HHS Public Access

Author manuscript

Appetite. Author manuscript; available in PMC 2022 October 07.

Published in final edited form as:

Appetite. 2020 August 01; 151: 104685. doi:10.1016/j.appet.2020.104685.

The Association of Food Insecurity with the Relative Reinforcing Value of Food, BMI, and Gestational Weight Gain among Pregnant Women

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Abstract

Objective: Food insecurity is associated with obesity among adults. During pregnancy, food insecurity increases obesity risk among mothers and infants. This study investigated the association of food security with pre-pregnancy body mass index (BMI), gestational weight gain (GWG) adequacy to date, and the relative reinforcing value (RRV) of food during pregnancy.

Methods: This secondary data analysis examined 258 pregnant women (mean gestational age = 21.21 ± 10.21 weeks) surveyed on pre-pregnancy weight, height, pregnancy due date and GWG to date, current diagnoses related to eating and pregnancy, and demographics. The survey also assessed current food security and RRV of meals, snacks, cognitive activities, and active activities. BMI was calculated from pre-pregnancy height and weight (kg/m^2). Gestational weight gain adequacy to date was derived from the Institute of Medicine guidelines. Multivariable linear regression models were used to examine the relation of food security with pre-pregnancy BMI and RRVs of foods/activities. The relation between food security and GWG adequacy to date was examined using multinomial regression models.

Results: Lower food security was related to both greater pre-pregnancy BMI ($\beta = 0.60$, $p < .001$) and greater RRV of snack foods ($\beta = 3.46$, $p < .05$), after controlling for covariates. Lower food security was also related to GWG to date below recommended levels (OR =1.25, $p < .05$).

Conclusions: Food insecurity is related to higher relative food reinforcement during pregnancy, and greater pre-pregnancy weight status. Future research should replicate and extend these findings by assessing them longitudinally to better evaluate the directions of these relationships.

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Disclosure: The authors declared no conflict of interest.

Keywords

Pregnancy; Food Insecurity; BMI; Food reinforcement

Introduction

Obesity rates among adults and children in the United States and around the world continue to rise, posing significant risk to public health (Lavie et al., 2016; Cynthia L. Ogden, Carroll, Fryar, & Flegal, 2015; C. L. Ogden et al., 2016; Yang & Colditz, 2015). Both maternal obesity and gestational weight gain above recommended levels are related to adverse pregnancy outcomes for both mother and offspring (Castro & Avina, 2002; Dolin & Kominiarek, 2018; Goldstein et al., 2017). These adverse outcomes are disproportionately concentrated in impoverished communities where both obesity risk and the risk of pregnancy related complications are high (Ivers & Cullen, 2011; B. Laraia, Vinikoor-Imler, & Siega-Riz, 2015; B. A. Laraia, Siega-Riz, & Gundersen, 2010).

Although malnutrition related to food shortages in the United States is uncommon, many impoverished families experience food insecurity, which is defined as a consistent worry or concern over one's ability to obtain an adequate amount of affordable, nutritious foods (Bhattacharya, Currie, & Haider, 2004; Burke, Frongillo, Jones, Bell, & Hartline-Grafton, 2016; de Araujo, Mendonca, Lopes, & Lopes, 2018; Nackers & Appelhans, 2013). Food insecurity is more prevalent in low income households and communities with lower employment rates (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2018). Food insecurity is related to lower food quality in the home, including a greater abundance of foods high in energy density and low in nutrient quality (Nackers & Appelhans, 2013). As food security falls, there is a loss of nutrient security first, followed by reports of hunger as the food/energy supply in the household becomes insufficient (Bhattacharya et al., 2004; Burke et al., 2016; (Choi, Frongillo, & Fram, 2013; Leung et al., 2012) Leung et al., 2012).

One way in which food insecurity could impact food intake is by changing one's motivation to obtain food. These changes in behavior may be the result of increases in the relative reinforcing value (RRV) of high energy density foods, which is the amount of work one is willing to put in to obtain a portion of a particular food relative to a non-food alternative (Crandall & Temple, 2018; Lin, Carr, Fletcher, & Epstein, 2012; Lin, Carr, Fletcher, & Epstein, 2013). The RRV of food partially mediates the relationship between socioeconomic status and body mass index (Epstein, Carr, Lin, Fletcher, & Roemmich, 2012). Previous work from our lab demonstrated that food insecure adults experienced greater RRV of food in response to experimentally manipulated scarcity (Crandall & Temple, 2018). Although there is strong evidence that food insecurity is related to obesity and emerging evidence that this may be related to greater RRV of food, these relationships have not been explored in pregnant populations.

A recent study demonstrated that women who exceeded the Institute of Medicine (IOM) guidelines for gestational weight gain to date had greater RRV of meals compared with those who were below or meeting the guidelines, while those meeting the guidelines had greater RRV of non-food activities compared with those who were above or below the

guidelines (Kong et al., 2018). Using this cohort of pregnant women, and based on previous work showing an association between food insecurity and RRV and BMI (Crandall & Temple, 2018; Dhurandhar, 2016), we examined the associations of food security with pre-pregnancy body mass index (BMI), RRV of food and non-food activities during pregnancy, and gestational weight gain adequacy to date. We hypothesized that: 1. women with lower food security would have greater pre-pregnancy BMIs, greater RRV of food (both meals and snacks, relative to the standard alternative) and 2. lower RRV of non-food activities (both cognitive stimulating or active activities, relative to the standard alternative); 3. women with lower food security would be more likely to gain weight above the IOM recommended amount to date.

Methods

Participants & Procedures

This analysis was conducted using data from our lab and survey collection methods can be found in previously published work (Kong et al., 2018). Briefly, participants were recruited online via research volunteer websites (e.g., researchmatch.com and Amazon's mechanical Turk) as well as local recruiting tools, such as Facebook and emails to the laboratory's database in the Buffalo, NY area. Those emailed from the participant database included women who had, or whose children or spouse/friends had, previously agreed to be contacted for research opportunities. Most of the sample (83.7%) was recruited from US-based websites and via local recruiting methods. For the remaining participants (i.e., those recruited via Amazon MTurk), US residents were requested during recruitment. All data were collected via online surveys hosted by REDCap (Harris et al., 2009). In order to meet eligibility criteria, participants needed to be females aged 18–40, reporting a current singleton pregnancy. Surveys from 258 women were examined and, in order to ensure accurate data, participants with likely erroneous data were removed, including those who reported gestational weight gain of greater than 80 pounds (n = 3). Additionally, due to the nature of the research questions, participants were asked their pre-pregnancy height and weight as well as if they were currently diagnosed with an eating disorder. Those who reported a current eating disorder (n = 6) or a BMI less than 15 (n = 1) were also excluded. The final sample included 248 pregnant women.

Measures of Interest

Economic position.

Poverty.: All demographic information related to economic position was collected using a standard questionnaire (Kong et al., 2018). Because these data were collected online, with most recruitment methods focused on deriving a sample from the United States, we elected to use the United States federal poverty line to distinguish participants living in poverty. Participants indicated from a list of ranges of incomes where their annual gross income before taxes and deductions fell. Participants also indicated how many people resided in their households. We coded families as below the poverty line if they rated their total, pre-tax, income lower than 130% of the US federal poverty line for their household size (ASPE et al., 2019). The ranges for this question did not always line up perfectly with the income cutoff for 130% of the poverty line. However, in all cases the upper limit on

the income questionnaire response was within 5% of our 130% of the federal poverty line cutoff.

Subjective Social Status.: Participants were shown an image of a ladder with ten rungs and asked to select where they would place themselves relative to others in the community and others in the United States, with the highest rung (i.e., #1) being the best off and the lowest (i.e., #10) being the worst off. The resulting number represented the participants subjective understanding of their placement in society, which is associated with true economic position (Adler, Epel, Castellazzo, & Ickovics, 2000; Demakakos, Nazroo, Breeze, & Marmot, 2008).

Education & Employment Status.: Both educational attainment and employment status were assessed by standard multiple-choice questions (Kong et al., 2018). For educational attainment, participants chose from eight options ranging from “less than seventh grade” to “completed graduate degree”, with partial completion options throughout high school and college. These ordinal categories were maintained throughout the analysis. For employment status, participants ranked themselves as working full time, working part time, laid off, homemaker, retired, disability, or other. In order to examine the association of employment status with our variables of interest, participants were categorized as working full time or not working full time. This method was chosen based on evidence that those living in poverty are less likely to be employed full time (Bureau of Labor & Statistics, 2016).

Food Security.: The six-item short form of the United States Department of Agriculture (USDA) household food security survey module was used to assess food security status in the sample. This 6-item measure asks participants if, in the last 12 months, they were unable to eat an adequate amount of nutritious food due to a lack of funds. For example, participants were asked if in the last 12 months they could not afford to eat balanced meals. Affirmative answers were summed to create a food security total score (0–6), in which greater scores indicated less food security (i.e., more food insecurity). These total scores were then recoded into an interval score (0–10) provided by the USDA for use as a continuous variable (Blumberg, Bialostosky, Hamilton, & Briefel, 1999). Finally, in order to create the standard categories of food security, the total scores were broken into four groups of food security status: food secure (0), marginal food security (1), low food security (2–4), and very low food security (5–6) (Blumberg et al., 1999). Analyses were conducted with the interval score (termed food security) unless a nonlinear relationship emerged, in which case the categorical variable (termed food security status) was used.

Health and pregnancy.—Health status and pregnancy outcomes were assessed via standard questionnaire (Kong et al., 2018). Participants were asked if they currently had a diagnosis of a variety of disorders, such as eating disorders, diabetes, gestational diabetes, allergies, cancer, and cardiovascular disease. Participants reported their height, pre-pregnancy weight, current weight, last menstrual period, due date, and nulli- vs multiparity (i.e., whether or not this was their first pregnancy). Due dates and survey dates were used to calculate gestational age. Using prenatal weight gain charts, based on pre-pregnancy BMI, adequacy of weight gain to date was categorized as within, below, or above the IOM recommendation for gestational age (Rasmussen & Yaktine, 2009). This is classification of

gestational weight gain to date in relation to the IOM recommendations accounts for the length of the pregnancy to date and pre-pregnancy BMI. These calculated variables were the same as those used in our previous work (Kong et al., 2018).

Reinforcing value of foods and activities.: The data for RRV of foods and activities, as well as liking of those activities were operationalized in the same manner as Kong and colleague's original analysis (Kong et al., 2018). Participants were presented with a list of foods and activities and were asked to pick their favorite of each and rate their liking of each on a scale of 1 (least liked) to 9 (most liked). The options for a favorite meal included hamburger & fries, seafood entrée, chicken dish, pizza, tacos, and eggs and bacon. The snack food choices were salt & vinegar chips, chicken wings, peanut butter cookies, chocolate chip cookies, ice cream, and Cheez-its™. The options for active activities included biking, walking, yoga, gardening, dancing, and swimming. Finally, the available choices for cognitive activities were reading, computer access (excluding social media), home spa remedies, crafting/art work, logic puzzles, and listening to music.

The behavioral choice questionnaire was used to measure the reinforcing value of each favorite food or activity separately relative to an alternative sedentary behavior of watching DVDs (Goldfield, Epstein, Davidson, & Saad, 2005). Participants were asked to indicate if they would click a mouse button 20 times in order to earn their chosen reinforcer or click a mouse button 20 times to earn 10 minutes of time to spend watching a DVD. The queried number of clicks for the food or activity then increased by 20 at each question through 640 clicks. When the participant switched to preferring the alternative activity (i.e., DVD time for 20 clicks), the questionnaire moved on to the next reinforcer. RRV was operationalized as the breakpoint, or reported maximum number of clicks, for access to the food or activity relative to 20 clicks for the DVD alternative. The participants did not actually click the mouse for the reinforcer, but rather speculated if they would be willing to do so (Goldfield et al., 2005; Kong et al., 2018).

Analytic Plan

SPSS version 25 was used for all analyses. Frequency data and percentages were calculated to examine the proportions of food security, poverty, education levels, and gestational weight gain above, within, and below recommended levels in our sample. Multinomial logistic regression models were created with food secure as the reference group in order to examine group differences in categorical participant characteristics (Table 1). Raw group differences among continuous variables were examined using one-way ANOVAs (Table 1). Differences between MTurk participants and the rest of the sample were also examined using one-way ANOVA and chi-squared tests. Visual examination of scatterplots between variables were used to assess linearity of each relationship with food security. In order to investigate the validity of our measurements of economic scarcity and social positioning as well as examine bivariate relationships between variables, Pearson product moment correlation coefficients were calculated (Table 2). To test the hypotheses that food security accounted for a significant portion of the variance in pre-pregnancy BMI and the reinforcing value of meals, snacks, cognitive activities, and active activities, above and beyond those of other important factors, multivariable regression models were created. Finally, to test the

hypothesis that lower food security is related to the odds of gaining weight below, within, or above the IOM recommendations multinomial logistic regression analyses were conducted.

Results

Subject Characteristics and Food Security

Among all of our participants, 73% (n = 180) reported full food security. Nine percent (n = 23) reported marginal food security, 9% (n = 23) reported low food security, and 9% (n = 22) reported very low food security. Group differences on demographic characteristics between food secure and food insecure (i.e., those with low or very low food security) are shown in Table 1. Participants recruited from MTurk did not differ significantly from the rest of the sample in terms of food security scores or falling below the poverty level (both $p < .05$). The MTurk participants reported significantly lower ages, $F(1, 246) = 6.81$, $p < .05$, and education levels, $F(1, 246) = 26.67$, $p < .001$, compared with the rest of the sample. The MTurk participants had significantly greater RRV of snacks, $F(1, 245) = 22.48$, $p < .001$, and RRV of meals, $F(1, 246) = 9.13$, $p < .01$ compared with the rest of the sample. Finally, the MTurk participants were more likely to have had a previous pregnancy compared with the rest of the sample, X^2 (1, N = 248) = 8.18, $p < .01$.

Bivariate relationships between the variables of interest are reported in Table 2. Younger participant age was associated with less food security, $r(246) = -0.22$, $p < .01$. Lower food security was associated with both lower educational achievement for the participant, $r(246) = -0.32$, $p < .001$ and that of their fathers, $r(239) = -0.25$, $p < .001$, and mothers, $r(242) = -0.16$, $p < .05$. Lower food security was also associated with not working full time, $r(242) = -0.18$, $p < .01$, and with both lower household income, $r(245) = -0.49$, $p < .001$, and falling below the federal poverty line, $r(246) = 0.38$, $p < .001$. Finally, lower food security was associated with lower subjective social status, both in one's own community, $r(246) = 0.27$, $p < .001$, as well as in the broader United States, $r(244) = 0.27$, $p < .001$.

Food Insecurity Related to Pre-Pregnancy BMI

Greater pre-pregnancy BMI was associated with lower food security at the bivariate level, $r(242) = 0.21$, $p < .01$. This relationship remained significant after controlling for participant age, education, parity ≥1, and poverty status, $\beta = 0.60$, $t(248) = 3.23$, $p < .001$. The model was significant and accounted for 17% of the variance in pre-pregnancy BMI, $F(5, 238) = 9.46$, $p < .001$ (Table 3).

Food Security Related to RRV of food and activity

Due to an apparent nonlinear relationship between food security and RRV, the categorical levels of food security were dummy coded with the fully food secure group used as the referent category. Additionally, because of a slight variation in normality, likely due to the negative skew of the RRV data, a square root transformation of the dependent variables was performed. Finally, for each analysis, participants were excluded if they reported less than moderate liking for their chosen reinforcer, which resulted in the removal of one participant for the snack food and meal reinforcer analyses and two participants for the active activity reinforcer analysis. In bivariate analyses, RRV of snack foods was associated with very

low food security status, r(245) = 0.19, p < .01. This relationship remained significant after controlling for participant pre-pregnancy BMI, snack food liking, education, parity ≥1, poverty status, and the other food security categories, β = 3.46, *t*(247) = 2.29, p < .05). F(8, 238) = 3.95, p < .001 (Table 3).

At the bivariate level, there were no associations of food security at any level with the reinforcing value of favorite meal, cognitive activity, or active activity.

Food Security Related to Gestational Weight Gain

In multinomial logistic regression models examining the relationship of food security and gestational weight gain adequacy to date, weight gain within the IOM recommendations was used as the reference group. The addition of the food security score to an intercept-only model improved the fit of the model, χ^2 (2, N = 248) = 6.11, Nagelkerke R^2 = 0.03, p < .05. A U-shaped relationship emerged from this comparison suggesting that lower levels of food security were related to greater odds of gaining weight both above the IOM recommendations by 1.14 (p = 0.05) and below the IOM recommendations by 1.25 (p < .05). The significantly greater odds of gaining weight below the recommendation related to lower food security remained significant when education level was added to the model. The second model fit the data better than an intercept-only model, χ^2 (4, N = 248) = 9.98, Nagelkerke R^2 = 0.04, p < .05) (Table 4). The addition of poverty status, age, and parity ≥1 did not significantly improve the model compared with an intercept-only model.

Due to the apparent nonlinear relationship between food security and gestational weight gain, an additional multinomial regression model was created with the dummy coded food security categories with fully food secure as the reference group. This model did not improve model fit over and intercept-only model (p > .05). Descriptively however, the pattern that emerged from this comparison showed an increase in odds of 3.15 for gaining weight below the recommendation for those with very low food security, which trended toward significance (p = .064). Additionally, there was an increase in odds of gaining weight above the recommendation among those with low food security of 2.81, which again trended toward significance (p = 0.065).

Discussion

This study examined the associations of food security during pregnancy with pre-pregnancy BMI, gestational weight gain adequacy to date, and reinforcing value of food and non-food activities. Approximately 18% of the pregnant women in our sample reported some level of food insecurity (i.e. either low or very low food security), which is greater than the 11.8% of overall United States households (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2018). Our findings provide initial evidence that lower food security is related to greater pre-pregnancy BMI, and the most severe level of food insecurity is related to greater RRV of snack foods, but not meals or non-food alternative activities.

These results support our hypothesis that lower food security would be related to greater pre-pregnancy BMI. The relationship is expected as adult BMI, particularly among women, is related to lower food security (Bhattacharya et al., 2004; Burke et al., 2016; Franklin et

al., 2012; Ivers & Cullen, 2011), but because these data are cross-sectional, we cannot be certain of the temporality of this relationship. Food insecure homes tend to have more foods high in energy density, and food insecurity is prospectively related to greater BMI (Burke et al., 2016; de Araujo et al., 2018; Dhurandhar, 2016a). Thus, we suspect that the lower food security influences BMI, however people with obesity are often victims of employment discrimination, and therefore, this relationship may be bidirectional (Lee, Ata, & Brannick, 2014; Puhl, Heuer, & Sarda, 2011).

Our hypothesis that lower food security would be related to greater RRV of both snack foods and meals was partially supported, in that those with very low food security had significantly greater RRV of snack foods. Observing this relationship in terms of snack foods only, which are high in energy density, is in line with previous research related to food reinforcement. Prior RRV studies have tended to focus on high energy density snack foods as these are highly reinforcing, cheaply available, and likely to relate to excess energy intake (Clark, Dewey, & Temple, 2010; Crandall & Temple, 2018; Epstein & Leddy, 2006; Lin et al., 2013). Again, the temporality of these relationships cannot be ascertained from this dataset. However, experimental evidence in this area has suggested that resource scarcity increases one's motivation to obtain energy from food (Briers & Laporte, 2013; Salerno & Sevilla, 2019). We suspect that food insecurity has a similar effect on food motivation, but further investigation is need to confirm this hypothesis.

Our final hypothesis, that lower food security would be related to a greater odds of gestational weight gain above the IOM recommendations was not supported. Conversely, extant studies report a relationship between lower food security and gestational weight gain above the IOM recommendations (Laraia, Epel, & Siega-Riz, 2013; Laraia et al., 2010). Past research has not shown an increased risk of low gestational weight gain related to food insecurity, but there is a paucity of research in resource-poor areas (Ivers & Cullen, 2011). Our analysis, though not significant, suggested this relationship was driven by participants with very low food security. The short-form food security scale used in this study is not able to distinguish between food insecurity with and without hunger. However, it is likely that if hunger is present in any food insecure group, it would be in the very low food security group (Blumberg et al., 1999). Weight gain below the IOM recommendation is also associated with more pregnancy complications in both the mother and the infant (Dolin & Kominiarek, 2018). Future research in this area should examine this risk in more detail and investigate the potential interaction between pre-pregnancy obesity and severe food insecurity as it relates to risk of low gestational weight gain.

Kong and colleagues (2018) found that gestational weight gain adequacy to date was related to greater RRV of meals but not snack foods. Our results suggest that the relationship between lower food security and gestational weight gain adequacy to date is not mediated by the RRV of food. Rather, lower food security is independently related to gestational weight gain that may simply relate to the available foods in the home during pregnancy (i.e., too little food to meet the energy needs of pregnancy). Regardless of gestational weight gain, a greater RRV of snack foods during pregnancy is likely to pose a health risk to both mother and offspring. Such foods (e.g., salt & vinegar chips, chocolate chip cookies, ice cream,

etc.) provide little in nutrient quality and are unlikely to aid pregnant women in meeting the recommended daily amounts of essential nutrients.

Because this study is cross-sectional, we cannot determine if the relationship between lower food security and a greater RRV of snack food in our sample of pregnant women is one that developed before or during pregnancy. There is evidence that one's RRV of foods high in energy density is related to low SES (Lin et al., 2013) and food insecurity (Crandall & Temple, 2018), and the relationship observed here may be a further reflection of this. Conversely, pregnancy may increase the likelihood of this relationship developing because pregnancy is a time of increased energy needs (Plecas, Plesinac, & Vucinic, 2014). Those with very low food security may experience an increase in the reinforcing value of snack food due to the stress of experiencing pregnancy under conditions of limited resources (Adam & Epel, 2007). As such, the impoverished pregnant women are likely to increase their consumption of low cost and high energy density snack foods engendering compounding negative health outcomes to themselves and their offspring (Adam & Epel, 2007; Bergmann et al., 2016; Block, He, Zaslavsky, Ding, & Ayanian, 2009; Dhurandhar, 2016b)

This study has many strengths, including a detailed look at food insecurity and the RRV of food and non-food activities among pregnant women, a large sample size relative to the laboratory work that has been conducted in this area of inquiry, and a high number of participants with food insecurity. However, this study is not without limitations. All of the data was collected via online survey and, although these methods are valid (Bannon et al., 2017), misreporting may affect the results. Although the survey assessed current eating disorder diagnoses, one limitation is that history of eating disorders was not assessed, which may have led to biased estimates of associations. The survey also did not include any attention check items, so we have no way of ascertaining if all of the participants were sufficiently engaged with the survey items. Likewise, the online administration of this study meant the participants were not actually working for the rewards in question. Despite the survey having been validated in adults (Goldfield et al., 2005), we cannot be sure that the same relationship would appear in a laboratory setting. The original goals of this research did not intend to examine food security in detail, thus the short form of the food security scale was used, which is limited in sensitivity to severe forms of food insecurity (Blumberg et al., 1999). Further, the interval-level scoring for food security that we used does not accurately distinguish between scores of 0 and 1 responses, and therefore limits the conclusions that can be drawn in these analyses. Additionally, this was a convenience sample of women who were already in a registry of people agreeing to be contacted for research, which may not be representative of a normal population, and no data was collected on the participants' geographical locations, limiting the accuracy of our poverty estimates. Because multiple platforms were used for recruitment of study participants, the underlying population from which this sample was derived cannot be determined, which greatly limits our ability to make population inferences from this study. Finally, the resulting sample in this study are mostly white and highly educated and thus, may be primarily graduate students or recent graduates. This level of education was associated with our variables of interest, which may not generalize to many pregnant women in the United States. Overall, this sample and the survey methodology, limit our ability to see relationships among

our variables and draw population level inferences. Thus, the relationships that we have observed require further testing to fully elucidate their importance in affecting the health of pregnant women and their offspring.

Future research in this area would benefit from recruiting a stratified sample of pregnant and non-pregnant women matched by BMI categories (i.e., pre-pregnancy BMI for the pregnant group) for comparisons that will account for the particular influence of pregnancy. Further, targeted recruitment of low-income women will help to create adequate power for more detailed examinations of the effects of low food security and RRV of food on gestational weight gain. Finally, this study suggests that food insecurity may exert differential effects on the reinforcing value of various types of foods. Future research should include multiple types of food, including high and low energy density foods along with those typically associated with meals versus snacks only. The current study helps to further the evidence for the impact of economic disadvantage on the RRV of food as well as elucidate some of the potential impacts of food insecurity on gestational weight gain.

Conclusions

Results from this study provided insight into the role of food insecurity during pregnancy in terms of gestational weight gain and the relative reinforcing value of snack foods. Future research should further elucidate when the association between food insecurity and the relative reinforcing value of snack foods during pregnancy may develop, and the full gestational consequences for mothers and infants.

Acknowledgments

We thank Katherine S. Gerard for her work in data collection and management.

Funding:

Research reported in this article was supported by the National Institute on Child Health and Human Development of the National Institutes of Health (NIH) under Award R01 HD087082-01. AKC is supported by the National Institute of Diabetes and Digestive and Kidney Diseases of NIH under award F31 DK116426-01A1. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

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Study Importance:

What is already known about this subject?

- Both food insecurity and the relative reinforcing value of food during pregnancy are, separately, related to gestational weight gain and adverse pregnancy outcomes.
- Evidence suggests that food insecurity may increase the relative reinforcing value of foods in non-pregnant adults.

What does this study add?

- Lower food security is related to greater pre-pregnancy BMI and gestational weight gain below the Institute of Medicine recommendations.
- Lower food security is also related to greater relative reinforcing value of snack foods.
- The evidence does not suggest that greater reinforcing value of snack foods in this sample of pregnant women is related to weight changes during pregnancy.

Table 1:

Participant (n = 248) Characteristics: Food Secure vs. Food Insecure

	Food Secure (n = 180)	Marginal Food Security (n = 23)	Low Food Security (n = 23)	Very Low Food Security (n = 22)
	N (%)	N (%)	N (%)	N (%)
Poverty Indicators				
Below Poverty Line	8 (4)	1 (4)	3 (13)	10 (45)***
Working Full Time	116 (64)	15 (65)	9 (39)*	7 (32)*
Education Level				
Some High School	2 (1)	0 (0)	0 (0)	0 (0)
High School Graduate	6 (3)	0 (0)	2 (9)	2 (9)
Some College/Voc. Training	15 (8)	4 (17)	7 (30)**	11 (50)***
Completed 2 Year Degree	13 (7)	2 (9)	1 (4)	3 (14)
Completed 4 Year Degree	60 (33)	4 (17)	5 (22)	5 (23)
Completed Graduate Degree	84 (47)	13 (57)	8 (35)	1 (5)**
Race/Ethnicity				
Hispanic/Latino	9 (5)	2 (9)	2 (9)	0 (0)
Asia	6 (3)	0 (0)	1 (4)	0 (0)
Black/African-American	5 (3)	4 (17)**	3 (13)*	3 (14)*
American/Alaskan Native	2 (1)	0 (0)	0 (0)	0 (0)
Other	11 (6)	0 (0)	2 (9)	3 (14)
White	155 (86)	18 (78)	16 (70)	16 (73)
Pre-Pregnancy Characteristics				
Pre-Pregnancy Obesity	34 (19)	5 (22)	9 (39)*	10 (45)**
Nulliparous	75 (42)	14 (61)	13 (57)	9 (41)
Parous ≥1	105 (58)	9 (39)	10 (43)	13 (59)
Pregnancy Weight Gain				
Below IOM Rec.	54 (30)	9 (39)	6 (26)	10 (45)
Within IOM Rec.	68 (38)	6 (26)	5 (22)	4 (18)
Above IOM Rec.	58 (32)	8 (35)	12 (52)	8 (36)
	M (SD)	M (SD)	M (SD)	M (SD)
Participant/Pregnancy Characteristics				
Participant Age	31.38 (3.96)	28.74 (4.32)**	30.09 (5.91)	28.64 (5.52)**
Pre-Pregnancy BMI	25.87 (5.76)	25.44 (6.63)	29.70 (9.36)*	31.66 (12.13)***
Weeks of Pregnancy	21.39 (10.26)	22.26 (10.63)	18.48 (9.32)	20.50 (10.66)
Gestational Weight Gain to Date	12.67 (13.54)	14.52 (14.35)	10.26 (17.60)	9.50 (13.64)
Reinforcer Liking				
Snack Food Liking	8.42 (0.88)	8.17 (1.15)	8.26 (1.25)	8.41 (0.91)
Meal Food Liking	8.33 (0.87)	8.13 (1.49)	8.39 (0.94)	8.55 (0.80)

	Food Secure (n = 180)	Marginal Food Security (n = 23)	Low Food Security (n = 23)	Very Low Food Security (n = 22)
Active Activity Liking	7.94 (1.14)	7.61 (1.56)	7.78 (1.44)	7.64 (1.50)
Quiet Activity Liking	8.17 (1.00)	8.04 (1.15)	8.30 (1.06)	8.41 (0.91)
Relative Reinforcing Value				
Snack Food RRV	9.75 (6.25)	9.00 (6.09)	9.25 (6.08)	13.85 (5.35) **
Meal Food RRV	10.32 (6.06)	9.52 (5.54)	10.55 (4.96)	12.19 (5.97)
Active Activity RRV	8.39 (6.44)	6.73 (7.51)	7.23 (6.32)	7.45 (7.49)
Quiet Activity RRV	9.01 (5.98)	8.71 (5.93)	11.05 (6.36)	9.82 (6.61)

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 2:

Associations with Food Insecurity

	2	3	4	5	6	7	8	9	10	11	12	13	14
	Min	**Age**	**Pre - BMI**	**P**	**Pov**	**WFT**	**Edu**	**SS - Comm**	**SS - USA**	**RRV - Meal**	**RRV - Snack**	**RRV - Act**	**RRV - Cog**
1. Food Security Score	.14*	−.22**	.25***	−.04	.38***	−.18**	−.32***	.27***	.27***	.06	.13*	−.08	.06
2. Minority Status (Min)	--	−.07	.12	−.14*	.26**	−.10	−.26***	.16*	.16*	−.07	.03	−.07	.02
3. Participant Age (Age)		--	.18**	.27***	−.10	.07	.30***	−.15*	−.08	−.12	−.09	.04	−.08
4. Pre-Pregnancy BMI (Pre-BMI)			--	.14*	.23***	−.04	−.24***	.20**	.19**	−.03	.05	−.08	.03
5. Parity ≥1 (P)				--	.17**	−.23***	−.06	−.00	−.08	−.06	−.13*	−.06	−.09
6. Poverty (Pov)					--	−.20**	−.51***	.13*	.16*	.10	.04	.01	.03
7. Working Full Time (WFT)						--	.30***	−.17**	−.14*	−.03	−.02	.06	−.00
8. Educational Level (Edu)							--	−.29***	−.26***	−.16*	−.20**	.13*	.05
9. Low Social Status: Community Level (SS-Comm)								--	.58***	−.10	.02	−.05	−.01
10. Low Social Status: Country Level (SS-USA)									--	.03	.05	−.07	.01
11. RRV of Favored Meal (RRV-Meal)										--	.68***	.26***	.33***
12. RRV of Snack Foods (RRV-Snack)											--	.22***	.32***
13. RRV of Active Activities (RRV-Act)												--	.66***
14. RRV of Cognitive Activities (RRV-Cog)													--

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 3

Multivariable Regression Analyses

	B	SE	β	t	p	F	p	R^2
Pre-Pregnancy BMI						9.46	0.000	*0.20*
Age	0.47	0.11	0.29	4.35	0.00			
Education	−1.26	0.42	−0.22	−3.02	0.00			
Parous ≥1	−0.92	0.93	−0.06	−0.99	0.32			
Poverty	0.79	1.80	0.03	0.44	0.66			
Food Security Score	0.60	0.19	0.21	3.23	0.00			
RRV of Snack Food						3.95	0.000	*0.08*
Pre-Pregnancy BMI	−0.01	0.06	−0.01	−0.19	0.85			
Snack Food Liking	1.12	0.41	0.17	2.73	0.01			
Education	−0.94	0.36	−0.19	−2.63	0.01			
Parous ≥1	1.86	0.79	0.15	2.35	0.02			
Poverty	−1.56	1.66	−0.07	−0.94	0.35			
Marginal Food Security	−0.80	1.33	−0.04	−0.60	0.55			
Low Food Security	−1.04	1.36	−0.05	−0.76	0.45			
Very Low Food Security	3.46	1.51	0.16	2.29	0.02			

Table 4:

Multinomial Logistic Regression Analysis of Gestational Weight Gain Adequacy to Date

Group	*B*	*SD*	Wald[b]	*p*	OR	95% CI
Gestational weight gain to date below IOM Rec.						
Food Security Score	0.16	0.07	4.77	0.03	1.17	[1.02, 1.34]
Education	0.03	0.14	0.04	0.84	1.03	[0.78, 1.36]
Gestational weight gain to date above IOM Rec.						
Food Security Score	0.10	0.07	2.07	0.15	1.11	[0.96, 1.27]
Education	−0.20	0.13	2.42	0.12	0.82	[0.63, 1.05]