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# The Impact of Inappropriate Gestational Weight Gain on Pregnancy, Delivery, and Neonatal Outcomes

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RUNNING HEAD: GESTATIONAL WEIGHT GAIN

The Impact of Inappropriate Gestational Weight Gain on Pregnancy, Delivery, and Neonatal  
Outcomes

Thesis submitted in partial fulfillment of University Honors

By

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## Abstract

Inappropriate weight gain during pregnancy is a widespread problem associated with adverse maternal and newborn outcomes. This study's objective was to examine the impact of gestational weight gain (GWG) above and below the Institute of Medicine (IOM) guidelines on pregnancy, delivery, and newborn outcomes in a rural population. Women were recruited at the first prenatal visit, and data was collected through research interviews and examination of prenatal and delivery medical records. Prepregnancy weight and weight at delivery were obtained, and the final sample (n=913) was restricted to women with singleton pregnancies. Participants were categorized by prepregnancy body mass index (BMI) and GWG above, within, or below IOM guidelines based on gestational length. After controlling for pregnancy smoking, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to identify significant outcomes associated with high or low weight gain, with normal GWG as the control. Of the 913 participants, 208 (22.8%) had inadequate GWG, 255 (27.9%) gained within the recommended range, and 450 (49.3%) gained more than recommended. Inadequate GWG was associated with delivery before 39 weeks, oxygen administration to the infant, admission to the neonatal intensive care unit (NICU), and a hospital stay longer than seven days. Excess GWG was associated with preeclampsia, pregnancy-induced hypertension (PIH), gestational diabetes mellitus, cesarean delivery, labor longer than 12 hours, macrosomia, and large-for-gestational-age (LGA) infants. GWG outside IOM guidelines was prevalent in the sample and associated with numerous adverse outcomes, suggesting a need for increased awareness and improved management of GWG in this population.

*Keywords:* gestational weight gain, body mass index, pregnancy outcomes

The Impact of Inappropriate Gestational Weight Gain on Pregnancy, Delivery, and Neonatal  
Outcomes

**Introduction**

Towards the end of the twentieth century, addressing proper pregnancy nutrition became an important part of prenatal care. The Institute of Medicine (IOM) partnered with the Food and Nutrition Board (FNB) to address a knowledge gap in this area by examining and interpreting existing evidence for the development of guidelines for appropriate gestational weight gain (GWG). Up to this point, all pregnant women had been advised to gain the same amount of weight, regardless of prepregnancy weight status. However, the IOM recognized the need to tailor gestational weight gain based on a woman's prepregnancy body mass index (BMI), and this was reflected in the guidelines released in 1990. The IOM also encouraged further research so that the impact of GWG could be more fully and accurately understood (National Research Council, 1990).

In the years following the release of the 1990 guidelines, the body of research on GWG began to grow, and changes were noted in the United States' population of pregnant women. In 2009, the IOM released a new set of guidelines for weight gain during pregnancy in response to overall increases in both prepregnancy BMI and GWG, as well as demographic changes in the United States' pregnant population. These updated guidelines were based on the World Health Organization's classification of body mass index and recommend a more precise and narrow weight gain range for obese women than that proposed by previous guidelines (IOM, 2009). The 2009 IOM guidelines are presented in Table 1.

Research reveals that relatively few women meet the IOM's guidelines for gestational weight gain. The Centers for Disease Control and Prevention (CDC) found in their *Pregnancy Nutrition Surveillance 2010 Report* that among low-income women enrolled in public health programs in the United States, 30.6% met the IOM's guidelines for GWG, 21.5% gained below recommendations, and 48.0% gained above (Dalenius et al.). Meanwhile, other research has revealed even more alarming results. A study by Johnson et al in 2013 found that, of the 8,293 pregnancies examined, only 17.5% gained within IOM guidelines for weight gain, with 73% gaining above, and 9.5% gaining below the recommended amount. The Screening for Pregnancy Endpoints (SCOPE) study conducted in Ireland, New Zealand, and Australia obtained similar results, with 74.3% of participants having high GWG, 8.6% having low GWG, and only 17.2% achieving the recommended GWG (Chung et al., 2012). Overweight and obese women in particular are found to be more likely to gain above IOM recommendations (Dalenius et al., 2010; Chung et al., 2012).

The IOM formulated GWG guidelines with the purpose of minimizing negative outcomes for both mothers and newborns, and many subsequent studies found that, when followed, the guidelines effectively achieve this goal. The CDC endorsed the IOM's recommendations in their *Pregnancy Nutrition Surveillance 2010 Report*, stating that GWG outside of the IOM's recommended ranges results in adverse maternal and neonatal outcomes. The report found that gaining below the recommended amount increases the risk of delivering a low-birth-weight (LBW) infant, as well as preterm birth. Meanwhile, gaining above the recommended range increases the risk of high birth weight (HBW), which may cause complications during delivery (Dalenius et al., 2010). Numerous other studies found that falling above or below the IOM guidelines is associated with significant harms. Research conducted by Liu et al. on 292,568

pregnancies in China revealed an association between low GWG and an increased risk of LBW and small-for-gestational-age (SGA) infants, as well as newborn asphyxia (2012). Similarly, Harper et al. found that inadequate weight gain in adolescents increased the risk of preterm delivery, SGA infants, and infant death (2011). Excess GWG has also been linked to various adverse pregnancy, delivery, and newborn outcomes. Johnson et al. reported that women who gained more than recommended by the IOM were more likely to experience gestational hypertension and preeclampsia, require delivery by cesarean section, and give birth to LGA infants (2013), and Harper et al. found similar outcomes in adolescents (2011). Alberico et al. found that excess GWG was an independent predictor of macrosomia (2014). In addition, excess GWG is associated with the development of gestational diabetes mellitus and prolonged hospital stay (Mamun et al., 2011).

Although many studies support the IOM guidelines for GWG, research has not shown unanimous agreement with the recommendations. Disputes have arisen particularly concerning the appropriateness of the IOM guidelines for obese women, with additional uncertainty regarding adolescents. The American College of Obstetricians and Gynecologists (ACOG) has made strong claims against the suitability of the IOM guidelines for obese women of varying degrees of severity, particularly the morbidly obese. ACOG asserts that overweight women with low GWG but a properly developing fetus should not be encouraged to increase weight gain simply to meet IOM recommendations. Instead, they propose an individualized care plan for overweight and obese women based on clinical judgment that balances fetal and maternal complications related to GWG (Committee on Obstetric Practice, 2013). Other research backs the ACOG in their dissent from the IOM's guidelines for overweight and obese women, finding that lower GWG among these women decreases the occurrence of cesarean delivery, LGA,

macrosomia, and gestational hypertension (Blomberg, 2011; Yee et al., 2013). Some studies recommend the formulation of individual guidelines for each class of obesity (Bodnar et al., 2010; Hinkle et al., 2010), while another suggests different rates of gain for different trimesters of pregnancy (Drehmer et al., 2013).

One study also questioned the appropriateness of the IOM guidelines for adolescents, finding that those who gained more than recommended were at a lower risk of SGA and preterm delivery, and obese adolescents in particular were at a decreased risk of infant death with excess GWG compared to weight gain within the recommended range. However, excess GWG increased the odds of preeclampsia, LGA, and cesarean delivery (Harper et al., 2011). Risks and benefits coexist with GWG outside the IOM's recommendations, and additional research is needed before a consensus can be reached on the appropriateness of the IOM's guidelines and the consequences of failing to follow them. The purpose of this study is to examine the impact of inadequate and excess GWG, as defined by the IOM, on various pregnancy, delivery, and newborn outcomes in the rural population of Northeast Tennessee.

## **Methods**

### **Participants**

Study participants were recruited from five prenatal practices in rural Southern Appalachia over a four year period. All women entering prenatal care at three of the five practices were eligible, with only current or former smokers eligible at the other two (due to recruitment criteria for the larger research project from which this sample and data set are drawn).

### **Procedure and Measures**

At the first prenatal visit the project was explained by study staff, and those patients who were interested completed informed consent. Participants completed an initial research interview within two weeks of recruitment, and a second during the third trimester. Research interviews included demographic assessment and detailed smoking surveys. At delivery, prenatal medical charts and hospital delivery charts were reviewed for pregnancy and birth outcomes.

Using pre-pregnancy weight, BMI, and weight at delivery information extracted from the medical charts, participants were classified on GWG status using 2009 IOM guidelines (Table 1). For women who delivered prior to 39 weeks, recommended weight gain was adjusted for length of pregnancy (Beyerlein, 2010; Crane, 2009). Three groups were created: gained below guidelines, gained within guidelines, and gained above guidelines.

### **Data Analysis**

Descriptive statistics were used to describe the characteristics of the sample. Analysis of variance (continuous variables) and chi-square analysis (categorical variables) were used to examine differences between the three GWG status groups on background characteristics. Logistic regression analysis, controlling for smoking status (the only background characteristic associated ( $p > .10$ ) with GWG status), was used to compare the three GWG status groups on pregnancy, delivery, and newborn outcomes, and included calculation of adjusted odds ratios.

### **Results**

Of the 1063 women from the TIPS program, 115 were eliminated because of missing data for gestational weight gain, 32 were eliminated due to multi-fetal pregnancy, and 3 women delivered prior to viability and were therefore not included in the study. Of the 913 participants, over 90 percent were Caucasian, and the majority were unmarried with a family income below



20,000 dollars per year. The average age was approximately 25 years, average education level was twelfth grade, and average gestational age at the first prenatal visit was approximately eleven weeks. Based on prepregnancy BMI, 71 women (7.8%) were underweight, 399 (43.7%) were normal weight, 210 (23.0%) were overweight, and 233 (25.5%) were obese, as shown in Figure 1.

Based on prepregnancy BMI, GWG of participants was classified as low, normal, or high according to 2009 IOM guidelines with consideration for gestational duration. Nearly half (49.3%) of participants gained above IOM recommendations, while 22.8% gained below, and only 27.9% gained within the recommended range. Results for GWG are shown in Figure 2.

Maternal characteristics are shown in relation to GWG in Table 2. Differences in total pregnancy weight gain were not associated with age, race, or socioeconomic status; however, smoking during pregnancy was marginally associated with an increased incidence of inadequate GWG. A relationship was also found between prepregnancy BMI and GWG. Women who were underweight at the beginning of pregnancy were more likely to gain less than the recommended amount, while overweight and obese women were more likely to have excess weight gain. The proportion of women with inadequate, normal, and excess weight gain in each BMI category is shown in Figure 3.

Next, pregnancy and delivery complications as well as adverse newborn outcomes were examined in relation to GWG. Odds ratios (ORs) were calculated, adjusting for smoking status, and factors were considered significant if the 95% confidence interval (CI) did not include 1.0. Excess gestational weight gain was associated with an increased risk of several pregnancy and delivery complications, including preeclampsia (OR 1.89), pregnancy-induced hypertension (OR

1.62), gestational diabetes mellitus (OR 1.53), Cesarean section (OR 1.40), and labor lasting longer than 12 hours (OR 1.61). Conversely, inadequate weight gain was associated with only one pregnancy/delivery complication, delivery at less than 39 weeks (OR 1.48). Pregnancy and delivery outcomes associated with inadequate and excess GWG are shown in Table 3.

A similar pattern emerged concerning adverse newborn outcomes related to infant size. Excess GWG was associated with increased odds of delivering an infant that was large for gestational age (LGA) (OR 2.23), had a length greater than the 90<sup>th</sup> percentile for gestational age (OR 1.92), and macrosomia, or head circumference greater than the 90<sup>th</sup> percentile for gestational age (OR 2.98). Meanwhile, no associations were found between inadequate GWG and adverse newborn outcomes related to size. Inadequate weight gain did increase a woman's odds of having other adverse newborn outcomes, however. Infants born to women with low GWG were more likely to need supplemental oxygen at birth (OR 1.39), be admitted to the neonatal intensive care unit (NICU) (OR 1.28), and stay in the hospital for longer than seven days (OR 1.47). Excess GWG decreased a woman's risk of giving birth to a SGA infant (OR .52). Associations between adverse newborn outcomes and inappropriate GWG are shown in Table 4. Overall, excess GWG was associated with more pregnancy and delivery complications, while inadequate GWG was linked with more adverse newborn outcomes.

### **Discussion**

Of the 913 women who participated in this study, nearly one half began pregnancy as overweight or obese, and approximately the same proportion gained more weight during pregnancy than recommended by the IOM. In accordance with previous research, overweight and obese women were much more likely to gain above the guidelines, while underweight women were more likely to gain below them (Dalenius et al., 2010; Chung et al., 2012). This

could be attributable to the challenging nature of the guidelines, as underweight women are encouraged to gain a relatively large amount of weight compared to overweight and obese women, who are advised to restrict their weight gain. In addition to prepregnancy BMI, the only other maternal factor found to influence GWG was smoking during pregnancy, which was controlled for in analysis of the data. Women across the three weight gain categories were comparable in age, race, socioeconomic and marital statuses, education level, and timing of entry into prenatal care.

Upon analysis, numerous relationships were found between both inadequate and excess GWG and adverse maternal and neonatal outcomes. Women who gained less than the recommended amount had greater odds of experiencing outcomes detrimental to the newborn, including premature delivery (<39 weeks), need for oxygen supplementation, NICU admission, and hospital stay longer than seven days. Conversely, excess GWG primarily impacted the mother, increasing her risks of preeclampsia and pregnancy-induced hypertension, gestational diabetes mellitus, prolonged labor (>12 hours), and cesarean delivery. The only adverse newborn outcomes associated with excess weight gain were a twofold increase in LGA and a threefold increase in macrosomia, which likely contributed to the rise in prolonged labor and cesarean delivery among these women. In line with previous research, this study found that gaining more than the recommended amount actually decreased a woman's risk of having an SGA infant (Johnson et al., 2013); however, this benefit is greatly outweighed by the numerous adverse outcomes linked to excess GWG. Overall, these results reinforce the IOM guidelines for weight gain during pregnancy, as weight gain outside the recommended ranges significantly increased a woman's risk of adverse outcomes for herself and her child.

As evidenced by the large proportions of women with unhealthy prepregnancy BMIs and inappropriate GWG found in this and other studies, deficiencies exist in the management of maternal body weight and awareness of its impact on pregnancy outcomes. Healthcare providers need to be alerted to the importance of these factors and given tools to assist pregnant women to achieve optimal weight before, during, and after pregnancy. Ideally, women should attain a normal BMI before becoming pregnant; however, this can be difficult to accomplish due to the challenging nature of weight management and the frequency of unplanned pregnancies. Fortunately, as this study reveals, appropriate weight gain can protect mothers and newborns from harmful outcomes, regardless of prepregnancy size. By counseling women on appropriate nutrition and exercise during pregnancy, healthcare providers can promote healthy pregnancies that are more likely to result in healthy infants. Additionally, providers should assist women in reaching a healthy weight after pregnancy to increase the likelihood that they will enter subsequent pregnancies with an appropriate BMI.

This study has several strengths. By identifying smoking during pregnancy as a covariate and controlling for this factor in data analysis, the validity of the results was fortified. Women with multi-fetal pregnancies were also eliminated from the study, as GWG guidelines differ for this group. Moreover, length of gestation was considered when classifying participants by amount of weight gain, and values were adjusted to reflect whether or not women achieved appropriate GWG based on the duration of their pregnancies. This prevented any false associations between inadequate GWG and preterm delivery in the findings, while still permitting the inclusion of women with preterm deliveries so that this outcome could be properly examined.

Limitations of this study include the fact that the sample was relatively small (n=913) and homogenous (>90% Caucasian), and was collected solely from the Northeast Tennessee region; therefore, findings should be applied with caution to groups outside this population. Also, prepregnancy weight was self-reported, allowing the possibility for inaccurate estimations of GWG. Obtaining body weight at the first prenatal visit is another possible method for collecting this data, but this would not accurately represent a woman's prepregnancy weight for those with late entry into prenatal care. Thus this limitation is difficult to overcome. Because prepregnancy BMI and adequacy of weight gain are highly correlated in this and other samples, it is difficult to determine if the observed results are related to weight gain and not prepregnancy BMI. Furthermore, only immediate outcomes were examined; no information was gathered on the long-term effects of inappropriate GWG on mother and child. A final limitation of this correlational study is the inability to confirm causality of GWG on the factors examined.

Much more can be learned about the impact of inappropriate weight gain during pregnancy. By examining the rate of weight gain, insights could be gained concerning the timing of GWG and whether weight gain during one trimester affects outcomes differently than weight gain in another trimester. Multi-fetal pregnancies should also be considered to determine safe amounts of GWG for women carrying more than one child. The appropriateness of the IOM guidelines for the adolescent population should also be examined in more detail. While the current sample contained adolescents, there were too few to allow for a separate analysis of this age group. As mentioned above, no long-term effects were examined in this study, but investigating the lasting impact of GWG is a worthy endeavor. Variations in GWG could possibly impact the neurodevelopment of the child and influence the risk for conditions such as obesity and asthma (IOM, 2009). Improper GWG could also have long-term consequences for

the mother, such as postpartum weight retention and problems with blood glucose regulation and hypertension later in life (Dalenius et al., 2010; Fraser et al., 2011). Mechanisms behind inappropriate GWG also need to be identified in order to inform the development of more effective methods of weight management for pregnant women.

### **Conclusion**

This study found that many women in rural, Southern Appalachia do not enter pregnancy with a healthy BMI, and even more gain an inappropriate amount of weight during pregnancy. Inappropriate weight gain was found to increase the risk of adverse outcomes, with excess GWG associated primarily with pregnancy and delivery complications, and inadequate GWG increasing the odds of harmful effects on newborns. These results suggest that the current IOM recommendations are appropriate for women from the rural South. The findings of this study also reveal the need to increase awareness of the negative effects of inappropriate GWG and improve weight management techniques for pregnant women.

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Table 1

*2009 IOM Guidelines for GWG Based on Prepregnancy Body Mass Index (BMI)*

Prepregnancy BMI	BMI (kg/m <sup>2</sup> )	Recommended GWG (lbs)
Underweight	<18.5	28-40
Normal weight	18.5-24.9	25-35
Overweight	25.0-29.9	15-25
Obese (all classes)	≥30.0	11-20

Table 2

*Maternal Characteristics by Gestational Weight Gain (GWG) Status*

	Gained Below Guidelines (n=208)	Gained Within Guidelines (n=255)	Gained Above Guidelines (n=450)	F/ $\chi^2$	p
Age (yrs)	24.6	24.7	24.5	.14	.869
Family income (%<20,000/yr)	63.9%	59.6%	58.9%	1.58	.455
Education (yrs)	12.6	12.9	12.9	1.73	.178
Marital status (% married)	38.5%	43.9%	42.0%	1.43	.489
Race (% Caucasian)	91.8%	93.7%	94.4%	3.39	.758
<b>Pregnancy Smoking (%)</b>	<b>39.4%</b>	<b>35.7%</b>	<b>30.2%</b>	<b>5.91</b>	<b>.052</b>
Gestational age at 1 <sup>st</sup> prenatal visit (wks)	11.1	11.5	10.9	.96	.383

*Note:* Gestational weight gain status according to 2009 IOM guidelines for gestational weight gain based on pre-pregnancy BMI and gestational duration

Table 3

*Adjusted Odds of Adverse Pregnancy and Delivery Outcomes Associated with Low and Excess Gestational Weight Gain (GWG)*

	Adjusted Odds Associated with Low Weight Gain	Adjusted Odds Associated with Excess Weight Gain
<b>Preeclampsia</b>	1.06 (.48-2.34)	<b>1.89 (1.01-3.51)</b>
<b>Gestational Hypertension</b>	.70 (.38-1.31)	<b>1.62 (1.04-2.53)</b>
<b>Gestational Diabetes</b>	1.01 (.51-2.00)	<b>1.53 (1.09-2.63)</b>
<b>Cesarean Delivery</b>	1.17 (.79-1.73)	<b>1.40 (1.01-1.95)</b>
<b>Labor &gt; 12 hours</b>	1.09 (.66-1.82)	<b>1.61 (1.07-2.43)</b>
Delivery at < 37 weeks	.99 (.59-1.67)	.85 (.54-1.34)
<b>Delivery at &lt; 39 weeks</b>	<b>1.48 (1.02-2.14)</b>	1.00 (.73-1.36)

*Note:* Reference group is women gaining within 2009 IOM guidelines based on prepregnancy BMI and gestational length. Analysis adjusted for pregnancy smoking. Significant values bolded. Data format: OR (95% CI)

Table 4

*Adjusted Odds of Adverse Infant Outcomes Associated with Low and Excess Gestational Weight Gain (GWG)*

	Adjusted Odds Associated with Low Weight Gain	Adjusted Odds Associated with Excess Weight Gain
Low birth weight (<2500g)	1.15 (.67-1.99)	.67 (.41-1.12)
<b>Small for gestational age (SGA)<sup>a</sup></b>	1.02 (.56-1.86)	<b>.52 (.29-.93)</b>
<b>Large for gestational age (LGA)<sup>b</sup></b>	.93 (.43-2.01)	<b>2.23 (1.25-3.97)</b>
Length <10 <sup>th</sup> percentile <sup>c</sup>	1.21 (.65-2.27)	.88 (.50-1.56)
<b>Length &gt;90<sup>th</sup> percentile<sup>d</sup></b>	.68 (.30-1.50)	<b>1.92 (1.10-3.34)</b>
Head circumference <10 <sup>th</sup> percentile <sup>e</sup>	.82 (.46-1.44)	1.01 (.63-1.60)
<b>Head circumference &gt;90<sup>th</sup> percentile<sup>f</sup></b>	1.13 (.45-2.84)	<b>2.98 (1.48-6.00)</b>
<b>Oxygen administered</b>	<b>1.39 (1.03-2.07)</b>	1.20 (.86-1.68)
Jaundice	.96 (.64-1.44)	.94 (.67-1.32)
<b>NICU admission</b>	<b>1.28 (1.04-1.99)</b>	1.02 (.68-1.23)
Hospital stay > 3 days	1.16 (.78-1.73)	<b>1.29 (.92-1.80)</b>
<b>Hospital stay &gt; 7 days</b>	<b>1.47 (1.01-2.69)</b>	1.30 (.77-2.22)

*Note:* Reference group is women gaining within 2009 IOM guidelines based on prepregnancy BMI and gestational length. Analysis adjusted for pregnancy smoking. Significant values bolded. Data format: OR (95% CI)

<sup>a</sup>SGA defined as birth weight below 10<sup>th</sup> percentile for gestational age

<sup>b</sup>LGA defined as birth weight above 90<sup>th</sup> percentile for gestational age

<sup>c</sup>Birth length below 10<sup>th</sup> percentile for gestational age and gender

<sup>d</sup>Birth length above 90<sup>th</sup> percentile for gestational age and gender

<sup>e</sup>Birth head circumference below 10<sup>th</sup> percentile for gestational age and gender

<sup>f</sup>Birth head circumference above 90<sup>th</sup> percentile for gestational age and gender

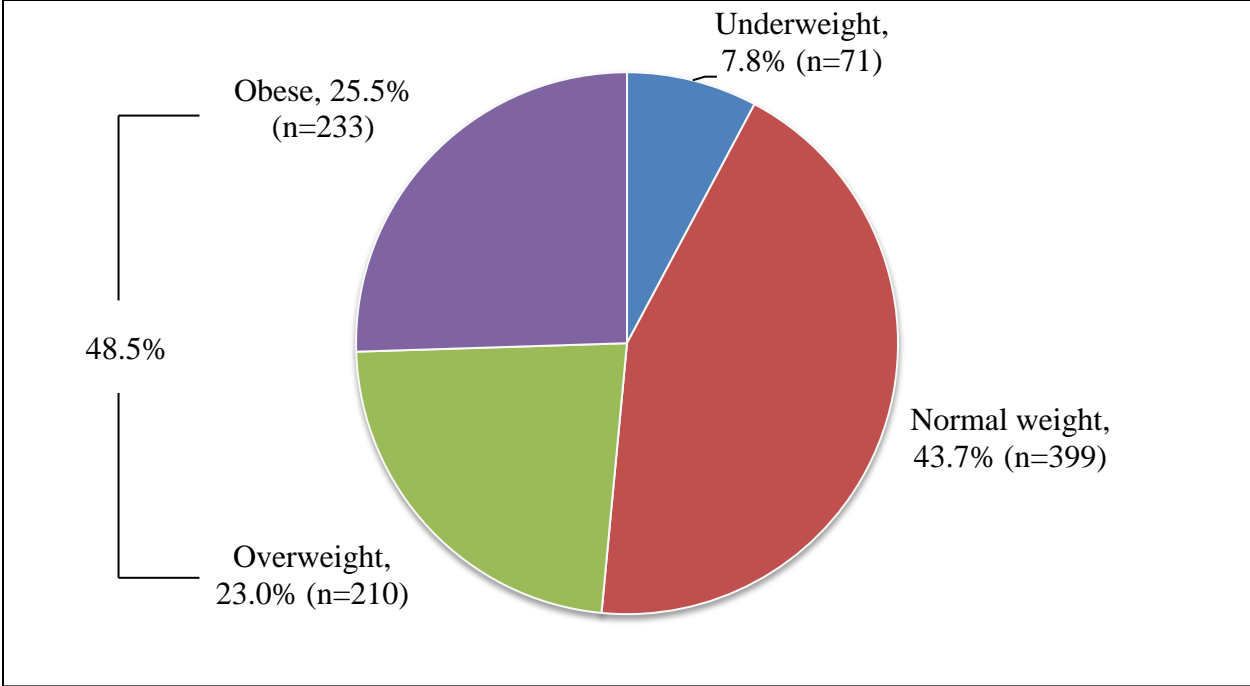


Figure 1 Prepregnancy body mass index (BMI) of sample

Note: Prepregnancy BMI according to WHO guidelines

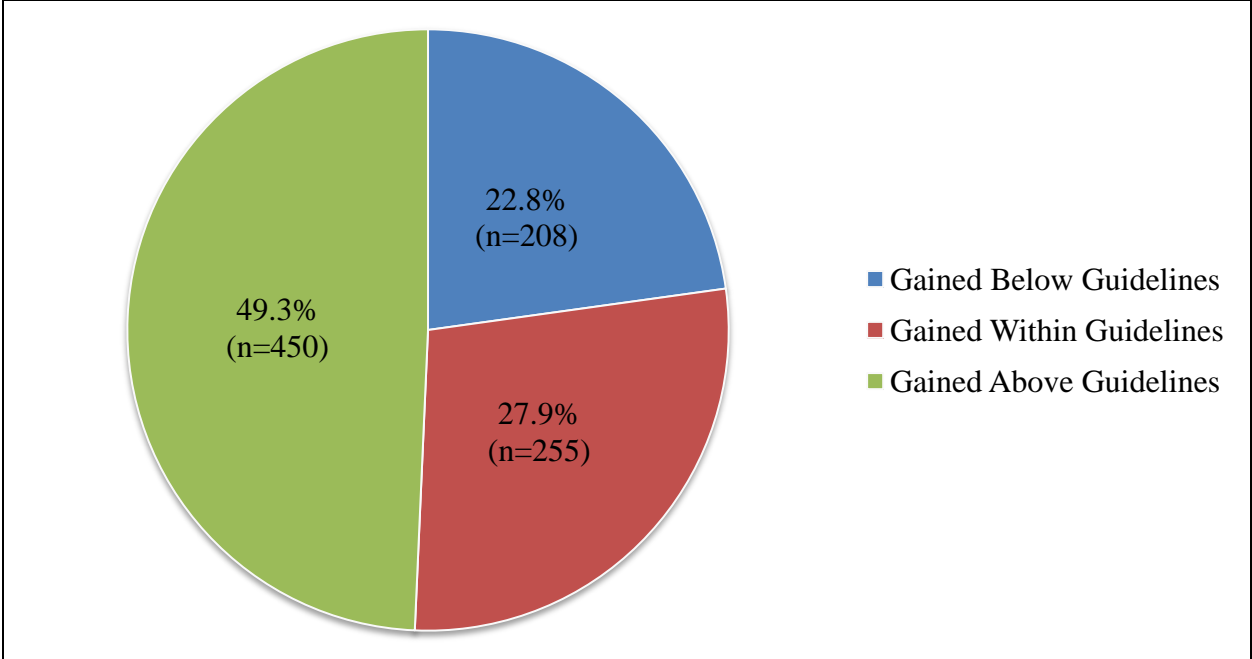


Figure 2 Gestational weight gain (GWG) of sample

Note: Gestational weight gain status according to 2009 IOM guidelines for gestational weight gain based on pre-pregnancy BMI and gestational duration

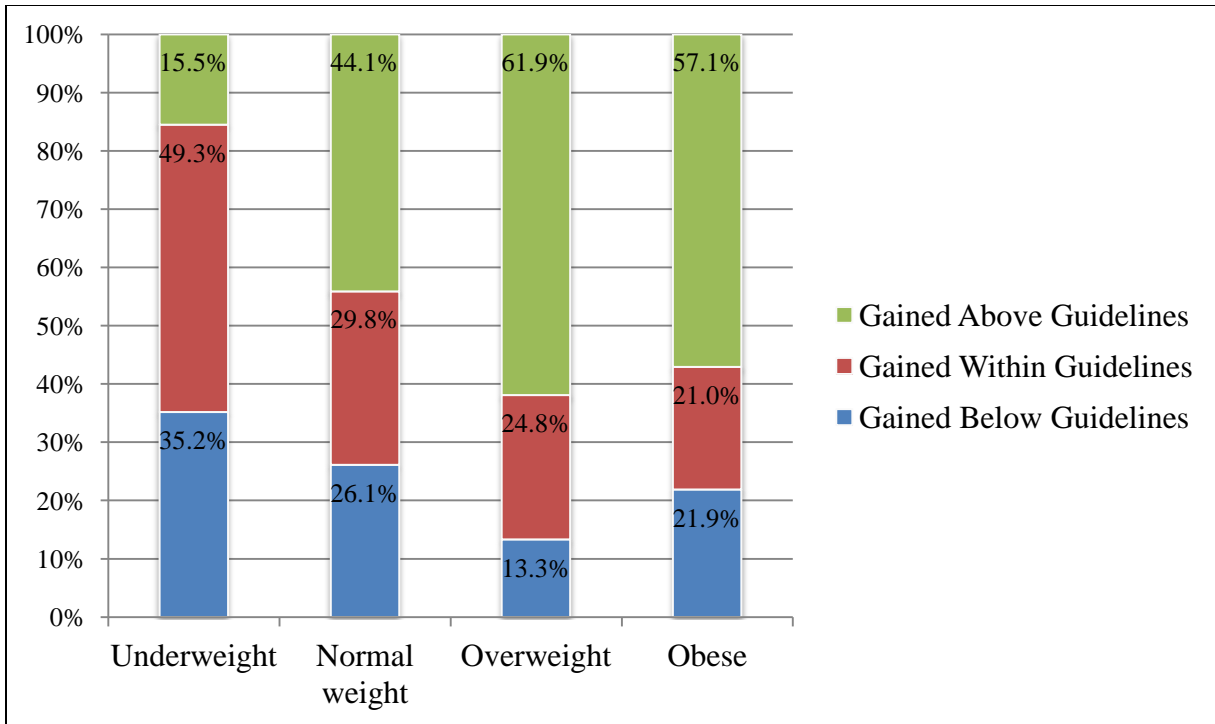


Figure 3 Gestational weight gain (GWG) of sample by prepregnancy body mass index (BMI)

Note: Gestational weight gain status according to 2009 IOM guidelines for gestational weight gain based on pre-pregnancy BMI and gestational duration