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Food insecurity during pregnancy leads to stress, disordered eating and greater postpartum weight among overweight women

Barbara Laraia,

Division of Community Health and Human Development, School of Public Health, University of California, Berkeley

Lisa C. Vinikoor-Imler, and

National Center for Environmental Assessment, U.S. Environmental Protection Agency, 109 T.W. Alexander Drive, Research Triangle Park, NC 27711 USA

Anna Maria Siega-Riz

Department of Epidemiology and Nutrition, Gillings School of Global Public Health, University of North Carolina, Chapel Hill, NC 27599

Abstract

Objective—We sought to understand the influence of food insecurity on women's stress, disordered eating, dietary fat intake and weight during the postpartum period. Design and Methods: We estimated the association between marginal food security and food insecurity—measured during pregnancy and postpartum—and stress, disordered eating, dietary fat intake and weight at 3 and 12 months postpartum using multivariate linear regression, controlling for demographic and socioeconomic characteristics and health behaviors. We assessed effect modification between level of food insecurity and prepregnancy weight status, hypothesizing a stronger association would be found among women who started pregnancy overweight or obese.

Results—Food insecurity status during pregnancy was strongly associated with higher levels of stress, disordered eating, and dietary fat intake at 3 and 12 months postpartum; during the postpartum period it was associated with these measures at 12 month postpartum. A significant interaction was found between level of food insecurity and prepregnancy weight status; food insecurity was associated with greater weight and BMI at 12 months only among overweight/obese women.

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Corresponding Author: Barbara A. Laraia, Ph.D., M.P.H. RD, Associate Professor, Chair, Public Health Nutrition, School of Public Health, 207-B University Hall, #7360, University of California, Berkeley, Berkeley, CA 94720-7360, blaraia@berkeley.edu, Tel: (510) 643-7896, Fax: (510) 643-6426.

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Author contributions: BL: Conceived of the research question, study design and analysis, oversaw all analysis, and interpreted the findings. LV conducted all of the analysis, created the data tables, assisted with the interpretation of the results, and drafted the methods and results sections. AMSR assisted with all aspects of the study—data collection, research question, analysis, and interpretation of results. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Conclusions—In order to return to one's prepregnancy weight, overweight and obese women who face household food insecurity may need multipronged assistance that addresses not only having enough high quality food, but include stress reduction and eating behavior interventions.

Keywords

Food Insecurity; Pregnancy; Weight Gain; Stress; Eating Behavior

Introduction

Food insecurity is a multidimensional construct that captures anxiety associated with the uncertainty of being able to obtain enough food, material resources constraints, and compromised dietary intake because of the dependence on purchasing low-cost, calorie dense foods and in some instances binge eating ^{1,2}. Therefore, the household food insecurity scale can be viewed as a crude measure that captures psychosocial stress, poor diet quality and economic hardship. In recent years there has been a concern about the observed co-existence of household food insecurity and obesity, especially among women ³⁻⁸. Evidence is inconsistent for the association between food insecurity and being overweight among women ^{3,4,6,7}, with more studies finding no association with being overweight ^{3,4,7}. Conversely, the association between either moderate or severe food insecurity and obesity is a more consistent finding ³⁻⁵, especially among women of color ⁵.

Food insecurity may influence weight gain through a number of mechanisms. First, women from food insecure households may become economically dependent on low cost, processed, high calorie foods in order to stretch the household budget. Consuming processed, high calorie foods over time may lead to weight gain ⁹. Food insecurity is also a stressful event; in many studies food insecurity is associated with anxiety, depression and perceived stress ¹⁰⁻¹². Stress brought on by food insecurity may cause non-homeostatic eating, eating for reasons other than caloric need, and lead to the selection of “comfort” foods, or highly palatable foods that are rich in fat, sugar and sodium ¹³⁻¹⁵ and have been found to physiologically reduce stress ¹⁶. Furthermore, eating high fat foods under stressful conditions is associated with accumulation of visceral fat and weight gain in animals ^{17,18} as well as humans ^{15,19}.

Pregnancy is a period when women are expected to gain weight for an optimal birth outcome. The Institute of Medicine (IOM) guidelines recommend a target range for weight gain given a woman's pre-pregnancy weight ²⁰; however, upwards of 60% of women gain outside their weight gain range ^{20,21}. Women who are overweight or obese are more likely to gain either above or below the guidelines of 7 to 11 kilograms and 5 to 9 kilograms, respectively ²⁰. We previously found that food insecurity during pregnancy was associated with greater gestational weight gain, a greater observed-to-recommended weight gain ratio and increased risk for developing gestational diabetes mellitus ²². Research from both animal and human studies suggest that being worried or concerned about having enough food, therefore the uncertainty about one's ability to obtain food is associated with stress-related weight gain ^{3,23}. Variable foraging protocol, alternating ad lib and hidden food every two weeks for 16 weeks, was found to cause increased anxiety, aggression, and decreased

attentiveness toward offspring in mother Bonnet Macaque monkeys. Among the offspring, an increase in obesity, insulin resistance and metabolic syndrome was found at four years, especially among females¹⁷. Therefore, we hypothesize that even marginal food insecure is a condition for weight gain.

Pregnancy is a unique time for weight-related expectations for women. Not only are they expected to gain weight, they are expected to return to their pre-pregnancy weight at some point during the postpartum period; however, women who gain above the IOM recommendations are more likely to be heavier postpartum²¹. In a small sample of pregnant women from rural upstate New York, pre-pregnancy obesity was associated with food insecurity at two years post-partum, when compared to food secure, normal weight women. Furthermore, pre-pregnancy obesity combined with food insecurity was associated with greater risk for higher weight (>4.55 kg) from pre-pregnancy to two year postpartum²⁴, suggesting that food insecurity among women who are obese may drive additional weight gain.

In this study we investigate the relationships among food security status and perceived stress, disordered eating behavior, percentage of calories from fat, and postpartum weight status at 3 and 12 months. We hypothesize that any level of food insecurity experienced *during pregnancy* will be associated with higher levels of perceived stress, disordered eating, and percentage of calories from fat at 3 and 12 months. Any level of food insecurity experienced *during the postpartum period* would also be associated with higher levels of perceived stress, disordered eating, percentage of calories from fat at 12 months. In addition, we hypothesized effect modification between pre-pregnancy overweight or obesity and food insecurity with greater weight at 3 and 12 months postpartum.

Methods

This study included women from the Pregnancy, Infection, and Nutrition (PIN) Study cohort from 2000 to 2006 who provided information both during and after pregnancy regarding their food insecurity status and other factors. In this analysis, we examined the association between food security status during and after pregnancy and psychosocial factors, dietary factors, and weight status.

Study population

The sample is from the PIN Postpartum Study (n=688); a prospective longitudinal study of women in North Carolina enrolled during pregnancy and followed until 1 year after giving birth. Further details on recruitment and eligibility have been previously reported^{12, 25}. This analysis includes the 550 women who enrolled in the postpartum study and completed the protocols through 12 months postpartum²⁵. Inclusion criteria were age > 16 years at time of conception, English speaking, plans to continue care or deliver at the study site, and a singleton pregnancy. Information on preconception and perinatal factors including sociodemographic characteristics and medical history was assessed by interviews, self-administered questionnaires, and information from medical records. Medical charts were abstracted to collect data on reproductive history, weight gain, pregnancy complications, and labor and delivery events. In the postpartum period (3 and 12 months) home visits were

made to collect information on factors that potentially influence the mother's postpartum weight status including diet, physical activity, psychological factors, smoking and breastfeeding. A total of 526 women were included in the final analyses (n=24 were excluded due to missing information on food security status at 12 months postpartum). Few differences in SES characteristics were found among PIN participants who did not participate in the postpartum study, and among those who enrolled but did not complete the 12 month time point ²⁵. The protocols for this study were approved by the UNC School of Medicine Institutional Review Board.

Food insecurity

Food insecurity during pregnancy was measured between 27 and 30 weeks' gestation with a telephone interview using the 18-item Core Food Security Module (CFSM) for families with children ²⁶. At 12 months postpartum, the women were asked about food insecurity in the year since giving birth during a home visit using a six-item short form, which is a validated subset of the 18-item module ²⁷. Household food security was defined as answering no to all questions. Marginally food secure households were defined as answering "yes" to two of 18-item scale during pregnancy and one of the six-item questions during the postpartum period, food insecure households were defined as answering "yes" to three or more of the 18-item questions and two or more of the six-item questions. The socioeconomic and demographic characteristics were not statistically significantly different between women from marginally secure and insecure households but were statistically significantly different compared to the food secure women, confirming that they should not be grouped with respondents from food secure households as previously identified^{12,28}.

Maternal Outcomes

Maternal outcomes investigated in this study included psychological factors, dietary factors, and weight status. Perceived stress, a psychological factor, was determined at 3 time points: 27-30 weeks gestation, 3 months postpartum, and 12-months postpartum. It was measured using a 10-item Perceived Stress Scale ^{29, 30}. Cohen's Perceived Stress has been used and validated with pregnant women ³¹. This scale is used to evaluate the respondent's perception of how threatening or demanding a stressful event was. This measure of the "degree to which situations in one's life are appraised as stressful" and has been assessed for internal consistency. The 10-item scale provides a stable index of chronic stress or strain, and coping with these stresses. Each item is rated on a five-point scale ranging from never to almost always totaling 40 points. Another psychological factor, eating attitudes and behaviors, was evaluated at 3 and 12 months postpartum. This was performed using the 26-item Eating Attitude Test (EAT) that measures disordered eating ³². Questions ask about avoidant food behaviors, binge eating, dieting, guilt about eating, preoccupation with food and weight, and vomiting. The 26-items are scored on a 6 point Likert scale, collapsing "never", "rarely" and "sometimes" to a 0 value, and a point each for responses of "often", "usually" and "always", and summed for a possible total of 78 points. Scores 10 are considered normal, 11-20 moderate eating disturbance, and 21 abnormal eating.

Women completed the validated NCI-Block Food Frequency Questionnaire (FFQ), modified and validated for our population, at 24-29 weeks of gestation, 3 months postpartum, and 12

months postpartum and were told to consider their diet during the 3 months prior³³. Change in calories from fat was calculated by subtracting energy-adjusted fat intake during pregnancy from energy-adjusted fat intake at 3 and 12 months postpartum.

Weight prior to pregnancy was ascertained by self-report and checked against measured weight if a value was available before 15 weeks' gestation. An imputed weight for 3% (n=16) was used when self-reported weight was missing or considered implausible; women gaining more than 2.3 kg per week or lost more than 1.1 kg per week between prepregnancy and first clinical measured weight³⁴. Imputed weight was created by using the measured weight prior to 15 weeks minus the recommended amount of weight for that time period defined by the Institute of Medicine²⁰. Height and weight were measured at 3 and 12 months. This information was used to calculate change in weight (in pounds) at 3 and 12 months as well as change in BMI at 3 and 12 months.

Covariates and demographic information

Telephone interviews and self-administered questionnaires were used to obtain information on maternal race, age, marital status, education, parity, physical activity, smoking during pregnancy, and poverty level. In addition, information on smoking at 12 months postpartum, breastfeeding at 3 and 12 months postpartum, and poverty level were collected during in-person interviews.

Statistical Analysis

Differences between maternal characteristics and outcome for women by food security status during pregnancy or postpartum were assessed using chi-square and t-tests. Associations between food security status and psychological factors, dietary factors, and weight status were performed using multivariate linear regression. All models were adjusted for demographic (age, maternal race, parity) and socioeconomic (poverty level during pregnancy, education, marital status) variables previously identified in the literature. We tested additional confounders of physical activity, smoking, breastfeeding and poverty level at different timepoints; only breastfeeding and smoking were associated with food security status or the outcomes at $p < 0.15$ and retained for some models. Multiplicative interaction between food security status and pre-pregnancy weight status (overweight/obese vs. normal/underweight) was tested using likelihood ratio test. A Chi squared with a p value > 0.15 indicated the interaction term contributed to the model³³. When the interaction term was significant, stratified models by pre-pregnancy weight status were used. Sensitivity analysis restricting the sample to $< 400\%$ poverty were used to make sure that the results were robust to exclusion of women living at higher income levels as their exposure to food insecurity is extremely low. All analyses were performed using STATA 10.1 and statistical significance noted at p value < 0.05 .³⁴

Results

Among women in the analytical sample, approximately 7.8% reported marginal food security and 5.2% food insecurity during pregnancy, and 4.4% reported marginal food security and 6.2% food insecurity during postpartum. Almost 6% of women experienced

some level of food insecurity at both time points and food security status at each time point was significantly associated ($\chi^2=176.90$, $p < 0.001$). Black women comprised a larger proportion of the less food secure groups (Table 1). Women experiencing any level of food insecurity were more likely to be single, younger, less educated, and had higher levels of poverty compared to women from food secure households. The mean number of children was also slightly higher among those from food insecure households during pregnancy. A greater proportion of women from marginally food secure or food insecure households smoked during the 12 months postpartum and breastfed for a shorter duration compared to women from food secure households.

Table 2 reports the psychological factors, dietary factors, and weight status by food security status. Overall, perceived stress and poor eating attitudes were higher for women from marginally food secure and food insecure compared to those from food secure households. Those from food insecure households during pregnancy had a greater change in the percentage of calories consumed from fat at 12 months postpartum. Prepregnancy BMI was higher among women reporting any level of food insecurity during pregnancy. In addition, women from any level of food insecurity gained and retained more weight postpartum at 3 and 12 months than women from food secure households.

In adjusted models, women exposed to either level of food insecurity during pregnancy had higher scores on the perceived stress scale at both 3 and 12 months postpartum (Table 3). Marginal food security was consistently associated with the eating attitudes test, and food insecurity was consistently associated with a higher percentage of calories from fat at 3 and 12 months postpartum, although 95% confidence intervals overlap between the groups. Women exposed to any level of food insecurity during the postpartum period also had higher scores on the perceived stress scale, the eating attitudes test, and a higher percentage of calories from fat at 12 months postpartum, compared to women from food secure households. Sensitivity analysis of these models (data not shown), restricting the sample to those at or below 400% of the income/poverty ratio (those most at risk of household food insecurity), resulted in very similar point estimates and remained statistically significant for perceived stress, eating attitudes, and for percentage of calories from fat, although less precise at 3 months.

Among women exposed to marginal food security during pregnancy or the postpartum period there were no significant associations with weight change and BMI after adjustment (Table 4). At 3 months postpartum, women exposed to food insecurity during pregnancy weighed 6.4 pound more and were 1.74 BMI unit higher, and at 12 month a significantly greater BMI (1.65) persisted, compared to women from food secure households. Exposure to food insecurity during the postpartum period was associated with approximately a 1 BMI unit increase at 12 months postpartum compared to women from food secure households. Sensitivity analysis restricting the dataset to women at 400% of the income/poverty ratio resulted in associations in the same direction and of similar magnitude but with wider confidence intervals (data not shown).

We found a significant interaction between food security status and pre-pregnancy weight status with BMI at 12 months (Table 5). Food insecurity among overweight/obese women

was associated with 11 pounds and 2.6 BMI units greater if exposed to food insecurity during pregnancy, and 7.34 pounds and 1.6 BMI units greater if exposed to food insecurity during postpartum compared to overweight/obese food secure women. No postpartum weight differences were found by food security status among normal weight women or among any women at 3 months postpartum.

Discussion

This study sought to understand the association of household food security status with stress, disordered eating behavior, dietary fat intake and weight status as women transition from pregnancy to the postpartum period. We found in adjusted models, that food security status (at either time point) was associated with higher levels of perceived stress, disordered eating behavior and dietary fat intake above the recommended amount at 3 and 12 months postpartum. Sensitivity analysis were significant for stress, eating attitudes and percentage of energy from fat suggesting that findings were robust to the exclusion of upper income women who have a very low risk of marginal food insecurity. These findings are consistent with the notion that food insecurity is a multidimensional measure, and one that can alter eating behaviors and potentially influence metabolic processes and fat storage.

Our findings are consistent with results from animal studies that find stress is associated with weight gain, gestational weight gain, and postpartum weight. More specifically, stress, and stress-induced eating is associated with the accumulation of visceral fat, with and without added weight^{37, 38}. The accumulation of visceral fat is thought to be brought about because stress that is perceived as a threat will invoke the hypothalamus-pituitary-adrenal axis setting off a cascade of hormones such as cortisol, insulin and leptin as well as neuropeptide Y that directly influence central fat storage³⁷. Exposure to food insecurity has been hypothesized as this type of threat to one's wellbeing and survival, even in an environment with sufficient calories¹⁷. Both animal and human studies that find stress is associated with dysregulated eating patterns and consumption of highly palatable foods^{13-17,19,37}.

A significant interaction between food security status and pre-pregnancy weight status was found; among overweight/obese women, food insecurity was associated with a higher BMI at 12 months postpartum compared to overweight/obese women from food secure households. This finding is consistent with our hypothesis that overweight and obese women who experience food insecurity are more likely to retain additional weight. This finding supports the previous research conducted by Olson and Strawderman²⁴ that found women who were obese during pregnancy and who experienced food insecurity retained or gained significant weight at 2 years after pregnancy.

Although food insecurity was associated with postpartum weight status, we were not able to explore other weight measures, especially the accumulation of central adiposity or visceral fat. It is possible that using visceral fat or waist-to-hip circumference as a measure of the more metabolic fat pad associated with stress induced eating instead of the more general body mass index or weight gain that we used here, may better capture shifts in metabolic processes brought on by stress. Another important effect modifier may be the synergistic

relationship of being exposed to marginal food insecurity at both time points. Due to sample size we were not able to assess the association of persistent food insecurity on health behaviors and weight. We would hypothesize that women exposed to food insecurity at both time points would result in greater risk of negative behaviors and higher weight.

Although we cannot substantiate causality, the temporal sequence of the data is a major improvement over cross sectional studies. We had a measure of household food insecurity at two time points and we were able to assess the association of food insecurity at each time point with subsequent stress, disordered eating behavior, dietary fat intake and weight status. For example, food insecurity status reported during pregnancy was associated with meaningful higher scores on perceived stress and disordered eating after controlling for a number of important covariates. Furthermore, we hypothesized that the exposure of household food insecurity during and after pregnancy would impact a woman's level of stress and her eating behavior, dietary fat intake and ability to return to her pre-pregnancy weight; although household food insecurity was associated with these outcomes, we cannot be certain that additional intervening factors also did not influence these outcomes. Intervening factors such as postpartum depression, a lack of social support, poor access to resources and a subsequent pregnancy may all influence weight status at 12 months. There was a very low prevalence of food insecurity in this sample. Future studies are needed that have an adequate sample size of women who are the most at-risk for food insecurity, that can assess the severity of food insecurity, and distinguish the influence of persistent versus intermittent food insecurity during pregnancy and the postpartum period. Additionally, future studies are needed to assess how these associations differ by race/ethnicity and by SES. Finally, self-reported weight was used to calculate pregravid BMI, which may not be as accurate as weight measured during the study. There are several studies that suggest self-report correlates well with actual weight, and all weights in this study were checked for biologic plausibility of the self-reported weight with the first prenatal visit measured weight if it occurred before 15 weeks and were corrected if deemed implausible. However, adequacy of the gestational weight gain was based on pregravid BMI, which may be a less accurate variable.

These findings support the hypothesis that household food insecurity is a multifactorial insult on women's health by potentially increasing stress, promoting disordered eating behavior, and promoting increased fat intake during the postpartum period; all of which have been associated with increased weight status. Food insecurity experienced either during pregnancy or the postpartum period was associated with negative health outcomes. Furthermore, among women who are susceptible to gaining weight; those who began pregnancy overweight or obese, the strong association between household food insecurity and increased weight at 12 months underscore the importance of the emerging field examining the extent to which household food insecurity plays a large role in weight gain and obesity.

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What is already known about this subject

- Food insecurity is associated with maternal weight status
- Food insecurity is associated with maternal stress
- Inconsistent association between food insecurity and postpartum maternal weight status

What this study adds

- Food insecurity is associated with higher levels of stress, disordered eating, and fat intake at 3 and 12 months postpartum
- Food insecurity is associated with greater maternal weight and BMI at 3, and greater BMI at 12 months postpartum
- Among overweight/obese women, at 12 months food insecure women were over 2 BMI units heavier than pre-pregnancy compared to their food secure counterparts

Table 1

Maternal Characteristics by food security status, expressed as mean \pm sd or as number (percentage) of participants in the Pregnancy, Infection and Nutrition Study (n=526).

	During Pregnancy			During Postpartum		
	Food insecure (n=467)	Marginally food secure (n=34)	Food insecure (n=25)	Food secure (n=468)	Marginally food secure (n=24)	Food insecure (n=34)
Socioeconomic & demographics						
Race, number (%)						
White and Other	427 (91.83)	21 (61.76)	13 (52.00)	423 (88.78)	16 (66.67)	25 (73.53)
Black	38 (8.17)	13 (38.24)*	12 (48.00)*	55 (11.22)	8 (33.33)*	9 (26.47)*
Marital Status, number (%)						
Married	414 (89.61)	19 (55.88)*	15 (60.00)*	427 (87.68)	11 (45.83)*	22 (64.71)
Single	48 (10.39)	15 (44.12)*	10 (40.00)*	60 (12.32)	13 (54.17)*	12 (35.29)*
Pre pregnancy age, years (sd)	30.45 \pm 5.08	25.97 \pm 6.14*	28.26 \pm 6.22	30.30 \pm 5.27	26.46 \pm 5.84**	26.44 \pm 5.32*
Pre pregnancy children, mean (sd)	0.72 \pm 0.83	1.0 \pm 1.0	1.4 \pm 1.41*	0.75 \pm 0.85	1.04 \pm 1.12	1.12 \pm 1.08
Maternal education, years (sd)	16.48 \pm 2.44	14.0 \pm 2.55*	13.0 \pm 2.31*	16.28 \pm 2.59	14.2 \pm 2.6*	13.44 \pm 2.52*
High School, number (%)	50 (10.73)	14 (42.42)*	13 (52.00)*	63 (12.86)	11 (45.83)*	20 (58.82)*
Some College, number (%)	416 (89.27)	19 (57.58)*	12 (48.00)*	427 (87.14)	13 (54.17)*	14 (41.18)*
Mean poverty index, mean (sd)						
Pre-pregnancy	475.6 \pm 199.7	196.8 \pm 153.9*	158.4 \pm 137.4*	461.6 \pm 208.4	214.1 \pm 150.8*	191.1 \pm 146.0*
Postpartum	340.4 \pm 152.7	146.3 \pm 83.9*	121.3 \pm 124.2*	330.2 \pm 158.4	168.0 \pm 125.9*	127.5 \pm 85.35*
Health indicators						
Pre pregnancy Physical activity (total MET), mean (sd)	24.96 \pm 25.96	36.48 \pm 43.00	31.76 \pm 36.47	25.0 \pm 26.0	36.5 \pm 43.0	31.8 \pm 36.5
Smoking at 12 m postpartum, mean (sd) among smokers	10.16 \pm 5.81	11.62 \pm 6.01	7.33 \pm 5.09	10.87 \pm 6.03	8.29 \pm 4.19	8.18 \pm 4.29
Yes (%)	25 (5.35)	14 (23.73)*	14 (23.73)*	31 (6.30)	7 (29.17)*	11 (32.35)*
No (%)	461 (93.70)	17 (70.83)*	23 (67.65)*	461 (93.70)	17 (70.83)*	23 (67.65)*
Breastfeeding duration, weeks (sd)						

	During Pregnancy		During Postpartum	
	Food insecure (n=467)	Marginally food secure (n=34)	Food secure (n=468)	Marginally food secure (n=24)
3 months postpartum	9.97±4.00	8.07±4.55**	9.81±4.07	6.24±5.28*
12 months postpartum	33.95±21.06	22.68±21.88**	33.15±21.29	15.42±19.29*
				7.92±5.16**
				20.79±21.51**

Significantly different from referent group (food secure) at

* p-value<0.001 or

** <0.05;

chi2 for categorical, t-test for continuous variables

Table 2
Maternal Outcomes by food security status, expressed as mean (sd) of participants in the Pregnancy, Infection and Nutrition Study (n=526)

Psychosocial factors	During Pregnancy			During Postpartum		
	Food insecure (n=467)	Marginally food secure (n=34)	Food insecure (n=25)	Food secure (n=468)	Marginally food secure (n=24)	Food insecure (n=34)
Mean PSS 3 m postpartum	12.59±5.52	18.21±6.15 [*]	17.8±6.7 [*]	12.79±5.66	16.92±6.02 ^{**}	18.97±6.44 [*]
Mean PSS 12 m postpartum	12.76±5.85	19.03±6.15 [*]	17.9±7.4 [*]	12.81±5.88	18.58±6.21 [*]	19.94±6.94 [*]
Mean EAT 3 m postpartum	4.32±4.56	7.15±7.05 ^{**}	7.8±6.0 ^{**}	4.29±4.36	8.33±9.76 [*]	9.35±6.99 [*]
Mean EAT 12 m postpartum	4.53±4.59	7.41±6.44 ^{**}	6.92±5.48 ^{**}	4.50±4.36	10.92±10.20 [*]	7.15±5.20 ^{**}
Calories from Fat						
Percentage of calories from fat pre-pregnancy	34.09±5.53	34.26±6.81	34.09±8.18	34.22±5.53	31.21±6.86	34.14±7.80
% of calories from fat 3m postpartum-pregnancy	-0.79±5.93	0.68±9.83	1.80±8.20	-0.88±6.17	2.11±7.39	1.08±6.75
% of calories from fat 12 m postpartum-pregnancy	-0.90±5.89	-1.21±10.47	2.83±9.65 ^{**}	-1.10±6.06	2.73±10.01	1.52±8.18
Weight Status						
BMI pre-pregnancy	24.47±6.04	27.45±7.73 ^{**}	33.73±9.45 [*]	24.81±6.39	26.62±8.39	29.11±7.96 [*]
BMI 3 m postpartum - pre-pregnancy	1.92±1.94	2.28±2.63	4.00±2.83 [*]	1.89±1.93	3.23±2.81 ^{**}	3.72±2.65 [*]
BMI 12 m postpartum - pre-pregnancy	1.12±2.19	2.45±3.25 ^{**}	4.01±3.35 [*]	1.18±2.24	3.32±3.17 [*]	2.93±3.46 [*]
Weight (pounds) pre-pregnancy	147.28±37.65	162.13±47.39	208.11±63.34 [*]	149.25±39.78	161.17±53.28	179.05±56.70 [*]
Weight 3m postpartum - pre-pregnancy	8.92±10.72	11.80±14.15	16.26±15.01 ^{**}	8.75±10.67	15.37±14.83 ^{**}	17.40±13.67 [*]
Weight 12 m postpartum - pre-pregnancy	4.53±12.01	12.86±18.13 [*]	16.18±17.91 [*]	4.73±12.31	16.17±15.22 [*]	12.62±19.23 ^{**}

Significantly different from referent group (food secure) at

* p-value<0.001 or

** <0.05;

t-test for continuous variables

PSS=Cohen's Perceived Social Stress; EAT=Eating Attitude Test; BMI=Body Mass Index

Table 3
Association between food insecurity status and perceived stress, eating attitude test and change in percent energy intake from fat at 3 and 12 months among postpartum women in the Pregnancy, Infection and Nutrition study

	3 Months Postpartum				12 Months Postpartum			
	Perceived Stress ^a	EAT Score ^b	% Energy from fat ^a	Perceived Stress ^a	EAT Score ^c	% Energy from fat ^c		
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)		
Food security status during pregnancy	(n=506)	(n=503)	(n=426)	(n=506)	(n=506)	(n=396)		
Marginally Secure	4.30 (2.12, 6.49)	2.44 (0.58, 4.30)	2.40 (-0.59, 5.38)	5.86 (3.54, 8.19)	2.62 (0.77, 4.46)	-0.30 (-3.43, 2.84)		
Food Insecure	3.36 (0.79, 5.92)	1.95 (-0.25, 4.16)	3.17 (0.07, 6.28)	3.67 (0.94, 6.41)	0.77 (-1.42, 2.96)	4.86 (1.44, 8.27)		
Constant	13.07 (8.50, 17.63)	3.58 (-0.47, 7.63)	-7.22 (-12.86, -1.57)	10.10 (5.24, 14.97)	2.46 (-1.55, 6.47)	-1.76 (-7.90, 4.38)		
Food security status during postpartum period				(n=526)	(n=526)	(n=406)		
Marginally Secure				5.33 (2.72, 7.93)	5.79 (3.70, 7.88)	4.42 (1.09, 7.76)		
Food Insecure				6.12 (3.86, 8.38)	1.79 (-0.03, 3.62)	3.47 (0.64, 6.31)		
Constant				9.27 (4.65, 13.89)	0.93 (-2.92, 4.78)	-3.80 (-9.78, 2.19)		

^a adjusted for pre-pregnancy BMI, age, race, education, income, marital status, children

^b adjusted for pre-pregnancy BMI, age, race, education, income, marital status, children, smoking at 3 months and breastfeeding duration at 3 months

^c adjusted for pre-pregnancy BMI, age, race, education, income, marital status, children, smoking at 12 months and breastfeeding duration at 12 months

Note: Sample size varies due to missing values of the outcome

Table 4
Association between food insecurity status and 3 and 12 month weight status change from pre-pregnancy weight

	3 month postpartum*			12 month postpartum**		
	Weight (pounds) β (95% CI)	BMI β (95% CI)	(n=505)	Weight (pounds) β (95% CI)	BMI β (95% CI)	(n=492)
Food security status during pregnancy						
Marginally Secure	0.19 (-4.12, 4.51)	-0.25 (-1.03, 0.53)		2.91 (-1.89, 7.71)	0.28 (-0.59, 1.14)	
Food Insecure	6.36 (1.25, 11.47)	1.74 (0.81, 2.66)		5.00 (-0.69, 10.70)	1.65 (0.62, 2.68)	
Constant	23.28 (13.91, 32.65)	4.28 (2.59, 5.97)		17.15 (6.69, 27.61)	3.52 (1.63, 5.40)	
Food security status during postpartum						
Marginally Secure				4.47 (-1.00, 9.94)	0.84 (-0.15, 1.83)	
Food Insecure				3.97 (-0.82, 8.76)	0.93 (0.07, 1.80)	
Constant				16.87 (6.75, 26.99)	3.32 (1.50, 5.15)	

* controlling for pre-pregnancy BMI, age, race, education, income, marital status, children, smoking at 3 months and breastfeeding duration at 3 months

** controlling for pre-pregnancy BMI, age, race, education, income, marital status, children, smoking at 12 months and breastfeeding duration at 12 months

Note: Sample size varies due to missing values of the outcome

Association between food insecurity status at 12 month weight status change from pre-pregnancy weight stratified by pre-pregnancy weight

Table 5

	12 Month Weight (pounds) *			12 Month BMI *		
	Normal Weight β (95% CI)	Overweight/Obese β (95% CI)	Normal Weight β (95% CI)	Overweight/Obese β (95% CI)	Overweight/Obese β (95% CI)	
Food security status during pregnancy	(n=320)	(n=172)	(n=320)	(n=172)	(n=172)	
Marginally Secure	0.85 (-4.70, 6.39)	4.48 (-4.02, 12.98)	-0.11 (-1.15, 0.92)		0.60 (-0.90, 2.10)	
Food Insecure	-2.46 (-10.71, 5.78)	10.37 (0.89, 19.84)	-0.11 (-1.64, 1.43)		2.60 (0.92, 4.27)	
Constant	11.56 (-2.54, 25.66)	30.55 (10.43, 50.68)	2.70 (0.06, 5.33)		6.00 (2.45, 9.56)	
Food security status during postpartum	(n=320)	(n=180)	(n=320)	(n=172)		
Marginally Secure	3.36 (-2.78, 9.52)	6.80 (-3.55, 17.15)	0.28 (-0.87, 1.43)		1.50 (-0.34, 3.34)	
Food Insecure	-2.02 (-7.90, 3.88)	7.33 (-1.39, 16.05)	-0.30 (-1.40, 0.80)		1.59 (0.04, 3.14)	
Constant	9.99 (-4.15, 24.12)	24.66 (4.41, 44.90)	2.55 (0.09, 5.19)		4.49 (0.89, 8.09)	

* controlling for pre-pregnancy BMI, age, race, education, income, marital status, children, smoking at 12 months and breastfeeding duration at 12 months

Note: Sample size varies due to missing values of the outcome