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GESTATIONAL WEIGHT GAIN WITHIN RECOMMENDED RANGES IN CONSECUTIVE PREGNANCIES: A RETROSPECTIVE COHORT STUDY

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Abstract

Objective—To examine whether, among parous women, adherence to gestational weight gain (GWG) recommendations in the most recent previous pregnancy is associated with adherence to GWG recommendations in the current pregnancy.

Design—Retrospective cohort study.

Setting—Review of labour & delivery records from a Massachusetts tertiary-care centre.

Participants—1,325 women who delivered two consecutive singletons from April 2006 through March 2010.

Measurements—Pre-pregnancy weight status and adherence to GWG recommendations were categorized using 1990 Institute of Medicine (IOM) guidelines. Analyses were stratified by weight status before the second pregnancy.

Findings—56% and 46% of women gained more than 1990 IOM recommendations during the first and second of consecutive pregnancies; 57% gained within the same adherence category in both pregnancies. Excessive GWG during the first pregnancy was strongly associated with excessive gain during the second pregnancy (adjusted odds ratio [AOR] = 5.4 [95% CI: 1.7–16.4] for underweight, 3.7 [95% CI: 2.4–5.5] for normal weight, 3.0 [95% CI: 1.2–7.6] for overweight, and 5.3 [95% CI: 2.4–11.7] for obese women). Inadequate gain in the first of consecutive pregnancies was strongly associated with subsequent inadequate GWG for underweight women

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CONFLICT OF INTEREST STATEMENT
The authors have no declarations of interest.

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(AOR = 13.7; 95% CI: 3.9–48.0), normal weight women (AOR = 2.9; 95% CI: 1.7–5.1), and obese women (AOR = 3.6; 95% CI: 1.4–9.3). Results were similar in sensitivity analyses using IOM 2009 guidelines.

Key conclusions—Adherence to GWG recommendations in consecutive pregnancies is highly concordant.

Implications for practice—Consideration of GWG during previous pregnancies may facilitate discussions about GWG during prenatal care.

Keywords

gestational weight gain; pregnancy; pre-pregnancy weight status; parity

INTRODUCTION

The Institute of Medicine (IOM) provides guidelines for weight gain during pregnancy which are based on optimizing short- and long-term maternal and child health outcomes (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990; Rasmussen and Yaktine, 2009). An estimated two-thirds to three-quarters of women experience gestational weight gain (GWG) outside of these recommended ranges: 40–60% of women experiencing excessive gain and 15–30% inadequate gain (de la Torre et al., 2011; Fortner et al., 2009; Mamun et al., 2011; Moore Simas et al., 2010; Stotland et al., 2006). Excessive GWG increases risk for negative maternal and child health outcomes including gestational diabetes (Hedderson et al., 2010), pre-eclampsia (DeVader et al., 2007; Fortner et al., 2009) or pregnancy-related hypertension (de la Torre et al., 2011), Caesarean delivery (de la Torre et al., 2011; DeVader et al., 2007; Margerison Zilko et al., 2010), macrosomia or large-for-gestational age birthweight (DeVader et al., 2007; Mamun et al., 2011; Margerison Zilko et al., 2010; Moore Simas et al., Epub ahead of print 14 December 2011; Siega-Riz et al., 2009; Stotland et al., 2006), maternal post-partum weight retention (Gunderson et al., 2000 Dec; Huang et al., 2010; Siega-Riz et al., 2009; Vesco et al., 2009), and overweight in the offspring (Oken et al., 2007). Inadequate GWG is associated with elevated risk of small-for-gestational age neonatal birthweight (Bodnar et al., 2010; DeVader et al., 2007; Moore Simas et al., Epub ahead of print 14 December 2011; Siega-Riz et al., 2009; Stotland et al., 2006), and pre-term delivery (Bodnar et al., 2010). Helping women achieve healthy GWG is critical in promoting the long-term health of both women and their children. There is little research on adherence to GWG recommendations in consecutive pregnancies (Chin et al., 2010), yet consideration of GWG in previous pregnancies may aid in counselling about GWG by prenatal care providers. The objective of this study was to examine whether, among parous women, adherence to GWG recommendations in the most recent previous pregnancy is associated with adherence to GWG recommendations in the current pregnancy. We hypothesized that compared to women with gain within IOM recommendations in her most recent previous pregnancy, women with previous inadequate gain would more likely to experience inadequate gain in the current pregnancy and women with excessive gain in the most recent previous pregnancy would more likely to experience excessive gain in the current pregnancy.

METHODS

Design and Setting

The [MEDICAL SCHOOL'S] clinical partner, [HOSPITAL] Labour & Delivery (L&D) unit houses approximately 4,200 pregnant women per year that are delivered by family medicine and obstetric staff including private, community, academic, and resident physicians. It is the

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tertiary care referral hospital for [STATE]. [HOSPITAL'S] L&D electronic medical record (EMR) provided data for this study. Deliveries from April 1, 2006 through March 31, 2010 were included in the export database. The database is surveyed periodically to evaluate internal consistency by direct comparison with patient charts. Missing data and outliers were verified or corrected by chart review where possible. The [INSTITUTION'S] Institutional Review Board approved this study.

Measures

The exposure variable is adherence to GWG recommendations during the first study pregnancy and the outcome is adherence to GWG recommendations during the second study pregnancy. Adherence to GWG recommendations was determined using pre-pregnancy weight status, GWG, and gestational age at delivery. Pre-pregnancy weight status was assessed with body mass index (BMI; kg/m^2) calculated from pre-pregnancy weight and height. Pre-pregnancy weight recorded in the L&D EMR at the time of delivery was, as available, self-reported pre-pregnancy weight from first prenatal visit, self-reported pre-pregnancy weight upon presentation for delivery, or measured weight at first prenatal visit transferred from the prenatal medical record. Height in the L&D EMR was either transferred from the prenatal record or self-reported at time of delivery. If height was missing at one pregnancy, height from the other pregnancy was used for calculation of BMI before both pregnancies. BMI was categorized according to weight categories outlined in the Institutes of Medicine (IOM) 1990 GWG guidelines: underweight ($< 19.8\ kg/m^2$), normal weight ($19.8\ kg/m^2 \leq BMI < 26.0\ kg/m^2$), overweight ($26.0\ kg/m^2 \leq BMI < 29.0\ kg/m^2$), and obese ($29.0\ kg/m^2 \leq BMI$) (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990). Adherence to GWG guidelines was assessed using the IOM 1990 guidelines (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990), as these guidelines defined standard of care during the majority of the study period, and therefore were most relevant to women's GWG goals and their providers' counselling efforts. GWG was ascertained by, as available, self-report GWG at time of delivery admission or difference between documented weight at last prenatal visit and pre-pregnancy weight. GWG was categorized as inadequate, appropriate, or excessive based on the IOM 1990's pre-pregnancy BMI-specific GWG guidelines. Minimum and maximum gain at each week of gestational age was determined using recommended gain by end of first trimester and rates of gain during the second and third trimesters, assuming the following ranges of gain by week 40: 28 – 40 pounds for women who were underweight before pregnancy, 25 – 35 pounds for women of normal weight, and 15 – 25 pounds for overweight women (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990). Because the 1990 IOM report did not provide a recommended range of GWG for women who were obese before pregnancy, the recommended range GWG for overweight women (15 – 25 pounds) was used for obese women (Moore Simas et al., 2010; Stotland et al., 2006). GWG below the BMI-specific range recommended by the IOM was considered to be inadequate gain, weight gain within the recommended gain was considered appropriate gain, and weight gain above the recommended range was considered excessive gain. We conducted a sensitivity analysis utilizing updated IOM GWG recommendations published in 2009 (Rasmussen and Yaktine, 2009). In this sensitivity analysis, pre-pregnancy weight status was categorized as: underweight ($BMI < 18.5\ kg/m^2$), normal weight ($18.5\ kg/m^2 \leq BMI < 25.0\ kg/m^2$), overweight ($25.0\ kg/m^2 \leq BMI < 30.0\ kg/m^2$), or obese ($30.0\ kg/m^2 \leq BMI$) and GWG was categorized as inadequate, appropriate or excessive using the approach described above for recommended GWG by week 40: 28 – 40 pounds for underweight, 25 – 35 pounds for normal weight, 15 – 25 pounds for overweight, and 11–20 pounds for obese women (Rasmussen and Yaktine, 2009).

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Other maternal and pregnancy characteristics were abstracted from the L&D EMR. Race/ethnicity was obtained from the EMR and may represent either self-reported or attributed race/ethnicity. Smoking included smoking any time before or during pregnancy. Diabetes and hypertension included both pre-gestational and gestational conditions. Inter-pregnancy interval was calculated as the number of months between the date of the first delivery and the estimated date of conception for the second study pregnancy as determined by date and gestational age of delivery, and was categorized as less than 12 months, at least 12 months but less than 18 months, or at least 18 months.

Statistical Analyses

We initially included women of any pre-pregnancy weight status in our analyses and tested one-way interactions. The interaction between weight status before the second pregnancy and adherence to GWG recommendations during the first pregnancy was statistically significant. Because our interest was in describing how adherence to GWG recommendations during a previous pregnancy might inform prenatal counselling regarding weight gain goals for the current pregnancy, we stratified our analyses by weight status before the second consecutive pregnancy. This way, our results are more easily interpreted in the context of providing useful and effective counselling for multipara women presenting for prenatal care.

We estimated odds ratios (ORs) and 95% confidence intervals (CIs) for inadequate and excessive GWG during the latter of consecutive pregnancies in relation to appropriateness of GWG during the first consecutive pregnancies using polytomous logistic regression models. In polytomous logistic regression, the outcome takes one of three or more categories and models are simultaneously fit using maximum likelihood to estimate odds ratios for each group compared to a common reference group (Kutner et al., 2005, pp. 608–618). In these analyses, the reference group was women with appropriate weight gain in their first study pregnancy. We controlled for confounding using multivariate adjustment. We evaluated characteristics of women at their second consecutive pregnancy for potential confounding: age, race, marital status, smoking, diabetes, hypertension, parity, receipt of prenatal care, and inter-pregnancy interval. We included in multivariate-adjusted models those covariates that were significantly related to GWG adherence at the first consecutive pregnancy at $p < 0.10$ within strata of pre-pregnancy weight status. Analyses were conducted in SAS (Version 9.2, SAS Institute, Inc., Cary, NC).

FINDINGS

Of the 1,753 women who delivered two singletons during the four-year study period, we excluded women missing information to calculate adherence to gestational weight gain recommendations (pre-pregnancy weight, GWG, and/or gestational age of delivery at either pregnancy, and/or height at both pregnancies; n = 392), and women missing covariates at their second pregnancy (n = 36), resulting in an analytic sample of 1,325 women (Figure 1). We compared available characteristics of women who were included in the analytic sample and those who were excluded; excluded women delivered half a week earlier (estimated mean gestational age at delivery: 38.4 [SD: 3.3] weeks versus 38.9 [SD: 2.4] weeks; p = 0.0063) but otherwise did not differ from the analytic sample.

At their first of two consecutive pregnancies within the study period, women in our sample averaged 27.8 years of age and parity of 0.7, 65% were white, and 63% were married (Table 1). Women had an average pre-pregnancy BMI of 25.2 kg/m^2 and gained an average of 33 pounds during pregnancy. Eighteen percent of women had inadequate GWG, 26% gained appropriately, and 56% gained excessively. Infants had an average gestational age of 38.7 weeks at delivery and had birthweights of nearly 3,300 grams. Eighty percent of births were

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vaginal. The vast majority of women received prenatal care during both pregnancies. At their second of consecutive pregnancies under evaluation, women were 1.6 years older (average age 29.6 years) and 69% were married (Table 1). Women were, on average, 0.9 kg/m^2 heavier at their second pregnancy (average BMI of 26.1 kg/m^2) and gained 29.7 pounds during this pregnancy. Twenty-one percent of women had inadequate GWG, a third had gained appropriately, and 46% gained excessively. Infants had an average gestational age of 38.9 weeks and weighed 3,268 grams at birth.

Before the start of their second consecutive pregnancy, approximately half of women were normal weight, 9% were underweight, 15% were overweight, and 25% were obese (Table 1). Appropriateness of GWG in consecutive pregnancies was strongly associated (Tables 2 and 3, Figure 2). Fifty-seven percent of women gained within the same IOM category (inadequate, appropriate, or excessive) in both pregnancies; concordance was similar stratified by weight status before the second consecutive pregnancy (64% of underweight women, 56% of normal weight women, 62% of overweight women, and 56% of obese women gained within the same category in both pregnancies). Excessive GWG during the first of two consecutive pregnancies was associated with significantly increased odds of excessive gain during the second pregnancy (adjusted ORs ranged from 3.0 – 5.4, Table 3). For overweight women, inadequate gain during the first pregnancy was associated with lower odds of excessive gain during the second pregnancy (adjusted OR = 0.2) and among obese women, inadequate gain in one pregnancy was associated with 3.3 times the odds of excessive gain in the next pregnancy (Table 3). For underweight, normal weight, and obese women, inadequate gain in one pregnancy was significantly associated with inadequate gain in the next pregnancy (adjusted ORs ranged from 2.9 to 13.7, Table 3). For normal weight women, excessive gain during the first pregnancy was also associated with lower odds of inadequate gain during the second pregnancy (adjusted OR = 0.4, Table 3).

In sensitivity analyses categorizing pre-pregnancy weight status and adherence to GWG recommendations according to the IOM's 2009 recommendations,(Rasmussen and Yaktine, 2009) fewer women were classified as underweight or obese and more were categorized as overweight, as expected given the differences in BMI cut-offs between the 1990 and 2009 reports.(Moore Simas et al., 2011) Concordance of adherence to GWG recommendations during consecutive pregnancies and results from multivariate-adjusted regression models were similar to the results of the main analyses (data not shown).

DISCUSSION

In summary, 57% of women gained within the same IOM category (inadequate, appropriate, or excessive) in both of two consecutive pregnancies. Excessive GWG during one pregnancy was strongly associated with excessive GWG during the woman's next pregnancy, regardless of the woman's pre-pregnancy weight status. Among normal weight and obese women, inadequate gain during one pregnancy was strongly associated with subsequent inadequate GWG. These results are similar to the only other study to our knowledge that has examined adherence to IOM recommendations for GWG in consecutive pregnancies (Chin et al., 2010). Chin et al. (2010) examined a similar question in a retrospective cohort of women eligible for North Carolina's Special Supplemental Nutrition Program for Women, Infants, and Children (Chin et al., 2010). Chin et al. included only women's first and second births, while in the current study, 41% of the women in the current study were parous at the first of consecutive pregnancies examined, highlighting the concordance of GWG adherence not only between first and second pregnancies, but between any two consecutive pregnancies. The current study demonstrates the association between GWG in consecutive pregnancies among multiparous as well as primiparous women.

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In 2009, the IOM updated its 1990 GWG recommendations to balance maternal and foetal benefits instead of the previous report's focus on decreasing the prevalence of small-for-gestational age neonates (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990). The revised guidelines provide a recommended range of gain for obese women and use World Health Organization cut-offs for pre-pregnancy weight status (Rasmussen and Yaktine, 2009). Chin et al. (2010) categorized adherence to GWG recommendations using the updated 2009 guidelines (Chin et al., 2010). While this approach provides an estimate of current population burden of inadequate or excessive GWG, these guidelines were not contemporary with the pregnancy experiences of women in their sample. We utilized the 1990 IOM guidelines so that our findings would represent the experiences of women at the time they were receiving prenatal care. We conducted a sensitivity analysis categorizing pre-pregnancy weight status and adherence to GWG recommendations using the 2009 IOM recommendations; results were similar to our main analyses. We explored one potential reason for gain outside recommended ranges during the second consecutive pregnancy despite adherent GWG in the first of consecutive pregnancies: weight change between pregnancies resulting in classification into a different BMI category and thus a different recommended range of gain. In this scenario, a woman may have gained a similar amount in her two pregnancies, but this amount of GWG would no longer have been adherent. Among women who gained within recommended ranges during their first pregnancy but outside the recommended ranges in her second pregnancy (N=178), for only 14 of the 49 women whose BMI category changed between pregnancies would their GWG in the second pregnancy have been classified as adherent according to what they weighed before their first pregnancy. Thus, different recommended ranges of GWG due to inter-pregnancy weight change does not provide an explanation the discordant adherence to IOM recommendations regarding GWG in two consecutive pregnancies in our sample. Provider counselling consistent with national recommendations is associated with GWG within recommended ranges (Cogswell et al., 1999; Stotland et al., 2005), yet as many as two-thirds of women report no GWG counselling or counselling inconsistent with GWG guidelines (Cogswell et al., 1999; McDonald et al., 2011; Phelan et al., 2011; Stotland et al., 2005). In a recent review of prenatal care records, we found that for only 15% of patients was a discussion about GWG documented, and only 10% of charts noted a specific weight gain goal (Moore Simas et al., 2010). Barriers to weight gain counselling identified by prenatal providers include insufficient training, concern about topic sensitivity, and misperceptions that counselling is ineffective (Stotland et al., 2010). Framing GWG goals in terms of GWG experiences in previous pregnancies including barriers and challenges to gaining within recommended ranges may facilitate effective communication between prenatal providers and pregnant women, and thus may help women achieve GWG within ranges recommended by the IOM.

Excessive GWG is associated with negative maternal and child outcomes for women of all weights (de la Torre et al., 2011; DeVader et al., 2007; Fortner et al., 2009; Gunderson et al., 2000 Dec; Hedderson et al., 2010; Huang et al., 2010; Mamun et al., 2011; Margerison Zilko et al., 2010; Moore Simas et al., Epub ahead of print 14 December 2011; Oken et al., 2007; Siega-Riz et al., 2009; Stotland et al., 2006; Vesco et al., 2009). However, excessive GWG may be particularly detrimental for obese women and their neonates given the elevated risk imparted by pre-pregnancy obesity (de la Torre et al., 2011; Fortner et al., 2009; Hedderson et al., 2010; Moore Simas et al., Epub ahead of print 14 December 2011). In this study, 25% of women were obese before the beginning of their second pregnancy. Only a quarter of obese women gained within IOM recommended ranges, while 27% had inadequate GWG and 48% had excessive gain. Sixty percent of obese women who gained excessively in their first pregnancy gained excessively in their next pregnancy as well. Helping obese pregnant women gain within recommended ranges is challenging because of lower gain recommendations but also because of the stigmatization and humiliation some obese

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pregnant women feel because of their weight (Furber and McGowan, 2011; Nyman et al., 2010). In one study, obese women were concerned about post-partum weight retention and strove to not gain excessively in order to return to their pre-pregnancy weight after delivery, yet many women expressed concern over their ability to control their weight gain, and all would prioritize the health and growth of their foetus over their own post-partum weight (Wiles, 1998). Despite feeling that the advice they had received from their prenatal care providers about weight gain and diet during pregnancy was insufficient, participants spoke to the important role their prenatal care providers could play in helping them achieve a healthy weight gain (Wiles, 1998). In addition to the challenges inherent to counselling about GWG in the prenatal care setting (Stotland et al., 2010), providers report additional challenges about discussing weight and weight gain with obese patients (Schmied et al., 2011), Our findings reinforce the importance of sensitive, relevant counselling about GWG for obese pregnant women, and suggest that for obese women, as well as normal weight or overweight women, GWG in a previous pregnancy could inform discussions about GWG goals in the context of prenatal care.

This study has strengths and limitations. The study includes a contemporary sample of women. A quarter of our sample was obese before the beginning of their second pregnancy, similar to national estimates (Chu et al., 2009). We examined GWG during consecutive pregnancies, thus only women who gave birth to two singletons during the study period were included in our sample. Regression analyses were conducted separately within category of weight status before the second study pregnancy and analyses may be underpowered to detect modest differences, particularly analyses of women who were underweight (n=118) or overweight (n=198) before their second study pregnancy. Because the study data were derived from a clinical database, we were unable to examine socioeconomic, psychosocial, and behavioural factors potentially associated with GWG during consecutive pregnancies. Finally, pre-pregnancy weight was self-reported at first prenatal visit or at delivery, potentially resulting in misclassification of pre-pregnancy weight status and therefore recommended GWG ranges. While previous studies noted overreporting of weight by underweight adults and underreporting of weight by overweight and obese adults (Stommel and Schoenborn, 2009), a recent study found that self-reported and clinically measured pre-pregnancy weights were highly correlated ($r = 0.99$) and that the mean underreporting of weight by approximately two pounds did not differ by race/ethnicity, gestational age, or pre-pregnancy weight (Oken et al., 2007). In another study, 85% of women were categorized the same into weight categories using self-reported pre-pregnancy weight and measured weight at the end of the first trimester (Lederman and Paxton, 1998). Thus, while misclassification of pre-pregnancy weight status is possible, it is unlikely to explain our findings. To estimate the potential impact self-reported delivery weight had on our findings, we conducted a sensitivity analysis in which we adjusted GWG by the average amounts underreported in a previous study (Schieve et al., 1999). As expected, more women experienced excessive gain and fewer had inadequate gain in each pregnancy; estimated ORs and 95% CIs were consistent with our main findings (data not shown).

Inadequate and excessive GWG are modifiable risk factors for adverse child and maternal health outcomes. We found a strong concordance between adherence to GWG recommendations during consecutive pregnancies, suggesting a potential utility in including GWG in previous pregnancies in discussions about GWG in the context of prenatal care.

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REFERENCES

Bodnar LM, Siega-Riz AM, Simhan HN, Himes KP, Abrams B. Severe obesity, gestational weight gain, and adverse birth outcomes. American Journal of Clinical Nutrition. 2010; 91:1642–1648. [PubMed: 20357043]

Chin JR, Krause KM, Ostbye T, Chowdhury N, Lovelady CA, Swamy GK. Gestational weight gain in consecutive pregnancies. American Journal of Obstetrics & Gynecology. 2010; 203:e1–e6. [PubMed: 20816151]

Chu SY, Callaghan WM, Bish CL, D'Angelo D. Gestational weight gain by body mass index among US women delivering live births, 2004–2005: fueling future obesity. American Journal of Obstetrics and Gynecology. 2009; 200:e1–e7.

Cogswell ME, Scanlon KS, Beck Fein S, Schieve LA. Medically advised, mother's personal target, and actual weight gain during pregnancy. Obstetrics & Gynecology. 1999; 94:616–622. [PubMed: 10511369]

Committee on Nutritional Status During Pregnancy, Institute of Medicine. , editor. Nutrition during Pregnancy: Part I: Weight Gain, Part II: Nutrient Supplements. Washington, D.C.: National Academy Press; 1990.

de la Torre L, Flick AA, Istwan N, Rhea D, Cordova Y, Dieguez C, Desch C, Gonzalez-Quintero VH. The effect of new antepartum weight gain guidelines and prepregnancy body mass index on the development of pregnancy-related hypertension. American Journal of Perinatology. 2011; 28:285–292. [PubMed: 21229471]

DeVader SR, Neeley HL, Myles TD, Leet TL. Evaluation of gestational weight gain guidelines for women with normal prepregnancy body mass index. Obstetrics & Gynecology. 2007; 110:745–751. [PubMed: 17906004]

Fortner RT, Pekow P, Solomon CG, Markenson G, Chasan-Taber L. Prepregnancy body mass index, gestational weight gain, and risk of hypertensive disorders of pregnancy among Latina women. American Journal of Obstetrics & Gynecology. 2009; 200:167.e1–167.e7. [PubMed: 19070831]

Furber CM, McGowan L. A qualitative study of the experiences of women who are obese and pregnant in the UK. Midwifery. 2011; 27:437–444. [PubMed: 20483513]

Gunderson EP, Abrams B, Selvin S. The relative importance of gestational gain and maternal characteristics associated with the risk of becoming overweight after pregnancy. International Journal of Obesity & Related Metabolic Disorders: Journal of the International Association for the Study of Obesity. 2000 Dec.24:1660–1668. [PubMed: 11126221]

Hedderson MM, Gunderson EP, Ferrara A. Gestational weight gain and risk of gestational diabetes mellitus. Obstetrics & Gynecology. 2010; 115:597–604. [PubMed: 20177292]

Huang T, Wang H, Dai F. Effect of pre-pregnancy body size on postpartum weight retention. Midwifery. 2010; 26:222–231. [PubMed: 18657887]

Kutner, MH.; Nachtsheim, CJ.; Neter, J.; Li, W. Applied Linear Statistical Models. New York, NY: McGraw-Hill Irwin; 2005.

Lederman SA, Paxton A. Maternal reporting of prepregnancy weight and birth outcome: consistency and completeness compared with the clinical record. Maternal and Child Health Journal. 1998; 2:123–126. [PubMed: 10728268]

Mamun AA, Callaway LK, O'Callaghan MJ, Williams GM, Najman JM, Alati R, Clavarino A, Lawlor DA. Associations of maternal pre-pregnancy obesity and excess pregnancy weight gains with adverse pregnancy outcomes and length of hospital stay. BMC Pregnancy and Childbirth. 2011; 11:62. [PubMed: 21892967]

Margerison Zilko CE, Rehkopf D, Abrams B. Association of maternal gestational weight gain with short- and long-term maternal and child health outcomes. American Journal of Obstetrics & Gynecology. 2010; 202:e1–e8. [PubMed: 20132923]

McDonald SD, Pullenayegum E, Taylor VH, Lutsiv O, Bracken K, Good C, Hutton E, Sword W. Despite 2009 guidelines, few women report being counseled correctly about weight gain during

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pregnancy. American Journal of Obstetrics and Gynecology. 2011; 205:e1–e6. [PubMed: 21784404]

Moore Simas TA, Curiale DKD, Hardy J, Jackson S, Zhang Y, Xun L. Efforts needed to provide Institute of Medicine-recommended guidelines for gestational weight gain. Obstetrics & Gynecology. 2010; 115:777–783. [PubMed: 20308839]

Moore Simas TA, Liao X, Garrison A, Sullivan GMT, Howard AE, Hardy JR. Impact of updated Institute of Medicine guidelines on prepregnancy body mass index categorization, gestational weight gain recommendations, and needed counseling. Journal of Women's Health. 2011; 20:837–844.

Moore Simas TA, Waring ME, Liao X, Garrison A, Sullivan GMT, Howard AE, Hardy JR. Pre-pregnancy weight, gestational weight gain, and risk of growth affected neonates. Journal of Women's Health. 2011 Dec 14. Epub ahead of print.

Nyman VMK, Prebensen AK, Flensner GEM. Obese women's experiences of encounters with midwives and physicians during pregnancy and childbirth. Midwifery. 2010; 26:424–429. [PubMed: 19100667]

Oken E, Taveras EM, Kleinman KP, Rich-Edwards JW, Gillman MW. Gestational weight gain and child adiposity at age 3 years. American Journal of Obstetrics & Gynecology. 2007; 196:e1–e8. [PubMed: 17403405]

Phelan S, Phipps MG, Abrams B, Darroch F, Schaffner A, Wing RR. Practitioner advice and gestational weight gain. Journal of Women's Health. 2011; 20:585–591.

Rasmussen, KM.; Yaktine, AL., editors. Weight Gain during Pregnancy: Reexamining the Guidelines. Washington, D.C.: Institute of Medicine and National Research Council of the National Academies; 2009.

Schieve LA, Perry GS, Cogswell ME, Scanlon KS, Rosenberg D, Carmichael S, Ferre C. for the NMIHS Collaborative Working Group. Validity of self-reported pregnancy delivery weight: an analysis of the 1988 National Maternal and Infant Health Survey. American Journal of Epidemiology. 1999; 150:947–956. [PubMed: 10547140]

Schmied VA, Duff M, Dahlen HG, Mills AE, Kolt GS. 'Not waving but drowning': a study of the experiences and concerns of midwives and other health professionals caring for obese childbearing women. Midwifery. 2011; 27:424–430. [PubMed: 20381222]

Siega-Riz AM, Viswanathan M, Moos M, Deierlein A, Mumford S, Knaack J, Thieda P, Luz LJ, Lohr KN. A systematic review of outcomes of maternal weight gain according to Institute of Medicine recommendations: birthweight, fetal growth, and postpartum weight retention. American Journal of Obstetrics & Gynecology. 2009; 201:e1–e14. [PubMed: 19788965]

Stommel M, Schoenborn CA. Accuracy and usefulness of BMI measures based on self-reported weight and height: findings from the NHANES and NHIS 2001– 2006. BMC Public Health. 2009; 9

Stotland NE, Cheng YW, Hopkins LM, Caughey AB. Gestational weight gain and adverse neonatal outcome among term infants. Obstetrics & Gynecology. 2006; 108:635–643. [PubMed: 16946225]

Stotland NE, Gilbert P, Bogetz A, Harper CC, Abrams B, Gerbert B. Preventing excessive weight gain in pregnancy: how do prenatal care providers approach counseling? Journal of Women's Health. 2010; 19:807–814.

Stotland NE, Haas JS, Brawarsky P, Jackson RA, Fuentes-Afflick E, Escobar GJ. Body mass index, provider advice, and target gestational weight gain. Obstetrics & Gynecology. 2005; 105:633–638. [PubMed: 15738036]

Vesco KK, Dietz PM, Rizzo J, Stevens VJ, Perrin NA, Bachman DJ, Callaghan WM, Bruce FC, Hornbrook MC. Excessive gestational weight gain and postpartum weight retention among obese women. Obstetrics & Gynecology. 2009; 114:1069–1075. [PubMed: 20168109]

Wiles R. The views of women of above average weight about appropriate weight gain in pregnancy. Midwifery. 1998; 14:254–260. [PubMed: 10076321]

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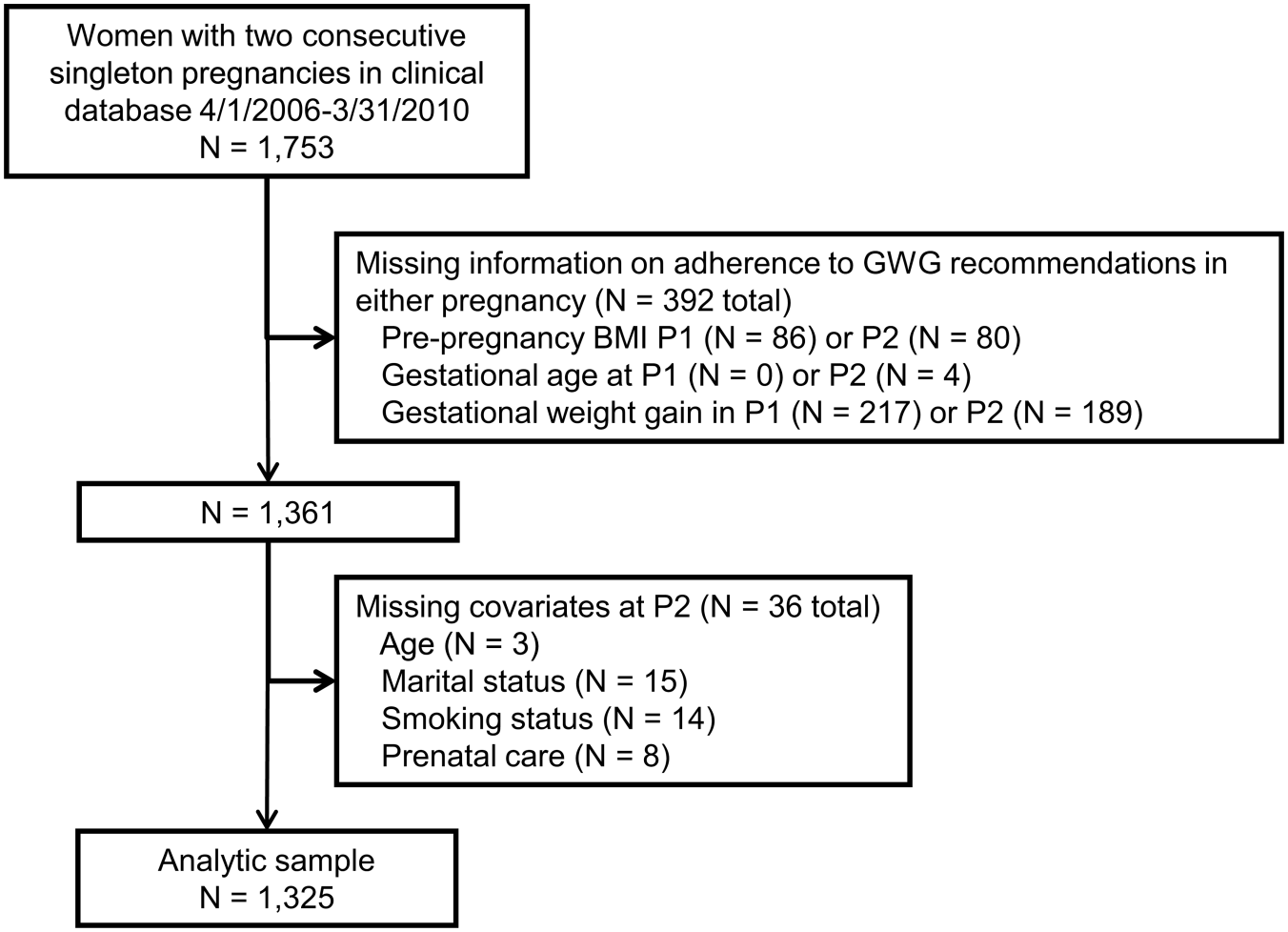

Figure 1.
Study flow diagram.
BMI: body mass index; P1: first study pregnancy; P2: second study pregnancy.

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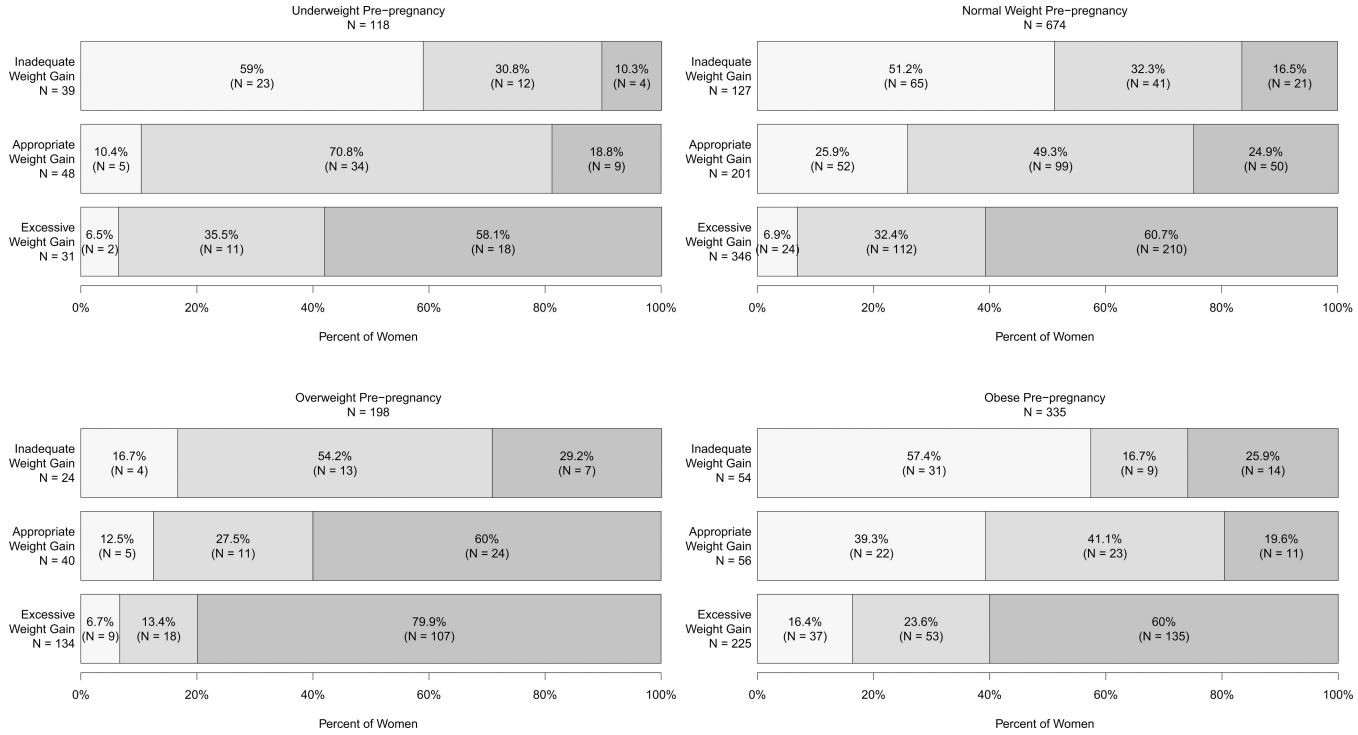

Figure 2.

Adherence to gestational weight gain recommendations during the second of consecutive pregnancies in relation to adherence to weight gain recommendations during first pregnancy, by weight status at start of second pregnancy*

Light grey bars represent inadequate gestational weight gain (GWG) during second pregnancy, medium grey bars represent appropriate GWG during the second pregnancy, and darker grey bars represent excessive GWG during the second pregnancy.

* Pre-pregnancy weight status categorized as underweight (BMI < 19.8 kg/m^2), normal weight (19.8 kg/m^2 ≤ BMI < 26.0 kg/m^2), overweight (26.0 kg/m^2 ≤ BMI < 29.0 kg/m^2), and obese (29.0 kg/m^2 ≤ BMI) (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990).

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Table 1

Characteristics of 1,325 women with two consecutive singleton births, in relation to weight status* before second study pregnancy, % or M (SD)

	First study pregnancy	Second study pregnancy				
	All women (n = 1325)**	**All women (n = 1325)#**	**Underweight (n = 118)**	**Normal weight (n = 674)**	**Overweight (n = 198)**	**Obese (n = 335)**
Age (years)	27.8 (5.7)	29.6 (5.7)	28.7 (5.8)	29.7 (5.7)	30.2 (5.8)	29.4 (5.6)
15–19 years	8.2	3.0	3.4	3.3	4.0	1.8
20–24 years	21.5	18.9	21.2	18.8	15.2	20.3
25–29 years	30.0	24.5	28.0	21.4	23.7	29.9
30–34 years	27.9	32.9	33.1	35.5	31.8	28.4
35+ years	12.5	20.8	14.4	21.1	25.3	19.7
Race/ethnicity	65.1	65.0	67.8	65.7	66.2	61.8
White	18.4	18.3	18.6	16.2	20.2	21.2
Hispanic	7.3	7.3	1.7	6.2	8.6	10.8
Black	9.2	9.4	11.9	11.9	5.1	6.3
Other (Asian, other, missing)						
Married	62.7	69.0	68.6	71.8	68.7	63.6
Ever smoker	9.1	11.5	15.3	8.6	13.6	14.6
Diabetes (pre-gestational and gestational)	4.5	5.1	2.5	4.2	3.0	9.0
Hypertension (pre-gestational and gestational)	6.1	4.5	0	3.9	4.6	7.5
Parity	0.7 (1.0)	1.7 (1.0)	1.7 (1.3)	1.6 (0.9)	1.7 (1.0)	1.8 (1.2)
0	58.5	--	--	--	--	--
1	26.6	58.5	61.0	62.2	57.1	51.0
2+	14.9	41.5	39.0	37.8	42.9	49.0
Pre-pregnancy BMI (kg/m^2)	25.2 (5.6)	26.1 (5.9)	18.7 (0.9)	22.9 (1.7)	27.5 (0.9)	34.4 (4.8)
Underweight	10.4	8.9				
Normal weight	56.4	50.9				
Overweight	13.4	14.9				
Obese	19.9	25.3				
Gestational weight gain (lbs)	33.2 (15.0)	29.7 (13.7)	33.1 (11.5)	32.0 (11.6)	30.4 (12.3)	23.4 (16.8)
Inadequate gain	18.4	21.1	25.4	20.9	9.1	26.9
Appropriate gain	26.0	32.9	48.3	37.4	21.2	25.3
Excessive gain	55.6	46.0	26.3	41.7	69.7	47.8
Prenatal care	98.7	98.4	95.8	98.4	99.5	98.8
Estimated gestational age at delivery (weeks)	38.7 (3.2)	38.9 (2.4)	38.8 (2.2)	38.9 (2.5)	38.9 (2.6)	38.9 (2.3)
Infant birth weight (grams)	3268 (697)	3393 (619)	3232 (593)	3374 (605)	3441 (665)	3459 (619)

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	First study pregnancy	Second study pregnancy				
	All women (n = 1325)**	**All women (n = 1325)#**	**Underweight (n = 118)**	**Normal weight (n = 674)**	**Overweight (n = 198)**	**Obese (n = 335)**
Inter-pregnancy interval (months)		14.6 (8.1)	14.0 (7.2)	15.2 (7.9)	13.8 (8.6)	13.9 (8.5)
< 12 months		39.9	40.7	35.6	41.9	47.2
12 – <18 months		28.9	30.5	30.7	31.3	23.3
≥ 18 months		31.2	28.8	33.7	26.8	29.6
Mode of delivery	70.4	74.4	80.5	77.5	73.2	66.9
Spontaneous vaginal	10.3	3.0	2.5	3.4	2.5	2.4
Operative vaginal delivery	13.8	5.1	2.5	5.2	5.6	5.7
Primary C-section	5.5	17.5	14.4	13.8	18.7	25.1
Repeat C-section						

*Pre-pregnancy weight status categorized as underweight (< 19.8 kg/m^2), normal weight (19.8 kg/m^2 ≤ BMI < 26.0 kg/m^2), overweight (26.0 kg/m^2 ≤ BMI < 29.0 kg/m^2), and obese (29.0 kg/m^2 ≤ BMI) (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990).

**Some women were missing information about their first pregnancy: age (n = 1), race (n=2), marital status (n = 1), prenatal care (n = 11), infant birthweight (n=1), or model of delivery (n=1).

#Two women were missing information on mode of delivery in their second pregnancy.

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Table 2

Adherence to GWG recommendations in the second study pregnancy in relation to weight status* preceding second pregnancy and adherence to GWG recommendations in the first study pregnancy, N (%)

		Weight gain during the second study pregnancy		
Weight status preceding second study pregnancy	**Weight gain during first study pregnancy**	**Inadequate gain**	**Appropriate gain**	**Excessive gain**
Underweight (n=118)	Inadequate gain (n=39)	23 (59.0)	12 (30.8)	4 (10.3)
	Appropriate gain (n=48)	5 (10.4)	34 (70.8)	9 (18.8)
	Excessive gain (n=31)	2 (6.5)	11 (35.5)	18 (58.1)
Normal weight (n=674)	Inadequate gain (n=127)	65 (51.2)	41 (32.3)	21 (16.5)
	Appropriate gain (n=201)	52 (25.9)	99 (49.3)	50 (24.9)
	Excessive gain (n=346)	24 (6.9)	112 (32.4)	210 (60.7)
Overweight (n=198)	Inadequate gain (n=24)	4 (16.7)	13 (54.2)	7 (29.2)
	Appropriate gain (n=40)	5 (12.5)	11 (27.5)	24 (60.0)
	Excessive gain (n=134)	9 (6.7)	18 (13.4)	107 (79.9)
Obese (n=335)	Inadequate gain (n=54)	31 (57.4)	9 (16.7)	14 (25.9)
	Appropriate gain (n=56)	22 (39.3)	23 (41.1)	11 (19.6)
	Excessive gain (n=225)	37 (16.4)	53 (23.6)	135 (60.0)

*Pre-pregnancy weight status categorized as underweight (BMI < 19.8 kg/m^2), normal weight (19.8 kg/m^2 ≤ BMI < 26.0 kg/m^2), overweight (26.0 kg/m^2 ≤ BMI < 29.0 kg/m^2), and obese (29.0 kg/m^2 ≤ BMI) (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990).

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Table 3

Association between adherence to GWG recommendations in consecutive pregnancies, in relation to weight status[*] preceding second pregnancy, OR (95% CI)

		Weight gain during second study pregnancy			
		Inadequate gain		Excessive gain	
Weight status preceding second study pregnancy	Weight gain during first study pregnancy	Crude	Adjusted	Crude	Adjusted
Underweight (n=118)[†]	Inadequate gain (n=39)	13.0 (4.0 – 42.0)	13.7 (3.9 – 48.0)	1.3 (0.3 – 4.9)	1.2 (0.3 – 4.8)
	Appropriate gain (n=48)	(Referent)	(Referent)	(Referent)	(Referent)
	Excessive gain (n=31)	1.2 (0.2 – 7.3)	1.0 (0.2 – 6.3)	6.2 (2.2 – 17.7)	5.4 (1.7 – 16.4)
Normal weight (n=674)[‡]	Inadequate gain (n=127)	3.0 (1.8 – 5.1)	2.9 (1.7 – 5.1)	1.0 (0.5 – 1.9)	1.0 (0.5 – 1.9)
	Appropriate gain (n=201)	(Referent)	(Referent)	(Referent)	(Referent)
	Excessive gain (n=346)	0.4 (0.2 – 0.7)	0.4 (0.2 – 0.7)	3.7 (2.5 – 5.6)	3.7 (2.4 – 5.5)
Overweight (n=198)[§]	Inadequate gain (n=24)	0.7 (0.1 – 3.2)	0.5 (0.1 – 2.4)	0.2 (0.1 – 0.8)	0.2 (0.1 – 0.7)
	Appropriate gain (n=40)	(Referent)	(Referent)	(Referent)	(Referent)
	Excessive gain (n=134)	1.1 (0.3 – 4.1)	1.3 (0.3 – 5.1)	2.7 (1.1 – 6.5)	3.0 (1.2 – 7.6)
Obese (n=335)[¶]	Inadequate gain (n=54)	3.6 (1.4 – 9.3)	3.6 (1.4 – 9.3)	3.3 (1.1 – 9.8)	3.3 (1.1 – 9.8)
	Appropriate gain (n=56)	(Referent)	(Referent)	(Referent)	(Referent)
	Excessive gain (n=225)	0.7 (0.4 – 1.5)	0.7 (0.4 – 1.5)	5.3 (2.4 – 11.7)	5.3 (2.4 – 11.7)

[*] Pre-pregnancy weight status categorized as underweight (BMI < 19.8 kg/m^2), normal weight (19.8 kg/m^2 ≤ BMI < 26.0 kg/m^2), overweight (26.0 kg/m^2 ≤ BMI < 29.0 kg/m^2), and obese (29.0 kg/m^2 ≤ BMI) (Committee on Nutritional Status During Pregnancy, Institute of Medicine, 1990).

[†] Adjusted for marital status (not married versus married), smoking status (ever smoked versus never smoked), and parity (2+ versus 1).

[‡] Adjusted for race (Black, Hispanic, other versus White), diabetes (gestational or pre-gestational versus neither), and inter-pregnancy interval (12 ≤ interval < 18 months, 18+ months versus < 12 months).

[‡] Adjusted for inter-pregnancy interval (12 ≤ interval < 18 months, 18+ months versus < 12 months).

[¶] Not adjusted for additional covariates.