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Research Article

Associations of Trimester-Specific Eating Behaviors and Eating Patterns with Excessive Gestational Weight Gain

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ABSTRACT

Objective: The modifiable predictors of excessive gestational weight gain (GWG) are not clear. The objective of this study was to examine the associations of trimester-specific eating behaviors and eating patterns with GWG.

Methods: This is a secondary analysis of data from a 3-arm, randomized controlled trial. Data were collected at early pregnancy (≤ 28 weeks gestation: 1st and 2nd trimesters) and late pregnancy (32 weeks gestation to birth: 3rd trimester). Participants from all three arms who completed both early and late pregnancy assessments were included for analyses. Eating behaviors (i.e., compensatory restraint, routine restraint, emotional eating, external eating) and eating patterns (i.e., frequency of consuming sugar-sweetened beverages, eating out at fast-food or full-service restaurants, consuming three meals, and snacking) were measured using online surveys. Weights were abstracted from the prenatal chart. Statistical analyses included multinomial logistic regressions.

Results: Participants (N=1,035) were predominantly white (77.4%) and had a mean age of 28.1 ± 4.5 years. The mean GWG was 13.7 ± 5.4 kg, and 44.7% of women had excessive GWG. Women's eating patterns significantly predicted excessive GWG. Specifically, women who had a higher frequency of consuming soda or fruit drinks in the 2nd (≤1 time/month: reference; ≥5-6 times/week: OR=2.54, 95% CI 1.16-5.59) and 3rd trimesters (≤1 time/month: reference; ≥5-6 times/week: OR=1.73, 95% CI 0.95-3.14, marginally significant), eating at fast-food restaurants in the 3rd trimester (never or rarely: reference; 1 time/month: OR=2.42, 95% CI 1.31-4.48), consuming morning snacks in the 1st (never: reference; 3-4 times/week: OR=2.18, 95% CI 1.01-4.71) and 3rd trimesters (never: reference; 1-2 times/week: OR=1.36, 95% CI 0.96-3.20, marginally significant), and consuming lunch in the 3rd trimester (0-4 times/week: reference; 5-6 times/week: OR=1.98, 95% CI 0.98-4.01, marginally significant) were more likely to have excessive GWG. None of the examined eating behaviors significantly predicted excessive GWG.

Conclusion: Reducing the frequency of consuming soda or fruit drinks (2nd and 3rd trimesters), eating at fast-food restaurants (3rd trimester), and consuming snacks (1st and 3rd trimesters) may prevent or reduce excessive GWG.

Keywords: Eating behaviors, Sugar-sweetened beverage, Snacking, Meal frequency, Eating out, Pregnancy, Gestational weight gain

INTRODUCTION

Excessive gestational weight gain (GWG) occurs in 40-60% of pregnancies [1,2] and increases the risk for adverse maternal and neonatal outcomes, including gestational diabetes mellitus, fetal macrosomia, postpartum weight retention, and childhood obesity [3]. To improve maternal and neonatal health, efforts have been made to identify modifiable predictors of excessive GWG. Pre-pregnancy body mass index (BMI) has been consistently reported as a strong predictor of excessive GWG [4], and dietary intake during pregnancy has been investigated as a potential contributor. The recently published Scientific Report of the 2020 Dietary Guidelines Advisory Committee suggested that certain food consumption during pregnancy (e.g., higher in vegetables, fruits, nuts and lower in red meat) is associated with a lower risk of excessive GWG [5]. Eating behaviors and eating patterns are closely related to the food consumption of pregnant women [6,7], thus may also have an effect on excessive GWG.

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Eating behaviors, including compensatory restraint, routine restraint, emotional eating, and external eating, have a confirmed effect on weight status in the non-pregnant population [8-11]. Compensatory restraint is a balanced approach of restrained eating, defined by adopting healthy behaviors (e.g., eat less) to compensate episodes of unhealthy eating [12]. On the contrary, routine restraint is an all-or-none approach of restrained eating, characterized by constant dieting and strict calorie counting [12]. In various non-pregnant samples, a high level of compensatory restraint and a low level of routine restraint are both associated with greater weight loss and better weight maintenance [10,11]. Emotional eating and external eating refer to food consumption in response to emotional (e.g., anxiety) or environmental cues (e.g., presence of highly palatable foods) respectively, and both of these eating behaviors diminish weight loss and contribute to weight gain in the adult population [8,9].

In pregnant women, the distinct effects of compensatory and/or routine restraint on excessive GWG have not been reported. Studies that examined general restrained eating revealed conflicting results with some reporting a positive association [13,14] and others no association [15,16] with GWG, possibly because these studies did not dissociate compensatory and routine restraint. One systematic review that synthesized evidence on eating behaviors and GWG found a paucity of studies that examined associations between emotional eating and GWG (n=4) and between external eating and GWG (n=2) [17]. Furthermore, although these few studies supported a positive association of emotional eating and external eating with GWG, they were predominantly cross-sectional in design [17], and consequently limited in scope.

In addition to eating behaviors, eating patterns can also influence a person's weight status. Eating patterns refer to an individual's food choices (e.g., sugar-sweetened beverages [SSBs]), eating locations (e.g., eating at fast-food or full-service restaurants), and eating frequency (e.g., frequency of eating breakfast, lunch, dinner, or snacks). In a meta-analysis of 88 studies of the non-pregnant population, a strong association between intake of SSBs (e.g., soda, fruit drinks) and increased body weight was reported [18]. Systematic reviews and population-based studies have indicated that eating away from home (especially fast-food restaurants) is associated with an increased likelihood of being obese [19,20]. Several empirical studies have shown that adults who skip meals or engage in frequent snacking are more likely to be overweight or obese [21,22]. Therefore, behavioral weight loss interventions for the general population typically recommend avoidance of SSBs, meal preparation at home, and regular consumption of three main meals per day [23].

In response to the physiological changes accompanying pregnancy (e.g., altered appetite-regulation hormones, nausea and vomiting), women often involuntarily change eating patterns. For example, some women reported skipping breakfast due to morning sickness and snacking frequently to attain adequate caloric intake [24]. However, it is unclear how altered eating patterns influence excessive GWG. For instance, unlike what has been observed in the general population, the associations between SSBs and weight gain are more mixed in the pregnant population—several well-powered studies have documented an inverse association between SSBs intake in early pregnancy and GWG [25-27]. In addition, although there is evidence suggesting a positive association between a higher consumption of fast food and excessive GWG [28,29], the association between frequency of actual visits to fast-food or full-service restaurants with GWG has never been studied. Finally, results are inconsistent regarding the relationship between eating frequency and GWG: while some studies indicated that skipping breakfast or frequent snacking increases the odds of excessive GWG [30,31], others reported the opposite or no associations [32,33]. Importantly, the Scientific Report of the 2020 Dietary Guidelines Advisory Committee attempted to synthesize evidence on the relationships between eating frequency and GWG, but identified no eligible studies that could answer this question [5]. Therefore, the committee called for further studies to examine how pregnant women's eating patterns affect excessive GWG [5]. The purpose of this study was to examine the associations of trimester-specific eating behaviors and eating patterns with excessive GWG in a cohort of pregnant women.

METHODS

Study Design

This was a secondary analysis of data from the eMoms study, which was a 3-arm randomized controlled trial that tested the effect of electronically-mediated behavioral interventions to prevent excessive GWG and postpartum weight retention. Eligibility criteria of the eMoms' study included being 18-35 years old, consenting at or before 20 weeks gestation, and planning to keep the baby. Women who had a BMI out of range (<18.5 kg/m^2 or >34.9 kg/m^2), had a multiple gestation, or had medical conditions (e.g., cardiovascular event) were excluded. A total of 1,722 women were randomized to one of the three arms: intervention during pregnancy only, intervention during pregnancy and postpartum, and a control group. Intervention features included setting diet and physical activity goals, self-monitoring weight, and delivering educational materials. Data were collected at two time points during pregnancy: early (from randomization to 28 weeks gestation) and late pregnancy (from 32 weeks gestation to birth).

Details of the study design and CONSORT flow diagram have been published elsewhere [34]. The study was approved by the University of Rochester Research Subject Review Board and the Cornell University Institutional Review Board. Informed consent was obtained from all study participants.

Participants

The interventions did not have a significant effect on GWG [35], therefore participants from all three arms who completed both early and late pregnancy assessments were included for analysis. A total of 1,414 participants completed the early pregnancy assessment; among these, 95 were excluded from the original study for the following reasons: BMI of underweight (n=15), medical exclusion (n=27), miscarriage (n=39), preterm birth <28 weeks gestation (n=8), and multiple gestations (n=6). Many of these 95 women (e.g., BMI of underweight, medical exclusion) although enrolled in the eMoms study were ineligible: they completed the early pregnancy assessment because eligibility was determined via self-report at recruitment, and later, at the time of medical record abstraction, were found to be ineligible. Among the remaining 1,319 participants who completed the early pregnancy assessment, 284 of them did not complete the late pregnancy assessment thus were excluded from analyses, resulting in a final sample of 1,035.

Participants were divided into two groups based on gestation at the time of completing the early pregnancy assessment: 1st trimester (≤12 weeks, n=518) and 2nd trimester (13-27 weeks, n=517). For the

late pregnancy assessment, every participant was in the 3rd trimester (≥28 weeks, N=1,035).

Measurements

Sociodemographic data (e.g., age, race, marital status), eating behaviors, and eating patterns were collected via an online survey at the early and late pregnancy assessments.

Eating behaviors were measured by the 16-item Weight-Related Eating Questionnaire (WREQ) [36]. WREQ consists of four subscales that measure compensatory restraint (3 items), routine restraint (3 items), emotional eating (5 items), and external eating (5 items). Participants responded on a 5-point Likert scale ranging from 1 (not at all) to 5 (completely), and higher scores indicate higher levels of the behaviors. WREQ has demonstrated validity and reliability in women across a wide range of samples, such as postmenopausal women [8] and women with overweight or obesity [36]. Eating patterns were measured by separate questions, which are summarized in Table 1.

Early and late pregnancy weights were abstracted from prenatal charts. Early pregnancy weight was defined as the first measured weight taken <14 weeks gestational age, and it was used as a proxy of pre-pregnancy weight in this study. Late pregnancy weight was defined as the latest valid weight obtained ≥ 37 weeks gestation. GWG was calculated as the difference between late pregnancy weight and early pregnancy weight. Participants who gained weight above, within, and below the Institute of Medicine (IOM) recommendations for pregnancy weight gain [37] were categorized into excessive, adequate, and inadequate GWG groups.

Analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC). Continuous variables were described in mean and standard deviation; categorical variables were described in number and percentage. A p-value of <0.05 was considered statistically significant. Missing data were assumed as missing at random, and no imputation was performed.

Multinomial logistic regressions were performed to examine the associations of trimester-specific eating behaviors and eating patterns with the likelihood of having excessive GWG vs. adequate GWG. Each eating behavior and eating pattern in relation to excessive GWG was first examined in univariate models, and the potential predictors that were identified in the univariate models (p<0.10) were entered into the multivariate model. Based on previous literature [4], the confounding variables that were controlled for in the univariate and multivariate models included age, race, marital status, education, income, and early pregnancy BMI. The associations of eating behaviors and eating patterns with the likelihood of having inadequate GWG vs. adequate GWG were also examined.

FINDINGS

Sample Description

At the early pregnancy assessment, participants (N=1,035) were predominantly white (77.4%), married (65.2%), and at least college-educated (54.6%). Participants had a mean age of 28.1 ± 4.5 years old, a gestational age of 12.5 ± 4.6 weeks, and a mean BMI of 25.2 ± 4.2 kg/m^2. The mean GWG was 13.7 ± 5.4 kg; the proportion of women who had excessive, adequate, and inadequate GWG was 44.7%, 35.7%, and 19.6%, respectively (Table 2). The descriptions of women's eating behaviors and eating patterns are presented in Table 3.

Compared with participants who completed both early and late pregnancy assessments, those who only completed the early pregnancy assessment (excluded from analyses) were younger (26.4 vs. 28.1 years, p<0.01), had a higher early pregnancy BMI (26.4 vs. 25.3 kg/m^2, P<0.01) and lower GWG (12.4 vs. 13.7 kg, p<0.01). In addition, a higher proportion of those women were black (30.3% vs. 13.9%, p<0.01), single (19.3% vs. 8.3%, p<0.01), had an income <$ 35,000 (70.8% vs. 51.2%, p<0.01), and educationally had an associate degree or less (70.1% vs. 45.5%, p<0.01). Furthermore, women with a single assessment had a lower level of compensatory restraint (5.4 vs. 5.9, p<0.01), consumed fruit drinks more frequently (≥1 time/day: 18.2% vs. 14.0%, p<0.01), and consumed breakfast, lunch, and dinner less frequently (7 times a week: 52.8% vs. 66.9% for breakfast; 55.1% vs. 70.4% for lunch; 70.9% vs. 82.6% for dinner, p_s<0.01).

Associations of Trimester-Specific Eating Behaviors and Eating Patterns with Excessive Gwg

In the 1st trimester, the frequency of consuming fruit drinks and morning snacks were marginally associated with excessive GWG in the univariate model (p_s<0.1). In the multivariate model, women who had a frequency of fruit drinks of 1-2 times/week (OR=0.53, 95% CI 0.26-1.08, p=0.08) were less likely to have excessive GWG compared to those who drank ≤1 time/month (marginally significant). In contrast, those who had a higher frequency of morning snacks (never: reference; 1-2 times/week: OR=2.11, 95% CI 0.97-4.60, p=0.06; 3-4 times/week: OR=2.18, 95% CI 1.01-4.71, p=0.04) were more likely to have excessive GWG Table 4.

In the 2nd trimester, frequency of consuming soda and dinner were significantly associated with excessive GWG in the univariate model (p_s<0.05). However, only the frequency of consuming soda remained significant in the multivariate model: women who had a higher frequency of soda (≤1 time/month: reference; ≥5-6 times/week: OR=2.54, 95% CI 1.16-5.59, p=0.02) were more likely to have excessive GWG (Table 4).

In the 3rd trimester, frequency of consuming fruit drinks, eating at fast-food restaurant, consuming breakfast, lunch, dinner, and consuming morning snacks were significantly or marginally associated with excessive GWG in the univariate model (p_s<0.1). In the multivariate model, women who had a higher frequency of consuming fruit drinks (≤1 time/month: reference; ≥5-6 times/week: OR=1.73, 95% CI 0.95-3.14, p=0.07), higher frequency of eating at fast-food restaurants (never or rarely: reference; 1 time/month: OR=2.42, 95% CI 1.31-4.48, p<0.01; 2-3 times/month: OR=1.62, 95% CI 0.94-2.79, p=0.08; 1-2 times/week: OR=1.82, 95% CI 0.99-3.32, p=0.05; ≥3-4 times/week: OR=2.81, 95% CI 1.22-6.48, p=0.01), higher frequency of eating lunch (0-4 times/week: reference; 5-6 times/week: OR=1.98, 95% CI 0.98-4.01, p=0.06), and higher frequency of eating morning snacks (never: reference; 1-2 times/week: OR=1.36, 95% CI 0.96-3.20, p=0.07) were more likely to have excessive GWG (Table 4).

In all three trimesters, early pregnancy BMI was consistently, positively associated with the odds of having excessive GWG in each multivariate regression model (p_s<0.01). None of the eating behaviors emerged as a significant predictor of excessive GWG in any of the models. The associations of eating behaviors and eating patterns with the likelihood of having inadequate GWG vs. adequate GWG are presented in Table 5.

Table 1: Measurements of Eating Patterns.

Eating patterns	Measurements/Questions	Responses
Frequency of consuming soda	Over the past 30 days, how often did you drink soda or pop?	The ten possible answers were collapsed into five categories: 1 time/month or less, 2-3 times/month, 1-2 times/week, 3-4 times/week, and 5-6 times/week or more
Frequency of consuming fruit drinks	Over the past 30 days, how often did you drink fruit drinks (such as cranberry cocktail, lemonade)?	The ten possible answers were collapsed into five categories: 1 time/month or less, 2-3 times/month, 1-2 times/week, 3-4 times/week, and 5-6 times/week or more
Frequency of eating at fast food restaurants	Over the past 30 days, how many times did you buy food at a fast-food restaurant, such as MaDonald's?	The nine possible answers were collapsed into five categories: never or rarely, 1 time/month, 2-3 times/month, 1-2 times/week, and 3-4 times/week or more
Frequency of eating at full-service restaurants	Not including the fast-food restaurants listed above, over the past 30 days, how many times did you buy food at any other full-service restaurant?	The nine possible answers were collapsed into five categories: never or rarely, 1 time/month, 2-3 times/month, 1-2 times/week, and 3-4 times/week or more
Frequency of eating breakfast	In a typical week, how many times do you eat breakfast?	The five possible answers were collapsed into three categories: 0-4 times/week, 5-6 times/week, and 7 times/week
Frequency of eating lunch	In a typical week, how many times do you eat lunch?	The five possible answers were collapsed into three categories: 0-4 times/week, 5-6 times/week, and 7 times/week
Frequency of eating dinner	In a typical week, how many times do you eat dinner?	The five possible answers were collapsed into three categories: 0-4 times/week, 5-6 times/week, and 7 times/week
Frequency of eating mid-morning snack	In a typical week, how many times do you eat mid-morning snack?	The possible answers were: never, 1-2 times/week, 3-4 times/week, 5-6 times/week, and 7 times/week
Frequency of eating mid-afternoon snack	In a typical week, how many times do you eat mid-afternoon snack?	The possible answers were: never, 1-2 times/week, 3-4 times/week, 5-6 times/week, and 7 times/week
Frequency of eating evening snack	In a typical week, how many times do you eat evening snack?	The possible answers were: never, 1-2 times/week, 3-4 times/week, 5-6 times/week, and 7 times/week

Table 2: Sample description at early pregnancy assessment and description of gestational weight gain (N=1,035).

Characteristics	Values
Age (years), mean ± SD (n)	28.09 ± 4.46 (1035)
Gestational age (weeks), mean ± SD (n)	12.47 ± 4.57 (1035)
Race, (n)	1023
White or Caucasian, n (%)	792 (77.42)
Black or African-American, n (%)	162 (15.83)
Asian	33 (3.23)
Other	36 (3.52)
BMI (kg/m^2), mean ± SD (n)	25.25 ± 4.21 (1035)
BMI <18.5, n (%)	0 (0)
18.5≤ BMI <25, n (%)	573 (55.36)
25≤ BMI <30, n (%)	301 (29.08)
BMI ≥30, n (%)	161 (15.56)
Education, (n)	1021
Associate degree or lower, n (%)	464 (45.44)
College graduate or baccalaureate degree, n (%)	274 (26.84)
Masters or doctoral degree, n (%)	283 (27.72)
Income, (n)	1020
≤ $ 34,999, n (%)	522 (51.17)
> $ 34,999, n (%)	498 (48.83)
Marital status, (n)	1016
Single, n (%)	84 (8.27)
Engaged or marriage-like relationship, n (%)	260 (25.59)
Currently married, n (%)	662 (65.16)
Separated, divorced, or widowed, n (%)	10 (0.98)
Gestational weight gain (kg), mean ± SD (n)	13.73 ± 5.38 (1035)
Inadequate gestational weight gain, n (%)	203 (19.61)
Adequate gestational weight gain, n (%)	370 (35.75)
Excessive gestational weight gain, n (%)	462 (44.64)

Table 3: Description of eating behaviors and eating patterns at the 1st, 2nd, and 3rd trimesters (N=1,035).

Participants with 1st and 3rd trimester assessments						
	1st trimester			3rd trimester		
Eating behaviors, mean ± SD (n)						
Compensatory restraint (3-15)	6.01 ± 2.69 (513)			5.08 ± 2.69 (513)		
Routine restraint (3-15)	4.69 ± 2.20 (512)			4.44 ± 1.98 (513)		
Emotional eating (5-25)	8.09 ± 3.87 (504)			7.66 ± 3.44 (507)		
External eating (5-25)	11.04 ± 4.27 (511)			10.47 ± 4.24 (512)		
Eating patterns, n (%)						
Frequency of drinks, (n)	Soda (517)		Fruit drink (516)	Soda (517)		Fruit drink (517)
1 time/month or less	164 (31.72)		270 (52.33)	158 (30.56)		239 (46.23)
2-3 times/month	140 (27.08)		86 (16.67)	121 (23.40)		104 (20.12)
1-2 times/week	79 (15.28)		55 (10.66)	104 (20.17)		69 (13.35)
3-4 times/week	67 (12.96)		54 (10.46)	77 (14.89)		62 (11.99)
5-6 times/week or more	67 (12.96)		51 (9.88)	57 (11.02)		43 (8.02)
Frequency of restaurants, (n)	Fast-food (509)		Sit-down (512)	Fast-food (513)		Sit-down (517)
Never or rarely	70 (13.75)		60 (11.72)	64 (12.48)		73 (14.12)
1 time/month	83 (16.31)		95 (18.55)	93 (18.13)		105 (20.31)
2-3 times/month	201 (39.49)		211 (41.21)	213 (41.52)		215 (41.59)
1-2 times/week	114 (22.40)		124 (24.22)	112 (21.83)		104 (20.12)
3-4 times/week or more	41 (8.05)		22 (4.30)	31 (6.04)		20 (3.87)
Frequency of three meals, (n)	Breakfast (517)	Lunch (514)	Dinner (512)	Breakfast (516)	Lunch (513)	Dinner (515)
0-4 times/week	108 (20.89)	71 (13.81)	37 (0.73)	67 (12.98)	59 (11.50)	33 (6.41)
5-6 times/week	57 (11.02)	72 (14.01)	39 (7.62)	43 (8.33)	59 (11.50)	37 (7.18)
7 times/week	352 (68.08)	371 (72.18)	436 (85.16)	406 (78.68)	395 (77.00)	445 (86.41)
Frequency of snacks, (n)	Morning (507)	Afternoon (516)	Evening (507)	Morning (514)	Afternoon (510)	Evening (514)
Never	66 (13.02)	43 (8.33)	70 (13.81)	47 (9.14)	29 (5.69)	40 (7.78)
1-2 times/week	101 (19.92)	92 (17.83)	123 (24.26)	109 (21.21)	102 (20.00)	129 (25.10)
3-4 times/week	105 (20.71)	130 (25.19)	103 (20.32)	96 (18.68)	97 (19.02)	96 (18.68)
5-6 times/week	114 (22.48)	115 (22.29)	100 (19.72)	113 (21.98)	124 (24.31)	106 (20.62)
7 times/week	121 (23.87)	136 (26.36)	111 (21.89)	149 (28.99)	158 (30.98)	143 (27.82)
Participants with 2nd and 3rd trimester assessments						
	2nd trimester			3rd trimester		
Eating behaviors, mean ± SD (n)						
Compensatory restraint (3-15)	5.91 ± 2.75 (501)			5.59 ± 2.07 (500)		
Routine restraint (3-15)	4.48 ± 2.02 (507)			4.20 ± 1.83 (503)		
Emotional eating (5-25)	7.73 ± 3.85 (498)			7.35 ± 3.39 (498)		
External eating (5-25)	10.62 ± 4.41 (501)			9.99 ± 4.03 (497)		
Eating patterns, n (%)						
Frequency of drinks, (n)	Soda (513)		Fruit drink (512)	Soda (509)		Fruit drink (508)
1 time/month or less	154 (30.02)		183 (35.74)	124 (24.36)		209 (41.14)
2-3 times/month	104 (20.27)		97 (18.94)	136 (26.72)		96 (18.90)
1-2 times/week	107 (20.86)		70 (13.67)	116 (22.79)		62 (12.20)
3-4 times/week	79 (15.40)		69 (13.48)	60 (11.79)		66 (12.99)
5-6 times/week or more	69 (13.45)		93 (18.16)	73 (14.34)		75 (14.76)
Frequency of restaurants, (n)	Fast-food (509)		Sit-down (509)	Fast-food (507)		Sit-down (509)
Never or rarely	44 (8.64)		77 (15.13)	55 (10.85)		87 (17.09)
1 time/month	84 (16.50)		99 (19.45)	80 (15.78)		118 (23.18)
2-3 times/month	183 (35.95)		207 (40.67)	222 (43.79)		200 (39.29)
1-2 times/week	132 (25.93)		102 (20.04)	113 (22.29)		88 (17.29)
3-4 times/week or more	66 (12.97)		24 (4.71)	37 (7.30)		16 (3.14)
Frequency of three meals, (n)	Breakfast (513)	Lunch (512)	Dinner (512)	Breakfast (509)	Lunch (505)	Dinner (505)
0-4 times/week	106 (20.66)	77 (15.04)	50 (9.77)	71 (13.95)	65 (12.87)	36 (7.13)
5-6 times/week	70 (13.64)	84 (16.41)	52 (10.16)	72 (14.14)	76 (15.05)	42 (8.32)
7 times/week	337 (65.69)	351 (68.55)	410 (80.07)	366 (71.91)	365 (72.08)	427 (84.55)

Frequency of snacks, (n)	Morning (505)	Afternoon (508)	Evening (504)	Morning (506)	Afternoon (498)	Evening (504)
Never	67 (13.27)	36 (7.09)	57 (11.31)	54 (10.67)	33 (6.63)	47 (9.32)
1-2 times/week	116 (22.97)	113 (22.24)	132 (26.19)	104 (20.55)	96 (19.28)	115 (22.82)
3-4 times/week	100 (19.80)	107 (21.06)	124 (24.60)	117 (23.12)	117 (23.49)	117 (23.21)
5-6 times/week	106 (20.99)	113 (22.24)	84 (16.67)	104 (20.55)	115 (23.09)	93 (18.45)
7 times/week	116 (22.97)	139 (27.36)	107 (21.23)	127 (25.10)	137 (27.51)	132 (26.19)

Table 4: Factors associated with the likelihood of having excessive GWG (n=462, 44.64%) vs. adequate GWG (n=370, 35.75%) in multiple multinomial logistic regression.

	Odds ratio	95% CI	p-value
Likelihood of having excessive GWG vs adequate GWG in the 1st trimester			
Age	1.01	0.94-1.08	0.79
Race			
White (reference)			
Black	1.21	0.48-3.04	0.69
Other	1.09	0.47-2.53	0.82
Marital status			
Single (reference)			
Engaged or marriage-like	1.25	0.48-3.26	0.64
Currently married	1.25	0.45-3.50	0.67
Separated, divorced, or widowed	0.19	0.10-3.92	0.28
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	0.67	0.35-1.27	0.22
Masters or doctoral degree	0.88	0.45-1.73	0.71
Income			
≤ $ 34,999 (reference)			
> $ 34,999	0.75	0.46-1.23	0.25
Early-pregnancy BMI***	1.16	1.09-1.23	<0.01
Fruit drink			
≤1 time/month (reference)			
2-3 times/month	1.09	0.60-1.96	0.78
1-2 times/week*	0.53	0.26-1.08	0.08
3-4 times/week	0.95	0.45-2.01	0.89
≥5-6 times/week	0.64	0.27-1.49	0.30
Morning snack			
Never (reference)			
1-2 times/week*	2.11	0.97-4.60	0.06
3-4 times/week**	2.18	1.01-4.71	0.04
5-6 times/week	1.73	0.81-3.72	0.16
7 times/week**	1.92	0.90-4.09	0.09
Likelihood of having excessive GWG vs adequate GWG in the 2nd trimester			
Age *	0.94	0.88-1.00	0.06
Race			
White (reference)			
Black	0.71	0.34-1.47	0.35
Other**	0.43	0.19-0.95	0.04
Marital status			
Single (reference)			
Engaged or marriage-like	0.57	0.23-1.43	0.23
Currently married	0.56	0.19-1.59	0.28
Separated, divorced, or widowed	0.56	0.07-4.59	0.95
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	0.71	0.39-1.30	0.27
Masters or doctoral degree	0.98	0.45-1.98	0.96
Income			
≤ $ 34,999 (reference)			

	Odds ratio	95% CI	p-value
> $ 34,999	0.77	0.46-1.27	0.30
Early-pregnancy BMI***	1.16	1.09-1.23	<0.01
Soda			
≤1 time/month (reference)			
2-3 times/month	1.49	0.79-2.78	0.21
1-2 times/week	1.16	0.61-2.19	0.66
3-4 times/week	1.08	0.54-2.15	0.82
≥5-6 times/week**	2.54	1.16-5.59	0.02
Dinner			
0-4 times/week (reference)			
5-6 times/week	0.52	0.18-1.51	0.23
7 times/week	0.86	0.35-2.13	0.75
Likelihood of having excessive GWG vs adequate GWG in the 3rd trimester			
Age	0.98	0.93-1.02	0.33
Race			
White (reference)			
Black	1.01	0.56-1.82	0.96
Other	0.77	0.44-1.33	0.34
Marital status			
Single (reference)			
Engaged or marriage-like	1.05	0.54-2.01	0.89
Currently married	1.00	0.48-2.09	0.99
Separated, divorced, or widowed	0.56	0.11-2.84	0.48
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	0.73	0.47-1.14	0.17
Masters or doctoral degree	0.89	0.55-1.44	0.64
Income			
≤ $ 34,999 (reference)			
> $ 34,999*	0.72	0.51-1.02	0.06
Early-pregnancy BMI***	1.15	1.11-1.20	<0.01
Fruit drinks			
≤1 time/month (reference)			
2-3 times/month	1.13	0.74-1.72	0.57
1-2 times/week	1.06	0.65-1.72	0.82
3-4 times/week	1.11	0.67-1.84	0.69
≥5-6 times/week*	1.73	0.95-3.14	0.07
Fast-food restaurants			
Never or rarely (reference)			
1 time/month***	2.42	1.31-4.48	<0.01
2-3 times/month*	1.62	0.94-2.79	0.08
1-2 times/week*	1.82	0.99-3.32	0.05
≥3-4 times/week**	2.81	1.22-6.48	0.01
Breakfast			
0-4 times/week (reference)			
5-6 times/week	0.83	0.42-1.64	0.59
7 times/week	1.12	0.60-2.09	0.72
Lunch			
0-4 times/week (reference)			
5-6 times/week*	1.98	0.98-4.01	0.06
7 times/week	1.57	0.80-3.07	0.18
Dinner			
0-4 times/week (reference)			
5-6 times/week	1.12	0.45-2.74	0.81
7 times/week	1.63	0.70-3.78	0.25
Morning snack			

	Odds ratio	95% CI	p-value
Never (reference)			
1-2 times/week*	1.75	0.96-3.20	0.07
3-4 times/week	1.36	0.45-2.48	0.31
5-6 times/week	1.39	0.76-2.53	0.28
7 times/week	1.29	0.17-2.33	0.41

Adequate gestational weight gain (GWG) was used as the reference group

*: p<0.1; **: p<0.05; ***: p<0.01

Table 5: Factors associated with the likelihood of having inadequate GWG (n=203, 19.61%) vs adequate GWG (n=370, 35.75%) in multiple multinomial logistic regression.

	Odds ratio	95% CI	p value
Likelihood of having inadequate GWG vs adequate GWG in the 1st trimester			
Age	1.06	0.96-1.17	0.23
Race			
White (reference)			
Black**	3.74	1.05-13.35	0.04
Other	1.29	0.37-4.56	0.68
Marital status			
Single (reference)			
Engaged or marriage-like	2.19	0.49-9.81	0.30
Currently married	3.25	0.62-17.08	0.16
Separated, divorced, or widowed	26.37	0.06->999.99	0.29
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	1.05	0.42-2.65	0.91
Masters or doctoral degree	1.73	0.64-4.69	0.28
Income			
≤ $ 34,999 (reference)			
> $ 34,999	0.56	0.28-1.14	0.11
Early-pregnancy BMI*	0.93	0.85-1.01	0.08
External eating*	0.93	0.86-1.00	0.07
Soda			
≤1 time/month (reference)			
2-3 times/month***	0.33	0.14-0.74	<0.01
1-2 times/week	0.93	0.36-2.38	0.87
3-4 times/week	1.21	0.47-3.16	0.69
≥5-6 times/week	1.50	0.55-4.08	0.42
Fruit drinks			
≤1 time/month (reference)			
2-3 times/month*	0.39	0.16-1.01	0.05
1-2 times/week	0.57	0.22-1.49	0.25
3-4 times/week	0.76	0.26-2.27	0.62
≥5-6 times/week	0.86	0.31-2.37	0.77
Sit-down restaurants			
Never or rarely (reference)			
1 time/month	0.43	0.14-1.30	0.13
2-3 times/month*	0.36	0.13-1.04	0.06
1-2 times/week**	0.27	0.08-0.87	0.03
≥3-4 times/week	0.56	0.12-2.66	0.47
Dinner			
0-4 times/week (reference)			
5-6 times/week	1.42	0.28-7.33	0.67
7 times/week	1.84	0.45-7.49	0.39
Evening snack			
Never (reference)			

	Odds ratio	95% CI	p value
1-2 times/week	2.22	0.79-6.22	0.13
3-4 times/week*	2.72	0.97-7.64	0.06
5-6 times/week	2.49	0.83-7.48	0.10
7 times/week	2.01	0.68-5.89	0.20
Likelihood of having inadequate GWG vs adequate GWG in the 2nd trimester			
Age	0.96	0.88-1.04	0.29
Race			
White (reference)			
Black	1.24	0.52-2.93	0.62
Other	0.39	0.12-1.33	0.13
Marital status			
Single (reference)			
Engaged or marriage-like	1.15	0.31-4.20	0.83
Currently married	1.33	0.32-5.45	0.69
Separated, divorced, or widowed	<0.01	<0.01-	0.99
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	0.86	0.38-1.93	0.71
Masters or doctoral degree	1.32	0.52-1.34	0.56
Income			
≤ $ 34,999 (reference)			
> $ 34,999*	0.53	0.27-1.04	0.07
Early-pregnancy BMI	0.99	0.92-1.07	0.90
Lunch			
0-4 times/week (reference)			
5-6 times/week	0.57	0.16-1.97	0.37
7 times/week	0.95	0.30-2.99	0.93
Dinner			
0-4 times/week (reference)			
5-6 times/week*	0.21	0.04-1.19	0.08
7 times/week	0.66	0.18-2.40	0.53
Morning snack			
Never (reference)			
1-2 times/week	0.88	0.30-2.53	0.80
3-4 times/week	1.18	0.41-3.45	0.76
5-6 times/week	0.44	0.14-1.41	0.17
7 times/week	0.44	0.12-1.61	0.21
Afternoon snack			
Never (reference)			
1-2 times/week	0.50	0.13-1.89	0.30
3-4 times/week	0.57	0.14-2.25	0.42
5-6 times/week	0.81	0.19-3.49	0.77
7 times/week	1.01	0.22-4.68	0.99
Likelihood of having inadequate GWG vs adequate GWG in the 3rd trimester			
Age	1.00	0.45-1.06	0.89
Race			
White (reference)			
Black	1.64	0.84-3.17	0.14
Other	0.67	0.33-1.36	0.27
Marital status			
Single (reference)			
Engaged or marriage-like	1.71	0.69-4.19	0.24
Currently married	1.83	0.70-4.78	0.21
Separated, divorced, or widowed	0.85	0.07-9.70	0.89

	Odds ratio	95% CI	p value
Education			
Associate degree or lower (reference)			
College graduate or baccalaureate degree	0.86	0.48-1.51	0.59
Masters or doctoral degree	1.28	0.69-2.36	0.43
Income			
≤ $ 34,999 (reference)			
> $ 34,999***	0.51	0.33-0.79	<0.01
Early-pregnancy BMI	0.99	0.94-1.05	0.82
Emotional eating**	0.93	0.88-0.99	0.03
Fruit drinks			
≤1 time/month (reference)			
2-3 times/month	1.16	0.70-1.91	0.56
1-2 times/week**	0.39	0.19-0.82	0.01
3-4 times/week	0.72	0.37-1.39	0.32
≥5-6 times/week	1.64	0.82-3.65	0.16

Adequate gestational weight gain (GWG) was used as the reference group*: p<0.1; **: p<0.05; ***: p<0.01

DISCUSSION

This secondary analysis examined whether trimester-specific eating behaviors and eating patterns predicted the likelihood of having excessive GWG vs. adequate GWG. Results indicated that a higher frequency of consuming soda or fruit drinks (trimesters 2 and 3), higher frequency of eating at fast-food restaurants (trimester 3), regular consumption of lunch (trimester 3), and higher frequency of eating morning snacks (trimesters 1 and 3) were risk factors of excessive GWG. On the contrary, higher frequency of consuming fruit drinks (trimester 1) was a protective factor of excessive GWG. Additionally, eating behaviors including compensatory restraint, routine restraint, emotional eating, and external eating were not related to the odds of excessive GWG.

SSBs are the largest source of added sugar in the diet for both pregnant and non-pregnant women [38], and have been consistently and strongly related to weight gain in the non-pregnant population [18,32]. In this study, increased frequency of consuming soda or fruit drinks in the 2nd and 3rd trimesters (marginally significant) was associated with an increased likelihood of excessive GWG, which is in line with the findings from the general population. However, a counterintuitive result was observed in the 1st trimester where an increased frequency of consuming fruit drinks (1-2 times/week) was associated with a decreased likelihood of excessive GWG. Unlike the convergent evidence in the general population, studies among pregnant women have reported conflicting results regarding the relationship of SSBs with excessive GWG. For example, one study assessed the diet of 342 pregnant women and found that women who consumed one or more soft drinks/day in the 1st trimester had a lower GWG compared to women with no soft drink consumption [26]. Similarly, another study surveyed 1388 pregnant women from eastern Massachusetts and reported that greater SSB intake in early pregnancy was associated with lower total GWG [27]. In contrast, one study of 160 pregnant women found those consuming one or more fruit drinks/day in the 2nd trimester was more likely to have excessive GWG [39].

Given the evidence that even a low consumption of SSBs (e.g., 1-4 times/month) confers negative health consequences (e.g., higher mortality) in the general adult population [40], it is difficult to explain why fruit drink intake at a frequency of 1-2 times/week in the 1st trimester was protective from excessive GWG. It could be that women who had a higher intake of fruit drinks in the 1st trimester received dietary counseling, thus improved their eating patterns in the later period of pregnancy, which ultimately might lower the odds of excessive GWG. Another explanation could be that during the 1st trimester, women may eat very differently due to the common challenge of nausea and vomiting early in pregnancy and alter their intake as those symptoms are resolved. Of note, this study did not exclude sugar-free fruit drinks and did not control for other diet and lifestyle factors (e.g., total caloric intake, physical activity) that could confound the relationship between consumption of fruit drinks and excessive GWG. Additionally, the results obtained with fruit drinks may reflect an inflated type 1 error due to multiple comparisons.

Eating at fast-food restaurants contributes to higher energy intake and weight gain in the general population [19,20]. In this study, it was observed that an increased frequency of eating at fast-food restaurants in the 3rd trimester—even as low as 1 time/month—increased the odds of having excessive GWG. The relationship between restaurant visits and excessive GWG has been minimally examined in pregnant women; however, greater access to fast-food restaurants has been found to increase the risk of excessive weight gain [41]. For the first time, the relationship between frequency of eating at full-service restaurant and excessive GWG was examined, although no significant associations were detected in any of the three trimesters. Given that studies in the general population with large sample sizes have reported that frequent eating out at full-service restaurants was associated with increased energy intake [42] and increased likelihood of being overweight or having obesity [43], more studies are needed to clarify whether visits to full-service restaurants influence GWG.

Extensive evidence has shown that non-pregnant adolescents or adults who consume three meals regularly are less likely to be overweight or obese [21,22]. In this study for women in the 2nd trimester, compared to frequent meal skipping, regular consumption of dinner (5-6 times/week) was a protective factor of excessive GWG (in the univariate model), which is consistent with the literature. However, consuming lunch 5-6 times/week appeared to be a risk factor in the 3rd trimester, which is counterintuitive. Very few studies have examined breakfast, lunch, and dinner consumption in relation to excessive GWG, and results are mixed. In one study with 272 pregnant women, the authors found that

regular breakfast consumption in the 1st trimester was associated with higher odds of excessive GWG [32]. Another study found that eating breakfast daily in the 3rd trimester was associated with a lower risk of inadequate GWG, but no association was found with excessive GWG [31].

Two reasons might explain why regular meal consumption in the 3rd trimester increased the odds of excessive GWG in the current study. First, the notion that skipping meals favors obesity is based on the hypothesis that skipping meals leads to higher subsequent snacking and higher energy intake [44]. However, in this study, the frequency of breakfast, lunch, or dinner was individually and positively correlated with the frequency of morning, afternoon, or evening snacking in the 3rd trimester (p_s<0.01, data not shown), which may account for the increased risk of excessive GWG. Second, given evidence that certain foods (e.g., high-sugar, high-fat) increase the risk of excessive GWG, there is a possibility that women who regularly consumed three meals a day also had a high intake of these high-risk foods.

Frequent snacking contributes to obesity in the non-pregnant populations [22]. In this study, it was found that increased snacking frequency (especially morning snacking) in the 1st and 3rd trimesters increased the risk of excessive GWG. Controversy exists regarding the relationship between snacking and GWG. For example, one study surveyed the food intake of 178 women in their 3rd trimester and reported a positive relationship between snack intake and greater GWG [30]. However, another study with 120 African American women did not find significant associations between snacking during the first two trimesters with GWG [33]. Therefore, our finding may clarify the mixed evidence by showing that frequent snacking, especially morning snacking, may be a risk factor of having excessive GWG.

Surprisingly, this study did not find any significant associations between eating behaviors, including compensatory restraint, routine restraint, emotional eating, and external eating, and excessive GWG, which differs from the existing literature. Albeit the research to date is limited, existing evidence consistently supports emotional eating and external eating [45,46] as risk factors for higher BMI and/or greater GWG, and also partially supports dietary restraint as a risk factor for higher BMI and/or greater GWG [13,14]. It is worth noting that most of the studies that reported a significant relationship used BMI or continuous GWG as the primary outcome [14,45,46]. However, in this study, GWG was categorized as excessive, adequate, and inadequate, and it was found that women with higher levels of external eating (1st trimester) and emotional eating (3rd trimester) were more likely to achieve adequate rather than inadequate GWG (see Table 5). Therefore, eating behaviors may be better for differentiating between inadequate and adequate GWG, but not between excessive and adequate GWG.

Following completion of this examination of the associations of eating behaviors and eating patterns with excessive GWG, uncertainty remains as to whether regular meal consumption is a protective or a risk factor for excessive GWG and whether eating behaviors contribute to excessive GWG. Yet, regression models highlight the importance of reducing the frequency of consuming soda and fruit drinks (trimesters 2 and 3), eating at fast-food restaurants (trimester 3), and snacking (trimesters 1 and 3) in pregnant women at different stages of pregnancy.

Current dietary interventions for pregnant women mainly focus on promotion of healthy eating via strategies such as daily calorie goals, food choices, and meal plans, and they only demonstrate a modest effect in preventing or reducing excessive GWG [47]. Furthermore, most existing dietary interventions have not used specific behavioral change techniques to reduce the frequency of consuming SSBs, eating at fast-food restaurants, or snacking, which are the three major factors that contributed to excessive GWG in this study. Techniques such as prompting barrier identification, providing contingent rewards, and self-regulation training [48] have been effective in reducing SSBs and fast food intake in non-pregnant adults, thus may have potential to complement dietary interventions in pregnant women. Strategies may be less straightforward for reducing the frequency of snacking, as approximately 80% of women in the 1st trimester experience nausea and vomiting all day and the frontline therapy is to eat frequent small meals and snacks [49]. In this context, recommending healthy snacks such as fruits and yogurt may help women to alleviate discomfort and, in the meanwhile, achieve the recommended weight gain [50]. In the 3rd trimester, as most women do not have nausea at this point, efforts could be made to encourage them to limit snacking.

Despite major strengths (e.g., large sample size, longitudinal study design), this secondary analysis has several limitations. First, only participants who completed both early and late pregnancy assessments were included. There were several statistically significant differences in sociodemographic, eating behaviors, and eating patterns between the included and excluded women that could have explain some of the observed results. Second, the data from the 1st and 2nd trimester came from different women, creating difficulty in interpreting study results. Third, several important lifestyle factors such as caloric intake, diet quality, and physical activity that can influence GWG were not controlled for in the analyses, which may bias the study findings. Fourth, GWG categorization was based on IOM recommendations for total pregnancy weight gain, as many women in this study delivered between 37 and 40 weeks, their GWG categorization could potentially be misclassified. Future studies may benefit from categorizing the adequacy of weight gain based on IOM recommended rate of weekly gain and the actual length of gestation, thus possibly increasing preciseness in examination of the risk factors of GWG.

CONCLUSION

In conclusion, increased frequency of consuming soda or fruit drinks (trimesters 2 and 3), eating at fast-food restaurants (trimester 3), and snacking (trimesters 1 and 3) conferred risk of excessive GWG, which may serve as future intervention targets. More studies are needed to clarify whether regular consumption of three meals a day is a protective or risk factor for excessive GWG and to examine whether eating behaviors contribute to excessive GWG.

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