Impact of gestational weight gain on maternal and neonatal clinical outcomes: A retrospective cohort study

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ABSTRACT

Objectives: Inadequate or excessive gestational weight gain (GWG) increases the risk of adverse outcomes associated with pregnancy. We aim to explore the association between GWG and adverse events during pregnancy.

Materials and Methods: A retrospective study was conducted to evaluate the perinatal outcomes in singleton women whose weight gain during pregnancy was below, within, or above the 2009 Institute of Medicine's (IOM) guidelines, and delivered between 24 and 42 weeks' gestation. GWG was derived using weight at delivery minus the pre-pregnancy or first trimester weight.

Results: Mothers with low GWG had increased odds of having small-for-gestational-age neonates (adjusted OR 1.202; 95% CI 1.031-1.403), and preterm birth (adjusted OR 2.03; 95% CI 1.769-2.439), but decreased odds of having macrosomia (adjusted OR 0.523; 95% CI 0.24-0.991). Mothers with GWG above the IOM recommendations had higher odds of having hypertensive disease of pregnancy (adjusted OR 2.07; 95% CI 1.314-3.535), gestational diabetes (adjusted OR 1.227; 95% CI 1.038-1.448), cesarean section (adjusted OR 1.34; 95% CI 1.279-1.512), induced labor (adjusted OR 1.219; 95% CI 1.051-1.409), failure of induced labor (adjusted OR 1.432; 95% CI 1.03-1.992), macrosomia (adjusted OR 1.987; 95% CI 1.384-2.725), shoulder dystocia (adjusted OR 1.715; 95% CI 1.292-2.18), and treatment for neonatal hypoglycemia (adjusted OR 1.742; 95% CI 1.229-2.506).

Conclusion: GWG is an important predictor of adverse maternal and neonatal outcomes during pregnancy.

Key Words: Gestational weight gain, obesity, offspring outcomes, perinatal outcomes, pregnancy

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INTRODUCTION

Gestational weight gain (GWG) is a distinctive and composite biological phenomenon that supports the functions of fetal growth and development.¹ However, the great variability and differences in GWG observed in pregnant females may be affected by ethnic and racial variation, the medical status of the patient, including the presence of pre-existing conditions such as diabetes mellitus and hypertension.² Research conducted across the world has considered the impact of GWG on maternal and fetal clinical outcomes.³⁻⁴ Excess or deficient GWG is associated with a higher risk of adverse pregnancy outcomes, including preterm birth, macrosomia, and cesarean delivery.⁵

Clinically, it is considered unfavorable to have excessive weight gain in women suffering from obesity. On the other hand, underweight women are considered high-risk cases if they do not gain the weight required for the normal, physiologically complex, and interactive processes occurring during pregnancy.⁶ The weight gain process can be influenced by lifestyle and dietary patterns before and throughout pregnancy.⁷ In attempts to improve health outcomes, the Institute of Medicine’s (IOM) 2009 guidelines categorize the appropriateness of GWG with reference to pre-pregnancy body mass index (BMI).⁸

Despite various research studies investigating the impact of gestational weight gain on perinatal outcomes, no studies have evaluated the relationship between GWG and perinatal outcomes in the Middle East or Saudi Arabia. Therefore, the objective of this study was to evaluate the maternal and neonatal clinical outcomes with regard to GWG at a large private hospital in Jeddah, Saudi Arabia.
PATIENTS AND METHODS

A retrospective population-based cohort study was conducted on 23,736 women giving birth to a singleton baby over a period of 8 years. All women admitted to the obstetric department of a large private hospital in Jeddah, Saudi Arabia, from January 1st, 2010 to December 31st, 2017, were included in the study. Data were collected from a hospital database. The study was approved by the Local Institutional Review Board and Ethics Committee. All women with a singleton pregnancy who had delivered between 24 and 42 weeks of gestational age were included. In addition, included women were required to have a documented height and pre-pregnancy or first-trimester weight (defined as 13 weeks of gestation or less), and weight at delivery. Pregnant women with pre-gestational diabetes and/or chronic hypertension were excluded from our study. Women with extreme weight gain (greater than 50 kg) or loss (greater than 30 kg) were also excluded, as per Beyerlein et al.[10]

GWG was derived by means of a pre-pregnancy or first prenatal visit weight at 13 weeks of gestation or less subtracted from a delivery weight. Maternal pre-pregnancy BMI was categorized into underweight (<18.5 kg/m2), normal (18.5–24.9 kg/m2), and overweight (≥25 kg/m2), according to the classification by the World Health Organization.[11] GWG was defined as the average weight gained per week during pregnancy, based on the IOM guidelines. The IOM recommends a GWG of 12.5–18.0 kg gained per week during pregnancy, based on the IOM guidelines.[9] The IOM guidelines, 3,045 (21.2%) women had low GWG, 3,993 (27.8%) women had normal GWG, and 7,326 (51%) women had high GWG (Figure 1).

GWG EFFECTS ON MOTHER & NEONAT

Comparing the below and within GWG groups revealed that there was a statistically significant difference observed with regards to prior cesarean delivery (p = 0.013).

RESULTS

Initial recruitment included 23,736 women. 14,364 women were eligible for our study. Based on the IOM guidelines, 3,045 (21.2%) women had low GWG, 3,993 (27.8%) women had normal GWG, and 7,326 (51%) women had high GWG (Figure 1).

Table 1 reveals the demographic characteristics of the research study cohort comparing low, normal, and high GWG research groups. There was a statistically significant difference between them in relation to age, nulliparity, pre-pregnancy BMI, smoking, and gestational age at delivery (ps <0.001). There was also a statistically significant difference observed in relation to age, nulliparity, pre-pregnancy BMI, smoking, and gestational age at delivery (ps <0.001).

Table 2 displays the maternal outcomes in line with IOM weight gain categories (below, within, and above GWG). Comparing the below and within GWG groups found no statistically significant difference in relation to maternal outcomes. Conversely, comparison between the within and above GWG categories revealed that there was a higher odds of having hypertensive disease of pregnancy (adjusted OR 2.07; 95% CI 1.314 to 3.535), GDM (adjusted OR 1.227; 95% CI 1.038 to 1.448), cesarean section (adjusted OR 1.34; 95% CI 1.279 to 1.512), induced labor (adjusted OR 1.219; 95% CI 1.051 to 1.409), and failure of induced labor (adjusted OR 1.432; 95% CI 1.03 to 1.992).

With reference to neonatal outcomes, mothers with low GWG had an increased odds of having an SGA neonate (adjusted OR 1.202; 95% CI 1.031 to 1.403), preterm birth (adjusted OR 2.03; 95% CI 1.769 to 2.439), spontaneous preterm birth (adjusted OR 1.981; 95% CI 1.652 to 2.314), and planned preterm birth (adjusted OR 1.711; 95% CI 1.337 to 2.314); however, they were also at lower odds of having macrosomia (adjusted OR 0.523; 95% CI 0.24 to 0.991; Table 3). On the other hand, mothers with GWG above the IOM recommendations had a higher odds of having macrosomia (adjusted OR 1.987; 95% CI 1.384 to 2.725), shoulder dystocia (adjusted OR 1.715; 95% CI 1.292 to 2.18), and treatment for neonatal hypoglycemia (adjusted OR 1.742; 95% CI 1.229 to 2.506; Table 3).

STATISTICAL ANALYSIS

Baseline clinical characteristics and maternal and neonatal clinical outcomes were compared according to gestational weight gain categories (below, within, and above the IOM guidelines). The quantitative data with a parametric distribution were presented as mean and standard deviations. Qualitative variables were presented as number and percentages. Comparisons between groups for the qualitative data were done using the Chi-square test, and for quantitative data were done using one-way analysis of variance (ANOVA) testing, as appropriate. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for each of the clinical outcomes of interest. Multivariable logistic regression was used to adjust for maternal age, pre-pregnancy BMI, smoking status, parity, prior delivery type, and gestational age at delivery. A p value was considered significant at the level of <0.05. All analyses were performed using the Statistical Package for Social Science (SPSS) version 23 for Windows (IBM Corp., Armonk, NY, USA).
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Fig. 1: Patients Flow Chart

Table 1: Maternal demographics and characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Below (n = 3045)</th>
<th>Within (n = 3993)</th>
<th>Above (n = 7326)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>28.87 ± 5.32</td>
<td>29.72 ± 6.74</td>
<td>29.2 ± 6.52</td>
<td>&lt;0.001†</td>
</tr>
<tr>
<td>Nulli-parous</td>
<td>1020 (33.5%)</td>
<td>1598 (40.02%)</td>
<td>3465 (47.3%)</td>
<td>&lt;0.001†</td>
</tr>
<tr>
<td>Pre-pregnancy BMI</td>
<td>26.92 ± 6.83</td>
<td>25.42 ± 5.42</td>
<td>27.34 ± 6.25</td>
<td>&lt;0.001†</td>
</tr>
<tr>
<td>Underweight</td>
<td>195 (6.4%)</td>
<td>200 (5.0%)</td>
<td>117 (1.6%)</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>1425 (46.8%)</td>
<td>2232 (55.9%)</td>
<td>3282 (44.8%)</td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>502 (16.49%)</td>
<td>847 (21.2%)</td>
<td>2336 (31.9%)</td>
<td></td>
</tr>
<tr>
<td>Obese</td>
<td>923 (30.3%)</td>
<td>714 (17.9%)</td>
<td>1591 (21.7%)</td>
<td></td>
</tr>
<tr>
<td>Prior caesarean delivery</td>
<td>583 (19.2%)</td>
<td>659 (16.5%)</td>
<td>1267 (17.3%)</td>
<td>0.013†</td>
</tr>
<tr>
<td>Smoking</td>
<td>314 (10.3%)</td>
<td>244 (6.1%)</td>
<td>718 (9.8%)</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td>GA at delivery (weeks)</td>
<td>38.63 ± 3.3</td>
<td>38.52 ± 4.6</td>
<td>38.9 ± 4.5</td>
<td>&lt; 0.001†</td>
</tr>
</tbody>
</table>

IOM, Institute of Medicine; BMI, body mass index; GA, gestational age.
Data are mean ± standard deviations or number (percent).
* One Way ANOVA test was used; † Chi-square test was used.
P-value < 0.05 is significant.
### Table 2: Maternal outcomes according to the institute of medicine gestational weight gain categories

<table>
<thead>
<tr>
<th>Maternal outcome</th>
<th>Below (n = 3045)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
<th>Within (Referent) (n = 3993)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
<th>Above (n = 7326)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertensive disease of pregnancy</td>
<td>215 (7.1%)</td>
<td>1.107 (0.92 - 1.113)</td>
<td>0.411</td>
<td>240 (6.0%)</td>
<td>901 (12.3%)</td>
<td>2.07</td>
<td>1.314 – 3.535</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Gestational diabetes</td>
<td>165 (5.4%)</td>
<td>1.019 (0.824 - 1.252)</td>
<td>0.84</td>
<td>212 (5.3%)</td>
<td>473 (6.5%)</td>
<td>1.227</td>
<td>1.038 - 1.448</td>
<td>0.019</td>
<td></td>
</tr>
<tr>
<td>Labor induction</td>
<td>231 (7.6%)</td>
<td>1.082 (0.901 - 1.298)</td>
<td>0.362</td>
<td>280 (7.0%)</td>
<td>618 (8.4%)</td>
<td>1.219</td>
<td>1.051 - 1.409</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Failure of labor induction</td>
<td>57 (24.7%)</td>
<td>1.128 (0.742 - 1.692)</td>
<td>0.571</td>
<td>63 (22.5%)</td>
<td>182 (29.4%)</td>
<td>1.432</td>
<td>1.03 - 1.992</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Caesarean delivery</td>
<td>837 (27.5%)</td>
<td>0.9285 (0.829 - 1.028)</td>
<td>0.164</td>
<td>1157 (36.3%)</td>
<td>1.34 (1.279 - 1.512)</td>
<td>0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum hemorrhage</td>
<td>82 (2.7%)</td>
<td>1.332 (0.989 – 2.432)</td>
<td>0.061</td>
<td>125 (1.7%)</td>
<td>0.031 (0.877 – 1.124)</td>
<td></td>
<td></td>
<td></td>
<td>0.315</td>
</tr>
<tr>
<td>3rd or 4th degree laceration in vaginal delivery only†</td>
<td>68 (3.1%)</td>
<td>0.82 (0.59 - 1.169)</td>
<td>0.117</td>
<td>193 (4.0%)</td>
<td>1.127 (0.881 to 1.439)</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum infection</td>
<td>21 (0.7%)</td>
<td>1.125 (0.819 – 1.245)</td>
<td>0.628</td>
<td>41 (0.6%)</td>
<td>1.031 (0.895 – 2.314)</td>
<td>0.098</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval.
* Odds ratio were adjusted for maternal age, pre-pregnancy BMI, prior delivery type, smoking and GA at delivery
† The denominator for the 3rd or 4th degree laceration outcome varies from the total sample size because it was limited to women with vaginal deliveries (n=2208 below; n=2863 within; n=4813 above).
P-value< 0.05 is significant.

### Table 3: Neonatal outcomes according to the institute of medicine gestational weight gain categories

<table>
<thead>
<tr>
<th>Neonatal outcome</th>
<th>Below (n = 3045)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
<th>Within (Referent) (n = 3993)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
<th>Above (n = 7326)</th>
<th>Adjusted OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGA</td>
<td>342 (11.2%)</td>
<td>1.202 (1.031 - 1.403)</td>
<td>0.021</td>
<td>379 (9.5%)</td>
<td>645 (8.8%)</td>
<td>0.918</td>
<td>0.802 to 1.048</td>
<td>0.229</td>
<td></td>
</tr>
<tr>
<td>Preterm birth</td>
<td>411 (13.5%)</td>
<td>2.03 (1.769 – 2.439)</td>
<td>&lt;0.001</td>
<td>278 (7.0%)</td>
<td>542 (7.4%)</td>
<td>1.063</td>
<td>0.913 – 1.21</td>
<td>0.398</td>
<td></td>
</tr>
<tr>
<td>Spontaneous preterm birth</td>
<td>253 (8.3%)</td>
<td>1.981 (1.652 – 2.314)</td>
<td>&lt;0.001</td>
<td>167 (4.2%)</td>
<td>278 (3.8%)</td>
<td>0.870</td>
<td>0.542 – 1.108</td>
<td>0.425</td>
<td></td>
</tr>
<tr>
<td>Indicated preterm birth</td>
<td>158 (5.2%)</td>
<td>1.711 (1.337 – 2.314)</td>
<td>&lt;0.001</td>
<td>111 (2.8%)</td>
<td>264 (3.6%)</td>
<td>1.299</td>
<td>1.037 – 1.490</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Shoulder dystocia in vaginal delivery only†</td>
<td>46 (2.1%)</td>
<td>0.896 (0.605 – 1.312)</td>
<td>0.498</td>
<td>66 (2.3%)</td>
<td>188 (3.9%)</td>
<td>1.715</td>
<td>1.292 – 2.18</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Macrosomia</td>
<td>15 (0.5%)</td>
<td>0.523 (0.24 – 0.991)</td>
<td>0.038</td>
<td>37 (0.9%)</td>
<td>139 (1.9%)</td>
<td>1.987</td>
<td>1.384 – 2.725</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Treatment for neonatal hypoglycemia</td>
<td>25 (0.8%)</td>
<td>1.098 (0.591 – 1.891)</td>
<td>0.487</td>
<td>28 (0.7%)</td>
<td>95 (1.3%)</td>
<td>1.742</td>
<td>1.229 – 2.506</td>
<td>0.007</td>
<td></td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval; SGA, small for gestational age.
* Odds ratio were adjusted to maternal age, pre-pregnancy BMI, prior delivery type, smoking and GA at delivery
† The denominator for the shoulder dystocia outcome varies from the total sample size because it was limited to women with vaginal deliveries (n=2208 below; n=2863 within; n=4813 above).
P-value< 0.05 is significant.
DISCUSSION

Maternal GWG is a natural physiologically progressive process that reflects adaptive changes in normal pregnancy. However, the disturbance of this normal physiological phenomena has been correlated with adverse maternal and neonatal clinical outcomes whether by excessive or reduced maternal GWG. The results of the current study suggest that not achieving the normal GWG is associated with multiple deleterious maternal and neonatal consequences including hypertensive disease of pregnancy, gestational diabetes, rates of induced labor, failure of induced labor, cesarean delivery, neonates that are small for gestational age, preterm birth, macrosomia, and shoulder dystocia.

In agreement with our findings, many studies have found that GWG above the IOM recommendations is associated with large for gestational age (LGA) neonates and fetal macrosomia. Conversely, GWG below the IOM recommendations has been associated with small-for-gestational-age neonates. In addition, several studies have recognized the relationship between low GWG and preterm birth. Hannaford and colleagues conducted a prospective cohort study including singleton, non-anomalous fetuses to evaluate perinatal outcomes in a prospective cohort study including singleton, non-anomalous fetuses to evaluate perinatal outcomes in patients who gained weight below or above the IOM’s recommendations, and found that women who gained weight below the IOM recommendations were 2.5 times more likely to deliver SGA neonates, and twice as likely to deliver preterm.

An association between excess GWG and cesarean delivery and induced labor is plausible. Excess GWG is associated with a higher incidence of LGA neonates and fetal macrosomia, and hence, a higher incidence of labor induction and cesarean delivery. This relationship has been evaluated previously by Maier and colleagues, who studied weight gain in pregnancy and its association with birthing complications among 591 women. They found that women with more GWG were at a higher risk for induced labor (55.0% vs. 45.7%, $p = 0.007$), significantly higher rates of secondary cesarean section (22.4% vs. 15.4%), and decreased chances of spontaneous vaginal birth (57.5% vs. 61.4%; $p = 0.008$).

Associations between excessive GWG and gestational diabetes as well as hypertensive disorders have been reported, but the evidence for these associations is limited. A positive correlation between excess gestational weight gain and GDM was reported in a recent prospective cohort study that included 565 pregnant women; the investigators found that pre-pregnancy obesity and excessive GWG during the first and second trimesters of pregnancy may increase the risk of GDM. However, a meta-analysis conducted by Brunner and co-workers found no evidence for an effect of GWG on GDM contingent on maternal pre-pregnancy BMI category. These conflicting opinions may be related to the use of total GWG as the exposure variable rather than weight gain until the time of diagnosis of GDM, because the management of GDM includes dietary control and efforts to control weight gain. Likewise, there is a lack of evidence to support the notion that GWG is associated with gestational hypertension and preeclampsia. It is well-known that preeclampsia is associated with vascular permeability and reduced plasma oncotic pressure, and hence rapid weight gain. Nonetheless, it is difficult to ascertain whether excessive GWG is a cause or effect of preeclampsia.

The strengths of our study include the large sample size and the assessment of multiple maternal and neonatal outcomes. However, there are several potential limitations to our study. First, we used the total GWG at delivery; this method is hypothetical and could differ from actual measurements. Second, pre-pregnancy BMI estimation is often self-managed and not performed by a healthcare professional, and as such a bias of under- or overestimation to an unknown degree is possible. Third, our study was conducted among women delivering in Saudi Arabia only.

CONCLUSION

Both gestational weight gain above and below the recommendations of the IOM guidelines have adverse maternal and neonatal consequences. However, racial and ethnic differences should be considered in future research studies, as they could influence the impact on GWG on clinical adverse outcomes.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

There are no conflicts of interests.

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