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Gestational Weight Gain and Post-Partum Weight Loss Among Young, Low-Income, Ethnic Minority Women

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Abstract

Objective—Document weight change trajectories that lead to *gestational weight gain* or *postpartum weight loss* outside clinical recommendations established by Institute of Medicine (IOM).

Methods—Women aged 14-25 receiving prenatal care and delivering singleton infants at term (N=427). Medical record review and four structured interviews conducted: second and third trimester, 6- and 12-months postpartum. Longitudinal mixed modeling to evaluate weight change trajectories.

Results—Only 22% of participants gained gestational weight within IOM guidelines. 62% exceeded maximum recommendations -- more common among those overweight/obese (BMI≥25.0; p<0.0001). 52% retained ≥10 pounds one-year postpartum. Increased weight gain and retention documented among smokers and women with pregnancy-induced hypertension; breastfeeding promoted postpartum weight loss (all p<.02). BMI by race interaction suggested healthier outcomes for Latinas (p=0.02).

Conclusion—Excessive pregnancy weight gain and inadequate postpartum weight loss are highly prevalent among young low-income ethnic minority women. Pregnancy and postpartum are critical junctures for weight management interventions.

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DISCLOSURE Ms. Rising is the executive director of the non-profit entity, the Centering Pregnancy and Parenting Association, Inc., which promotes the Centering Pregnancy model of care nationally and internationally. The other authors have no potential conflicts to disclose.

Keywords

Pregnancy; weight gain; obesity; longitudinal; racial differences

CONDENSATION

Excessive pregnancy weight gain and inadequate postpartum weight loss are highly prevalent among young urban women based on new IOM guidelines, indicating clinical intervention needs.

INTRODUCTION

Inappropriate patterns of gestational weight gain and post-partum weight loss have important public health implications. Inadequate weight gain during pregnancy is primarily associated with intrauterine growth restriction and preterm delivery (1-3). Excessive maternal weight gain is associated with cesarean delivery, maternal anemia, preterm labor, macrosomia and traumatic birth injury (4). Post-partum weight retention can contribute to maternal long-term obesity and associated adverse health sequelae of cardiovascular disease, hypertension, diabetes and degenerative joint disease, among others (5,6). Moreover, excessive gestational weight gain has also been associated with higher body mass index (BMI) and blood pressure in children and young adults (7-9). Several population-based cohort studies have documented that only 30-40% of women meet recommended weight gain guidelines during pregnancy (11-14).

In 2009, the Institute of Medicine (IOM) published new target gestational weight gain recommendations to address gestational weight gain based on pre-pregnancy BMI – articulating a narrow range for women who are obese (15). The panel noted that US women are heavier, and that a greater proportion are entering pregnancy overweight or obese, increasing health risks for both mother and child. The IOM panel also explicitly stated the need for research to identify factors that affect weight gain and weight retention in diverse populations. To date, few studies have focused on young minority women, and data examining gestational weight gain and retention in light of the new IOM guidelines are limited.

Epidemiologic investigations that have evaluated determinants of excessive gestational weight gain suggest that this is more likely among African-American women, women with hypertension, and among those who ceased smoking coincident with or immediately preceding the index pregnancy (11,17-20). Post-partum weight retention has been most strongly associated with increased gestational weight gain (4,6,12,17). Other factors such as exercise frequency, dietary choices, smoking status, educational attainment and bottle feeding have been inconsistently associated with postpartum weight retention (21-28).

The purpose of this study was to document the trajectory of weight change from pre-pregnancy baseline through pregnancy, delivery, and the first year post-partum among a cohort of young, predominantly African-American and Hispanic women. The application of longitudinal modeling techniques permits inclusion of correlation structures across repeated measures that reduce standard errors and increase the power to detect the effect of predictors – a substantial advantage over traditional cross-sectional data analysis (29). Controlling for relevant demographic, physiologic, and behavioral variables, we examined the role of pre-pregnancy BMI on trajectories of weight change that lead to either gestational weight gain or post-partum weight loss outside clinical recommendations recently established by the Institute of Medicine (15).

MATERIALS AND METHODS

Patient Selection and Data Collection

Data are from a randomized clinical trial that enrolled pregnant women ages 14-25 at the largest publicly-funded university-affiliated hospital clinics in New Haven, CT and Atlanta, GA (2001-2004). The trial was aimed at promoting improved reproductive outcomes through group prenatal care, and complete details of the clinical protocol have been published elsewhere (30). Inclusion criteria consisted of: (1) pregnant between 16-24 weeks gestation; (2) no severe medical problems at time of enrollment that would require individualized assessment and tracking as a “high-risk pregnancy”; and (3) conversant in either English or Spanish.

Participants completed structured interviews via ‘audio computer self-interviewing’ (A-CASI) on laptop computers assisted by trained study staff. Interviews were conducted during the second (average gestational age = 18 weeks, SD =3.3) and third (average gestational age = 35 weeks, SD=3.1) trimesters of pregnancy as well as six and twelve months post-partum. Labor, delivery and birth outcomes were obtained through medical chart review available for 95% of participants (990/1047). There were no systematic differences between those who were retained versus those lost to follow up. The study was approved by the Institutional Review Boards at both study sites, and all patients provided informed written consent prior to randomization. This analysis is restricted to participants enrolled in New Haven who delivered singleton infants at term (≥ 37 weeks gestation) and had BMI data available by medical record review (n=427).

Definition of variables

Outcome Variable—Change in weight was calculated as the difference in weight from pre-pregnancy at each study time-point. Usual pre-pregnancy weight and current weight during the second and third trimesters and at 6 and 12 months post-partum was obtained by self-report at each study interview. For participants whose last prenatal care visit occurred within two weeks of delivery, maximal pre-delivery weight was the measured weight using a standard triple-beam balance at that visit. For participants whose last obstetrical visit was greater than two weeks before delivery, maximal pre-delivery weight was that reported at a post-partum interview. Early post-partum weight was obtained from the medical record for women who returned to the clinic between 5 and 9 weeks post-partum.

Measurement of time—To account for variability in the timing of delivery and interviews, time was designated as a continuous variable measured in weeks since last menstrual period.

Time-invariant covariates: demographic and baseline clinical factors—Demographic factors were obtained by self-report at the baseline interview. Race was categorized as African-American/Black, Latina/Hispanic, Other. As many participants were still of school age, a single variable that combined educational and employment status was created, categorizing participants as: both in school and working, in school only, working full-time only, working part-time only, and neither in school nor working. Gravidity and parity were obtained by self-report at the intake visit. Pre-pregnancy lifestyle covariates of tobacco and alcohol use were dichotomized into never-and ever-users. Study group referred to the study condition randomly assigned for each participant. Baseline BMI (kg/m^2) was calculated from self-reported pre-pregnancy height and weight. Incidence of gestational diabetes, hypertension and cesarean delivery were extracted from obstetrical records. Total number of weeks of breastfeeding was determined from self-report six and twelve months post-partum.

Time-varying covariates: clinical and psychosocial factors—Time-varying covariates are collected serially at each interview and change with the progression of time. Lifestyle variables included use/non-use of tobacco, alcohol, marijuana, and other illicit drugs during the prior interval. A modified version of the Pregnancy-Relevant Health Behaviors Scale (PRHBS) (31) which included all items on the exercise, nutrition and sleep subscales was used to evaluate the scope of health-promoting behaviors pursued. Use/non-use of hormonal contraception (oral contraceptive pills, depot progesterone injections, transdermal patch) was assessed at each post-partum visit. Repeat pregnancy described whether the participant was newly pregnant at either the six- or twelve-month follow-up visit. Psychosocial factors were measured using validated and reliable scales: perceived stress (Perceived Stress Scale [PSS]) (32), depression (Centers for Epidemiologic Study-Depression [CES-D]) (33), and self-esteem (Rosenberg Self-Esteem Scale [RSES]) (34).

Statistical analyses

Descriptive statistics—The entire study population was subdivided according to pre-pregnancy BMI category, using the recently published IOM-defined cut-points (15). Within each BMI category, the number of participants gaining below, within, or above the IOM guidelines as well as the number of participants returning to within 10 lbs (4.5 kg) of their pre-pregnancy weight by one-year post-partum was tabulated. The distributions and associations between each fixed and time-varying covariate and baseline BMI category were evaluated. Exposures occurring in <5% of the study population were dropped from further analysis.

Longitudinal data modeling—Weight change over time was modeled using linear mixed models that included random variables for intercept (i.e., subject) and slope (i.e., time) that accounted for all higher orders of the time parameter with an unstructured correlation between the elements in the variance/covariance G matrix (29). As these modeling techniques are robust to unbalanced data, all available data were included. The underweight group (n=23) were excluded from the longitudinal modeling secondary to their small number.

First, the best relationship between weight change and time was established by beginning with the linear model and then adding successively higher order terms until the last term added had $p > 0.05$. Next, bivariate relationships between each fixed or time-varying covariate and the outcome variable of weight change were evaluated in a mixed model that contained all significant parameters for time as well as random effects for individual and time. The interaction between each parameter and time was subsequently considered in a bivariate model that included the interaction between the selected parameter and each polynomial term for time in addition to the main effects for both the selected parameter and the time polynomial expression. Multivariable mixed modeling was executed using several model selection strategies in parallel. Backwards elimination was initiated with the full model that included the time polynomial, main effects for all fixed and time-varying covariates, any significant bivariate interactions with time, and the random variables described above. All covariates with Type 3 likelihood ratio $p > 0.10$ were eliminated. Then, model parsimony was achieved through minimization of the Akaike Information Criterion (AIC). In parallel, a forward selection strategy was performed where, beginning with a model that included the time polynomial, variables were added in order of their significance on bivariate modeling. Variables were initially retained if $p \leq 0.15$ but required $p < 0.05$ to remain in the model following evaluation of all eligible variables. Interactions between the remaining covariates were evaluated with those significant at $p < 0.05$ retained. All analyses were performed using SAS version 9.1.3 [SAS Institute, Cary, NC].

RESULTS

Description of study participants

We included 427 of the 503 women originally enrolled at the New Haven site in these analyses. Six women were excluded for multiple gestations, 46 women were excluded for delivering preterm infants, 17 were missing birth outcomes data and 7 did not have a calculable BMI. The validity of self-reported weights was confirmed via comparison of actual weights recorded in medical records during the clinical visit occurring closest in time, with Pearson correlation coefficients ranging from 0.96 to 0.99 for all study time points.

Participant demographics stratified by pre-pregnancy BMI were calculated for both fixed and time-varying covariates with those yielding a significant ($p < 0.05$) association (Table 1). Overweight and obese women had greater parity ($p = 0.02$), were more likely to have had a cesarean delivery ($p = 0.02$), and less likely to use depo-provera 6 and 12 months postpartum ($p \leq 0.05$). There was no difference in pre-pregnancy classification of BMI on the basis of race/ethnicity, age, employment/education, relationship status, intervention condition, substance use, gestational diabetes or hypertension, breastfeeding interval, or other post-partum contraception choices (all $p > 0.05$). There was no significant difference in prenatal health behaviors, prenatal stress, or depression at baseline or at follow up interviews by BMI category.

Trajectory: Prenatal weight gain and subsequent postpartum weight loss

Prior to pregnancy, 23 (5.4%) women were underweight ($< 18.5 \text{ kg/m}^2$), 184 (43.1%) were normal weight ($18.5\text{--}24.9 \text{ kg/m}^2$), 100 (23.4%) were overweight ($25.0\text{--}29.9 \text{ kg/m}^2$), and 120 (28.1%) were obese ($> 30 \text{ kg/m}^2$). Only 94 (22%) women gained weight within 2009 IOM guidelines according to pre-pregnancy BMI. The majority of women ($n = 266$, 62.3%) exceeded recommendations for weight gain during their gestation (Table 1). Similar patterns were observed with respect to post-partum weight loss. Clinical recommendations target patients to return to within 10 pounds (4.5 kg) of their pre-pregnancy weight (15): 47.2% achieved or exceeded this targeted weight loss, whereas 52.5% retained 10 or more pounds twelve months post-partum.

Given excessive weight gain in pregnancy and lack of weight loss postpartum, a shift in BMI category was noted in the postpartum period (Table 2). Overall, of the 382 women for which both pre-pregnancy and 1-year post-partum BMI data were available, 36.1% of women ($n = 138$) moved up one or more BMI categories. The majority of women (58.4%; $n = 223$) remained in a stable classification, and only 5.5% of women ($n = 21$) moved down one or more BMI categories. Among women with a normal pre-pregnancy BMI, 52.5% remained normal weight, 39.5% became overweight and 4.9% were obese one-year postpartum. Among those with an overweight pre-pregnancy BMI, 52.7% became obese. Furthermore, of the 223 women who remained in the same classification, 134 (60.1%) continued to be overweight or obese, indicating both a shift towards a higher BMI class as well as maintenance of a previously unhealthy weight class. At 1 year postpartum, 68.5% of this population of young mothers was overweight or obese.

Predictors: Prenatal weight gain and subsequent postpartum weight loss

Longitudinal mixed modeling that included random effects for subject and time was conducted to model participant weight change from baseline throughout the study period. The underweight group ($n = 23$) were excluded from the longitudinal modeling secondary to their small number. Fitting the base polynomial model for time produced a cubic model with all terms significant at $p < 0.0001$. Next, parallel forwards and backwards model building techniques were executed as described. Baseline BMI ($p = 0.003$), any nicotine use 1 year

prior to the index pregnancy ($p=0.02$), onset of pregnancy-induced hypertension ($p=0.0006$), number of weeks breastfed ($p<0.0001$), post-partum use of depot-progesterone contraceptives ($p=0.02$) and incidence of a repeat pregnancy during the follow-up period ($p=0.001$) were significant in bivariate models that included the cubic time polynomial. The remaining 18 covariates yielded non-significant bivariate associations with weight change ($p>0.05$).

The final multivariable model ($AIC=11349.3$) that included the cubic polynomial for time ($p<0.0001$) as well as random effects for subject and time for revealed a significant interaction between baseline BMI and race (Wald Type 3 $p=0.048$), indicating modification of the effect of baseline BMI on pregnancy weight gain and post-partum weight loss by ethnic identification. This model also showed that more cigarette smoking in the year prior to the index pregnancy (regression parameter (β)=4.06, standard error (SE)=1.74; $p=0.02$), pregnancy-induced hypertension ($\beta=8.99$, SE=3.66; $p=0.01$), less current smoking ($\beta=-3.26$, SE=1.49; $p=0.03$), fewer weeks breastfed ($\beta=-1.53$, SE=0.20 per week; $p<0.0001$) and not using patch-based contraceptives ($\beta=-8.43$, SE=3.41; $p=0.01$) related to increased weight change from baseline.

To explore the public health implications of the effect modification of race on baseline BMI, mean predicted weight change trajectories for the each IOM-designated baseline BMI category by racial group was plotted and compared to 2009 IOM-recommended guidelines for gestational weight gain and post-partum weight loss (Figures 1A-C). Overall, the most notable over-gain was among overweight and obese women, where the mean weight gain for all 3 racial groups exceeded IOM recommendations. White, non-Hispanic women were most likely to exceed gestational weight gain guidelines across BMI categories; and among normal and overweight women retained the most post-partum weight at 23-27 pounds. Black women showed similar trajectories, but were more likely to lose more weight in the postpartum period. Hispanic women showed the most favorable trajectories overall. With respect to projected mean post-partum weight retention, overweight Hispanic women approached a zero net gain, normal weight and obese Hispanic women exceeded weight retention guidelines one-year postpartum, but only by an average of 2-5 pounds.

COMMENT

Rates of overweight and obesity have increased dramatically in the US and abroad. Among childbearing women, concerns have heightened regarding increased risks of obesity with respect to both maternal and neonatal morbidity and mortality. Pregnancy itself can alter the weight gain trajectory in adulthood, with excessive weight gain a major risk for increasing long-term BMI and subsequent risk for chronic disease (35). In this study of young women aged 14-25, more than one-half exceeded clinical guidelines for weight gain in pregnancy and weight retention postpartum. This resulted in more than one-third of participants moving to a higher BMI category 1-year postpartum and 68% of women being overweight or obese. Importantly, there was a notable shift in BMI categorization toward “obese”: 5% of women classified as normal weight and 53% of those classified as overweight prior to pregnancy were obese one year postpartum.

Our efforts to identify relevant demographic, clinical, behavioral, and social factors contributing to these shifts in BMI across the pregnancy and post-partum time course revealed that while cigarette smoking prior to pregnancy predicted increased weight gain during pregnancy and weight retention post-partum, ongoing tobacco smoking resulted in significantly lower gestational weight gains and reduced post-partum weight retention. Smoking during pregnancy is a known cause for low maternal weight gain (10). Two studies have shown that smoking cessation in the period immediately preceding pregnancy results in

higher absolute weight gain and higher rates of excessive weight gain during pregnancy (19,20). Among women who quit smoking during pregnancy, concerns regarding excessive post-partum weight retention prompt many to resume smoking after delivery (36). Although we did not observe a significant interaction between our smoking parameters, our data support all of these findings to suggest that additional efforts must be developed to encourage smoking cessation despite its increased risk for weight gain.

Breastfeeding predicted better weight loss post-partum. Although breastfeeding increases the daily energy demands of nursing women, there have been mixed results among those studies evaluating the association between breastfeeding and post-partum weight loss with some discovering a modest effect and others revealing a small or no effect (23). Among this sample of young mothers, we found a significant association for breastfeeding where on average, each week of breastfeeding led to an additional loss of 1.5 lbs ($p < 0.0001$). These data suggest that supporting this population in their efforts to breastfeed can have a significant impact on long-term weight targets post-partum.

The final longitudinal model yielded a significant interaction between baseline BMI and race. While risk for excessive gestational weight gain was most notable among the small group of White, non-Hispanic participants regardless of baseline BMI, overweight and obese individuals of all racial groups are at risk for overgain during pregnancy. These data are consistent with Caulfield *et al.* who observed that overweight and obese women were less likely to undergain and more likely to overgain relative to the IOM guidelines (21). Interestingly, though, regardless of gestational weight attainment, Hispanic women in all baseline BMI categories achieved the best 12-month post-partum weight loss and, among the overweight women, approached a zero net weight change from baseline BMI.

Strengths of our study include the use of longitudinal modeling to assess risks associated with weight change as a single trajectory, from pregnancy through postpartum and the sampling of young, predominantly ethnic minority women of low socioeconomic status who attend urban hospital clinics for prenatal care. This is a group at high risk of adverse outcomes, and therefore may be most in need of substantive clinical interventions to reduce many risks, including obesity. At the same time, given the restricted nature of our sample, replication with diverse patient populations and within alternate clinical settings is essential to ensure reliability. Other limitations include use of self-reported weights (37); however, the correlation of >0.96 with actual recorded weights argue against differential reporting bias, we cannot rule out consistent under- or over-reporting which could result in misclassification by baseline BMI and misrepresentation of weight trajectories during the interval of interest.

Pregnancy is a pivotal point for weight management. The shift in BMI categories seen after just one pregnancy is likely to be compounded with future childbearing. This cohort represents young women in the beginning of their reproductive years. The shift in BMI does not bode well for future reproduction. Pregnancy and the postpartum period are a critical time for weight change and a window of opportunity for interventions to improve weight management and reduce the shift towards obesity. These data support the need to develop health and lifestyle interventions for low-income, young women that lead to healthy weight trajectories both during and after pregnancy. Further research is needed on whether the current IOM guidelines lead to improvement in long term maternal outcomes or whether stricter weight gain guidelines particularly in obese and overweight women are necessary.

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Figure 1.

Mean predicted weight changes according to race within each of: (A) normal weight women (baseline BMI 18.5-24.9 kg/m²), (B) overweight women (baseline BMI 25.0-29.9 kg/m²) and, (C) obese women (baseline BMI ≥30.0). Within each graph, curves correspond to the weight change trajectories for the respective race categories as follows: Black = black curves, Hispanic=blue curves, all other ethnicities=red curves. The upper and lower solid horizontal lines represent the BMI-based upper-limit of the IOM recommendations for pregnancy-related weight gain and the suggested minimal 1-year post-partum weight loss, respectively.

Table 1

Distribution of fixed and time-varying covariates according to baseline BMI

Fixed Covariates	BMI < 18.5 (n=23)	BMI 18.5-24.9 (n=184)	BMI 25.0-29.9 (n=100)	BMI ≥ 30.0 (n=120)	p-value
Race					
African-American/Black	13 (56.5%) [†]	112 (60.9%)	58 (58.0%)	68 (56.7%)	p=0.93
Latina/Hispanic	6 (26.1%)	45 (24.5%)	28 (28.0%)	32 (26.7%)	
White	3 (13.0%)	24 (13.0%)	11 (11.0%)	19 (15.8%)	
Other	1 (4.4%)	3 (1.6%)	3 (3.0%)	1 (0.8%)	
Age (years)	20.48 ± 2.37	20.60 ± 2.79	20.99 ± 2.61	21.11 ± 2.47	p=0.32
Employment/Education Status					
Currently in school and working	3 (13.0%)	12 (6.5%)	13 (13.0%)	13 (10.8%)	p=0.39
Not in school, working full time	1 (4.4%)	26 (14.1%)	9 (9.0%)	12 (10.0%)	
Not in school, working part-time	7 (30.4%)	30 (16.3%)	15 (15.0%)	13 (10.8%)	
Currently in school, not working	4 (17.4%)	41 (22.3%)	20 (20.0%)	28 (23.3%)	
Neither in school, nor working	8 (34.8%)	75 (40.8%)	43 (43.0%)	54 (45.0%)	
Relationship Status					
Single, never married	11 (47.8%)	79 (42.9%)	53 (53.0%)	55 (45.8%)	p=0.52
Unmarried, living with partner	9 (39.1%)	79 (42.9%)	35 (35.0%)	48 (40.0%)	
Married	3 (13.0%)	24 (13.0%)	11 (11.0%)	11 (9.2%)	
Separated	0 (0.0%)	1 (0.5%)	1 (1.0%)	5 (4.2%)	
Widowed	0 (0.0%)	1 (0.5%)	0 (0.0%)	1 (0.8%)	
Study Condition					
Individual/standard prenatal care	13 (56.5%)	74 (40.2%)	36 (36.0%)	49 (40.8%)	p=0.54
CenteringPregnancy	3 (13.0%)	55 (29.9%)	35 (35.0%)	36 (30.0%)	
CenteringPregnancy+HIV	7 (30.4%)	55 (29.9%)	29 (29.0%)	35 (29.2%)	
Parity					
Nulliparous	19 (82.6%)	130 (70.7%)	60 (60.0%)	64 (53.3%)	p=0.02*
1 previous birth	3 (13.0%)	38 (20.7%)	24 (24.0%)	33 (27.5%)	
2+ previous births	1 (4.4%)	16 (8.7%)	16 (16.0%)	23 (19.2%)	

	BMI < 18.5 (n=23)	BMI 18.5-24.9 (n=184)	BMI 25.0-29.9 (n=100)	BMI ≥ 30.0 (n=120)	p-value
Total weeks breastfed this baby	4.33 ± 5.82	3.09 ± 5.00	2.89 ± 4.58	3.26 ± 5.48	p=0.70
Smoked cigarettes in the year prior to the index pregnancy					
No	14 (60.9%)	96 (52.2%)	57 (57.0%)	65 (54.2%)	p=0.79
Yes	9 (39.1%)	88 (47.8%)	43 (43.0%)	55 (45.8%)	
Drank alcohol in the year prior to the index pregnancy					
No	12 (52.2%)	91 (49.5%)	53 (53.0%)	72 (60.0%)	p=0.35
Yes	11 (47.8%)	93 (50.5%)	47 (47.0%)	48 (40.0%)	
Gestational diabetes with index pregnancy					
No	21 (91.3%)	177 (96.2%)	96 (96.0%)	115 (95.8%)	p=0.75
Yes	2 (8.7%)	7 (3.8%)	4 (4.0%)	5 (4.2%)	
Pregnancy-induced hypertension with index pregnancy					
No	20 (87.0%)	177 (96.2%)	91 (91.0%)	114 (95.0%)	p=0.14
Yes	3 (13.0%)	7 (3.8%)	9 (9.0%)	6 (5.0%)	
Type of delivery					
Vaginal delivery	21 (91.3%)	156 (86.2%)	87 (87.0%)	89 (74.2%)	p=0.02*
Cesarean section	2 (8.7%)	25 (13.8%)	13 (13.0%)	31 (25.8%)	
<u>Time-varying Covariates</u>					
Depression (CES-D)					
Mean CES-D score: Visit #1	11.57 ± 7.20	11.84 ± 8.13	12.54 ± 8.45	13.48 ± 9.01	p=0.39
Mean CES-D score: Visit #2:	8.82 ± 5.72	11.54 ± 8.99	11.77 ± 8.93	11.66 ± 9.73	p=0.56
Mean CES-D score: Visit #3	8.61 ± 6.67	9.70 ± 7.65	9.16 ± 7.41	10.13 ± 8.23	p=0.75
Mean CES-D score: Visit #4	7.45 ± 5.04	9.60 ± 8.11	9.89 ± 7.71	10.68 ± 9.06	p=0.37
Self-Esteem (RSES)					
Mean RSES score: Visit #1	33.30 ± 5.51	33.67 ± 5.04	32.83 ± 4.96	32.67 ± 5.44	p=0.34
Mean RSES score: Visit #2	34.68 ± 4.98	34.17 ± 4.88	34.45 ± 4.96	33.85 ± 5.87	p=0.82
Mean RSES score: Visit #3	33.96 ± 4.71	33.77 ± 5.32	34.24 ± 5.26	33.80 ± 5.22	p=0.91
Mean RSES score: Visit #4	34.64 ± 4.73	34.13 ± 5.15	33.74 ± 5.50	33.80 ± 5.44	p=0.85
Perceived Stress (PSS)					
Mean PSS score: Visit #1	17.22 ± 6.40	17.47 ± 6.51	17.30 ± 7.37	18.07 ± 7.22	p=0.83
Mean PSS score: Visit #2	16.68 ± 5.24	16.38 ± 7.25	16.43 ± 8.36	16.33 ± 7.23	p=1.00

	BMI < 18.5 (n=23)	BMI 18.5-24.9 (n=184)	BMI 25.0-29.9 (n=100)	BMI ≥ 30.0 (n=120)	p-value
Mean PSS score: Visit #3	16.48 ± 6.73	16.23 ± 7.00	15.78 ± 7.16	16.25 ± 7.39	p=0.95
Mean PSS score: Visit #4	16.55 ± 6.26	16.04 ± 7.54	16.45 ± 7.49	15.82 ± 6.90	p=0.93
Prenatal Health Behaviors (PRHBS)					
Mean PRHBS score: Visit #1	35.74 ± 5.97	34.01 ± 6.99	32.68 ± 7.74	32.74 ± 6.95	p=0.12
Mean PRHBS score: Visit #2	36.55 ± 5.21	34.96 ± 6.83	33.71 ± 7.16	34.02 ± 6.22	p=0.18
Mean PRHBS score: Visit #3	25.74 ± 6.38	27.83 ± 7.36	27.02 ± 6.98	27.73 ± 5.75	p=0.48
Mean PRHBS score: Visit #4	27.64 ± 7.43	26.77 ± 7.25	27.60 ± 6.79	27.77 ± 6.18	p=0.64
Smoked cigarettes since pregnant/last interview					
n (%) positive in Visit #1	5 (21.7%)	51 (27.7%)	25 (25.0%)	33 (27.5%)	p=0.90
n (%) positive in Visit #2	5 (22.7%)	34 (18.9%)	17 (17.2%)	25 (21.2%)	p=0.84
n (%) positive in Visit #3	7 (30.4%)	56 (34.4%)	32 (35.6%)	37 (33.6%)	p=0.97
n (%) positive in Visit #4	5 (22.7%)	67 (40.9%)	29 (31.9%)	40 (37.4%)	p=0.26
Drank alcohol since pregnant/last interview					
n (%) positive in Visit #1	1 (4.4%)	13 (7.1%)	7 (7.0%)	10 (8.3%)	p=0.92
n (%) positive in Visit #2	1 (4.6%)	4 (2.2%)	4 (4.0%)	3 (2.6%)	p=0.80
n (%) positive in Visit #3	9 (39.1%)	55 (33.7%)	33 (36.7%)	27 (24.6%)	p=0.22
n (%) positive in Visit #4	6 (27.3%)	64 (39.0%)	32 (35.2%)	29 (27.1%)	p=0.20
Used marijuana since pregnant/last interview					
n (%) positive in Visit #1	1 (4.4%)	16 (8.7%)	12 (12.0%)	6 (5.0%)	p=0.25
n (%) positive in Visit #2	1 (4.6%)	8 (4.4%)	6 (6.1%)	2 (1.7%)	p=0.44
n (%) positive in Visit #3	1 (4.4%)	12 (7.4%)	11 (12.2%)	7 (6.4%)	p=0.38
n (%) positive in Visit #4	1 (4.6%)	18 (11.0%)	8 (8.8%)	8 (7.5%)	p=0.66
Used hard drugs since pregnant/last interview					
n (%) positive in Visit #1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	---
n (%) positive in Visit #2	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	---
n (%) positive in Visit #3	0 (0.0%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	---
n (%) positive in Visit #4	0 (0.0%)	2 (1.2%)	0 (0.0%)	1 (0.9%)	---
Used oral contraceptive pills since delivered/last interview					
n (%) positive in Visit #3	3 (13.6%)	33 (22.8%)	20 (24.1%)	21 (21.9%)	p=0.77
n (%) positive in Visit #4	2 (10.5%)	35 (23.0%)	17 (20.0%)	24 (25.8%)	p=0.48

	BMI < 18.5 (n=23)	BMI 18.5-24.9 (n=184)	BMI 25.0-29.9 (n=100)	BMI ≥ 30.0 (n=120)	p-value
Used Depo-Provera since delivered/ last interview					
n (%) positive in Visit #3	9 (40.9%)	46 (31.9%)	15 (18.1%)	22 (22.9%)	p=0.04*
n (%) positive in Visit #4	8 (42.1%)	44 (29.0%)	17 (20.0%)	17 (18.3%)	p=0.053
Used contraceptive patch since delivered/last interview					
n (%) positive in Visit #3	0 (0.0%)	16 (11.1%)	9 (10.8%)	4 (4.2%)	p=0.10
n (%) positive in Visit #4	2 (10.5%)	18 (11.8%)	11 (12.9%)	7 (7.5%)	p=0.66
Repeat pregnancy in post-partum period					
n (%) repeat pregnancy at Visit #3	1 (4.4%)	15 (9.2%)	8 (8.9%)	17 (15.5%)	p=0.23
n (%) repeat pregnancy at Visit #4	4 (18.2%)	31 (18.9%)	22 (23.9%)	32 (29.6%)	p=0.21

[†] Numbers may not sum to total due to missing values; percents may not sum to 100% due to rounding

* Significant at p<0.05

Table 2

Distribution of gestational weight gain and post-partum weight loss by pre-pregnancy body mass index

	Low BMI (<18.5 kg/m ²) (n=23)		Average BMI (18.5-24.9 kg/m ²) (n=184)		Overweight BMI (25.0-29.9 kg/m ²) (n=100)		Obese BMI (≥ 30.0 kg/m ²) (n=120)		p-value
	Target weight change (lbs)*	n (%) [‡]	Target weight change (lbs)	n (%)	Target weight change (lbs)	n (%)	Target weight change (lbs)	n (%)	
<u>Gestational weight gain</u>									
>10 lbs below IOM range	<18.0	0 (0.0%)	<15.0	12 (6.6%)	<5.0	2 (2.0%)	<1.0	6 (5.1%)	p=0.05
0-10 lbs below IOM range	18.0-27.9	3 (13.0%)	15.0-24.9	18 (9.9%)	5.0-14.9	9 (9.2%)	1.0-10.9	10 (8.5%)	
Lower half IOM range	28.0-33.9	5 (21.7%)	25.0-29.9	25 (13.8%)	15.0-19.9	9 (9.2%)	11.0-15.4	9 (7.6%)	
Upper half IOM range	34.0-40.0	3 (13.0%)	30.0-35.0	26 (14.4%)	20.0-25.0	6 (6.1%)	15.5-20.0	11 (9.3%)	
0.1-10 lbs above IOM range	40.1-49.9	6 (26.1%)	35.1-44.9	34 (18.8%)	25.1-34.9	15 (15.3%)	20.1-29.9	21 (17.8%)	
>10 lbs above IOM range	≥ 50	6 (26.1%)	≥ 45	66 (36.5%)	≥ 35	57 (58.2%)	≥ 30.0	61 (51.7%)	
<u>Post-partum weight loss</u>									
Any net weight loss		0 (0.0%)		25 (15.4%)		18 (19.8%)		29 (27.1%)	p=0.03
0-9.9 lbs net weight retention		5 (22.7%)		39 (24.1%)		20 (22.0%)		22 (20.6%)	
10-19.9 lbs net weight retention		9 (40.9%)		38 (23.5%)		14 (15.4%)		15 (14.0%)	
>20 lbs net weight retention		8 (36.4%)		60 (37.0%)		39 (42.9%)		41 (38.3%)	

* As defined by the IOM (15)

[‡] Numbers may not sum to total due to missing values; percents may not sum to 100% due to rounding.

Table 3

Distribution of 1-year post-partum BMI according to pre-pregnancy baseline BMI

Pre-pregnancy BMI	1-year post-partum BMI			
	Underweight n (%) [‡]	Normal n (%)	Overweight n (%)	Obese n (%)
Underweight, n (%)	4 (18.2%)	16 (72.7.2%)	2 (9.1%)	0 (0.0%)
Normal, n (%)	5 (3.1%)	85 (52.5%)	64 (39.5%)	8 (4.9%)
Overweight, n (%)	0 (0.0%)	9 (9.9%)	34 (37.4%)	48 (52.7%)
Obese, n (%)	0 (0.0%)	1 (0.9%)	6 (5.6%)	100 (93.5%)
TOTAL, n (%)	9 (2.4%)	111 (29.1%)	106 (27.8%)	156 (40.8%)
				382 (100%)

p<0.0001

[‡] Percents may not sum to 100% due to rounding

Table 4

Mean observed weight change (lbs) from baseline during pregnancy and the first year post-partum according to baseline BMI category

Mean ($\pm$ S.D.) weight change (lbs) at:	Underweight BMI <18.5 kg/m ²	Normal weight BMI 18.5-24.9 kg/m ²	Overweight BMI 25.0-29.9 kg/m ²	Obese BMI $\geq$ 30.0 kg/m ²
2 nd trimester visit	12.8 $\pm$ 9.62 lbs	12.0 $\pm$ 11.7 lbs	11.1 $\pm$ 15.2 lbs	9.0 $\pm$ 17.8 lbs
3 rd trimester visit	31.5 $\pm$ 12.8 lbs	30.5 $\pm$ 13.9 lbs	31.1 $\pm$ 21.1 lbs	22.9 $\pm$ 21.3 lbs
Maximal pre-delivery weight	42.3 $\pm$ 14.4 lbs	39.4 $\pm$ 18.0 lbs	38.5 $\pm$ 22.7 lbs	31.2 $\pm$ 22.6 lbs
6 weeks post-partum visit	23.5 $\pm$ 16.0 lbs	18.0 $\pm$ 14.1 lbs	18.1 $\pm$ 17.7 lbs	11.1 $\pm$ 16.8 lbs
6 months post-partum visit	20.4 $\pm$ 11.9 lbs	14.2 $\pm$ 16.0 lbs	16.5 $\pm$ 21.6 lbs	9.0 $\pm$ 20.3 lbs
12 months post-partum visit	19.8 $\pm$ 15.6 lbs	14.1 $\pm$ 15.6 lbs	18.4 $\pm$ 25.0 lbs	10.5 $\pm$ 22.3 lbs