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Psychosocial Determinants of Adequacy of Gestational Weight Gain

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Abstract

Pregnancy is a critical time window for evaluating weight gain on subsequent risk for obesity among women of childbearing age. The purpose of this investigation was to determine if symptoms of depression, anxiety, stress, self-esteem and fetal health locus of control beliefs were significant risk factors for adequacy of gestational weight gain (GWG) when maternal sociodemographic characteristics and health behaviors were considered.

Sixteen hundred and five women were prospectively followed from ≤20 weeks' gestation through delivery. Participants completed standard self-report questionnaires. Adequacy of GWG was expressed as the ratio of observed/expected weight gain based on Institute of Medicine recommendations. Multivariate ANOVA models were conducted and generalized linear models were performed to calculate risk ratios..

Higher depressive symptoms reported throughout pregnancy were significantly associated with higher adequacy ratios. Stronger beliefs in chance in determining fetal health predicted inadequate relative to adequate GWG and was positively associated with larger GWG ratios overall. Several relationships were attenuated when adjusted for covariates.

The relationship between psychosocial status and adequacy of GWG is significantly impacted by maternal sociodemographic factors and health practices engaged in during pregnancy. Women who tend to believe that external factors primarily determine fetal health appear to be more vulnerable to non-adherence to clinical GWG guidelines. These results have important implications for targeting prevention and intervention efforts for improving maternal and fetal outcomes secondary to GWG patterns

Keywords

Pregnancy; Longitudinal; Depression; Anxiety; Stress

Introduction

Recent analysis of surveillance data from the National Health and Nutrition Examination Survey (NHANES) indicated rates of obesity [defined as a body mass index (BMI) of ≥ 30

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kg/m^2] among U.S. women may have reached a plateau at roughly 33% (1). While this trend is encouraging, women, especially those of ethnic minority status, still bear the disproportionate burden of obesity and are especially vulnerable to weight gain during the childbearing years (2). Researchers have given increasing attention to clarifying the roles of excessive weight gain during pregnancy and persistent postpartum weight retention as contributors to women's increased risk of obesity and the long-term health consequences (2, 3).

In 1990, the Institute of Medicine provided gestational weight gain (GWG) recommendations that were individualized to pregravid body mass index categories (4). These recommendations evolved from decades of observations made regarding birth outcomes; higher maternal weight gains have led to better overall infant outcomes (5). However, in spite of the amended guidelines and clear benefits to mother and child, only 30% to 40% of U.S. women gain in accordance with advised clinical recommendations (5, 6). Between 35% and 60% of pregnant women reported receiving no advice from their providers about appropriate pregnancy weight gain (7, 8).

In the face of persistent non-adherence to expert consensus together with the wide variability in the amount of weight gained during pregnancy, more researchers have acknowledged the determinants of the adequacy of GWG are multi-factorial in nature (7–9). More comprehensive analyses are needed that include biological characteristics and modifiable psychosocial and contextual indicators as predictors of weight gain during pregnancy. Whereas, the bulk of research in this area has emphasized the former (e.g., pregravid BMI, parity, height, race, age, age at menarche), the value of identifying pertinent psychological, socio-cultural and behavioral risk factors for inadequate and excessive GWG has gained momentum in the scientific literature in recent years (10, 11).

The biopsychosocial model (12) provides a flexible framework from which to explore the complex, multidimensional determinants and causal mechanisms that support inadequate or excessive GWG. Psychosocial factors may affect weight gain in the prenatal months through multiple conduits. Such pathways may include through the direct impact on physiological weight control mechanisms (e.g., reduced metabolic efficiency, neuroendocrine mediation of abdominal fat accrual 13–15). Additionally, psychosocial factors may indirectly exert influence on weight regulation in the gestational period through lifestyle practices (e.g., nutritional habits, level of physical activity engagement, frequency of tobacco use) 10). While lifestyle factors are forming a solid research base within the literature (9, 16–18), the former remains an important candidate for scientific inquiry.

An accumulating body of work has evaluated the relationship between psychosocial status variables and adequacy of prenatal weight gain with mixed results. Some investigations have found significant associations between self-reported stress and low maternal weight gain during pregnancy (19) while others have not (9). Similarly, comparisons involving the level of reported depressive symptoms have yielded robust (20, 21) as well as equivocal (11) associations with the adequacy of GWG in the existing literature. This conflicting evidence may be explained by regional variance in rates of GWG, differences in the sociodemographic diversity (e.g., ethnicity, age, pregravid BMI) of the samples in conjunction with variation in study design and execution (e.g., sample size, assessment methodology, weight gain in the continuous versus categorical form, inclusion of tobacco use, dietary and physical activity variables as covariates, analytic procedures implemented).

Using data obtained from women recruited in the Pregnancy Infection and Nutrition (PIN) longitudinal cohort study, the present analysis addresses some of the limitations of earlier work in this area. Informed by the biopsychosocial systems approach, the current study

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tested whether traditional (e.g., perceived stress, depression, anxiety, self-esteem) and more innovative (e.g., fetal health locus of control) psychosocial scales predict adequacy of GWG when adjusted for standard maternal biodemographic and health behavior covariates.

Research Methods and Procedures

The Pregnancy, Infection and Nutrition study conducted in central North Carolina enrolled 2006 English-speaking women age 16 and over between January, 2001 and June, 2005. Eligible women were identified through an initial review of medical records obtained from prenatal clinics comprising the UNC Hospital system. Study personnel recruited women at ≤20 weeks' gestation at their second prenatal visit. Interested women were invited to consent to participate in two in-person research clinic visits and two telephone interviews during their pregnancies. Women were retained for the current analysis if they met the following criteria: singleton pregnancy, live birth, and had GWG data available. Only one pregnancy per woman was included. This resulted in an analysis file of 1605 women.

Research clinic visits took place before 20 weeks' gestation and between 24–29 weeks' gestation. At these visits, women were given self-administered questionnaires that included several psychosocial scales. Completed questionnaires were returned by mail. Telephone interviews were conducted between 17–22 weeks' gestation and 27–30 weeks' gestation, and included collection of additional psychosocial scales and information about lifestyle practices. Study protocols were approved by the Institutional Review Boards of UNC Chapel Hill's School of Medicine.

Demographic Characteristics

Maternal sociodemographic information was obtained from the medical chart or during the first telephone interview, including participant's date of birth, race, ethnicity, marital status, level of education attained, and reproductive history (e.g., parity). Household income and the number of adults and children in the household were used to construct the percent of poverty index (22). All demographic variables were analyzed in the categorical format.

Pregravid BMI (kg/m^2) was calculated based on height routinely measured at the first research clinic visit and on self-reported pregravid weight obtained at recruitment. Although this estimate relies on retrospective accounts, research has indicated that self-reported weight is a reliable proxy for measured weight (23). Women were classified using IOM pregravid BMI cut point ranges: underweight (< 19.8), normal weight (19.8–26.0), overweight (26.1–29.0), and obese (> 29.0) (IOM 1990).

Gestational Weight Gain

Weight gain at each prenatal visit was abstracted from the medical chart after delivery. The absolute amount of weight (kg) gained throughout pregnancy was determined by subtracting the weight recorded at the last prenatal visit prior to delivery from the self-reported pregravid weight. The primary outcome of adequacy of GWG was expressed as the ratio of observed over expected weight gain using the IOM recommended weight gains[1] to calculate the expected for a given gestational age as previously described (24, 25). This ratio was devised in recognition of the individual differences in gestational age at delivery and how weight at delivery is rarely documented (24). To illustrate this, suppose a woman's adequacy ratio was 1.5. This number is interpreted as her having gained 50% in excess of recommended weight gain based on her pregravid BMI.

[1]The IOM GWG recommendations (4) based on pregravid BMI are as follows: underweight (BMI < 19.8 kg/m^2) = 28–40 lbs; normal weight (BMI = 19.8–25.9 kg/m^2) = 25–35 lbs.; overweight (BMI = 26–29 kg/m^2) = 15–25 lbs.; obese (BMI ≥ 29 kg/m^2) = at least 15 lbs.. There is no established upper limit for women in this last category.

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In addition to the continuous form, the adequacy of GWG variable was also evaluated in the categorical form according to IOM guidelines (4). The upper and lower limits of each respective pregravid BMI weight recommendation cutpoints were divided by the expected GWG at 40 weeks and then multiplied by 100 to yield inadequate, adequate and excessive weight gain percentage ranges as previously used (24, 25).

Perceived Stress

The Perceived Stress Scale (PSS; 26, 27) assesses individuals' stress appraisals and ability to successfully cope with the demands of stressors over the previous month. The 14-item PSS was administered during the 17–22 weeks' gestation telephone interview, and the 10-item version was administered between 27–30 weeks' gestation. Respondents were instructed to rate each item on a five-point scale ranging from 0 (never) to 4 (almost always). After reverse scoring positively worded items, a total score is calculated by summing across all items. Higher scores reflect greater distress and lower confidence in personal coping resources.

Depression

The Center for Epidemiological Studies-Depression Scale (CES-D; 28) is a 20-item measure of symptoms of depression manifest in the general population. It has been widely validated as a screening instrument for psychological distress in diverse community samples (29). This instrument requires respondents to endorse each item with respect to the last week using a Likert scale with total scores ranging from 0–60. Higher scores indicate greater reported depressive symptoms. The CES-D scale was self-administered at ≤ 20 weeks' gestation and between 24–29 weeks' gestation.

State and Trait Anxiety

The Spielberger State-Trait Anxiety Inventory (STAIS/T; 30) is a well-established measure of both transitory and dispositional anxiety. Each instrument includes a set of 20 items with Likert response categories. Higher scores on the state measure reflect greater current anxious affect, while higher trait scores indicate a more stable tendency to experience elevated levels of anxiety. Both the state and trait forms were self-administered before 20 weeks' gestation. The state form was re-administered between 24–29 weeks' gestation.

Self-esteem

The 10-item Self-esteem Scale (31) was used to evaluate participants' general estimations of self-worth and degree of positive or negative orientation toward the self. This measure has been extensively used in research that traverses multiple health-related disciplines. Respondents indicate their level of item agreement on a 6-point scale[2]. Higher scores reflect more positive self-appraisals. This instrument was self-administered between 17–22 weeks' gestation.

Fetal Health Locus of Control

The 18-item Fetal Health Locus of Control Scale (FHLC; 32) assesses the degree to which a woman believes the health of her fetus is principally under her own behavioral control (Internality Scale), is primarily influenced by authoritative figures (e.g., health professionals, a Higher Power; Powerful Others Scale) or is chiefly due to fate or chance (Chances Scale). Scores are calculated for each component with higher scores reflecting stronger beliefs

[2]In the standard administration of this measure respondents traditionally use a 4-point scale. A non-standard protocol was used here for the purposes of maintaining consistency of response scales across the variety of self-report measures administered to participants in the larger parent study.

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consistent with that particular locus of control for determining fetal health. This instrument was self-administered before 20 weeks' gestation.

Dietary Intake

Intake over the previous three months was assessed using a modified version of the Block-98 Food Frequency Questionnaire (33) which was self-administered between 24–29 weeks' gestation. The Block is a widely used 110-item measure of food intake that is well-validated in clinical and community samples. In the present study, only the total average daily calories (kcal) consumed were included in the multivariate analyses.

Physical Activity

The amount of physical activity engaged in during the gestational period was assessed during both telephone contacts (i.e., between 17–22 weeks' gestation and 27–30 weeks' gestation) using a measure that was specifically designed for this study(34). This instrument assesses the frequency and duration of a variety of reported physical activities participated in over the last 7 days at either a moderate or vigorous intensity level. Domains incorporated the following settings and/or roles: at work, for recreation, for transportation, during caregiving and as a part of indoor and outdoor household tasks. The average activity level for each domain is expressed in terms of standard metabolic equivalent hours per week (MET-HR). For this analysis, only recreational, indoor and outdoor physical activity levels at both time points were included.

Cigarette Smoking

Tobacco use over the first six months of pregnancy was assessed during the telephone interview at 27–30 weeks' gestation. The number of cigarettes smoked daily during that time period was categorized as follows: none, 1–9 cigarettes, 10–19 cigarettes and 20+ cigarettes; the last representing frequent smoker status.

Statistical Analysis

Standard point estimates (i.e., means and standard deviations) and frequency counts were used to describe the distributions of continuous and categorical variables, respectively, within the sample. An alpha level of .05 was established as the criteria for statistical significance for each series of analyses. All analytic procedures were performed using the SAS Enterprise Guide version 3.0 statistical software package (35).

Separate multivariable linear regression models were used to evaluate possible confounding by maternal sociodemographic and lifestyle factors. Confounding was defined as occurring when the adjusted beta coefficient for the original psychosocial indicator was modified by ≥ 10%. Identified confounders for each psychosocial variable were included in subsequent regression or ANOVA models. Measures of perceived stress, self-esteem, fetal health locus of control were transformed into tertiles (low, moderate and high). Cut points for state anxiety were based on tertiles at the first questionnaire administration. CES-D cut points were at 0–16, 17–24, and 25+, which were slightly higher than in a general population because scores may be inflated because of physical manifestations of pregnancy (36, 37). The low category was used as the reference in all cases except self-esteem and the Fetal Health Locus of Control-Internality Scale in which the high category served as the reference group.

Separate one-way ANOVA models were used to evaluate the relationship between the level of psychosocial status variable and the mean ratio of adequacy of GWG in the continuous form. Bartlett's test for the homogeneity of variances was performed to ensure basic assumptions for using this standard parametric procedure were tenable. In cases where these

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assumptions were not met, a Welch's variance-weighted ANOVA F-test was used. The Bonferroni correction was used to adjust for multiple comparisons in the post-hoc analyses. The likelihood ratio chi-square test from the multivariable regression models was subsequently used to assess the strength of the associations when adjusted for relevant covariates.

To examine the variables in their categorical forms, we performed a multivariable analysis using a generalized linear model to estimate the adjusted risk of inadequate or excessive gain associated with each psychosocial variable. Inadequate and excessive gains were modeled separately, with adequate gain as the referent variable in each model. All covariates were in the categorical form for this set of analyses. Thus, dietary and physical activity variables were quantified according to tertiles with the latter including a fourth "no activity" category. Crude and adjusted risk ratios and corresponding 95% confidence intervals were calculated.

Results

Table 1 presents select sociodemographic, behavioral, anthropometric, dietary, physical activity and psychosocial characteristics of the sample. Approximately 20% of the women were African American, a majority reported being married (74%), having attained at least a college education (59%), and living well above the poverty level (75%). Half of the sample was age 30 or older and 48% were nulliparous. Eleven percent of women reported smoking at least 1 cigarette per day during the first two trimesters. Regarding gestational weight changes, participants gained an average of 15.1 kilograms and 64.2% gained in excess of clinical guidelines. Only 21% of women studied gained within the recommended ranges. Women's activity levels decreased uniformly from early to late pregnancy.

Adequacy of GWG by Level of Psychosocial Status

Table 2 presents the crude and adjusted means for adequacy of GWG in the continuous form by psychosocial predictors in the categorical form. The Bonferroni-corrected results from unadjusted one-way ANOVA models showed that women scoring high in depressive symptoms at both <20 weeks ($p = 0.05$) and between 24–29 weeks ($p = 0.03$) gestation gained on average a significantly greater percentage of weight in excess of recommendations when compared to women reporting lower levels of depression at both assessments. However, even women endorsing few depressive symptoms on average gained in excess of clinical guidelines. It is worth noting that women classified as having gained an excessive amount of weight during the gestational period reported greater elevations of depressive symptoms than women who gained weight in adherence with clinical guidelines ($p < 0.01$; data not shown).

Greater beliefs in chance as a controlling factor in the health of the fetus were marginally associated with higher mean adequacy of weight gain achieved ($p = 0.06$). Similar trends emerged for self-esteem ($p = 0.08$) and trait anxiety ($p = 0.07$) in the uncorrected models (see Table 2). As shown in Table 2, results from likelihood ratio chi-square tests yielded from multivariable linear regression models indicated that when adjusted for important covariates these relationships were attenuated. Overall, pregravid BMI appeared to be the confounder with the greatest impact on results. This is illustrated here for the association between CES-D (≤ 20 weeks) and adequacy of GWG: 1) without confounders: $B = 0.007$, $p < 0.001$, 2) with pregravid BMI: $B = 0.001$, $p = 0.002$, 3) with parity: $B = 0.008$, $p < 0.001$, 4) with marital status: $B = 0.005$, $p < 0.05$, 5) with race: $B = 0.006$, $p < 0.01$, 6) with education: $B = 0.004$, $p < 0.05$, 7) with smoking: $B = 0.006$, $p < 0.01$, 8) with total calories: $B = 0.006$, $p < 0.01$, 9) with indoor MET-Hrs (27–30 weeks): $B = 0.006$, $p < 0.01$, 10) with outdoor MET-Hrs (27–30 weeks): $B = 0.006$, $p < 0.01$, and 11) with recreation MET-HR

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(27–30 weeks): $B = 0.006$, $p < 0.05$. Lastly, women who gained less weight than recommended on average reported marginally greater beliefs in the influence of powerful others on the health of their fetus in comparison to women who gained weight within the recommended range ($p = 0.09$; data not shown).

Risk of Inadequate or Excessive GWG by Level of Psychosocial Status

Table 3 presents the crude and adjusted risk ratios for dichotomized adequacy of GWG by psychosocial predictors in the categorical form. The first series of comparisons involved inadequate versus adequate GWG outcomes. As illustrated in Table 3, the relationship between the level of psychosocial status variables and inadequate relative to adequate weight gain during pregnancy tended to be modest at best when examining both crude and adjusted risk ratios. Women who reported moderate (RR: 1.75; 95% CI: 1.3, 2.4) and high (RR: 1.57; 95% CI: 1.2, 2.1) relative to low belief that chance influenced the health of her fetus tended to gain less weight than clinically advised. However, the risk ratios were significantly attenuated when adjusted for covariates (see Table 3). Finally, it would appear that the relative risk of excessive weight gain as compared to expected weight gain levels in this participant sample is similar across varying degrees of psychosocial exposure during the gestational period (see Table 3).

Discussion

Pregnancy serves as a unique life experience that poses increased risk for negatively affecting both psychological and physical wellness among women. Psychologically, women may face an amplification of stress and affective disturbance in attempting to emotionally and physiologically adjust to the transition to motherhood. For instance, an estimated 9–20% of women report experiencing clinically significant levels of depressive symptoms during pregnancy (38, 39) which in turn increases their vulnerability for subsequent episodes of depression in the post-partum period (39). From a physiological standpoint, childbearing also has major public health implications for enhancing the probability of short-and long-term adverse maternal and fetal outcomes with risk of overweight and obesity as primary concerns (1). Guided by the integrative biopsychosocial model, the present analysis is one of a growing number of studies that aim to describe the relationships between modifiable psychosocial risk factors assessed early and late in gestation to the adequacy of total weight gain achieved.

Over 60% of the women in our sample gained weight in excess of recommendations based on pre-gravid BMI; this rate falls somewhat above those cited in previous investigations (7, 8). We suspect this disparity may in part be attributable to the time period of when this study was conducted as well as differences in whether initial BMI and weight gained over the course of pregnancy were measured prospectively by research or medical staff or were obtained retrospectively based solely on patient reports. Regardless, this finding supports continued advocacy for greater awareness and education among health care providers and women and their families in the communities at large to promote better adherence to the IOM GWG guidelines and consequently, improve clinical outcomes. One important dimension of this health promotion initiative is by fostering greater empowerment for both patients and health care providers through identifying and managing modifiable psychosocial risk factors for excessive weight gain during pregnancy.

Towards this end, we found that select psychosocial status variables were significantly related to the adequacy of GWG attained in unadjusted models. Experiencing elevated depression symptoms both at earlier and later stages of pregnancy were positively related to gaining more weight than is clinically recommended based on pre-pregnancy BMI. Similarly, women classified as reporting high levels of depressive symptoms at both time

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points were shown to have significantly higher adequacy ratios relative to those women reporting minimal depressive symptoms at either administration. Both self-esteem and trait anxiety also played modest roles in predicting excessive GWG in this sample in the uncorrected models. However, the effects of psychosocial status on exceeding GWG clinical guidelines were overshadowed by maternal sociodemographic and health behaviors engaged in during pregnancy. This may suggest that they mediate the effects of psychosocial factors though this was not directly tested in our analysis.

In comparison to our initial findings regarding self-reported depressed mood, an analysis conducted by Walker et al. of Medicaid-eligible women receiving care at a local community hospital in the Southwest failed to find a strong relationship between depressive symptoms and GWG (11). This more socio-economically homogenous population reported notably higher levels of depressive symptoms on the CES-D than were documented in the current sample. Therefore, it is likely that the distribution of CES-D scores had a restricted range which precluded observing a more meaningful effect in this earlier study.

Additionally, the present study utilized a more systematic approach to capturing the *adequacy* of GWG achieved that was derived from the ratio of observed to expected weight gain based on pregravid BMI and gestational age at the last weight measurement. This is in contrast to the Walker study (as well as others) in which only the absolute amount of GWG attained at term was used as a primary outcome or dependent variable (11). Finally, the participants in our sample were administered the CES-D during the second and early third trimester while the Walker sample completed this instrument in the immediate postpartum period. Other experts have noted that the responses to stress and affective instruments may heavily depend upon where in the trajectory of pregnancy a woman is when these dimensions are assessed (40).

We generally did not find a robust association between the appraisals of stress and sufficiency of coping resources and adequacy of GWG in crude or adjusted models. However, when evaluating the risk ratio differences observed between women who gained inadequate or excessive weight (relative to women who gained adequate weight), the former tended to have a stronger, albeit modest, link to perceived stress than the latter. This distinction is comparable to a pattern also cited previously in another investigation (7). In that study, women who reported high stress during pregnancy tended to gain weight below clinical guidelines in contrast to those who did not report significant prenatal stress. This relationship failed to emerge among those who gained weight in excess of clinical advice. This finding is also consistent with earlier work that typically reported higher stress in relation to insufficient GWG (19).

The underlying biopsychosocial mechanisms giving rise to these differential relationships between indicators of psychological status and adequacy of GWG remain to be elucidated. Further, given the subjective nature of stress in particular, authors have urged scientists in this area to give careful consideration to measuring stress in this population using instruments that are sensitive to diverse cultural meanings and life events (10) and that include items relevant to the experience of pregnant women specifically (41). Focusing efforts on enhancing both the identification of distinct biophysical mechanisms and the validity of measures may improve the consistency and interpretation of data obtained across participant samples and may serve as benchmarks for evaluating the efficacy of targeted interventions.

One of the novel aspects of this analysis was the inclusion of an instrument that uniquely assessed fetal health locus of control beliefs as determinants of the adequacy of GWG achieved. The degree to which a woman perceives that she, powerful authority figures

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(actual or symbolic), or chance factors are responsible for the health of her fetus has been correlated with several health risk- and resilience-promoting behaviors in the existing literature. On the beneficial side, women reporting a greater internal fetal health locus of control demonstrated better adherence with limiting caffeine consumption (32), not smoking during pregnancy (32), attending childbirth classes (42) and intending to breastfeed (43).

Adversely, women who typically endorsed beliefs that fetal health is due to chance tended to also have higher rates of smoking (44) and heavy alcohol use (45) during pregnancy. Low personal responsibility for the health of the fetus was also particularly high in one study among pregnant smokers who were classified as precontemplative along the stages of change towards consideration of smoking cessation (46). Similarly, lower perceptions of personal control in affecting the health of the unborn baby were associated with higher scores on a composite self-care inventory reflecting poorer dietary, exercise, sleep, and hygiene practices, in conjunction with indexing greater problems with substance abuse and reckless behavior during pregnancy (13).

Our results showed marginally significant relationships between dimensions of fetal health locus of control and adequacy of GWG in the unadjusted ANOVA models. Women who were categorized as having reported high beliefs in chance factors gained a considerably higher than anticipated proportion of weight during pregnancy than women who were less likely to attribute fetal health to chance. Finally, the association between chance fetal health locus of control beliefs and GWG was further modified by the level of adequacy as indicated by the observed risk ratios. Women who gained weight below clinical expectations based on pregravid BMI reported stronger beliefs in chance factors relative to women who gained within the recommended ranges. An analogous relationship was not discerned from comparing risk for excessive (versus adequate) GWG based on the degree of reported beliefs in chance occurrences in impacting fetal health.

Importantly, these relationships were attenuated when adjusted for maternal sociodemographic (e.g., pregravid BMI, marital status, race, education) and lifestyle factors. Thus, it will be essential for future researchers to consider the cultural context of these health-specific locus of control beliefs. We believe adopting a greater culturally sensitive stance towards clarifying health beliefs during pregnancy will enhance attempts to promote positive maternal and fetal outcomes secondary to GWG among women of diverse ages, ethnicities and socioeconomic backgrounds.

Building upon prior work, subsequent research would further benefit from more formally testing specific modifiable weight-regulating behaviors (e.g., energy intake, the frequency of participating in moderate-vigorous physical activity) as mediators in the association between fetal health locus of control beliefs and the adequacy of weight gained during pregnancy. In addition to the biopsychosocial model, future work may also help extend the contributions of this line of research by utilizing existing theoretical models to inform psychological and behavioral risk assessment for problematic GWG and to identify predictors essential to successful prevention and therapeutic change efforts [e.g., the Health Belief Model (47), the Transtheoretical Model (48), the Theory of Planned Behavior (49)].

Lastly, not only does excessive weight gain in the prenatal period serve as a potential harbinger for detriments to physical well-being, it may conversely lead to more frequent and/or severe experiences of psychological and emotional distress throughout pregnancy, in the early post-partum and beyond. Our preliminary evidence revealed that women who gained a greater proportion of weight during pregnancy than clinically advised reported significantly more symptoms of depression than women who gained within the appropriate range. Likewise, DiPietro and colleagues found that when stratified by adequacy of GWG,

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women in their sample who gained an excessive amount of weight had more negative body image attitudes during pregnancy (16). More specifically, these overgainers experienced greater embarrassment when weighed, generally felt less attractive, were embarrassed about their weight and were more concerned about becoming fat than their adequate and undergaining counterparts (16). Undoubtedly, the bidirectional nature of this relationship is a rich area for further scientific scrutiny.

The current study has several notable strengths including a large, prospective cohort design, and inclusion of energy intake and physical activity as covariates. It is also important to consider limitations. Although the participant sample was more diverse than some others studied in previous research, the women were mostly Caucasian, well-educated, married, financially stable, and received early prenatal care at University-based clinics. These characteristics may limit the generalizability of our findings. Although we were obtained measures of psychological functioning at multiple times throughout pregnancy, we did not have access to information about psychological status prior to pregnancy. Conceivably, a history of clinical depression, anxiety, body image disturbance or significant life stress in the face of poor coping resources could potentiate risk for experiencing negative mood and affective changes in pregnancy, which could subsequently impact the adequacy of GWG achieved.

In summary, in the unadjusted models, symptoms of depression, anxiety, self-esteem and dimensions of fetal health locus of control all predicted significantly deviating from established GWG clinical guidelines. To a large extent, maternal sociodemographic and health behavior characteristics reduced these relationships thus suggesting their critical role in determining higher than expected weight gain ratios in the gestational period. Although additional work is needed, our findings contribute to a body of research that has important clinical implications for the early identification and treatment of women at risk for both undergaining and overgaining during pregnancy.

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Glossary

GWG	gestational weight gain
BMI	body mass index

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Table 1

Characteristics of women in the Pregnancy, Infection, and Nutrition Study, 2001–2005 (N = 1605)

	N	Percent/Mean (SD)
Demographic & Behavioral Characteristics		
Mother's Race		
African American	329	20.5
White	1127	70.3
Other	147	9.2
missing	2	
Mother's Education		
<12 years	122	7.6
12 years	233	14.5
13–15 years	305	19.0
16+ years	944	58.8
missing	1	
Mother's Age at Start of Pregnancy		
16–19 years	89	5.6
20–29 years	716	44.6
30+ years	800	49.8
missing	0	
Marital Status		
Not married	412	25.7
Married	1191	74.3
missing	2	
Parity		
0	769	48.0
1	535	33.4
2+	298	18.6
missing	3	

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	N	Percent/Mean (SD)
Percent of Poverty Index		
<100% of Poverty	192	12.7
100%–<200% of Poverty	187	12.4
200%+ of Poverty	1129	74.9
missing	97	
Smoked during Months 1–6 of Pregnancy		
None	1298	88.8
1–9 cigarettes/day	115	7.8
10–19 cigarettes/day	38	2.6
20+ cigarettes/day	11	0.8
missing	143	
Anthropometric Characteristics		
Pregravid Body Mass Index (BMI; kg/m^2)		
Underweight <19.8	227	14.1
normal weight 19.8–26	799	49.8
overweight 26–29	179	11.2
obese >29	400	24.9
missing	0	
Absolute Gestational Weight Gain (kg)	1605	15.1 (6.3)
missing	0	
Ratio of Gestational Weight Gain	1605	1.52 (0.82)
missing	0	
Adequacy of Gestational Weight Gain		
inadequate	234	14.6
adequate	341	21.2
excessive	1030	64.2
missing	0	
Dietary Factors (daily)		

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	N	Percent/Mean (SD)
Total Energy (kcals)	1276	2174 (873)
Physical Activity (per week)		
Indoor (MET-Hrs) 17–22 weeks	1544	5.6 (16.4)
Outdoor (MET-Hrs) 17–22 weeks	1544	1.6 (6.0)
Recreational (MET-Hrs) 17–22 weeks	1544	8.0 (12.4)
Indoor (MET-Hrs) 27–30 weeks	1422	4.7 (9.7)
Outdoor (MET-Hrs) 27–30 weeks	1422	1.2 (4.7)
Recreational (MET-Hrs) 27–30 weeks	1422	6.9 (10.8)
Psychosocial Characteristics		
Perceived Stress Scale (PSS) 17–22 weeks	1568	20.3 (7.8)
Perceived Stress Scale 27–30 weeks	1465	13.6 (6.3)
Trait Anxiety (STAI-T) <20 weeks	1445	36.6 (10.3)
State Anxiety (STAI-S) <20 weeks	1440	35.4 (11.1)
State Anxiety 24–29 weeks	1255	33.0 (11.2)
Depression Symptoms (CES-D) <20 weeks	1438	12.0 (9.7)
Depression Symptoms 24–29 weeks	1259	12.0 (9.3)
Self-esteem (SELF-EST) <20 weeks	1436	51.0 (8.1)
Fetal Health Locus of Control-Internality*	1428	29.1 (3.6)
Fetal Health Locus of Control-Powerful	1409	17.5 (4.8)
Others *	1404	22.3 (5.3)
Fetal Health Locus of Control-Chance*		

*These measures were administered at <20 weeks gestation.

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Table 2

Crude and Adjusted Means for Adequacy of Gestational Weight Gain Categorized by Psychosocial Status

Psychosocial Variable	N	Crude (ANOVA F-test)		Adjusted* (Likelihood Ratio Chi-square test)	
		Mean (SD)	P-value	Mean (SE)	P-value
PSS Low 17–22 weeks	535	1.51 (0.71)	0.14	1.56 (0.09)	0.27
PSS Moderate 17–22 weeks	482	1.47 (0.76)		1.50 (0.09)	
PSS High 17–22 weeks	551	1.57 (0.96)		1.48 (0.09)	
PSS Low 27–30 weeks	502	1.50 (0.80)	0.26	1.52 (0.08)	0.70
PSS Moderate 27–30 weeks	519	1.50 (0.74)		1.50 (0.08)	
PSS High 27–30 weeks	444	1.57 (0.89)		1.48 (0.08)	
STAI-T Low <20 weeks	469	1.55 (0.93)	0.07	1.49 (0.09)	0.93
STAIT-T Moderate <20 weeks	514	1.55 (0.81)		1.48 (0.09)	
STAI-T High <20 weeks	462	1.47 (0.68)		1.47 (0.09)	
STAI-S Low <20 weeks	489	1.59 (0.91)	0.14	1.55 (0.08)	0.89
STAI-S Moderate <20 weeks	484	1.48 (0.73)		1.52 (0.08)	
STAI-S High <20 weeks	467	1.50 (0.78)		1.53 (0.08)	
STAI-S Low 24–29 weeks	327	1.60 (0.96)	0.14	1.51 (0.09)	0.72
STAI-S Moderate 24–29 weeks	399	1.49 (0.69)		1.52 (0.09)	
STAI-S High 24–29 weeks	529	1.47 (0.78)		1.55 (0.09)	
CES-D Low <20 weeks	1098	1.49 (0.72) †	0.01	1.48 (0.09)	0.91
CES-D Moderate <20 weeks	188	1.55 (0.94)		1.46 (0.10)	
CES-D High <20 weeks	157	1.70 (1.07) †		1.50 (0.10)	
CES-D Low 24–29 weeks	938	1.47 (0.74) †	0.01	1.49 (0.09)	0.76
CES-D Moderate 24–29 weeks	191	1.60 (0.78)		1.47 (0.10)	
CES-D High 24–29 weeks	130	1.67 (1.20) †		1.53 (0.10)	
SELF-EST Low <20 weeks	478	1.58 (0.91)	0.08	1.54 (0.08)	0.24
SELF-EST Moderate <20 weeks	470	1.46 (0.72)		1.48 (0.09)	
SELF-EST High <20 weeks	488	1.53 (0.80)		1.57 (0.09)	
FHLC-I Low <20 weeks	570	1.56 (0.87)	0.46	1.64 (0.09)	0.88

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Psychosocial Variable	N	Crude (ANOVA F-test)		Adjusted* (Likelihood Ratio Chi-square test)	
		Mean (SD)	P-value	Mean (SE)	P-value
FHLC-I Moderate <20 weeks	376	1.49 (0.76)		1.61 (0.10)	
FHLC-I High <20 weeks	482	1.52 (0.79)		1.62 (0.09)	
FHLC-P Low <20 weeks	482	1.46 (0.68)		1.54 (0.05)	
FHLC-P Moderate <20 weeks	476	1.56 (0.87)	0.15	1.57 (0.04)	0.34
FHLC-P High <20 weeks	451	1.56 (0.88)		1.49 (0.04)	
FHLC-C Low <20 weeks	482	1.45 (0.66)		1.49 (0.10)	
FHLC-C Moderate <20 weeks	476	1.55 (0.86)	0.06	1.51 (0.09)	0.92
FHLC-C High <20 weeks	451	1.57 (0.89)		1.50 (0.09)	

Note: PSS = Perceived Stress Scale, STAI-T = Speilberger Trait Anxiety Inventory, STAI-S = Speilberger State Anxiety Inventory, CES-D = Center for Epidemiological Studies-Depression Scale, SELF-EST = Rosenberg Self-esteem Scale, FHLC-I = Fetal Health Locus of Control-Internality Scale, FHLC-P = Fetal Health Locus of Control-Powerful Others Scale, FHLC-C = Fetal Health Locus of Control-Chance Scale

*Adjusted for pregravid BMI and other identified maternal sociodemographic, dietary and physical activity variables which varied per psychosocial predictor.

†Significant difference at $p < 0.05$ in the Bonferroni-corrected post-hoc analyses.

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Table 3

Crude and Adjusted Risk Ratios for Categorized Psychosocial Variables and Adequacy of Gestational Weight Gain for women in the Pregnancy, Infection, and Nutrition Study, 2001–2005

Psychosocial Scale	Inadequate Weight Gain		Excessive Weight Gain	
	Crude RR (95% CI)	Adjusted RR* (95% CI)	Crude RR (95% CI)	Adjusted RR* (95% CI)
Perceived Stress Scale, 17–22 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.10 (0.8,1.4)	0.84 (0.6,1.1)	0.99 (0.9,1.1)	0.99 (0.9,1.0)
High	1.29 (1.0,1.6)	1.01 (0.8,1.3)	1.03 (1.0,1.1)	0.99 (0.9,1.1)
Perceived Stress Scale, 27–30 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.21 (0.9,1.6)	1.06 (0.9,1.3)	1.04 (1.0,1.1)	1.01 (1.0,1.1)
High	1.28 (1.0,1.7)	1.02 (0.8,1.2)	1.07 (1.0,1.2)	1.01 (1.0,1.1)
State-Trait Anxiety Scale – Trait, <20 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	0.95 (0.7,1.2)	1.07 (0.9,1.2)	1.04 (1.0,1.1)	1.02 (1.0,1.1)
High	0.88 (0.7,1.1)	1.07 (0.9,1.2)	0.98 (0.9,1.1)	1.01 (1.0,1.1)
State-Trait Anxiety Scale – State, <20 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	0.89 (0.7,1.1)	1.08 (0.9,1.3)	0.94 (0.9,1.0)	1.06 (1.0,1.1)
High	0.79 (0.6,1.0)	1.07 (0.9,1.3)	0.94 (0.9,1.0)	1.00 (0.9,1.1)
State-Trait Anxiety Scale – State, 24–29 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.10 (0.8,1.5)	1.08 (0.8,1.4)	1.00 (0.9,1.1)	1.01 (0.9,1.1)
High	1.02 (0.8,1.4)	1.04 (0.8,1.4)	0.95 (0.9,1.0)	0.99 (0.9,1.1)
Center for Epidemiologic Scale – Depression (CES-D), <20 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.24 (0.9,1.7)	0.98 (0.7,1.4)	1.06 (1.0,1.2)	1.01 (0.9,1.1)
High	1.06 (0.8,1.5)	0.85 (0.5,1.2)	1.03 (0.9,1.1)	0.98 (0.9,1.1)
Center for Epidemiologic Scale – Depression (CES-D), 24–29 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	0.90 (0.6,1.3)	0.94 (0.7,1.3)	1.08 (1.0,1.2)	1.02 (0.9,1.1)
High	1.36 (1.0,1.9)	1.12 (0.7,1.8)	1.12 (1.0,1.1)	1.02 (0.9,1.1)
Self Esteem Scale, <20 weeks' gestation				
Low	1.23 (0.9,1.6)	1.01 (0.8,1.3)	1.01 (0.9,1.1)	0.99 (0.9,1.1)
Moderate	1.29 (1.0,1.7)	1.10 (0.8,1.4)	1.03 (1.0,1.1)	1.02 (0.9,1.1)
High (REF)	1.0	1.0	1.0	1.0
Fetal Locus of Control, Internality Scale, < 20 weeks' gestation				
Low	1.24 (1.0,1.6)	1.04 (0.9,1.2)	1.07 (1.0,1.2)	1.02 (1.0,1.1)
Moderate	0.93 (0.7,1.3)	0.95 (0.8,1.1)	1.03 (0.9,1.1)	1.01 (0.9,1.1)

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Psychosocial Scale	Inadequate Weight Gain		Excessive Weight Gain	
	Crude RR (95% CI)	Adjusted RR* (95% CI)	Crude RR (95% CI)	Adjusted RR* (95% CI)
High (REF)	1.0	1.0	1.0	1.0
Fetal Locus of Control, Powerful Others Scale, < 20 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.32 (1.0,1.7)	1.03 (0.8,1.4)	1.10 (1.0,1.2)	1.00 (0.9,1.1)
High	1.22 (0.9,1.6)	0.93 (0.7,1.2)	1.05 (1.0,1.1)	0.96 (0.9,1.0)
Fetal Locus of Control, Chance Scale, < 20 weeks' gestation				
Low (REF)	1.0	1.0	1.0	1.0
Moderate	1.75 (1.3,2.4)	1.18 (1.0,1.4)	1.07 (1.0,1.2)	1.00 (0.9,1.1)
High	1.57 (1.2,2.1)	1.04 (0.9,1.2)	1.08 (1.0,1.2)	1.01 (0.9,1.1)

Note: Reference category is women who gained adequate amounts of weight.

* Adjusted for pregravid BMI and other identified maternal sociodemographic, dietary and physical activity covariates (in categorical form) which varied by psychosocial predictor.