food during pregnancy increases along with the increasing gestational week, but this occurs only if there if sufficient iron concentration in the diet. Although very rare, but incidences of anaemia causing low birth weight and pre-term birth have been reported [7].

It is very important to maintain maternal nutritional status during pregnancy since it directly affects the foetal growth prior and post-delivery. It is highly recommended to consume balanced diet during pregnancy which is described by Indian Council of Medical Research (ICMR). It is frequently observed that low or improper nutrition intake during pregnancy may lead to insufficient weight gain, pre-term delivery, still birth, IUGR, as well as increase the morbidity and mortality rates which directly affect the maternal and neonatal health [14].

In modern times, the stress is increasing day by day. Since antiquity, people have thought that the emotions and experiences of a pregnant woman impinge on her developing foetus. Maternal stress has been found to possess adverse effect on perinatal as well as future developmental outcomes. Various stressors may be responsible for causing stress in pregnant women such as various life events (death of a relative, divorce, serious illness etc.), any physical aggravations, financial, domestic or any such type of factor. Any of the stressors thus activates the hypothalamus–pituitary–adrenal cortex system (HPA axis) and the sympathetic nervous system–adrenal medulla system. Hormonal imbalance occurs within the system because of hormones like Corticotropin Releasing Hormone (CRH), Adrenocorticotropin-releasing Hormone (ACTH), cortisol, and noradrenaline release. Spontaneous abortions, structural malfunction, preeclampsia, preterm delivery and low birth weight are the general adverse outcomes of various types of stress during pregnancy [15, 16].

According to the recent estimates of third National Family Health Survey (NFHS-3, 2005–2006), more than one-third (33%) of ever-married women aged 15 ± 49 in India have a BMI below 18.5 indicating chronic nutritional deficiency (CED) or underweight, and 14.8% of women are overweight or obese. Out of 29 Indian states, in total 13 states, more than 35% of women are too thin, and the percentage of overweight are more than underweight women in the states of Delhi, Punjab, Sikkim, Kerala, that is, a significant proportion of underweight women coexisting with high rates of overweight or obese in these states. Thus, Indian women suffer from a dual burden of malnutrition, with nearly half (48%) being either too thin or overweight. On the other hand, the percentage of thinness and overweight or obese is somewhat lower for men aged 15 ± 49 (34 and 9%, respectively) than for women aged 15 ± 49 [17].

As such pregnancy and its complications can occur in any part of the world without any correlation with race or species. Various studies are conducted in India which correlate individually between various aspects of GWG and maternal pre-pregnancy BMI to preterm delivery, but no such studies are conducted in the state of Gujarat regarding the same. Hence a study was designed to investigate the correlation between GWG, pre-pregnancy BMI, haemoglobin concentrations, various stressors and diet during the period of pregnancy, with the preterm delivery. The main aim and objectives of the study were to study prevalence of underweight, overweight or obese pregnant women and GWG during pregnancy, to determine the risk of underweight, overweight or obese pre-pregnancy BMI, and other comorbidities in pregnant women, to study the correlation between Pre-pregnancy BMI as well as GWG during pregnancy and preterm birth.

2. Study methodology

2.1 Study design

This was a prospective, multi-centric study which involved pregnant women from various hospitals whose detailed information was filled in the case record form. The study involved pregnant women with gestation week ≤20 weeks.

Informed consent of the pregnant women and the permission from hospitals were study was conducted was taken. Study approval was obtained from Institutional Ethical Committee, in agreement with local legal prescriptions, for formal review and approval of the study conduct. CRF and ICF were also submitted along with this for ethics committee approval. The study proposal was approved by Institutional Ethical Committee, Nirma University (Approval No: IEC/NU/14/2).

A pre-designed case record form was used for data collection. Information on maternal and paternal demographic data, socio-economic status, education and habit was taken. Also details regarding type of family, physical or mental stress, dietary information, history regarding gravidity and parity, present data regarding last menstrual date, estimated delivery date, comorbid conditions, actual delivery date, type of delivery, infant weight and gender was noted. Details of laboratory investigations, vitals, GWG and current medications were recorded from the file of pregnant women given from respective hospitals. Weight and height were measured by standard protocol and calibrated instruments. BMI was calculated as weight (kg) divided by height (m^2).

Privacy and confidentiality of pregnant women was maintained at all levels and subject name, address or contacts was not revealed at any stage during the study.

2.2 Settings and location

Pregnant women were selected randomly from Gujarat Cancer Society Medical College, Hospital and Research Centre, Binal Maternity Nursing Home and Nanavati Maternity Hospital.

2.3 Sample size selection

Sample size calculated was 384. The sample size calculation was done based on the prevalence of pre-term delivery in pregnant women in India. Out of 384 women, study was done on 250 women due to limited time availability. Amongst them, 226 women appeared for delivery at the same hospital from which they were enrolled. So finally the data of 226 were used for the study purpose.

2.4 Sampling criteria

2.4.1 Inclusion criteria

- Women from age 19 years to 45 years.
- Women not suffering from diabetes mellitus at the time of enrolment.
- Women not suffering from hypertension at the time of enrolment
- Women who are of gestational age of not later than 20 weeks at the time of enrolment.

2.4.2 Exclusion criteria

- Women of age below 19 years and above 45 years.
- Women having previous history of epilepsy or other CNS disorders.
- Women having previous -history of any liver related disorders.

- Women with any type of cancer or previous history of any type of cancers.
- Women with pre-existing hypertension, diabetes
- Multiparous women were also not included.

2.5 Data collection tool

- Informed consent form (English and Gujarati) (Annexure IA and IB)
- Case record form (English and Gujarati) (Annexure IIA and IIB)
- Information for participants (English and Gujarati) (Annexure IIIA and IIIB)

2.6 Parameters

Following parameters were considered for occurrence of adverse pregnancy outcomes:

- Prepregnancy BMI
- GWG
- Previous obstetric history
- Diet
- Socioeconomic status
- Haemoglobin concentration

2.7 Data analysis method

After the collection of data, analysis was done by using various statistical parameters. Pearson Correlation was used to correlate the parameters with adverse pregnancy outcomes to find the significance. All continuous variables were presented as mean ± SD. Other variables were presented in the percentage of population having a specific value.

3. Results

A total of 226 pregnant women who met the inclusion and exclusion criteria's were enrolled and completed the study.

3.1 BMI distribution

It was observed during the study that out of 226 women enrolled, 44 women (19.47%) were underweight, 137 women (60.62%) were normal, 30 women (13.27%) were overweight and 15 women (6.64%) were obese. Thus maximum population was found to be normal according to BMI (**Figure 1**).

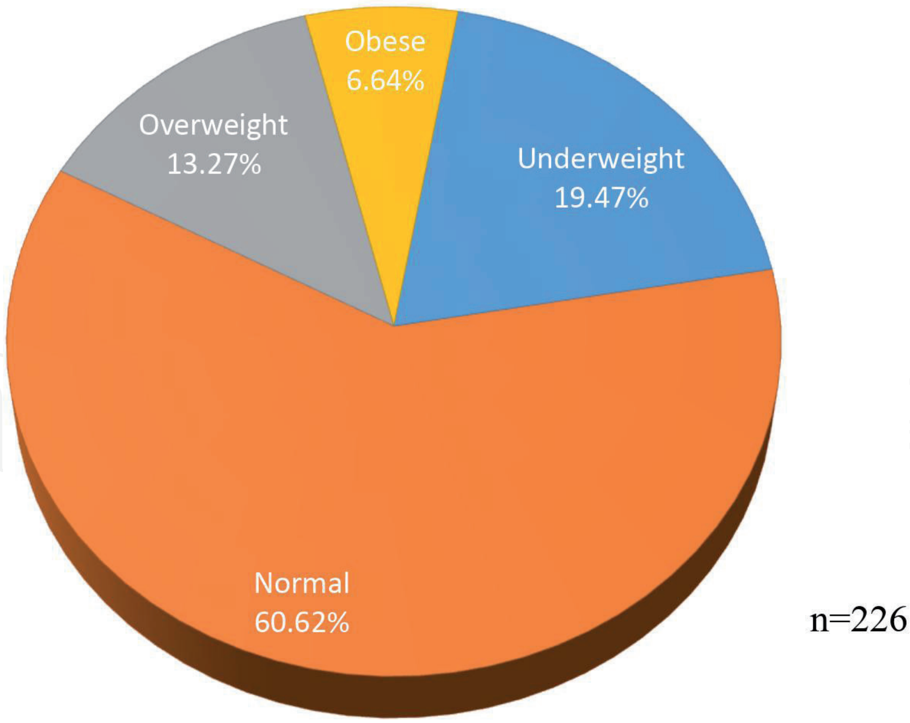

Figure 1.
Distribution of BMI ranges.

3.2 Maternal education

On grouping of maternal education with BMI, it was observed that in all the BMI ranges, there were very few subjects who were either illiterate or had just completed the primary education. Amongst underweight, 15.91% were illiterate or primarily educated, 50% had completed secondary education, and 34.09% had college or higher education completed. Within normal range, 12.41 were illiterate or primarily educated, 39.42% and 48.17% had their secondary and college or higher education completed. In overweight subjects, 23.33% were illiterate or primarily educated, 33.33% had secondary education and 43.33% had college or higher education completed respectively. In obese population, 13.33% were illiterate or primarily

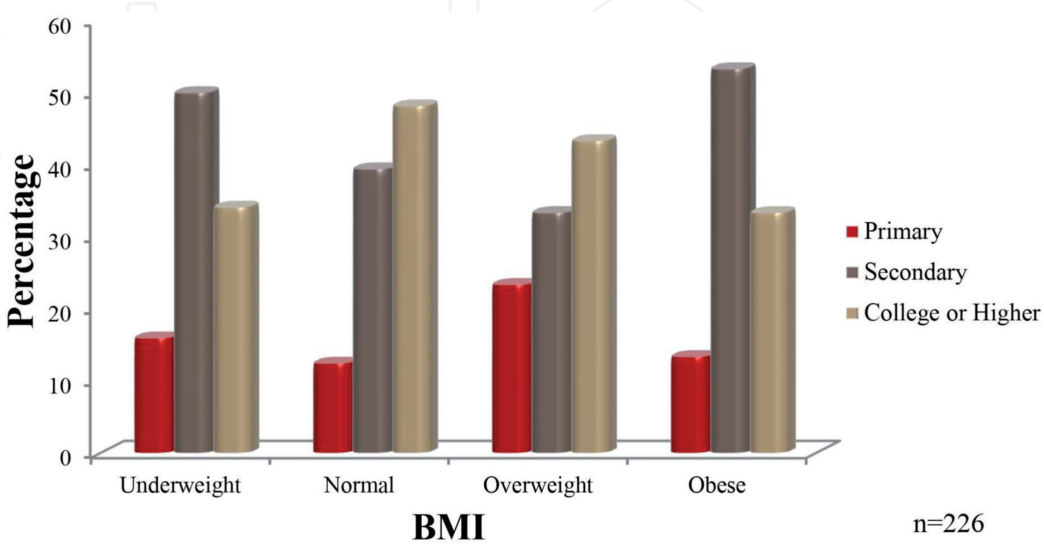

Figure 2.
Maternal education according to BMI.

educated, 53.33% had completed their secondary education and 33.33% had studied till college or higher education (**Figure 2**).

3.3 Paternal education

In paternal education also, there were more males who had their secondary or college or higher education finished compared to them who were just primary educated. In underweight population, 6.85% males were illiterate or had their primary education only. 61.36% and 31.82% had their secondary and college or higher education completed respectively. In normal BMI range, 8.03% were primarily educated, 35.77% had completed secondary education and 56.2% had completed college or higher education. In overweight class, 3.33% were illiterate or had their primary education, 40% and 56.67% had secondary and college or higher education completed. In obese population, 6.67% fathers were illiterate or primary educated, 53.33% had secondary education and 40% had college or higher education (**Figure 3**).

3.4 Total monthly income

An average subjects enrolled in all the BMI classes had their monthly income in range from 10,000-39,000. Very few had it below 5,000. In underweight population, 18.18% had monthly income below 4999, 31.82% had it between 5000–9999, 25% in 10,000-19,999, 15.91% in 20,000–39,999 and 9.09% had it above 40,000. In normal population, 11.68% had income below 4999, 19.71% between 5000–9999, 30.66% between 10,000-19,999, 27.01% between 20,000–39,999 and 10.95% above 40,000. In overweight population 13.33% were below 4999, 16.67% between 5000–9999, 30% between 10,000-19,999, 23.33% between 20–000-39,999 and 16.67% above 40,000. And in obese class, 13.33% were below 4999, 13.33% between 5000–9999, 26.67% between 10,000-19,999, 26.67% between 20,000–39,999 and 20% was above 40,000. It was found that in underweight, more subjects had income below 5,000 compared to other classes, whereas in obese, more subjects had income above 40,000 in comparison to other classes which indirectly reflected their nutritional status (**Figure 4**).

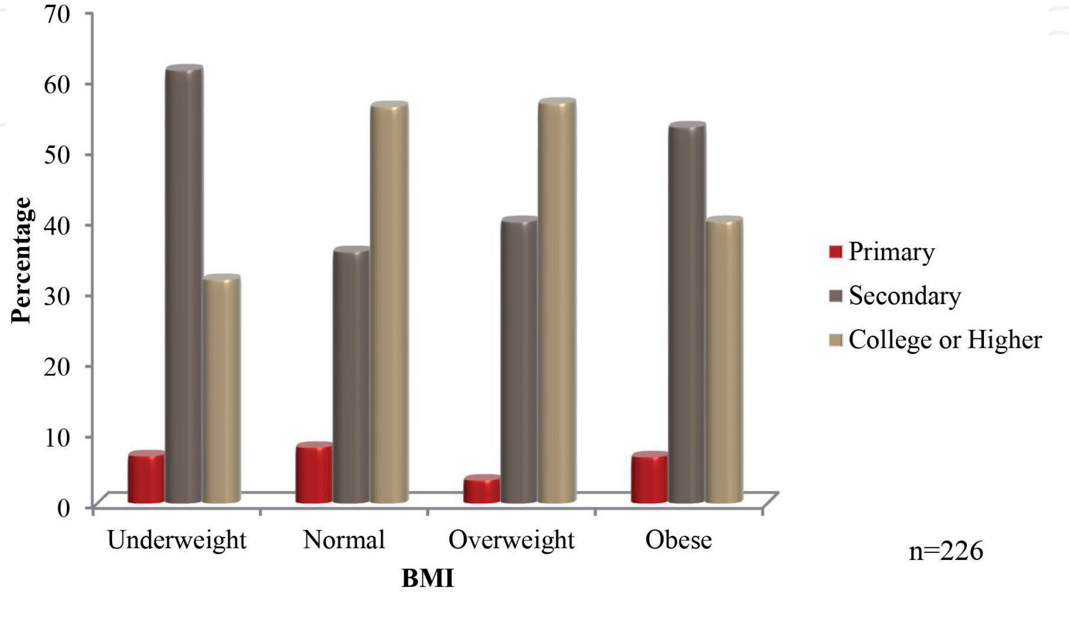

Figure 3.
Paternal education according to BMI.

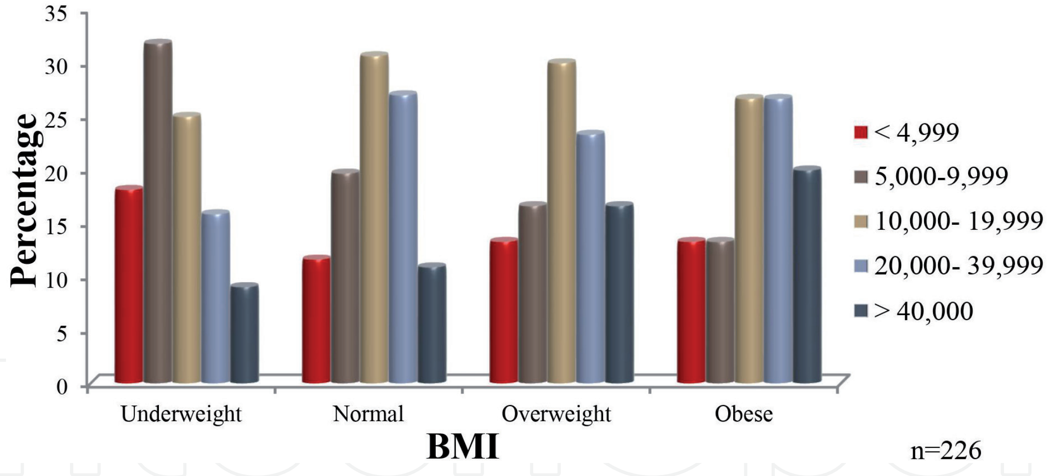

Figure 4.
Total monthly income of family according to BMI.

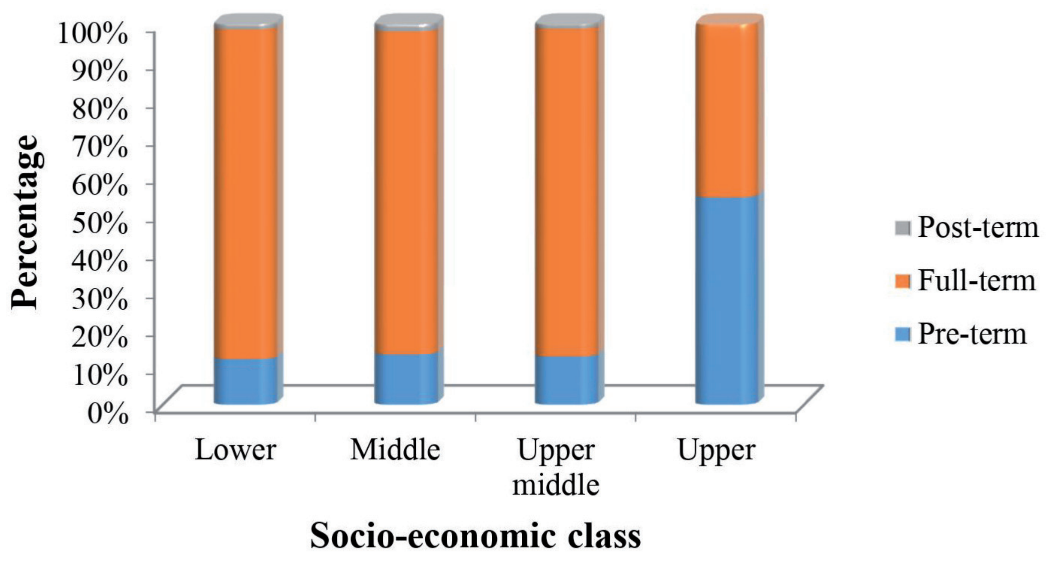

Figure 5.
Socio-economic status and term of delivery.

3.5 Socio-economic status

3.5.1 Socio-economic status and term of delivery

In present study, it was observed that in lower socio-economic class, incidence of pre-term birth (12%) was nearly equal to that observed in middle class (13.20%) and upper middle class (12.64%). But in upper socio-economic class, the incidence of pre-tem delivery was found 54.54%. In lower class, 86.67% had full-term and 1.33% had post-term delivery. In middle class, 84.90% and 1.89% had full-term and post-term delivery respectively. In upper middle class, 86.20% had full-term and 1.14% had post-term delivery. And in upper class, the rest of 45.54% had full-term delivery. A partial negative correlation (r = −0.116) was observed between socioeconomic status and term of delivery (**Figure 5**).

3.5.2 Socio-economic status and type of delivery

It was observed from the study that the frequency of normal delivery was lower in upper class compared to lower socio-economic class. In lower class, 58.67% had normal and 41.33% had caesarean section delivery. In middle class, 52.83% were having normal delivery, 43.39% were having caesarean section and 3.77 were having forcep delivery. In upper middle class, 48.27% were having normal, and 51.72% were having caesarean section delivery. And in upper class, 36.36%, 54.54% and 9.09% were having normal, caesarean section and forcep type of delivery respectively. A partial positive correlation (r = 0.177), thus is obtained between socio-economic class and type of delivery (**Figure 6**).

3.5.3 Socio-economic status and GWG

The study also showed, whether or not there is any correlation between socio-economic status and gestational weight gain. On an average, every class gained almost similar GWG. In lower class, underweight women gained 13.05 ± 2.01, normal gained 12.44 ± 1.61, overweight gained 9.88 ± 1.46 and obese gained 0.933 ± 0.58 of weight during gestational period. In middle class, underweight gained 12.5 ± 1.58, normal gained 12.1 ± 1.56, overweight gained 9.88 ± 1.55 and obese gained 9.6 ± 1.82 weight. In upper middle class women, underweight gained 13 ± 2.01, normal gained 12.48 ± 1.83, overweight gained 10.7 ± 1.06 and obese

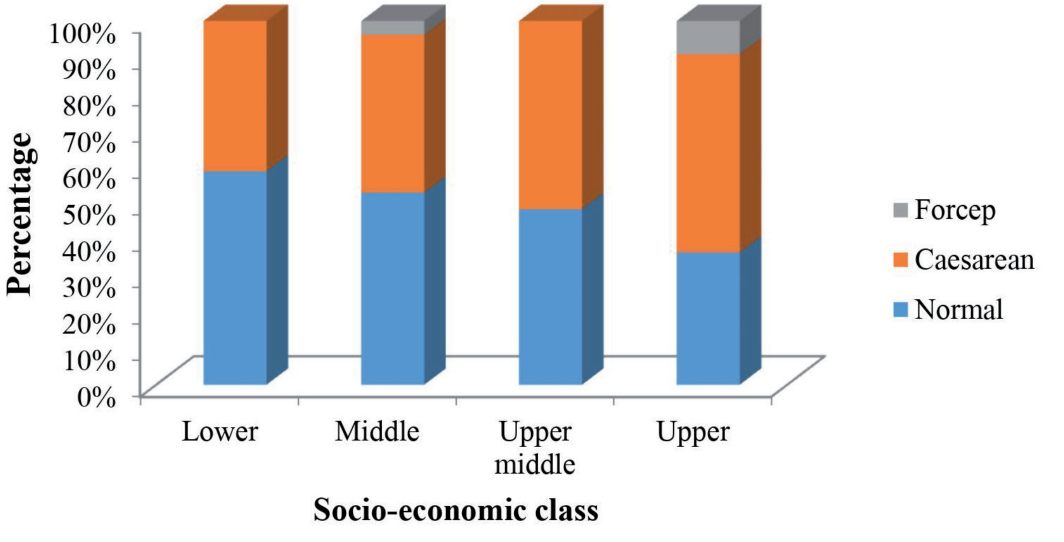

Figure 6.
Socio-economic status and type of delivery.

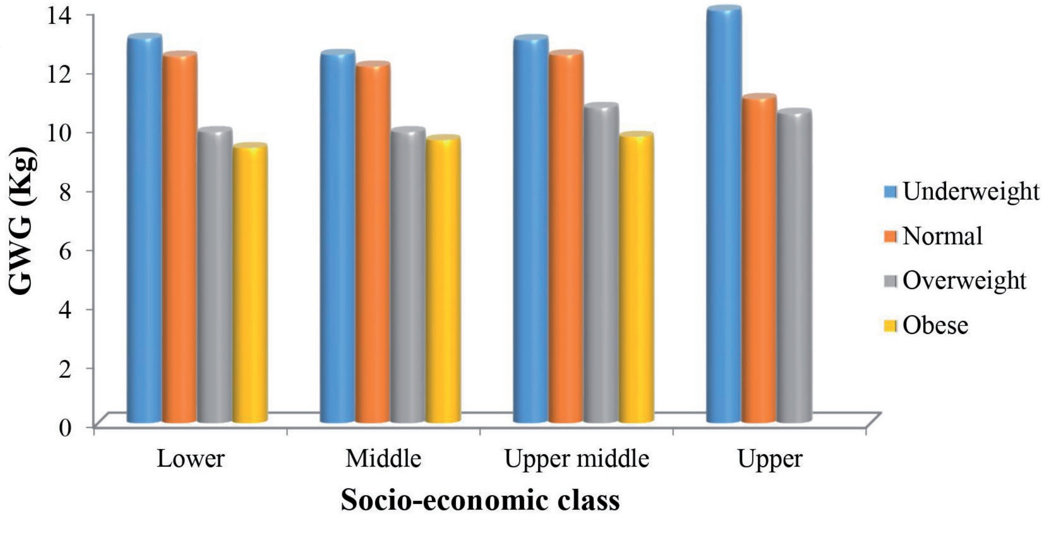

Figure 7.
Socio-economic status and GWG.

DOI: http://dx.doi.org/10.5772/intechopen.96922

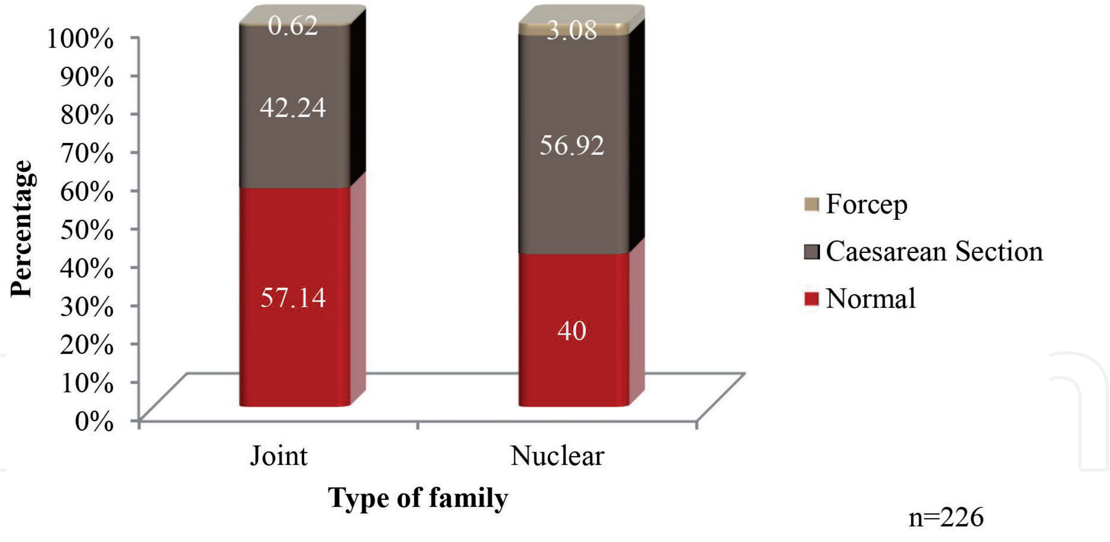

Figure 8.
Type of delivery according to type of family.

gained 9.71 ± 1.70. In obese women, underweight gained 14, overweight gained 11 ± 1.55 and overweight gained 10.5 ± 0.58 weight (**Figure 7**).

3.6 Type of family

In present study, 71.24% families were joint type and the rest 28.76% were nuclear. The incidence of caesarean delivery (56.92%) was more in nuclear family as compared to joint family (46.92%). 57.14% and 40% had normal delivery in joint and nuclear family respectively. Forcep delivery was observed in 0.62% in joint family and 3.08% in nuclear type of family. A fractional positive correlation (r = 0.16) is observed between type of family and type of delivery (**Figure 8**).

3.7 Past obstetric history

3.7.1 Previous delivery and present delivery

In present study we compared type of previous delivery(ies) to type of present delivery. It was observed that the risk of caesarean section delivery was more in women who had previous history of caesarean section. Rest 28.89% had previous caesarean section and 4.44% were such who had both type of deliveries. In women who presently had caesarean section delivery, 41.67% were having previous history of normal delivery and 58.33% were having previous history of caesarean section. In women who had previous normal delivery, 66.67% had normal delivery in present pregnancy also (**Figure 9**).

3.7.2 Number of abortions/miscarriage and term of delivery

It was observed during the study that not much of a significant correlation was observed between number of abortions/miscarriage and term of delivery. In women who had undergone no abortion/miscarriage, the incidences of pre-term, full-term and post-term delivery were 13.02%, 85.20% and 1.77% respectively. On the other hand, in females who had undergone 1 abortion/miscarriage, 20.45% had pre-term delivery and 79.54% had full-term delivery. In women who had more than 2 abortions/miscarriage, 15.38% and 84.61% had pre-term and full-term delivery respectively (**Figure 10**).

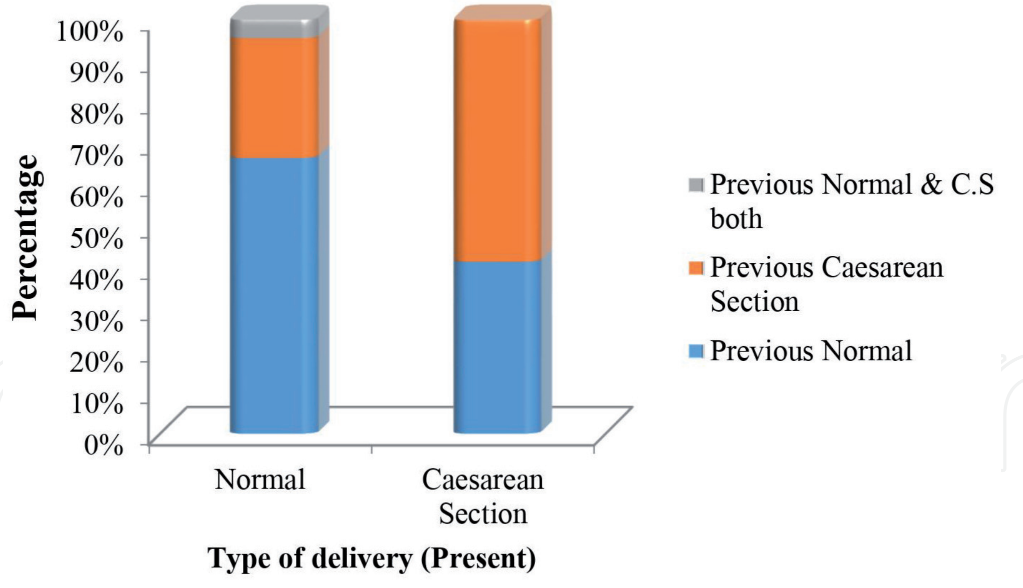

Figure 9.
Previous delivery and present delivery.

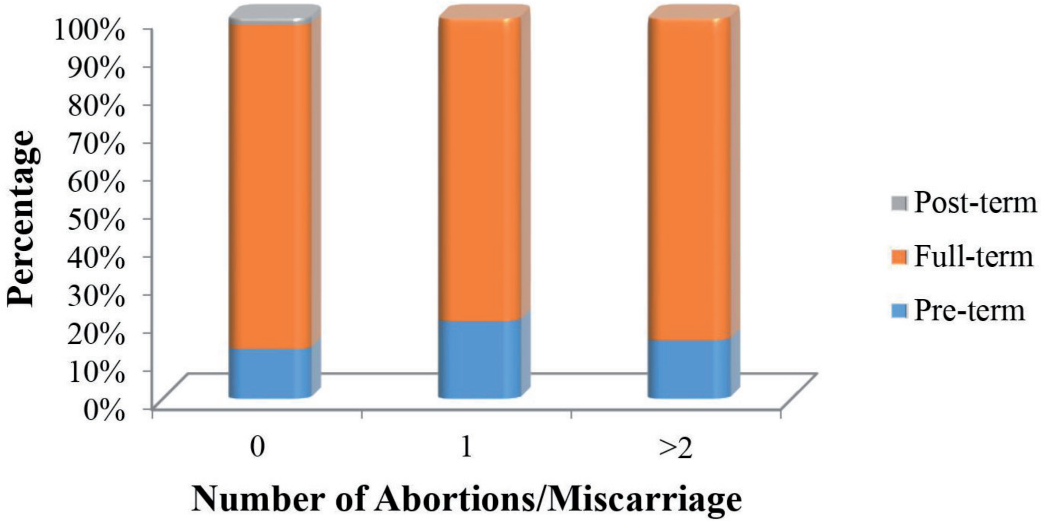

Figure 10.
Number of abortion/miscarriage and term of delivery.

3.7.3 Number of abortions/miscarriage and type of delivery

We also studied number of previous abortions/miscarriage and type of present delivery and tried to find out whether any correlation exists between the two or not. It was discovered that in women who had no history of abortion/miscarriage, 54.44% had normal delivery and 44.97% and 0.59% had caesarean section and forcep type of delivery respectively. In woman having 1 abortion/miscarriage, 47.73% had normal delivery, 47.7 had caesarean section and 4.4% had forcep delivery. And in women who had more than 2 abortions/miscarriage, 38.46% had normal delivery and 61.54% had caesarean section delivery (**Figure 11**).

3.8 Prevalance of stress

Current study showed that in underweight subjects, 50% had no stress at all. 34.09% had one type of stress. 13.64% had two types of stress and 2.27% had any 3 type of stress. In normal BMI women, 72.26% had no stress, 20.44%, 4.38% and

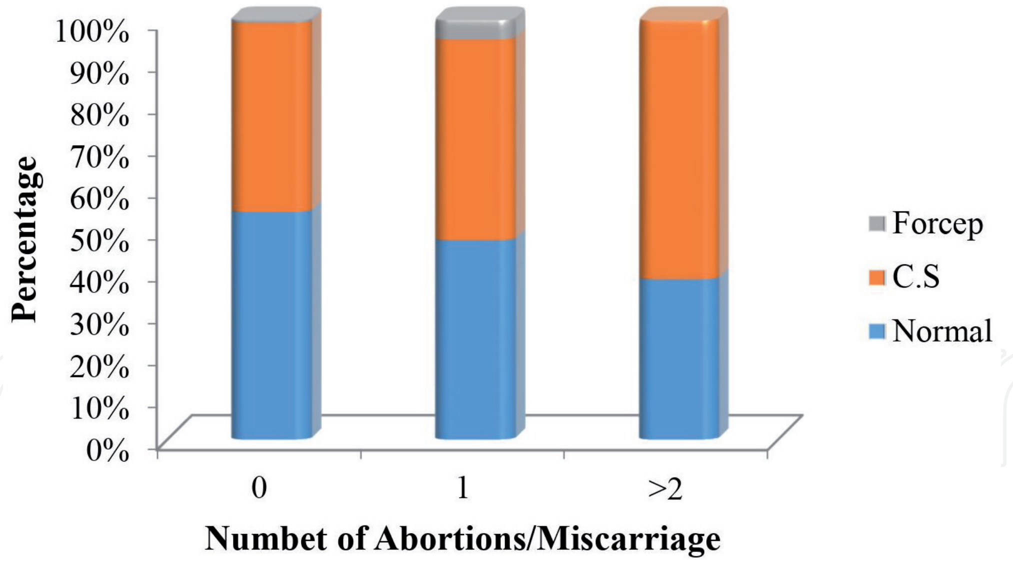

Figure 11.
Number of abortions/miscarriage and type of delivery.

2.92% had one type, two type and three type of stress respectively. In overweight women, 70% were stress free, 20% had one type and 10% had two types of stress. And in obese population, 33.33% had no stress, 40% had one type and 26.67% had two types of stress. The subjects having any 1 type of stress (physical, occupational, social, financial or pregnancy related) were more in underweight (34.09%) and obese (40%) class. The study revealed that in all BMI ranges, except obese, maximum subjects had no stress at all; whether physical or mental (**Figure 12**).

3.9 Dietary Information

3.9.1 Milk and infant birth weight

The study revealed that in women, who had consumed no milk during gestational period, 20.59% had LBW infant, 73.53% had normal and 5.88% had HBW infant. In subjects who occasionally had milk, 30.77% had LBW infant and 69.23% had normal infant birth weight. In women who had 1 glass milk daily, the incidence of LBW infant was 20.62%, normal birth weight was 75.26% and HBW was 4.12%. The mothers who drank 2 glass of milk, LBW, normal and HBW percentage was

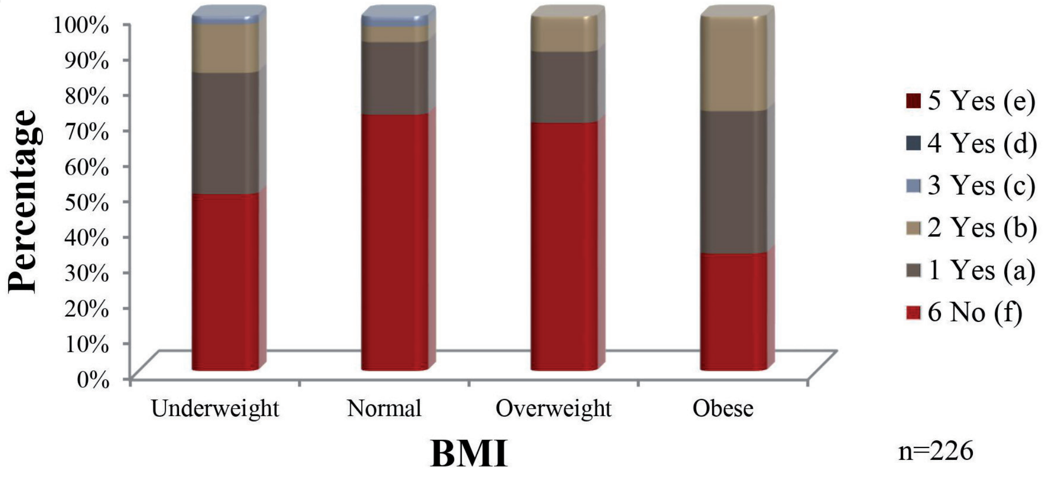

Figure 12.
Prevalence of stress according to BMI.

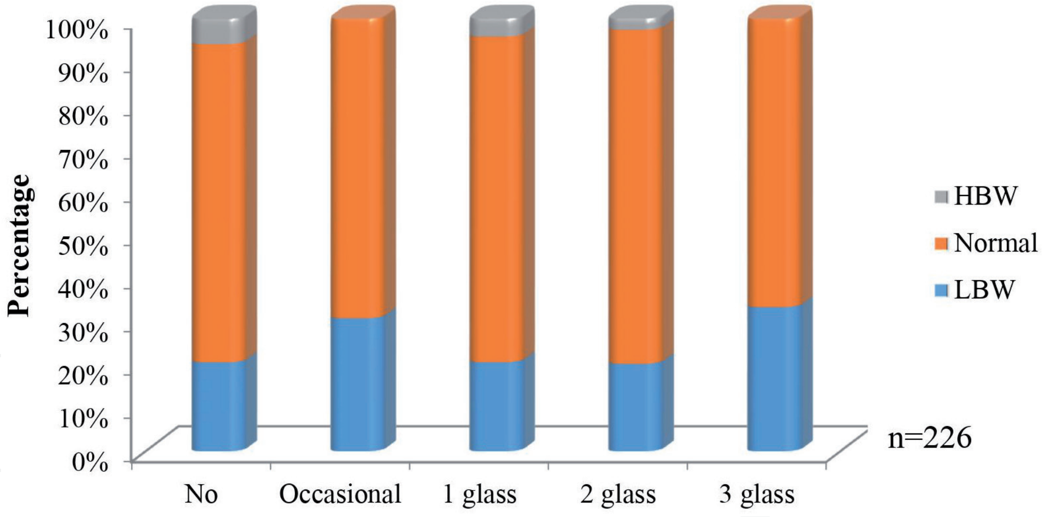

Figure 13.
Comparison of milk taken to infant birth weight.

found to be 20.25%, 77.22% and 2.53% respectively, while mothers who drank 3 glasses of milk, 33.33% were having LBW infant and 66.67% had normal infant weight. It was observed that the chances of LBW infant was less in women who had 1 or 2 glass of milk compared to them who had no milk or occasionally had milk (**Figure 13**).

3.9.2 Fruits and infant birth weight

It was observed in the study that 23.53% women who had no fruits during the gestational period were having LBW infant and 76.47% were having normal infant weight. In subjects who occasionally ate fruits, 23.29% were having LBW 76.71% normal birth weight infants. In women who had atleast 1 fruit the chances of LBW was 19.32%, normal birth weight was 74.62% and HBW was 6.15%. In women taking more than 1 fruit daily, 33.33% had LBW and 66.67% had normal birth weight infants. It is observed that the chances of LBW infant are comparatively less in women taking 1 fruit daily (**Figure 14**).

3.9.3 Junk food and infant birth weight

The frequency of junk food whether affects the infant birth weight was also determined in the study. It was found that in women taking no junk food at all, the chances of LBW were 16.39% and normal birth weight and HBW are 78.69% and 4.92% respectively. In women taking junk food once a month there were 22.33% LBW, 74.76% normal birth weight and 2.91% HBW infants. In women who took junk food every 15 days (fortnight), 25.58% were LBW, 72.09 were normal weight and 2.33% were HBW infants. Subjects who had junk food once or twice a week, 21.05%, 73.68% and 5.26% infants were LBW, normal weight and HBW respectively (**Figure 15**).

3.9.4 Diet and type of delivery

It was also observed that amongst women taking 1 glass milk daily (42.92%), about 55.67% of had normal type of delivery. Amongst women taking 1 fruit daily (57.52%), 53% women had normal delivery. No correlation was observed between junk food frequency and type of delivery.

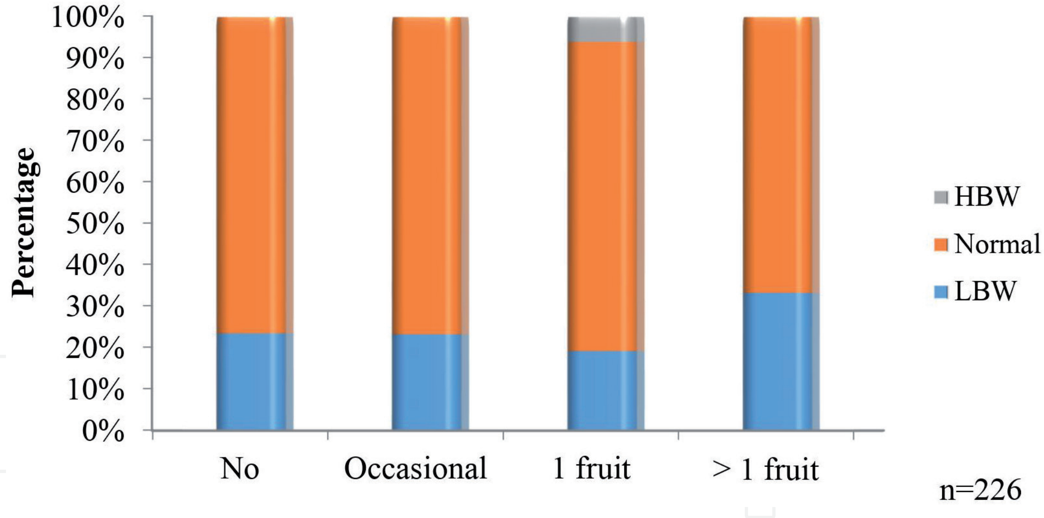

Figure 14.
Comparison of intake of fruits to infant birth weight.

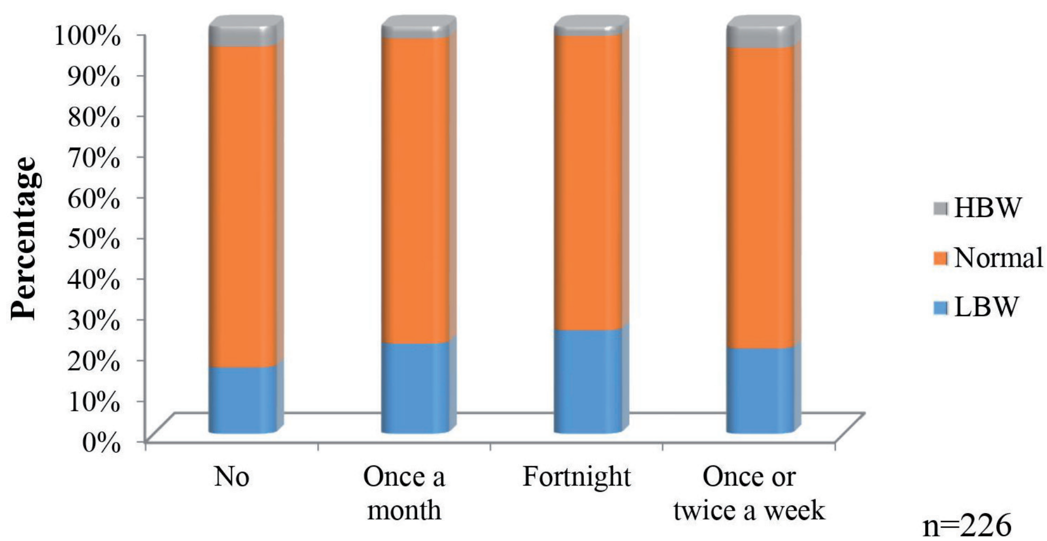

Figure 15.
Comparison of junk food to infant birth weight.

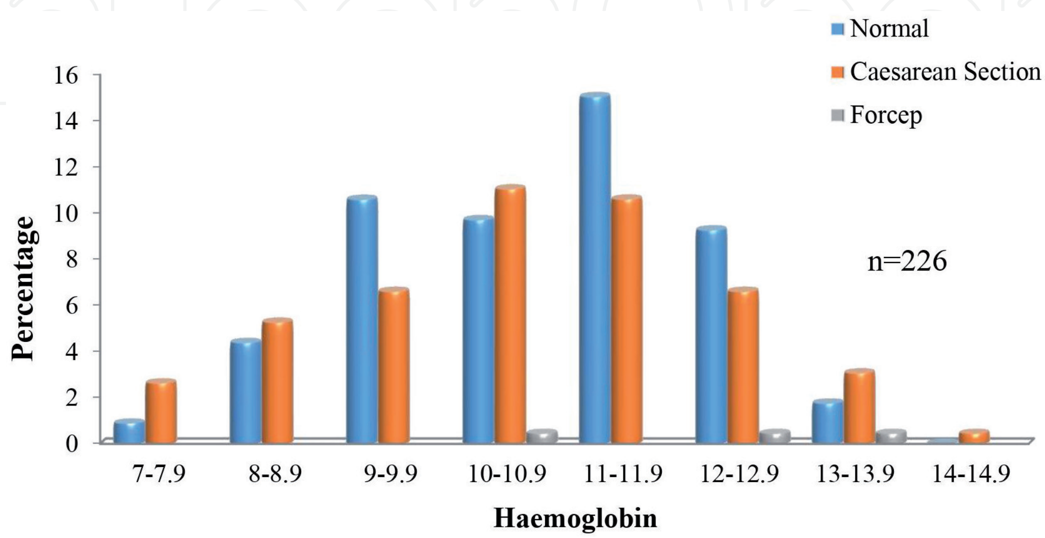

Figure 16.
Haemoglobin and type of delivery.

3.10 Haemoglobin

3.10.1 Haemoglobin and Type of delivery

From the present study it was spotted that an insignificant decrease in risk of caesarean delivery was observed with increase in maternal haemoglobin level from 9.0 gm/dl till 12.0 gm/dl (**Figure 16**).

3.10.2 Haemoglobin and GWG

No specific correlation was obtained between maternal haemoglobin concentration and GWG, as well as maternal haemoglobin concentration and term of delivery. It was observed that maximum weight gain is seen in the haemoglobin range 9.0–11.9 g/dl (**Figure 17**).

3.10.3 Haemoglobin and term of delivery

No exact correlation between haemoglobin level and term of delivery was observed within the current study. Maximum percentage of pre-term deliveries are observed within haemoglobin range 10–12.9 g/dl. As a fact it may be due to reason that this range contains maximum number of population (**Figure 18**).

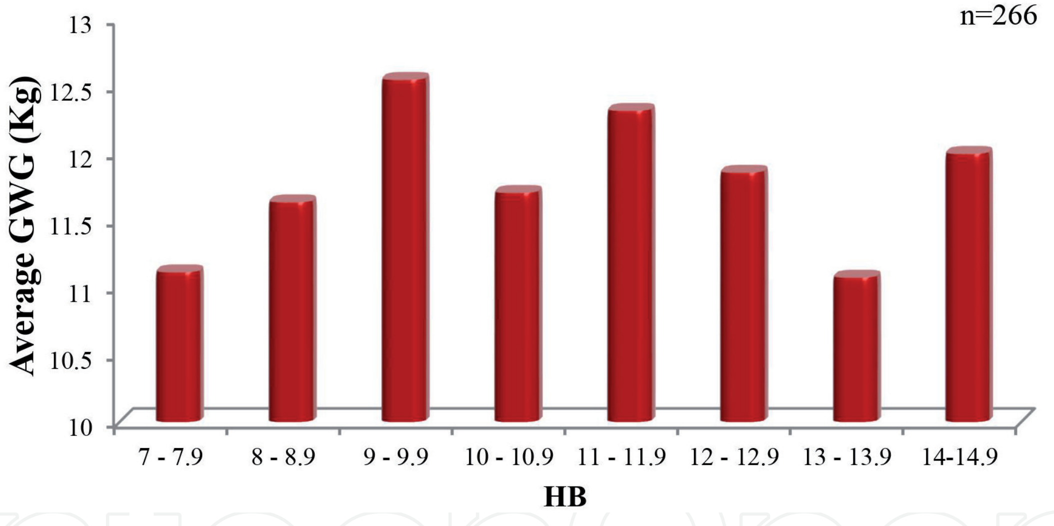

Figure 17.
Haemoglobin and average GWG.

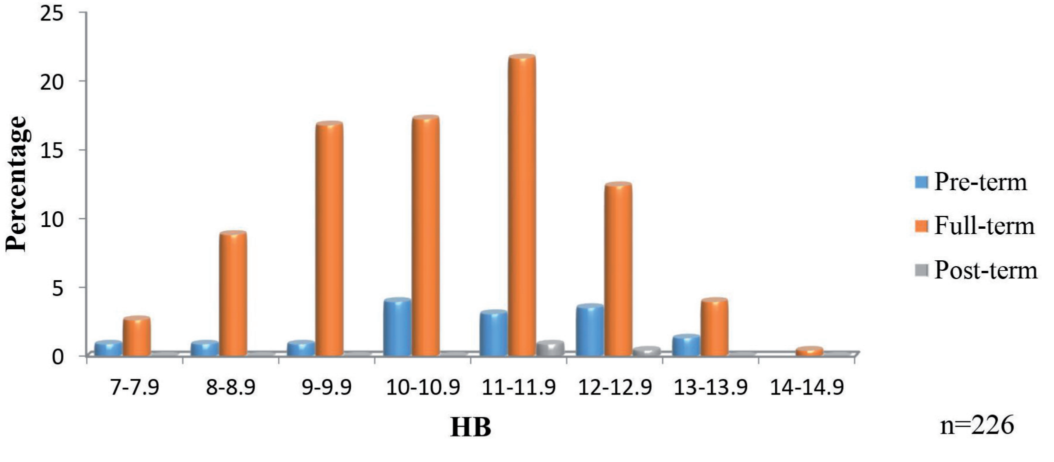

Figure 18.
Haemoglobin and term of delivery.

3.11 GWG

3.11.1 GWG according to BMI

The gestational weight gain observed in each BMI class was almost in accordance with that provided by IOM. Average weight gain observed in underweight was 12.93 ± 1.90, in normal 12.32 ± 1.71, in overweight 10.23 ± 1.28 and in obese 9.6 ± 1.50. A partial negative correlation (r = −0.474) was found between GWG and pre-pregnancy BMI, i.e. as pre-pregnancy BMI increases, the GWG decreases (**Figure 19**).

3.11.2 GWG and infant birth weight

It was observed that there is increase in infant birth weight as the GWG increases. But the increase is very minimal on observation. Thus as a fact, no correlation was obtained between GWG and infant birth weight.

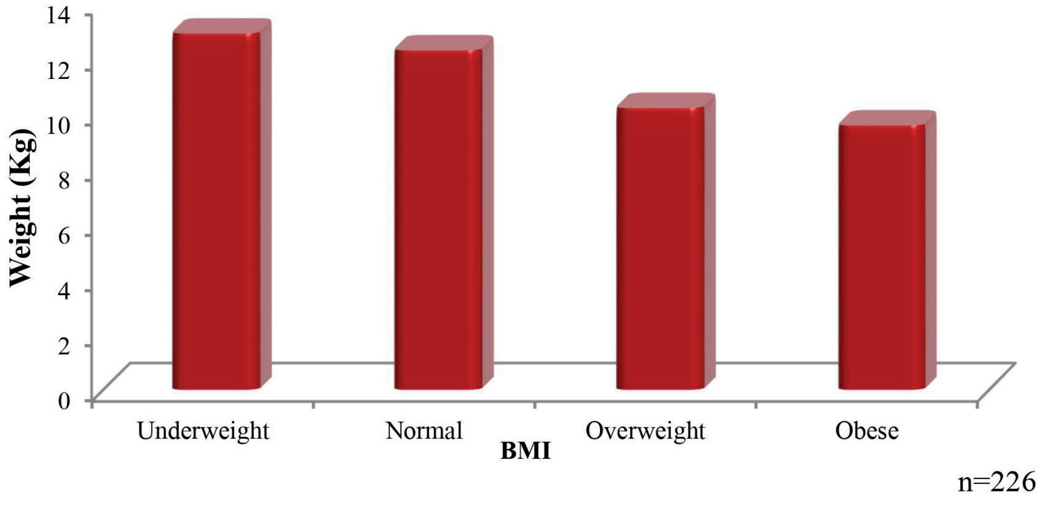

Figure 19.
Average GWG according to BMI.

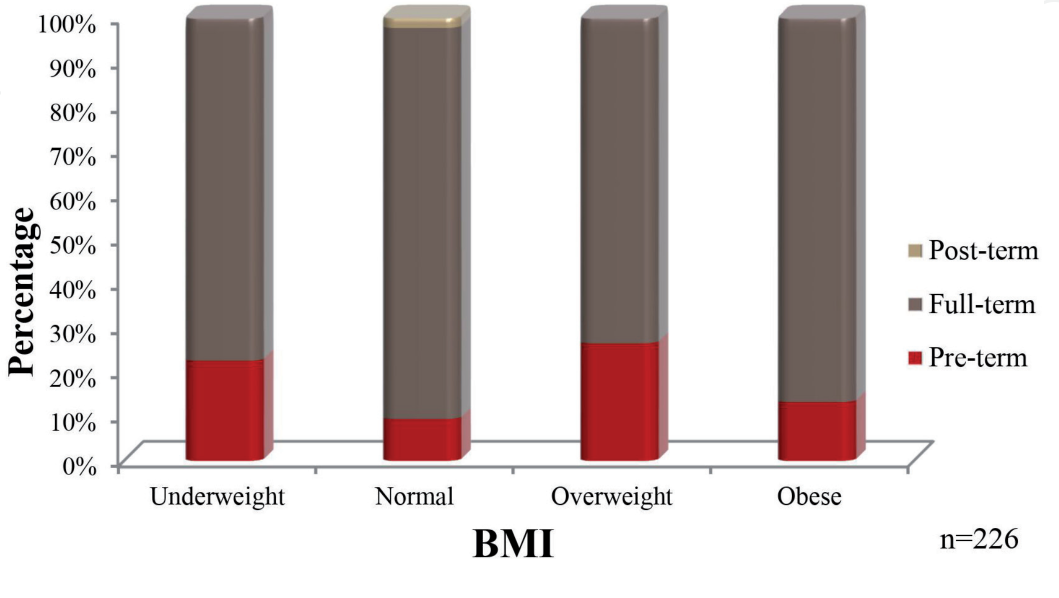

Figure 20.
Term of delivery according to BMI.

3.12 Term of delivery

The term of delivery is definitely affected by the pre-pregnancy BMI. In our study, in underweight women, 22.73% were pre-term and 77.28% were full-term deliveries. In normal BMI range, 9.49%, 88.32% and 2.19% were pre-term, full-term and post-term deliveries respectively. In overweight women, 26.67% were pre-term and 73.33 were full-term deliveries. In obese women, a total of 13.33% deliveries were pre-term and the rest of 86.67% were normal deliveries respectively. A partial positive correlation (r = 0.166) was found between term of delivery and pre-pregnancy BMI (**Figure 20**).

3.13 Infant weight

3.13.1 Maternal BMI and average infant birth weight

The association between maternal pre-pregnancy BMI and infant birth weight was clearly seen in the current study. The average weight in infant during birth is as shown in **Figure 21**. It is observed that highest birth weight is obtained in obese

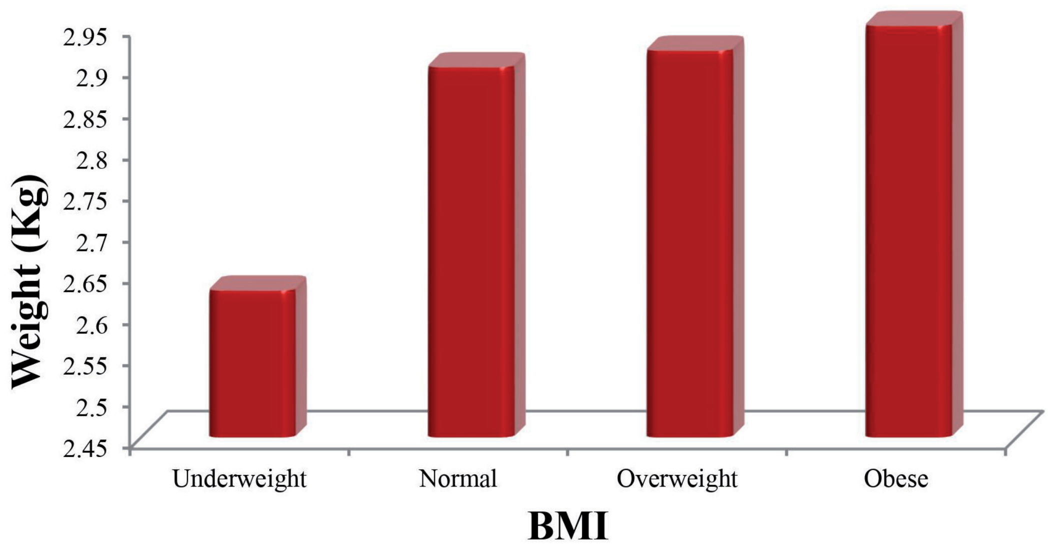

Figure 21.
Maternal BMI and average infant birth weight.

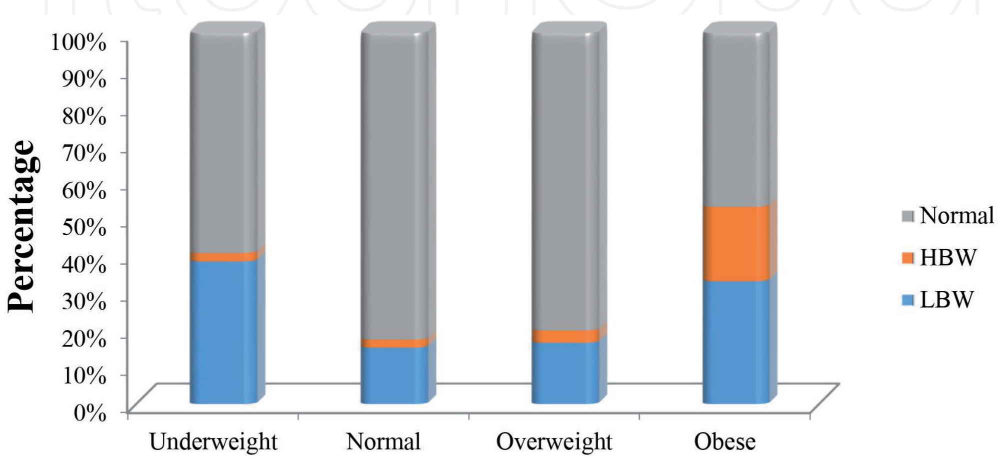

Figure 22.
Maternal BMI and average infant birth weight range.

women, which decreases as the maternal BMI range decreases. A partial positive correlation (r = 0.147) between pre-pregnancy BMI and infant birth weight.

3.13.2 Maternal BMI and infant birth weight range

An infant may have LBW, normal birth weight or HBW depending upon individual maternal gestational weight gain and other conditions. In our study, it was observed that in underweight women, 38.64% neonates are LBW, 2.27 with HBW and 59.09% with normal weight. In mothers with normal BMI, the infants born were 15.33%, 2.19% and 82.48% LBW, HBW and normal birth weight. In overweight women, 16.67% were LBW, 3.33% were normal birth weight and 80% were HBW infants. In obese population, 33.33%, 20% and 46.67% were LBW, normal birth weight and HBW infants respectively. A partial positive correlation (r = 0.16) is observed between maternal pre-pregnancy BMI and infant birth weight range (**Figure 22**).

4. Discussion

Different studies have been conducted in different parts of India, thus correlating pre-pregnancy BMI and GWG with the pregnancy outcomes. But very few or we can say no study have been conducted in Gujarat region which covers all such parameters affecting pregnancy. Thus we had conducted such as study which determines the prevalence and risk factors for BMI ranges like underweight, normal, overweight and obese. And also studies the GWG and correlation between GWG, pre-pregnancy BMI and different pregnancy outcomes. So we conducted a prospective, multicentric study including pregnant women in Ahmedabad for getting a better idea regarding GWG and pre-pregnancy BMI.

Our study possesses maximum population (62%) in normal BMI range followed by underweight, then overweight and finally least population was in obese BMI. A similar distribution of pre-pregnancy BMI was observed in a study conducted in Maharashtra in 2013, where amongst 400 pregnant women more than 50% had normal BMI and less than 10% population was found obese [18].

It was observed that in all the BMI ranges, there were more of women who had completed secondary or college or higher education compared to primary education. Same as that, there were nearly <10% males in all population range who either illiterate or were just primarily educated.

In present study, the upper socio-economic class showed higher incidences of pre-term delivery. A partial negative (r = −0.116) was observed between socio-economic status and term of delivery. In a similar study conducted by Wood et al., observed a modest increase in the risk of spontaneous preterm birth with low socio-economic status [19]. Regarding socio-economic status and type of delivery, decreasing incidence of normal delivery was observed from lower to upper socio-economic class. A partial positive correlation (r = 0.177), thus is obtained between socio-economic class and type of delivery.

Unlike this, a study by Gissler et al., concluded that women with the lowest socio-economic status were more likely to give birth by caesarean section delivery, indicating that increase in pregnancy complications increases the need for the same [20]. Socio-economic status showed no significant correlation to GWG. On an average, every BMI range belonging to every socio-economic class gained similar gestational weight during pregnancy. In contrast to this, a study by Andersson et al., observed that the mothers belonging to low socio-economic class gained only 5.5 kg weight during pregnancy while women from affluent societies gain about 12.5 kg.

They stated that the low gestational weight gain in low socio-economic family may be due to lack of food [21].

During our study, it was found that the incidence of caesarean type of delivery was more in nuclear family as compared to joint family. A fractional positive correlation ($r = 0.16$) was observed between type of family and type of delivery. Whereas in a study by Kilic, observed no correlation between type of family and type of delivery [22].

It was observed during the study that in women with previous caesarean section delivery, the risk of current delivery to be of caesarean section type increases. No significant correlation was observed between number of abortions/miscarriage and term of delivery. It was observed that as the number of abortions/miscarriage increases, the chances of caesarean section increases. Bhattacharya et al. [23], observed that the risk of preterm birth after abortion/miscarriage is lower than that after miscarriage but higher than that in a first pregnancy or after a previous live birth. This risk is not increased further in women who undergo two or more consecutive abortions [23]. Also in our study the incidence of increase in caesarean section and decrease in normal type of delivery is observed on increase in number of abortions.

Regarding stress, a partial positive correlation is observed in physical stress and GWG ($r = 0.115$) and type of delivery ($r = 0.10$). Thus as stress increase, there is increase in GWG. There is no correlation of physical stress with infant birth weight, whereas a negative partial correlation ($r = -0.13$) is observed with term of delivery. Any type of mental stress has no correlation with any of the outcomes such as GWG, type of delivery, term of delivery or infant birth weight. Study by Dole et al., stated that any psychosocial stress or anxiety is related to risk of pre-term delivery [24] another study by Zhu et al., observed that prenatal severe life events may increase the risk of pre-term birth or low birth weight infant [25].

The present study concluded that the risk of LBW infant in women who consumed 1 or 2 glass of milk daily was comparatively less than women who did not consumed milk at all. Also the risk of LBW infant decreases if minimum of 1 fruit is consumed everyday. No major deviation was observed in women who ate junk food as compared to them who did not have it. The occurrence of normal delivery is high in women consuming 1 glass of milk and 1 fruit daily.

Statistically no correlation was obtained between haemoglobin level and type of delivery. This is in contrast to the results obtained by Francis et al., who reported a significant relationship between maternal haemoglobin level and type of delivery [26]. It was observed during the study that no specific correlation occurs between haemoglobin level and term of delivery. A similar non-correlation was obtained between haemoglobin and term of delivery in a meta-analysis performed by Haider et al. [27] and Koura et al. [28]. Whereas a study by Bakhtiar et al. [29], observed that decrease in haemoglobin concentration can cause pre-term birth. No correlation was observed in present study between haemoglobin level and GWG [29]. Also no correlation has been found between haemoglobin level and GWG.

In our study a partial negative correlation (-0.474) was observed between GWG and pre-pregnancy BMI. As pre-pregnancy BMI increases, the gestational weight gain decreases. This is in contrast to study performed by Joshi et al. 2013, where they obtained significant association between prepregnancy BMI and GWG ($P < 0.001$). They suggested that the women with normal pre-pregnancy BMI gained adequate weight while women with low BMI gained inadequate weight and high BMI patients tend to move towards increased weight gain [18]. Another study by Montpetit et al., also observed a positive correlation ($r = 0.35$, $P = 0.007$) between pre-pregnancy BMI and GWG [30]. Unlike this, a study by Nohr et al. 2008, found high variation in weight gain, and it also increased across BMI groups. They observed that nearly 50% of underweight and normal weight women gained 10–15 kg, and that the low gain was more common among overweight and obese women than among underweight and normal weight women, and also that 40% of the obese women gained <10 kg [4].

The study shows a partial positive correlation (r = 0.421) between GWG and infant birth weight. However, a study by Chiba et al., observed no correlation between birth weight and GWG [31]. On contrary, a study by Mamun et al., found that mothers who gained excessive weight were more likely to have had higher birth weight infants [12]. A study by Rao et al., also found that with an increase in weight gain during pregnancy from 5 to 11 kg or more, there was a corresponding increase in mean birth weight. This increase was statistically significant (P < 0.05) [32].

Present study shows partial positive correlation (r = 0.166) between term of delivery and pre-pregnancy BMI. Various studies have been suggestive of effect of BMI on term of delivery. A study by Li et al. [3], suggested a positive association between maternal pre-pregnancy BMI and pre-term delivery (P < 0.001). Another study by Simas et al. also concluded the same association between BMI and term of delivery [11].

Present study found that the incidence of LBW (33.33%) and HBW (20%) was more in obese women compared to women with normal or underweight BMI. A study in Gorakhpur analysed maternal and foetal complications in overweight and obese women and observed that macrosomia and LBW were significantly (<0.05) more in overweight and obese women in contrast to normal BMI women [33]. Another study by Prabha et al. 2014, noted that LBW seemed to be more common with higher BMI groups; it was found to be non-significant after adjusting for confounders. However, macrosomia was more common and significant in the overweight and obese groups with ORs of 3.36 (95% CI: 1.51–7.49) and 8.30 (95% CI: 2.99–23.03) respectively, compared with the normal BMI group [34].

5. Conclusion

The percentage of pregnant women with normal BMI range is maximum followed by underweight, overweight and obese in Ahmedabad region. A partial negative co-relation was observed between socio-economic status and term of delivery. Moreover, there was a partial positive association of socio-economic class and type of family with type of delivery. In the women with previous caesarean section delivery, the risk of current delivery to be of caesarean section type increases. Additionally, it was observed that as the number of abortions/miscarriage increases, the chances of caesarean section increases. A negative partial correlation of physical stress is observed with term of delivery. Stress and dietary habits too modify the term of delivery, type of delivery and infant birth weight. As pre-pregnancy BMI increases, term of delivery decreases. As GWG decreases, the infant birth weight decreases. Present study found that the incidence of LBW and HBW was more in obese women compared to women with normal or underweight BMI.

Abbreviations

BMI	Body Mass Index
GWG	Gestational Weight Gain
HBW	high Birth Weight
LBW	Low Birth Weight
LGA	Large for Gestational Age
SGA	Small for Gestational Age

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