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Pregnancy Outcomes With Weight Gain Above or Below the 2009 Institute of Medicine Guidelines

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Abstract

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OBJECTIVE—To evaluate pregnancy outcomes according to 2009 Institute of Medicine (IOM) gestational weight gain guidelines.

METHODS—This study is a secondary analysis of a preeclampsia prevention trial among nulliparas carrying singletons. Odds ratios and 95% confidence intervals (adjusted for maternal age, race, smoking, and treatment group) were calculated based on total weight gain below or above the IOM guidelines, stratified by prepregnancy body mass index (BMI). The referent group was weight gain within the guidelines.

RESULTS—Of 8,293 pregnancies, 9.5% had weight gain below, 17.5% within, and 73% above IOM guidelines. With excess weight gain, all BMI categories had an increased risk of hypertensive disorders; normal weight and overweight women also had increased risk of cesarean delivery and infant birth weight at or above the 90th centile but a decreased risk of weight below the10th centile. There were no consistent associations with insufficient weight gain and adverse outcomes.

CONCLUSION—Excess weight gain was prevalent and associated with an increased risk of hypertensive disorders, cesarean delivery and large for gestational age infants..

Introduction

In 2009, the Institute of Medicine (IOM) released new guidelines for weight gain during pregnancy. (1) The recommendation is for underweight, normal weight, overweight, and obese women to gain 28–40, 25–35, 15–25, and 11–20 pounds, respectively. Changes from the initial guidelines set forth in 1990 include: a range for weight gain in obese women instead of a lower limit and a change in classification parameters resulting in the classification of fewer women as underweight and more women as overweight.

The current and previous recommendations are based on a variety of evidence, from expert opinion to population-based cohort studies. The majority of the evidence is rated as fair to poor. (2) The larger studies are primarily from self-reported questionnaires or population cohorts from countries other than the United States. Therefore, using data from a large multicenter trial conducted in the United States, we evaluated maternal and perinatal outcomes vis-à-vis the new IOM guidelines.

Materials and Methods

This study is a secondary analysis of a multicenter, placebo-controlled randomized double-blind trial evaluating the use of vitamins C and E to prevent serious complications associated with pregnancy related hypertension. The trial was conducted from 2003–2008 by 16 centers in the *Eunice Kennedy Shriver* National Institute of Child and Human Development Maternal-Fetal Medicine Units Network. (3) Women were eligible for this trial if they were nulliparous (no previous pregnancy lasting more than 19 6/7 weeks) and carrying a singleton gestation between 9 and 16 weeks according to a previously described algorithm that includes the date of the last menstrual period (if reliable) and the earliest ultrasound examination. (4) Exclusion criteria included elevated blood pressure (systolic of 135mm Hg or higher or diastolic of 85mm Hg or higher), proteinuria (300mg in a 24 hour collection or higher or more than trace protein on a urine dipstick), pregestational diabetes, treatment with antiplatelet or non-steroidal anti-inflammatory drugs, uterine bleeding within the week prior to recruitment, uterine malformation, serious medical condition (e.g. epilepsy), known fetal anomaly or aneuploidy, in vitro fertilization resulting in the current pregnancy, and illicit drug or alcohol abuse. In the original trial, the treatment (1000mg of vitamin C and 400 IU of vitamin E) and placebo (mineral oil) capsules were matching and neither the patients nor the investigators were aware of the treatment assignments. The

simple urn method, with stratification according to clinical center, was used by the data coordinating center to create a randomization sequence.

Women were eligible for this secondary analysis if their height and self-reported prepregnancy weight were recorded at study entry and a weight measured and recorded during a prenatal visit within two weeks prior to delivery. They were excluded from this secondary analysis if they delivered prior to 20 weeks, died prior to delivery, had an abortion, or their infant was found to have a major congenital malformation.

All maternal and neonatal data were collected by certified research personnel at each center and entered into a database managed by an independent data coordinating center. Height and self-reported prepregnancy weight were used to calculate the prepregnancy body mass index (BMI) in kg/ m^2. Weight gain during pregnancy was calculated by subtracting the prepregnancy weight from the last recorded pregnancy weight.

The outcomes for this secondary analysis were gestational hypertension, preeclampsia, cesarean delivery, indicated preterm birth, spontaneous preterm birth, birth weight at or above the 90^{th} centile (large for gestational age-LGA) and birth weight less than the 10^{th} centile (small for gestational age-SGA). Gestational hypertension was defined on the basis of systolic pressure of greater than or equal to 140mm Hg or a diastolic pressure of greater than or equal to 90mm Hg on two separate occasions 2– 240 hours apart after 20 weeks of gestation in the absence of proteinuria. Preeclampsia was defined as gestational hypertension with either proteinuria, defined as greater than or equal to 300mg in a 24 hour sample, or, if a 24-hour sample was not available, 2+ or higher on dipstick testing (3), or a protein:creatinine ratio of greater than or equal to 0.35 (3), pulmonary edema, thrombocytopenia, or eclampsia. Preterm birth was defined as delivery prior to 37 weeks' gestation. Birth weight centiles were adjusted for maternal height, weight, ethnicity, gestational age, and fetal gender. (5) Although we were interested in gestational diabetes as an outcome, the fact that many if not most women with this diagnosis have their diets modified in such a way as to limit maternal weight gain (and fetal growth), we did not include it as a dependent variable.

The data were stratified into groups based on prepregnancy BMI: underweight (less than 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), and obese (greater than or equal to 30.0 kg/m^2). Categorical variables were compared using the chi-square test and continuous variables with the Kruskal-Wallis test. The Cochran-Armitage test for linear trend was used to compare the three weight gain categories (below, within and above). For each category of BMI, logistic regression was used to calculate odds ratios and 95% confidence intervals for outcomes based on total gestational weight gain above or below the guidelines. Weight gain was calculated based on completed weeks' gestation. The expected weight gain was determined by using the IOM recommendations of 1.1–4.4 pounds in the first trimester (through 13 weeks) for all women regardless of prepregnancy BMI and combining it with the week specific guidelines for prepregnancy BMI of 1–1.3, 0.8–1, 0.5–0.7, and 0.4–0.6 pounds per week for underweight, normal weight, overweight, and obese women, respectively for the remainder of pregnancy up to the time of last weight within 2 weeks of delivery. (1) For example, if the prepregnancy weight of an overweight female was 160 lbs and her last weight prior to delivery was measured at 37 weeks, the recommended weight gain for her would be 13.1–21.2 lbs (1.1–4.4 pounds for the first trimester and a range of 0.5–0.7 lbs per week for the remaining 24 weeks). A second analysis was also performed in a similar manner using the weight recorded at study entry instead of the self-reported prepregnancy weight in the same group of women. The main difference in this analysis was expected weight gain during pregnancy was calculated by using the second trimester recommendations for weight gain per week based on the BMI at

study entry (and not the expected weight gain for the first trimester). For example, if the first recorded weight for an overweight female was 160 lbs at 11 weeks gestation and her last weight prior to delivery was measured at 37 weeks, the recommended weight gain for her would be 13–18.2 lbs (0.5–0.7 lbs per week from gestation at study entry to the last recorded weight [26 weeks total]).

The referent group in each weight category was weight gain within the guidelines. Adjustments were made for maternal age, smoking, and race, all of which were determined a priori as potential confounders. Adjustments were also made for treatment group given the analyzed cohort. A p-value of < 0.05 was considered statistically significant; no adjustments were made for multiple comparisons. Analyses were performed using SAS Software (SAS Institute, Cary, North Carolina). This study was exempt from Institutional Review Board approval at Women & Infants Hospital.

Results

Of the 10,154 women who underwent randomization in the original trial, outcome data was available on 9,969 women. Of these women, prepregnancy weight was not recorded for 203, 1 died prior to delivery, 114 delivered prior to 20 weeks, 9 had an intentional abortion after 20 weeks, and 99 had a major fetal malformation. This left 9,543 women, of whom 1,250 did not have a weight recorded within 2 weeks prior to delivery, resulting in a cohort for this secondary analysis of 8,293 women. Of these women, 389 (4.7%) were underweight, 4,522 (54.5%) of normal weight, 1,937 (23.4%) overweight, and 1,445 (17.4%) were obese based on their prepregnancy BMI. (Table 1) Of note, there was a high degree of concordance between prepregnancy BMI and BMI at study entry, with $\rho=0.96$.

We first evaluated the relationship between prepregnancy BMI category and weight gain according to the IOM guidelines and found that the majority (73%) of women gained more weight than recommended, fewer than 1 in 5 (17.5%) stayed within the guidelines, while 1 in 10 (9.5%) gained less than recommended (Table 2). In the overall cohort, the outcome rates were significantly different in women who gained more than recommended compared with women who gained within or below the guidelines (32% vs 21% for gestational hypertension and preeclampsia combined, 27% vs 19% for cesarean delivery, 11% vs 15% for SGA and 12% vs 7% for LGA, Table 3).

We then stratified outcomes by prepregnancy BMI and used a multivariable model to compare women who gained more than recommended and women who gained less than recommended with women who gained within the guidelines. After adjusting for maternal age, race, smoking, and treatment group, women with a normal pre-pregnancy BMI who gained above the IOM guidelines (Table 4) were at increased risk of developing gestational hypertension (OR 1.5, 95% CI 1.2–1.8) or preeclampsia (OR 2.5, 95% CI 1.6–3.9), undergoing cesarean delivery (OR 1.6, 95% CI 1.3–2.0), and delivering an LGA infant (OR 1.7, 95% CI 1.3–2.3). They were less likely to deliver an SGA infant (OR 0.6, 95% CI 0.5–0.7). Similarly, women who were overweight prior to pregnancy and gained more than recommended were more likely to develop preeclampsia (OR 4.2, 95% CI 1.7–10.4), undergo cesarean delivery (OR 1.8, 95% CI 1.2–2.6), and deliver an LGA neonate (OR 2.5, 95% CI 1.3–4.5). They were also 60% less likely to deliver an SGA infant (OR 0.4, 95% CI 0.3–0.6). Women who were obese prior to pregnancy and gained more than recommended had an increased risk of preeclampsia (OR 1.9, 95% CI 1.0–3.3).

Women with a normal prepregnancy BMI who gained less than recommended (Table 5) had a reduced risk of delivering an LGA infant (OR 0.5, 95% CI 0.3–0.8) but an increased risk of spontaneous preterm birth (OR 2.0, 95% CI 1.3–3.2). Women with a prepregnancy BMI

in the obese category were more likely to have an SGA infant if they did not gain the recommended amount of weight (OR 1.7, 95% CI 1.1–2.8).

Weight was recorded at first study visit in 8,291 women. Based on these weights, 232 women (2.8%) were underweight, 4,155 (50%) were normal weight, 2199 (27%) were overweight, and 1705 (21%) were obese at study entry. A total of 6,235 (75%) women gained above the recommended guidelines, 1,224 (15%) stayed within the guidelines, while only 832 (10%) did not gain the recommended weight.

Separate analyses performed using first recorded study weight yielded similar results to analyses based on self-reported prepregnancy weight with the following exceptions: underweight and normal weight women gaining above the guidelines were no longer at a statistically significant risk to develop gestational hypertension (OR 0.5, 95% CI 0.2–1.6 and OR 1.2, 95% CI 0.9–1.4, respectively), and women in the overweight group were at increased risk to develop gestational hypertension (OR 1.8, 95% CI 1.1–2.7). In women that did not gain the recommended amount, there were only three differences in outcomes when analyzed by first study visit weight: normal weight women were less likely to develop gestational hypertension (OR 0.6, 95% CI 0.4–0.9) and more likely to have an SGA neonate (OR 1.9, 95% CI 1.4–2.6), and there was no longer an association between obese mothers with inadequate weight gain and SGA (OR 1.5, 95% CI 0.9–2.5).

Discussion

In our cohort of 8,293 nulliparas, we made two important observations about weight gain in pregnancy. First, approximately three of every four women gained more weight than is recommended by the new IOM guidelines. Second, this excessive weight gain was associated with several adverse pregnancy outcomes. In general, excessive weight gain was associated with hypertensive disorders of pregnancy, delivering an LGA infant and undergoing a cesarean delivery. For some BMI categories, these increased risks were statistically significant at the $p < 0.05$ level, while in others they were not. Even so, the direction of association was the same across all categories. Conversely, except for obese women, the risk of delivering an SGA infant was reduced by weight gain above the guidelines.

There are few published studies examining outcomes in relation to the new IOM guidelines. De le Torre et al, in a retrospective cohort study, assessed the association between adherence to the new guidelines and pregnancy related hypertension (6). Their findings are consistent with ours. They found an increased risk of pregnancy related hypertension (preeclampsia and gestational hypertension) in all women except those that were underweight prior to pregnancy with excessive weight gain, while we found this association regardless of prepregnancy BMI. They also make the important point that while overweight and obese women are at risk for hypertensive disorders regardless of weight gain, excessive weight gain further increases that risk.

Of the publications assessing the impact of guideline adherence and pregnancy outcomes, the majority have focused on the association between weight gain and infant birth weight. Vesco et al. and Bodnar et al. performed retrospective analyses of weight gain in obese women. Both reported that weight gain above the guidelines was associated with an increased risk of delivering an LGA infant, whereas less than recommended weight gain was associated with an increased risk of delivering an SGA infant, consistent with our results. (7,8) Most recently, two studies based on birth certificate data report similar associations between excessive weight gain and LGA neonates and suboptimal weight gain and SGA neonates across BMI categories. (9,10)

Collectively, the available literature including the present study, suggests that the public health implications of excessive weight gain during pregnancy are potentially profound. In our study we found that the absolute risk increase of a hypertensive disorder associated with excess weight gain was 10.9%, the absolute risk increase of cesarean delivery 8.7%, and the absolute risk increase of delivering an LGA infant was 6.4%. If these associations were entirely causal, and our findings were generalizable to all pregnant women in the U.S., if the 73% of women who gained above the guidelines had actually gained within the guidelines, there would be up to 342,000 fewer cases of hypertensive disorders of pregnancy, up to 273,000 fewer cesarean deliveries, and up to 201,000 fewer LGA neonates every year among the 4.3 million pregnancies in our country.

Our study has both strengths and limitations. The data were rigorously and prospectively collected across multiple sites in the United States, resulting in a heterogeneous sample of patients, thereby increasing the external validity of this study. The inclusion criteria, nulliparous women without medical problems, were such that we were able to create a cohort of women at a theoretically low risk of these outcomes. Further, the data were adjusted for important confounders.

Limitations of this study include the fact that prepregnancy weight was self- reported, which could lead to overestimation or underestimation of gestational weight gain, a common problem in gestational weight gain studies. (11) For this reason, we also analyzed the data based on the first recorded weight at study entry. While there were fewer women in the normal weight and underweight BMI groups and more women in the overweight and obese groups when analyzing recorded weights, the outcomes were not significantly different, despite a potential misclassification bias. Furthermore, the percentage of women that gained above, within and below the guidelines remained essentially the same. While the best method for evaluating weight gain during pregnancy would be based on recorded weight at conception, this is not possible. By examining the data using self- reported prepregnancy weight and recorded weight at study entry, both of which have limitations, we were able to show that the associations were similar. Also, while our study was large, some of the subgroups were relatively small, and therefore, some important differences may not have been detected due to a lack of power in individual categories. Lastly, we have examined associations and are not able to confirm the causal implications of these data.

In summary, our study demonstrates a clear association between gestational weight gain and pregnancy outcome. Most of the women in our study gained more weight during pregnancy than is recommended by the current IOM guidelines and this excessive weight gain had clear clinical downsides. Interventional trials of targeted weight gain during pregnancy are urgently needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographic Characteristics

	Underweight n=389	Normal weight n=4,522	Overweight n=1,937	Obese n=1,445	P
Age (years)	22.1 ± 4.3	23.7 ± 5.3	23.9 ± 5.4	23.4 ± 5.0	<0.001
Race *					<0.001
African American	100 (25.7)	802 (17.7)	487 (25.1)	598 (41.4)	
Hispanic	108 (27.8)	1,402 (31.0)	642 (33.1)	315 (21.8)	
Caucasian	169 (43.4)	2,217 (49.0)	780 (40.3)	521 (36.1)	
Asian	8 (2.1)	71 (1.6)	16 (0.8)	4 (0.3)	
Other	4 (1.0)	30 (0.7)	12 (0.6)	7 (0.5)	
Prepregnancy BMI†	17.6 ± 0.8	21.9 ± 1.7	27.1 ± 1.4	35.6 ± 5.2	<0.001
Gestational age at study entry	13.5 ± 2.1	13.5 ± 2.1	13.4 ± 2.1	13.3 ± 2.1	0.05
BMI at study entry	18.7 ± 1.3	22.7 ± 2.1	28.0 ± 2.1	36.3 ± 5.3	<0.001
Smoker	82 (21.1)	576 (12.7)	293 (15.1)	312 (21.6)	<0.001
Education level (years)	12.6 ± 2.5	13.0 ± 2.8	12.7 ± 2.8	12.7 ± 2.3	<0.001

BMI, body mass index.
Data are mean ± standard deviation or number (%).

* Race or ethnic group is self-reported.

† Self-reported prepregnancy weight used to calculate prepregnancy body mass index.

Table 2

Weight Gain According to Prepregnancy Body Mass Index Category

	Underweight n=389	Normal weight n=4,522	Overweight n=1,937	Obese n=1,445
Weight gain above the IOM guidelines	170 (43.7)	3,190 (70.5)	1,635 (84.4)	1,063 (73.6)
Weight gain within the IOM guidelines	143 (36.8)	913 (20.2)	193 (10.0)	199 (13.8)
Weight gain below the IOM guidelines	76 (19.5)	419 (9.3)	109 (5.6)	183 (12.7)

IOM, Institute of Medicine.
Data are n (%).

Table 3

Outcomes For All Women and Their Neonates In Reference To Weight Gain

	Below IOM n=787	Within IOM n=1,448	Above IOM n=6,058	*P* *
Gestational hypertension	125 (15.9)	258 (17.8)	1,436 (23.7)	< 0.001
Preeclampsia	37 (4.7)	45 (3.1)	483 (8.0)	< 0.001
Cesarean delivery	138 (17.5)	276 (19.1)	1,647 (27.2)	< 0.001
Indicated preterm birth	25 (3.2)	35 (2.4)	173 (2.9)	0.99
Spontaneous preterm birth	66 (8.4)	75 (5.2)	283 (4.7)	< 0.001
Small for gestational age†	158 (20.4)	221 (15.3)	647 (10.7)	< 0.001
Large for gestational age‡	28 (3.6)	99 (6.9)	732 (12.1)	< 0.001

IOM, Institute of Medicine.
Data are n (%).

*P values are from the Cochran-Armitage test for trend.

†Small for gestational age defined as birth weight below the 10th percentile.

‡Large for gestational age defined as birth weight at or above the 90th percentile.

Table 4

Multivariable Analysis of Outcomes Among Women Gaining Above the Institute of Medicine Guidelines*

	Underweight OR (95% CI)	Normal weight OR (95% CI)	Overweight OR (95% CI)	Obese OR (95% CI)
Gestational hypertension	2.0 (1.0–3.8)	1.5 (1.2–1.8)	1.4 (0.9–2.0)	1.2 (0.9–1.7)
Preeclampsia	3.6 (0.9–13.8)	2.5 (1.6–3.9)	4.2 (1.7–10.4)	1.9 (1.0–3.3)
Cesarean delivery	1.3 (0.7–2.5)	1.6 (1.3–2.0)	1.8 (1.2–2.6)	1.1 (0.8–1.5)
Indicated preterm birth	0.8 (0.2–4.1)	1.2 (0.7–2.1)	1.2 (0.5–3.1)	0.9 (0.4–1.8)
Spontaneous preterm birth	0.8 (0.3–1.9)	0.9 (0.6–1.3)	0.7 (0.4–1.2)	1.3 (0.6–2.6)
Small for gestational age†	0.5 (0.3–1.1)	0.6 (0.5–0.7)	0.4 (0.3–0.6)	1.0 (0.7–1.4)
Large for gestational age‡	2.5 (1.0–6.1)	1.7 (1.3–2.3)	2.5 (1.3–4.5)	1.9 (1.0–3.7)

OR, odds ratio; CI, confidence interval.

*Adjusted for maternal age, race, treatment group and smoking. Referent group is women gaining within the guidelines.

†Small for gestational age defined as birth weight below the 10th percentile.

‡Large for gestational age defined as birth weight at or above the 90th percentile.

Table 5

Multivariable Analysis of Outcomes Among Women Gaining Below the Institute of Medicine Guidelines*

	Underweight OR (95% CI)	Normal weight OR (95% CI)	Overweight OR (95% CI)	Obese OR (95% CI)
Gestational hypertension	0.6 (0.2–1.5)	0.7 (0.5–1.1)	0.7 (0.4–1.4)	0.7 (0.5–1.2)
Preeclampsia	2.5 (0.5–11.5)	1.3 (0.7–2.5)	1.0 (0.2–4.4)	1.1 (0.5–2.3)
Cesarean delivery	0.4 (0.2–1.1)	0.9 (0.7–1.3)	0.7 (0.4–1.4)	0.9 (0.6–1.3)
Indicated preterm birth	1.2 (0.2–8.0)	1.2 (0.5–2.7)	1.4 (0.4–5.4)	0.9 (0.4–2.4)
Spontaneous preterm birth	1.2 (0.5–3.1)	2.0 (1.3–3.2)	1.0 (0.4–2.5)	1.8 (0.7–4.2)
Small for gestational age†	1.6 (0.8–3.4)	1.3 (1.0–1.8)	0.7 (0.4–1.4)	1.7 (1.1–2.8)
Large for gestational age‡	0.5 (0.1–2.6)	0.5 (0.3–0.8)	0.4 (0.1–1.6)	0.8 (0.3–2.2)

OR, odds ratio; CI, confidence interval.

*Adjusted for maternal age, race, treatment group and smoking. Referent group: women gaining within the guidelines.

†Small for gestational age defined as birth weight below the 10th percentile.

‡Large for gestational age defined as birth weight at or above the 90th percentile.