Published in final edited form as:
J Am Diet Assoc. 2010 May ; 110(5): 692–701. doi:10.1016/j.jada.2010.02.014.

Household food insecurity is associated with self-reported pregravid weight status, gestational weight gain and pregnancy complications

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Abstract

Background—Household food insecurity is positively associated with weight among women. The association between household food insecurity and pregnancy related weight gain and complications is not well understood.

Objective—To identify if an independent association exists between household food insecurity and pregnancy related complications.

Design—Data from the Pregnancy, Infection and Nutrition prospective cohort study were used to assess household food insecurity retrospectively using the United States Department of Agriculture (USDA) 18-item Core Food Security Module (CFSM) among 810 pregnant women with incomes ≤ 400% of the income/poverty ratio, recruited between January 2001 and June 2005 and followed through pregnancy.

Main outcome measures—Self-reported pregravid body mass index, gestational weight gain, second trimester anemia, pregnancy-induced hypertension, and gestational diabetes mellitus. Statistical analyses performed: Multivariate linear, multinomial logistic and logistic regression analyses.

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None of the authors have a conflict of interest with a funding source.

Results—Among 810 pregnant women, 76% were from fully food secure, 14% were from marginally food secure, and 10% were from food insecure households. In adjusted models, living in a food insecure household was significantly associated with severe pregravid obesity [adjusted odds ratio (AOR) 2.97, 95% confidence intervals (CI) 1.44, 6.14], higher gestational weight gain [adjusted β coefficient 1.87, 95% CI 0.13, 3.62] and with a higher adequacy of weight gain ratio [adjusted β 0.27, CI 0.07, 0.50]. Marginal food security was significantly associated with gestational diabetes mellitus [AOR 2.76, 95% CI 1.00, 7.66].

Conclusions—This study highlights the possibility that living in a food insecure household during pregnancy may increase risk of greater weight gain and pregnancy complications.

Keywords

Food insecurity; pregnancy; weight; obesity; weight gain

INTRODUCTION

Since 1995, household food insecurity, has been monitored as a public health issue for low-income households in the United States (US)—operationally defined as "whenever the availability of nutritionally adequate and safe food, or the ability to acquire acceptable foods in socially acceptable ways, is limited or uncertain" (1). In 2007, about 11.9% of all US households, experienced food insecurity (2). There are a number of factors associated with a household's probability of food insecurity including low-income, being headed by a single mother, the number of children, minority race, asset levels, and psychosocial factors (3–8).

There is some evidence that household food insecurity may be particularly important among women. For example, household food insecurity has been associated with reduced micronutrient intake among women of child-bearing age (9,10) and was associated with a significant decrease in fruit and vegetable consumption, and a significant increase in scores indicative of disordered eating patterns (10). Household food insecurity status is associated with overweight and obesity among women in several (11–18) but not all studies (19,20). In contrast, the association between household food insecurity and overweight status is inconsistent for men (11–13,18–20) and for children (21–27). The significant relationship between household food insecurity and overweight/obesity has been found to be stronger for women of minority ethnicities (14,15) and among women in rural settings (28) compared to non-Hispanic white women.

In addition to weight status, household food insecurity has been associated with compromised psychosocial functioning (20,28,29), poorer mental health (4,6,30,31), and depression (20,32). Household food insecurity may be precisely the type of stress induced exposure that is hypothesized to influence adverse eating behaviors, food choice and increase visceral adiposity (33). Among non-pregnant adults, household food insecurity may both predispose one to and exacerbate the manifestations of diabetes mellitus (34–36). In recent studies, household food insecurity was associated diabetes after controlling for weight status and other potential confounders (34,35). Among adults already diagnosed with diabetes, household food insecurity was further associated with poor diabetes management in a clinic setting (36).

Pregnancy is a time during which women can experience dramatic behavioral, physiologic and psychosocial changes that can have direct implications for both fetal development and future maternal health. Although pregnancy is often viewed as a period of a woman's life that may lead to improved health behaviors, over 40% of women begin pregnancy as overweight or obese (37). Pregravid overweight is associated with poor dietary intake (38,39) and excessive weight gain (40–45), as well as gestational diabetes mellitus (46,47),

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pre-eclampsia (48), pregnancy induced hypertension (49), and postpartum anemia (50,51). Many of these conditions may be exacerbated by living within a food insecure household during pregnancy.

Household food insecurity was hypothesized for this study as an exposure, predisposing women to gain excessive weight during adulthood. Therefore, a positive association was predicted between household food insecurity and pregravid weight status. Exposure to household food insecurity was also predicted to be associated with excessive gestational weight gain since pregnancy is a period of actual and perceived increase in food need. Furthermore, household food insecurity was hypothesized to be associated with pregnancy complications (See Figure 1). More specifically, the purpose of this study was to investigate the association between household food insecurity status and pregravid body mass index (BMI), gestational weight gain, pregnancy-induced hypertension (PIH), anemia and gestational diabetes mellitus (GDM) among pregnant women.

MATERIALS AND METHODS

Study Sample

This study used data from the Pregnancy, Infection, and Nutrition (PIN) cohort, a prospective study that examined the influence of several socio-behavioral and medical factors on the risk of preterm birth. Between January 2001 and June 2005, 2006 pregnant women were recruited through the University of North Carolina Hospitals residents and private physician obstetrics clinics before 20 weeks' gestation and followed through their pregnancy. Women completed a telephone interview between 27 and 30 weeks' gestation that included demographic and socioeconomic status, health behaviors, physical activity and a retrospective measure of household food security status. Full details are published elsewhere (4). Pregnant women were excluded from these analyses if they had incomplete household food security status and delivery information (n=337). From the 1669 pregnant women who completed the study and had complete information on household food security status, the analyses were limited to pregnant women from households with incomes at or below 400% of the income/poverty ratio (n=810). The household income restriction allowed better comparison among households that might have food insecurity due to financial and material constraints and purposefully excluded any households with higher incomes. The PIN study was app roved by and its procedures were in accordance with the ethical standards of the Institutional Review Board of the University of North Carolina School of Medicine.

Food Insecurity—Main Exposure

Household food insecurity status was assessed between 27 and 30 weeks' gestation using the 18-item CFSM administered via telephone (2). Questions were asked pertaining to all individuals' experience of food insecurity over the past 12 months who lived within the same household. Examples include "I worried whether our food would run out before we got money to buy more," (the least severe question); "Did you or the other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food;" "Did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?;" and "Did a child in the household ever not eat for a full day because you couldn't afford enough food" (the most severe question). Household food insecurity status appeared to be a stable estimate over the past 12 months in this sample as evidenced by two questions that were broken into two time segments, in addition to the general question for the past 12 months, pertaining to the six months before pregnancy and the six months during pregnancy. The same 5% of women (n=37) who reported that adults in the household needed to cut the size of a meal or skip a meal any time in the past 12 months, reported that this occurred between one to four months before pregnancy as well as one to four months during pregnancy. Additionally, the same 0.5% of women (n=4) who reported that adults in the household went a whole day without food any time in the past 12 months, reported that this occurred between one to three months before pregnancy and two to three months during pregnancy. A household was classified as (a) food secure if the respondent answered "no" to all 18-items; as (b) marginally food secure if the respondent answered in the affirmative to one or two questions indicating that there was anxiety about sufficient quantity of food; and as (c) food insecure if the respondent answered in the affirmative to three or more questions indicating insufficient quantity and reduced quality and desirability of food (2). A three level household food security variable was created to estimate the association between household food insecurity status over the last 12 months and the outcomes.

Heath Outcomes

Self reported pre-pregnancy weight and measured height were used to construct pregravid body mass index (BMI, kg/m^2). Recalled pre-pregnancy weight is shown to correlate well with measured weights (52). For 7% (n=58) of the analysis sample, an imputed weight was used in lieu of the self-reported measure only when it was missing or considered biologically implausible. This imputed weight used the measured weight at the first prenatal visit (if taken prior to 16 weeks) minus the recommended amount of weight to be gained in the first and second trimesters as defined by the Institute of Medicine (IOM) (53). If the first weight measurement was after 15 weeks of gestation, a pre-pregnancy weight could not be imputed. The majority of imputed weights (72%) were for women from food secure households; however, the proportion of imputed BMI values was not significantly different by food security category. This methodology has been previously used in other studies (54,55). Weight status categories for this analysis were defined using the IOM BMI cut points for pregnant women as follows: <19.8 kg/m^2 (underweight), 19.8–26.0 kg/m^2 (normal), >26– 29.0 kg/m^2 (overweight), >29–35.0 kg/m^2 (obese) (56) and ≥ 35 kg/ m^2 (severe obesity) (57). The IOM cut points were used because gestational weight gain recommendations are based on these categories. Gestational weight gain was measured three ways. First, total gestational weight gain was measured in kilograms. Second, an adequacy of gestational weight gain ratio was created, and third, a categorical variable was created using the IOM weight gain recommendations. Gestational weight gain was calculated as the difference between each woman's self-reported pregravid weight and her weight measured near the time of delivery. This variable took into consideration the gestational age at the last weight measurement (55,58,59). The continuous variable, adequacy of gestational weight gain ratio was calculated according to pregravid BMI status, and was a ratio of observed total weight gain over expected weight gain up until the last prenatal visit using the weight gain recommendations from the 1990 IOM report as previously described (51,55,58). Expected weight gain was calculated using the following formula: expected first-trimester total weight gain + [(gestational age at time of last weight measurement - 13 wk) × rate of weight gain expected for the second and third trimesters]. The expected total first-trimester weight gains were 3.2, 2.2, 1.0, and 0.5 kg, and the rates were 0.5, 0.4, 0.3, and 0.2 kg/wk for underweight, normal-weight, overweight, and obese women, respectively (53). These rates adjusted for the observation that not all women have a weight measurement at the time of delivery. For example, it is recommended that an overweight women gain between 7.0 and 11.5 kg, which corresponds to a ratio of 80% to 120% if the pregnancy is carried to term (40 wk). Therefore, a ratio >1.20 would be defined as gaining above the IOM recommendation (excessive) and those who have a ratio <0.80 would be defined as gaining below the IOM recommendation (inadequate). Adequacy of gestational weight gain was then categorized to determine inadequate and excessive weight gains again based on the IOM BMI-specific recommendations (53).

Pregnancy complications including pregnancy-induced hypertension (PIH), second trimester anemia and gestational diabetes mellitus (GDM) were abstracted from medical charts and constructed as dichotomous variables. Trained research staff conducted systematic medical chart abstraction after delivery using a computer-assisted program with internal edit checks. PIH was defined as "a systolic blood pressure level of 140 mm hg or higher or a diastolic blood pressure level of 90mm hg or higher that occurs after 20 weeks of gestation in a woman with previously normal blood pressure" (60). Using this definition, roughly 20% of the study sample was anticipated to meet the criteria for PIH. Universal screening protocols for identifying GDM were used in the UNC prenatal clinics (47,61). GDM was based on medical chart abstraction of glucose tolerance information from universal glucose screening between 24 and 29 weeks' gestation. An oral glucose tolerance test (OGTT) was administered in fasting state on serum samples using a glucose oxidase method with glucose tolerance analysis at fasting, and at 1, 2, and 3 hours after the oral glucose load. GDM was defined as having two or more abnormal values from an oral glucose tolerance test. Second trimester anemia was defined as Hgb <10.5 g/dl per Centers for Disease Control and Prevention definitions of anemia for pregnancy (62).

Statistical Methods

Descriptive analysis was performed to examine the association between the trichotomous household food security variable and each potential covariate using one-way analysis of variance with Bonferroni multiple-comparison test for the continuous variables of age, number of children, percent of income/poverty ratio and total metabolic equivalents hours per week of any physical activity, and the outcomes of kilograms of weight gain and adequacy of weight gain ratio. Self-reported physical activity was converted into metabolic equivalent of task (MET) hours using a standardized approach and a summary MET hours/week was calculated combining the total MET hours/week for each activity domain (65,66). Physical activity was assessed over a one week recall period using a nine-item questionnaire that included the domains of: work, recreational, household activities, and transportation with probes for type, frequency, duration and intensity (64). A χ^2 tests was used for the categorical covariates of maternal race (indicator for black compared with white and other), marital status (indicator for single compared with married), maternal education (indicator for less than 12 years, 12 years, some college compared with college or more), smoking (indicator for any smoking during the first 6 months of pregnancy compared with none), and BMI category (normal weight as the indicator), and outcome variables of pregnancy-induced hypertension, anemia and gestational diabetes mellitus.

Odds ratios were used for low prevalence outcomes (≤ 15% occurrence) as they can approximate risk ratios. Multinomial logistic regression models were used to estimate the association between household food insecurity status and BMI category, and logistic regression models were used to estimate the association between household food insecurity status and anemia and GDM. Linear regression models were used to estimate the association between household food insecurity status and the continuous outcome of kilograms of weight gained and adequacy of gestational weight gain ratio. Incident risk ratios were calculated using poisson regression with robust variance estimators to estimate common outcomes (> 15% occurrence) for the association between household food insecurity status and gestational weight gain as well as PIH (63). Adjusted models controlled for all of the covariates listed above. Gestational age was an additional covariate in the model estimating kilograms of weight gained. Models estimating the association between household food insecurity status and pregnancy complications did not adjust for gestational weight gain because a measure for gestational weight gain prior to diagnosis was needed but only total gestational weight gain was available for this analysis. Controlling for total gestational weight gain would be inappropriate since the pregnancy complications once diagnosed can be related to gestational weight gain as in the case of gestational diabetes mellitus or can be part a consequence of the condition as is the case in pregnancy induced hypertension or pre-eclampsia (67). Stata software was used for data management and statistical calculations (StataCorp. Stata statistical software: release 9.0. College Station (TX): Stata Corporation; 2003).

RESULTS

Characteristics of the study population by household food insecurity status

The general characteristics of this population have been previously reported (4). Women who met the inclusion criteria but who were excluded from the analysis due to missing information had a lower mean age (26.8 vs. 29.2 years), mean education (13.6 vs. 15.6 years), mean income (2.52 vs. 4.08 income/poverty ratio), respectively, and a higher proportion were black. Roughly, 76% of the sample were from food secure households, while 24% were from marginally food secure and 10% were from food insecure households. Overall, women from marginally food secure and food insecure households were similar with regard to most demographic, socioeconomic and weight status variables assessed in this study. Compared to women from food secure households, women from marginally secure and food insecure households were significantly more likely to be black, to be single, have less years of education, less income and be either overweight or severely obese (Table 1).

Association between pregravid BMI status and household food insecurity status

The prevalence of pregravid BMI was 13% underweight, 42% normal weight, 12% overweight, 17% obese, and 16% severely obese. In unadjusted models, women living in households with either marginal food security or food insecurity were associated with severe obesity (Table 2). In adjusted models, women from a food insecure household were associated with almost three times the odds of severe obesity compared to normal weight women, after controlling for covariates age, race, income, education, marital status and number of children.

Association between household food insecurity status and gestational weight gain

The extent of association between living in a food insecure household and gestational weight gain was estimated in three ways. First, in adjusted models, a significant association was found between living in a food insecure household and kilograms of weight gained after adjusting for age, race, income, education, marital status, number of children, smoking, physical activity, gestational age and pregravid BMI (Table 3). On average, women from food insecure households gained 1.87 kilograms, or 4 pounds, more than women from food secure household (adjusted β 1.87, 95% confidence intervals 0.1 3, 3.62). Second, women from food insecure households were significantly associated with higher adequacy of gestational weight gain ratio; an indicator of excessive weight gain, (adjusted β 0.27, 95% confidence intervals 0.03, 0.50) after adjusting for age, race, income, education, marital status, number of children, smoking, physical activity and pregravid BMI. Living in a marginally food secure household was not associated with either kilograms of weight gain or adequacy of weight gain ratio. Third, multinomial logistic regression models were used to assess the association between categories of adequacy of weight gain (inadequate and excessive compared with adequate weight gain) and living in a food insecure household but no association was found between household food insecurity status and either inadequate or excessive weight gain in adjusted models (data not shown). Therefore, although pregnant women from households experiencing food insecurity had significantly higher weight gain and a significantly higher adequacy of weight gain ratio, they were not at greater relative risk of falling into the excessive weight gain category compared with women from food secure households.

Association between household food insecurity status and pregnancy complications

Finally, the extent of association was estimated between household food insecurity status and pregnancy complications. In unadjusted models, women from marginally food secure households were associated with second trimester anemia and GDM, while women from food insecure households were associated with PIH (Table 4). However, in adjusted models, women from food insecure households were no longer associated with PIH, and women from marginally food secure households were no longer associated with second trimester anemia. The estimated association between women living in marginally food secure households and GDM remained greater than two fold after adjusting for age, race, maternal education, marital status, children, the income/poverty ratio, pregravid BMI, physical activity and smoking status. The estimates for the association between household food insecurity and GDM were similar to that of marginal food insecurity; however, the confidence interval was wide. Using a combined marginal/food insecure household category the association with GDM was estimated and a higher odds ratio resulted (OR 2.38, 95% CI: 0.99, 5.73) and was significant at $p \leq 0.05$, suggesting that women living in a household with any level of food insecurity may be associated with GDM.

DISCUSSION

Household food insecurity—the inability to obtain nutritious and safe foods in socially acceptable ways—is increasingly recognized as an independent risk factor for many poor health outcomes among women. Studies have shown that household food security and weight status can have a paradoxical relationship—with women living in food insecure households reporting higher prevalence rates of overweight (11–18) and related health complications (34–36). The present study was conducted to estimate the association between household food insecurity status and maternal health during pregnancy, when changes in both body weight and overall health can be dramatic. The results suggest that the experience of living in a food insecure household was associated with metabolic health indicators during pregnancy. Not only was living in a food insecure household associated with severe pregravid obesity—a condition that broadly predisposes women to adverse pregnancy outcomes—but also with greater weight gain and gestational diabetes mellitus.

The results of this study identified an observed relationship between household food insecurity and pregravid severe obesity. The finding of an association between household food insecurity and higher BMI has been observed among non-pregnant women, but a graduated relationship has not been previously documented (11–18). Being severely obese was associated with three times greater odds of reporting household food insecurity in adjusted analyses. Several other studies (11–18) have shown a consistent, significant relationship between household food insecurity and weight status among women, but only a few have shown evidence of a relationship between the experience of household food insecurity and actual weight gain (11,68). One study found no relationship with weight gain (69). Olson et al., found that among pregnant women in rural upstate New York pregravid obesity was associated with becoming food insecure during the postpartum period (70). In this study, pregnant women from food insecure households had significantly higher weight gain and a higher adequacy of weight gain ratio, compared with women from food secure households. However, living in a food insecure households was not associated with higher odds of excessive weight gain.

Household food insecurity may increase consumption of highly palatable foods through a stress-mediated pathway and/or through an economic dependence on inexpensive, calorie dense foods. Household food insecurity was previously found to be associated with several measures of psychosocial factors (4). When access to food is limited, it is hypothesized that women may rely on less expensive foods that are nutrient poor and calorie-rich (71); several studies have further speculated that early life exposure to household food insecurity may drive long term weight gain trajectories throughout life—possibly by food hording or dependence on high calorie dense foods (14,67,72). A previous study found that increased pregravid BMI was associated with poor diet quality (38). It is also possible that stress may synergize with the specific effect of household food insecurity on food selection, since eating highly palatable, highly gratifying but low quality foods can also be a response to stress (33). If exposure to household food insecurity mainly influences women's eating behaviors by increasing intake of highly palatable, high calorie dense foods, then one would expect higher gestational weight gains. Additionally, household food insecurity may be associated with decreased physical activity, although no research studies were identified to support this hypothesis. Decreased physical activity may be associated with household food insecurity status if decreased calorie consumption leads to an energy conservation state, however, MET hours/week was used in the model as a covariate and did not attenuate the association between household food insecurity and any outcome. Furthermore, stress associated with household food insecurity also may be associated with decreased physical activity. On average, less than 40% of pregnant women have been found to meet physical activity guidelines and levels of physical activity often decreases as pregnancy progresses (64).

Since the real demand for food, appetite, and stress can all increase during pregnancy, the influences of household food insecurity on health outcomes during pregnancy are an important concern. For this study, it was hypothesized that household food insecurity would be associated with three diet and weight associated pregnancy complications; PIH, second trimester anemia and GDM. The null finding for the relationships between household food insecurity, PIH and anemia may be because dietary and weight status are not strong influences on PIH and anemia. For instance, pregnancy related anemia may be more influenced by hemodilution, undernutrition, nausea/vomiting and a lack of iron supplement use (51). Although the etiology of PIH is believed to be influenced by metabolic abnormalities and possibly pregravid obesity, PIH may be less influenced by diet and more influenced by excessive pregnancy weight gain or another etiology (73). The significant finding between household food insecurity and GDM, independent of self-reported pregravid weight status is an important public health finding given that GDM has implications for both the fetus (e.g., macrosomia) as well as the mother (e.g., a significant precursor to type II diabetes later in life). The association between household food insecurity and GDM may be mediated through poor health behaviors and poor dietary intake during pregnancy such as a high fat intake (61).

Limitations of this study include the 337 women excluded from the analysis due to missing information who had significantly less education, less income and were more likely to be black, which are all risk factors for household food insecurity. Therefore, the exclusion of these women may have biased the findings to the null hypothesis of no association between household food insecurity and the assessed pregnancy complication. The analysis of the association between self-reported pregravid weight status and household food insecurity status for this study is cross-sectional and the observational nature of this study does not allow for causal relationships to be made, however, the temporal nature of weight gain and maternal complications coming after the reporting of household food insecurity suggests that household food insecurity may be an antecedent for these conditions. Further studies will need to be conducted on a representative sample of women from various ethnic backgrounds to confirm these findings. Also, the small sample size may have affected the lack of significant finding in the adjusted models. With only 10% (n=79 women) experiencing household food insecurity, combined with the large number of covariates, the sample size constraints likely affected the statistical power to detect significant associations. And finally, self-reported weight was used to calculate pregravid BMI. 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 corrected it if deemed implausible. However, self-reported weight is problematic since the adequacy of gestational weight gain outcome variables were based on pregravid BMI. For example, a weight gain of 30 pounds would be adequate for a normal weight woman (weight gain recommendation is between 25–35 pounds) but would excessive for an overweight woman (weight gain recommendation is between 15–25 pounds). If an overweight woman underreported her pregravid weight to the extent that she was classified as being within the normal pregravid BMI category, the 30 pound weight gain would be classified as adequate biasing the findings to the null hypothesis of no association with household food insecurity status.

CONCLUSION

In an analysis that controlled for a wide variety of socioeconomic and demographic covariates, the experience of household food insecurity was significantly, and independently, associated with being severely obese prior to pregnancy; with having higher weight during pregnancy compared with women from food secure households; and with developing gestational diabetes mellitus. This study emphasizes that a pregnant woman who also experienced household food insecurity may be at greater risk of complications of pregnancy. The results strongly support the recommendation that obese women should be targeted for tailored nutritional counseling and intervention which also includes the assessment of household food insecurity. Furthermore, assessing household food insecurity status could be particularly useful for obese pregnant women—for whom a positive association with household food insecurity has been found and living in a food insecure household is potentially more consequential than non-obese pregnant women. Public health efforts must continue to provide adequate funding and outreach to those in need, and population-based programs and policies must aim to ensure that pregnant women have access to high-quality, nutritious food.

Acknowledgments

This study was supported by the United States Department of Agriculture, Economic Research Service grant 43-3AEM-0-80086, entitled “Effects of Food Security on Pregnancy Outcomes”; and by grants HD28684 from the National Institute of Child Health and Human Development, National Institutes of Health; funding from the National Institutes of Health, General Clinical Research Centers program of the Division of Research Resources (grant # RR00046).

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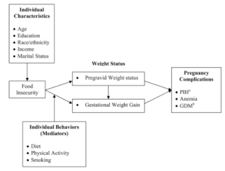

Figure 1.

Conceptual Framework of the influence of food insecurity status on gestational weight gain and pregnancy complications

[a] Pregnancy-Induced Hypertension

[b] Gestational Diabetes Mellitus

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Table 1

Maternal Characteristics by Food Security Status, restricted to ≤ 400% of the income/poverty ratio

		All (N=810)		Food Secure (n=616)		Marginally Secure (n=115)		Food insecure (n=79)
SOCIOECONOMIC & DEMOGRAPHICS	**N**	**(%) or mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**
Race (*percent*)	795		606		113		76	
White & Other	547	68.8	448	73.9	58	51.3	41	54.0
Black	248	31.2	158	26.1	55	48.7[b]	35	46.0[b]
Marital Status (*percent*)	783		602		110		74	
Married	483	61.4	401	66.6	42	38.2	40	54.0
Single	303	38.6	201	33.4	68	61.8[b]	34	46.0[b]
Age (*years*)	802	27.3 (5.5)	612	27.6 (5.5)	114	25.5 (5.5)[b]	76	27.7 (5.2)[c]
Children (*number*)	809	1.1 (1.1)	616	1.1 (1.1)	114	1.2 (1.2)	79	1.6 (1.3)[bc]
Education (*years*)	791	14.2 (2.9)	605	14.5 (3.0)	113	13.0 (2.6)[b]	73	13.2 (2.5)[b]
Income (*% income/poverty ratio*)	810	212.5 (113.0)	616	234.5 (108.4)	115	147.6 (103.2)[b]	79	136.0 (91.4)[b]
HEALTH INDICATORS								
Physical Activity (Total MET[d])	793	28.4 (37.3)	605	28.8 (37.6)	112	22.3 (25.9)	76	34.7 (46.9)
Smoking Status (*percent*)	808		615		115		78	
No smoking	646	79.8	497	80.8	93	80.9	55	70.5
Any smoking	163	20.2	118	19.2	22	19.1	23	29.5[b]
BMI[e] Status (*percent*)	793		601		114		78	
Underweight	104	13.1	87	14.5	10	8.8	7	9.0
Normal	332	41.9	270	44.9	41	36.0	21	26.9
Overweight	92	11.6	62	10.3	17	14.9[b]	13	16.7[b]
Obese	134	16.9	104	17.3	17	14.9	13	16.7
Severely obese	131	16.5	78	13.0	29	25.4[b]	24	30.8[b]
COMPLICATIONS								

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		All (N=810)		Food Secure (n=616)		Marginally Secure (n=115)		Food insecure (n=79)
SOCIOECONOMIC & DEMOGRAPHICS	**N**	**(%) or mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**	**n**	**(%) or Mean (sd)[a]**
Adequacy of Weight Gain Index	822	1.57 (0.95)	556	1.53 (0.89)	104	1.61 (0.99)	70	1.82 (1.13)[b]
Adequacy of Weight Gain	730		556		104		70	
Inadequate	123	16.8	92	16.5	18	17.3	13	18.6
Adequate (Referent)	143	19.6	121	21.8	15	14.4	7	10.0
Excessive	464	63.6	343	61.7	71	68.3	50	71.4[b]
Pregnancy Induced Hypertension	747		571		105		71	
No	544	72.8	429	75.1	71	67.6	44	62.0
Yes	203	27.2	142	24.9	34	32.4	27	38.0[b]
2nd Trimester Anemia	745		570		105		70	
No	675	90.6	523	91.8	89	84.8	63	90.0
Yes	70	9.4	47	8.2	16	15.2[b]	7	10.0
Gestational Diabetes Mellitus	747		571		105		71	
No	715	95.7	552	96.7	97	92.4	66	93.0
Yes	32	4.3	19	3.3	8	7.6[a]	5	7.0

[a] sd = standard deviation

[b] significant difference (p = <0.05) compared to the referent food secure group

[c] significant difference (p = <0.05) compared to the marginally secure group

[d] metabolic equivalent of task (MET) hours/week

[e] body mass index, calculated as weight in kilograms divided by height in meters squared

Table 2

Unadjusted and Adjusted Relative Risk Ratios[a] and 95% Confidence Intervals (95% CI) for the Association between Food Security Status and Pregravid Body Mass Index categories, restricted to ≤400% of the income/poverty ratio

	Unadjusted Relative Risk Ratios (95% CI)				Adjusted Relative Risk Ratios (95% CI)[b]			
	Underweight	**Overweight**	**Obese**	**Severely Obese**	**Underweight**	**Overweight**	**Obese**	**Severely Obese**
Food Secure	Referent	Referent	Referent	Referent	Referent	Referent	Referent	Referent
Marginally secure	0.76 (0.36, 1.57)	1.80 (0.96, 3.39)	1.08 (0.58, 1.98)	2.45 (1.43, 4.19)	0.74 (0.33, 1.64)	1.22 (0.60, 2.45)	0.97 (0.50, 1.88)	1.73 (0.95, 3.17)
Food insecure	1.03 (0.42, 2.52)	2.70 (1.28, 5.68)	1.61 (0.78, 3.33)	3.96 (2.09, 7.48)	1.30 (0.50, 3.34)	2.11 (0.92, 4.82)	1.53 (0.68, 3.43)	2.97 (1.44, 6.14)

[a] Multinomial logistic models comparing each pregravid weight category to normal weight / food secure category

[b] Model controlled for age, race, maternal education, marital status, number of children and income.

Table 3

Unadjusted and adjusted β coefficient and 95% confidence intervals (95% CI) for the association between household food security status and gestational weight gain and adequacy of weight gain ratio, restricted to ≤400% of income/poverty ratio

	Gestational weight gain (kg)[a]		**Adequacy of weight gain ratio**	
	β (95% CI) (n=747)	adjusted β[b] (95% CI) (n=673)	β (95% CI) (n=730)	adjusted β[c] (95% CI) (n=673)
Food Secure	Referent	Referent	Referent	Referent
Marginally Secure	0.18 (−1.17, 1.53)	0.22 (−1.26, 1.70)	0.08 (−0.11, 0.28)	0.04 (−0.16, 0.24)
Food insecure	1.48 (−0.13, 3.08)	1.87 (0.13, 3.62)	0.28 (0.05, 0.52)	0.25 (0.01, 0.49)

[a]Kilograms = kg

[b]Adjusted for pregravid body mass index, gestational age, age, education, race/ethnicity, marital status, number of children, income, number of cigarettes smoked and physical activity

[c]Adjusted for pregravid body mass index, age, education, race/ethnicity, marital status, number of children, income, smoking and physical activity

Table 4

Association of Food Insecurity with Pregnancy-Induced Hypertension, Pre-eclamsia, Anemia and Gestational Diabetes Mellitus (GDM), restricted to <400% of the income/poverty ratio

			Pregnancy Induced Hypertension[a]		**Anemia**[b]		**GDM**[b]	
			IRR (95% CI)	aIRR[c] (95% CI)	OR (95% CI)	aOR[c] (95% CI)	OR (95% CI)	aOR[c] (95% CI)
	n	%	(n=747)	(n=676)	(n=745)	(n=674)	(n=747)	(n=676)
Food Secure	571	76.4%	Referent	Referent	Referent	Referent	Referent	Referent
Marginally Secure	105	14.1%	1.30 (0.95, 1.78)	1.19 (0.87, 1.62)	2.00 (1.09, 3.68)	1.75 (0.85, 3.59)	2.40 (1.02, 5.63)	2.76 (1.00, 7.66)
Food insecure	71	9.5%	1.53 (1.10, 2.13)	1.23 (0.86, 1.75)	1.24 (0.54, 2.85)	0.94 (0.35, 2.50)	2.20 (0.80, 6.09)	2.35 (0.72, 7.72)

[a]Poisson with robust command to estimate incident rate ratio (IRR) and adjusted incident rate ratio (aIRR)

[b]Logistic regression to estimate odds ratio (OR) and adjusted odds ratio (aOR)

[c]Adjusted models controlled for age, race, maternal education, marital status, children, income, pregravid weight status, physical activity, smoking status