RESEARCH
Original Research

Prenatal Depression and Diet Quality During Pregnancy

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ABSTRACT

Background Maternal nutrition during pregnancy has a significant effect on the health of the offspring and mother, highlighting the need for identifying factors that may affect diet during pregnancy. Research in nonpregnant and pregnant populations suggest depression may play a role.

Objective To investigate the relationship between prenatal depression and diet quality during pregnancy overall and by race/ethnicity and to explore the relationships between prenatal depression and the 12 Healthy Eating Index 2010 dietary components.

Design A cross-sectional secondary analysis of a cohort study of Kaiser Permanente Northern California women entering prenatal care between October 2011 and April 2013.

Participants/setting Participants included 1,160 adult pregnant women.

Main outcome measures Poor diet quality was defined as a Healthy Eating Index 2010 score in the lowest quartile.

Statistical analyses performed Logistic regression was used to assess the relationship between prenatal depression (defined as a depression diagnosis, Patient Health Questionnaire score of 10 or greater or antidepressant medication dispensing between the last menstrual period and completion of the food frequency questionnaire) and poor diet quality overall and by race/ethnicity. Relationships between prenatal depression and each of the 12 Healthy Eating Index 2010 dietary components were assessed using *t*-tests and linear regression analyses.

Results One hundred fifty-nine (14%) participants had prenatal depression. Women with prenatal depression had nearly two times the odds of poor diet quality (odds ratio 1.80, 95% CI 1.23 to 2.60) compared with women without prenatal depression, after adjusting for potential confounders. Differences emerged by race/ethnicity; after adjusting for potential confounders the adjusted odds of poor diet quality were significant only among Hispanic women. Hispanic women with prenatal depression had an increased odds of poor diet quality compared with Hispanic women without prenatal depression (odds ratio 2.66, 95% CI 1.15 to 6.06). Women with prenatal depression had a higher consumption of empty calories (from solid fats, alcohol, and added sugars; threshold for counting alcohol >13 g/1,000 kcal) (P=0.01) and lower consumption of greens and beans (P<0.05), total fruit (P<0.01), and whole fruit (P<0.01), compared with women without prenatal depression. Except for empty calories, these findings remained after adjusting for potential confounders.

Conclusions Study findings suggest that women with prenatal depression are at a higher risk of poor diet quality compared with women without prenatal depression, and the relationship is stronger among Hispanic women. Nutrition counseling interventions for women with depression should consider the use of culturally sensitive materials and target limiting empty calories from solid fats, alcohol, and added sugars and encourage eating more greens, beans, and fruit.
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MATERNAL NUTRITION DURING PREGNANCY HAS a significant influence on fetal growth and development, as well as the woman's health status during and after pregnancy. Both under- or overnutrition during pregnancy is associated with poor long-term health outcomes of the offspring in childhood and adulthood, including metabolic disease and obesity.[1-4] A poor quality diet during pregnancy may also compromise maternal health by promoting obesity,[5,6] excessive gestational weight gain,[7] and postpartum weight retention.[8]

The assessment of overall diet quality has garnered attention because it considers the complex synergistic effect of

food and nutrients rather than individual items. Index scores such as the Healthy Eating Index 2010 (HEI-2010)[9] are often used to assess overall diet quality. The HEI-2010 measures conformance to the 2010 Dietary Guidelines for Americans (2010 DGA)[10] jointly published by the US Department of Agriculture (USDA) and Department of Health and Human Services. Healthy eating patterns that are consistent with the 2010 DGA emphasize fruits, vegetables, whole grains, fat-free/low-fat milk and milk products, seafood, lean meats and poultry, eggs, beans and peas, and nuts and seeds while limiting intake of sodium, solid fats, added sugars, and refined grains.[10] Disparities in diet quality by race/ethnicity have been documented in the United States among both nonpregnant[11] and pregnant women[12]; specifically, suboptimal diet quality is more common among pregnant Hispanics and non-Hispanic blacks.

Little is known about factors that may influence diet quality during pregnancy, but the nascent literature in both nonpregnant and pregnant populations suggests depression may play a role. Prenatal depression influences up to 22% of pregnant women[13,14] with higher rates in racial/ethnic minorities. An inverse relationship between prenatal depression and diet quality in low-income pregnant women has been suggested, such that women with prenatal depression reported a low-quality diet during pregnancy.[15] However, the research in pregnant populations is limited. Similar findings have also emerged in studies of nonpregnant populations.[16,17]

The influence that maternal nutrition has on the long-term health of both the offspring and the mother highlights the need for a greater understanding of factors that may affect diet quality during pregnancy. If prenatal depression is related to poor diet quality, it will provide information for targeted interventions. Further, understanding differences in the individual HEI-2010 components may provide important information for dietary guidance. Thus, the purpose of this study was to investigate the differences in overall diet quality during pregnancy between women with and without prenatal depression and whether this relationship differs by race/ethnicity. In addition, this study aimed to examine relationships between prenatal depression and the 12 individual HEI-2010 components in a cohort of pregnant women.

RESEARCH SNAPSHOT

Research Question: Is prenatal depression associated with diet quality during pregnancy as measured with the Healthy Eating Index 2010 (HEI-2010) and does this relationship differ by race/ethnicity? Are there differences in the 12 HEI-2010 dietary components for women with prenatal depression compared with women without prenatal depression?

Key Findings: In this cross-sectional examination of 1,160 pregnant participants in the study of how Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery, findings suggest that women with prenatal depression (defined as either a depression diagnosis, positive screen on the Patient Health Questionnaire, or antidepressant medication dispensing) may have a higher risk of poor diet quality (defined as falling in the lowest quartile of the HEI-2010 scores) compared with women without prenatal depression, and that the relationship may be stronger in Hispanic women. Women with prenatal depression had a significantly lower mean HEI-2010 component score for empty calories compared with women without depression indicating a higher percent energy intake from solid fats and added sugars. In addition, women with prenatal depression had a significantly lower mean HEI-2010 component score for greens and beans, total fruit, and whole fruit indicating a lower dietary intake per the density-based approach used by the HEI-2010 compared with women without prenatal depression.

MATERIALS AND METHODS

Study Setting

The study setting was Kaiser Permanente Northern California (KPNC), a large group practice prepaid health plan that provides comprehensive medical services to members living in a 14-county region of Northern California (approximately 30% of the surrounding population). The demographic, racial/ethnic, and socioeconomic characteristics of the KPNC membership are representative of the population residing in the same geographic area except that the very poor and very wealthy are underrepresented.[18,19]

Study Design

The current analysis is a secondary data analysis using data from the study of how Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery (PEAPOD) study. PEAPOD is a pregnancy cohort study in which participants were recruited from a sample of 12,662 KPNC reproductive-aged women members who completed a health survey between 2007 and 2009 and consented to be included in future research. Participants from this cohort who were pregnant between October 2011 and April 2013, English-speaking, and aged 18 years or older were eligible to be recruited for the PEAPOD study. The PEAPOD study enrolled women throughout pregnancy to examine the associations between maternal lifestyle and gestational weight gain and preterm birth and childhood overweight/obesity. A total of 2,136 eligible participants were identified from KPNC's electronic health records (EHR) and mailed a questionnaire to ascertain information on demographic characteristics including race, ethnicity, and lifestyle behaviors during pregnancy, as well as a modified Block Food Frequency Questionnaire (FFQ). The questionnaire was conducted to obtain patient reported information on lifestyle and demographic factors not available in the EHR. Follow-up telephone calls were conducted in the case that the survey was not returned within 3 weeks. Return of the survey was considered consent. The PEAPOD study includes a total of 1,810 pregnancies (85% of the 2,136 originally identified as eligible) for which women completed the survey and FFQ. This study was approved by the KPNC Institutional Review Board.

Measures

Prenatal Depression. KPNC began implementing a universal perinatal depression screening program in 2010 in which women are screened two times during pregnancy (at the first prenatal visit and at their 24-week visit)[14] using the Patient Health Questionnaire (PHQ-9). The PHQ-9 has been validated

in many studies as an instrument for screening for depression with high sensitivity (>88%) and specificity (>88%) in obstetric patients,[20-24] as well as a tool to establish depression severity and outcome.[25] It includes nine questions with potential scores from zero to 27. A score of ≥10 suggests moderate to severe depression. For this analysis prenatal depression was defined as any of the following between the start of pregnancy and the FFQ completion date: a PHQ-9 score ≥10 (indicating moderate to more severe depression severity) (in the case that ≥1 PHQ-9 score was >10, the highest PHQ-9 score was used), a depression diagnosis (International Classification of Diseases, Ninth Revision codes[26]: 296.20 to 296.25, 296.30 to 296.35, 296.82, 298.0, 300.4, 309.0, 309.1, 309.28, 648.41 to 648.44, or 311), or an antidepressant medication dispensing (amitriptyline, bupropion, citalopram, desipramine, doxepin, duloxetine, escitalopram oxalate, fluoxetine, mirtazapine, nefazodone, nortriptyline, paroxetine, sertraline, trazodone, venlafaxine).

Diet Quality. Dietary intake during pregnancy was assessed using a modified Block 2005 FFQ tailored to accommodate the diverse dietary habits of the multiracial/ethnic study cohort and has been used in previous studies.[27,28] The Block 2005 FFQ is designed to collect information on usual dietary intake during the previous months. The food list for the Block 2005 FFQ was developed from National Health and Nutrition Examination Survey 1999-2000 dietary recall data[29]; the nutrient database was developed from the USDA Food and Nutrient Database for Dietary Studies version 1.0.[30] A series of adjustment questions provide greater accuracy in assessing fat and carbohydrate intake.[31] Individual portion size is asked for each food, and pictures are provided to enhance accuracy of quantification. Dietary supplement intake was not included in the FFQ. Participants reported their usual intake and portion sizes of food and beverages. The Block 2005 FFQ has demonstrated adequate reliability and validity in comparison to multiple dietary records,[32] serving as a useful instrument for estimating energy, food, and nutrient intakes among diverse populations, including pregnant women.[27,33]

The HEI-2010 score was calculated using the simple HEI scoring algorithm method to assess overall diet quality on the individual level. The HEI-2010 score is a valid and reliable measure and was chosen over other measures of diet quality, such as the alternate Mediterranean diet scores,[34] because it reflects adherence to the 2010 DGA.[9] Notably, the HEI-2010 and not the HEI-2015[35] was used because the 2010 DGA cover the study period 2011 to 2013, whereas the 2015-2020 DGA[36] were not released until 2016. The HEI-2010 consists of 12 components (ie, total fruit, whole fruit, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, and empty calories) with a maximum possible score of 100.[37] The HEI-2010 scores are inversely related to dietary intake for refined grains, sodium, and empty calories components and positively related to dietary intake of the other nine dietary components. Based on the distribution of the HEI-2010 scores, quartiles were calculated. For the primary outcome, participants who scored in the lowest quartile were classified as consuming a poor-quality diet and compared with participants in the second,

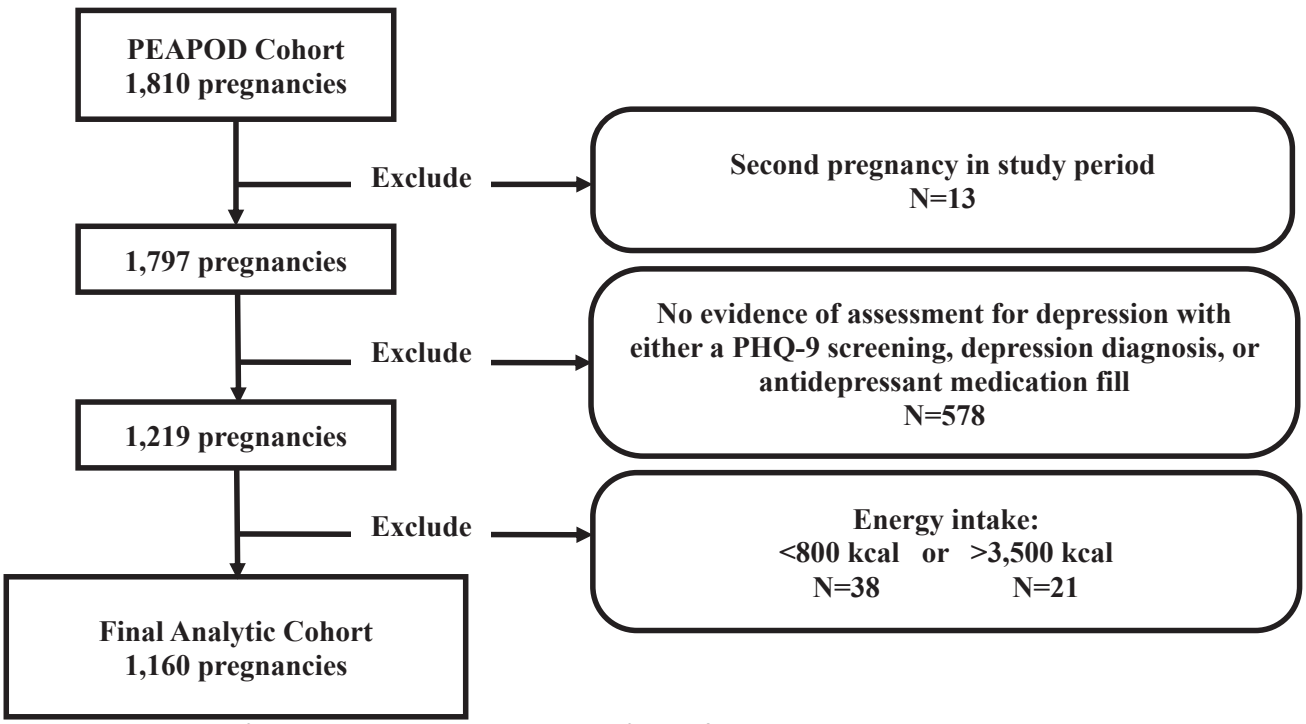

Figure. Flow diagram of the inclusion and exclusion criteria for the final analytic cohort to assess prenatal depression and diet quality during pregnancy among participants in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery (PEAPOD) Cohort Study. PHQ-9=Patient Health Questionnaire.

Table 1. Characteristics of pregnant women included in the analytic sample (n=1,160) compared with women participants of the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery Cohort study conducted in Kaiser Permanente Northern California between 2011 and 2013 who were excluded from the analytic sample (n=637) to assess the relationship between prenatal depression and diet quality

Characteristic	Excluded from Study Sample (n=637)	Current Sample (n=1,160)	*P* value[a]
	←n (%)→		
Maternal age at pregnancy start (y)			
<35	385 (60.4)	704 (60.7)	0.978
>35+	247 (38.8)	446 (38.4)	
Missing	5 (0.8)	10 (0.9)	
Marital status			
Single/divorced/separated	34 (5.3)	40 (3.4)	0.081
Married/living with partner	601 (94.3)	1119 (96.5)	
Missing	2 (0.3)	1 (0.1)	
Maternal education			
Less than college	40 (6.3)	61 (5.3)	0.349
College or beyond	595 (93.4)	1,098 (94.7)	
Missing	2 (0.3)	1 (0.1)	
Race/ethnicity			
Non-Hispanic white	329 (51.6)	631 (54.4)	0.684
Hispanic	119 (18.7)	213 (18.4)	
Asian/Pacific Islander	118 (18.5)	195 (16.8)	
Other/unknown[b]	71 (11.1)	121 (10.4)	
Parity			
≥1	375 (58.9)	732 (63.1)	0.086
0	262 (41.1)	428 (36.9)	
Prepregnancy body mass index[c]			
Underweight	19 (3.0)	32 (2.8)	0.099
Normal weight	356 (55.9)	626 (54.0)	

(continued on next column)

Table 1. Characteristics of pregnant women included in the analytic sample (n=1,160) compared with women participants of the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery Cohort study conducted in Kaiser Permanente Northern California between 2011 and 2013 who were excluded from the analytic sample (n=637) to assess the relationship between prenatal depression and diet quality (*continued*)

Characteristic	Excluded from Study Sample (n=637)	Current Sample (n=1,160)	*P* value[a]
	←n (%)→		
Overweight	137 (21.5)	270 (23.3)	
Obese	115 (18.1)	227 (19.6)	
Missing	10 (1.6)	5 (0.4)	
Alcohol use during pregnancy			
Yes	148 (23.2)	240 (20.7)	0.232
No	489 (76.8)	920 (79.3)	
Smoking during pregnancy			
Yes	13 (2.0)	21 (1.8)	0.871
No	624 (98.0)	1139 (98.2)	
Prenatal vitamin use			
Yes	612 (96.1)	1129 (97.3)	0.041
No	25 (3.9)	31 (2.7)	
Diet quality[d]			
Poor quality diet	168 (26.4)	291 (25.1)	0.588
Good quality diet	469 (73.6)	869 (74.9)	

[a]χ^2 test *P* value.
[b]Other/unknown category represents non-Hispanic black, Native American/Alaskan Native, multiple races, other, unknown, or not reported.
[c]Body mass index calculated as kg/m^2. Body mass index categories were defined as underweight <18.5, normal weight 18.5 to <25, overweight 25 to <30, and obese ≥30.
[d]Diet was assessed using the Healthy Eating Index 2010 score calculated from self-report dietary intake using a modified Block food frequency questionnaire. Poor quality diet was defined by scores that ranged in the lowest quartile (≤68.3). Good quality diet was defined by scores that ranged in the top three quartiles.

Table 2. Demographic characteristics of 1,160 pregnant women overall and by depression status in a study to assess the relationship between prenatal depression and diet quality among participants in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery Cohort Study, conducted in Kaiser Permanente Northern California between 2011 and 2013

Characteristic	Overall (N=1,160)	Depression (n=159 [13.7%])	No Depression (n=1,001 [86.3%])	*P* value[a]
	←n (%)→			
Maternal age at pregnancy start (y)				
<35	704 (60.7)	89 (56.0)	615 (61.4)	0.374
>35	446 (38.4)	69 (43.4)	377 (37.7)	
Missing	10 (0.9)	1 (0.6)	9 (0.9)	
Marital status				
Single/divorced/separated	40 (3.4)	10 (6.3)	30 (3.0)	0.099
Married/living with partner	1119 (96.5)	149 (93.7)	970 (96.9)	
Missing	1 (0.1)	0 (0.0)	1 (0.1)	
Maternal education				
Less than college	61 (5.3)	15 (9.4)	46 (4.6)	0.037
College or beyond	1,098 (94.7)	144 (90.6)	954 (95.3)	
Missing	1 (0.1)	0 (0.0)	1 (0.1)	
Race/ethnicity				
Non-Hispanic white	631 (54.4)	89 (56.0)	542 (54.1)	0.030
Hispanic	213 (18.4)	30 (18.9)	183 (18.3)	
Asian/Pacific Islander	195 (16.8)	16 (10.1)	179 (17.9)	
Other/unknown[b]	121 (10.4)	24 (15.1)	97 (9.7)	
Parity				
1+	732 (63.1)	85 (53.5)	647 (64.6)	0.009
0	428 (36.9)	74 (46.5)	354 (35.4)	
Prepregnancy body mass index[c]				
Underweight	32 (2.8)	3 (1.9)	29 (2.9)	0.301
Normal weight	626 (54.0)	79 (49.7)	547 (54.6)	
Overweight	270 (23.3)	37 (23.3)	233 (23.3)	
Obese	227 (19.6)	40 (25.2)	187 (18.7)	
Missing	5 (0.4)	0 (0.0)	5 (0.5)	
Alcohol use during pregnancy				
Yes	240 (20.7)	43 (27.0)	197 (19.7)	0.043
No	920 (79.3)	116 (73.0)	804 (80.3)	
Smoking during pregnancy				
Yes	21 (1.8)	7 (4.4)	14 (1.4)	0.02
No	1139 (98.2)	152 (95.6)	987 (98.6)	
Prenatal vitamin use				
Yes	1,129 (97.3)	154 (96.9)	975 (97.4)	0.894
No	31 (2.7)	5 (3.1)	26 (2.6)	

(*continued on next page*)

Table 2. Demographic characteristics of 1,160 pregnant women overall and by depression status in a study to assess the relationship between prenatal depression and diet quality among participants in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery Cohort Study, conducted in Kaiser Permanente Northern California between 2011 and 2013 (*continued*)

Characteristic	Overall (N=1,160)	Depression (n=159 [13.7%])	No Depression (n=1,001 [86.3%])	*P* value[a]
	←——	*n (%)*	——→	
Diet quality[d]				
Poor quality diet	291 (25.1)	58 (36.5)	233 (23.3)	0.001
Good quality diet	869 (74.9)	101 (63.5)	768 (76.7)	

[a]χ^2 test *P* value.
[b]Other/unknown category represents non-Hispanic black, Native American/Alaskan Native, multiple races, other, unknown, or not reported.
[c]Body mass index calculated as kg/m^2. Body mass index categories were defined as underweight <18.5, normal weight 18.5 to <25, overweight 25 to <30, and obese ≥30.
[d]Diet was assessed using the Healthy Eating Index 2010 score calculated from self-report dietary intake using a modified Block Food Frequency Questionnaire. Poor quality diet was defined by scores that ranged in the lowest quartile (≤68.3). Good quality diet was defined by scores that ranged in the top-three quartiles.

third, and fourth quartiles combined. The secondary outcome was the mean scores for each of the individual 12 components of the HEI-2010.

Race/Ethnicity. Self-reported race/ethnicity was categorized as non-Hispanic white, Asian/Pacific Islander, Hispanic, or other/unknown. There were very few non-Hispanic black participants; thus, they were combined with American Indian/Alaskan Native, multiple races, other, or unknown race/ethnicity participants in the other/unknown category.

Confounders

Potential confounders were ascertained from both the self-report questionnaire and EHR data. Self-report variables were maternal age at the start of pregnancy in years, marital status (married/partner vs single/divorced/widowed), maternal education (less than college vs college or greater), parity (0 vs ≥1), any alcohol use during pregnancy (yes/no), any smoking during pregnancy (yes/no), and prenatal vitamin use during pregnancy (yes/no). Prepregnancy body mass index was calculated using data from the questionnaire and supplemented with EHR data when missing. Body mass index was calculated as kg/m^2, and was categorized as underweight (<18.5), normal weight (18.5 to <25), overweight (25 to <30), and obese (≥30).[38]

Data Analysis

Differences in the percentage of women with prenatal depression (yes/no) across quartiles of the HEI-2010 total score were assessed with a χ^2 test. Bivariate analyses were conducted to compare characteristics between women with and without prenatal depression; χ^2 analyses were conducted for categorical data and *t* tests for continuous data. Unconditional logistic regression analysis was used to obtain odds ratios (ORs) and 95% CIs estimating the odds of poor diet quality (vs good diet quality) given prenatal depression status. Covariates included in the models were chosen based on the literature and included maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking status during pregnancy, prenatal vitamin use during pregnancy, and race/ethnicity.[39-42] A likelihood ratio test was conducted to assess the interaction between prenatal depression and race/ethnicity on diet quality by comparing the full model with all covariates and an interaction term for race/ethnicity and prenatal depression to the nested model that excluded the interaction term. Tests for interaction generally have less power to assess statistical significance and thus a *P* value <0.10 was accepted for the cutoff suggesting statistical significance.[43] The adjusted ORs and 95% CIs from the full model were calculated and reported for non-Hispanic whites, Hispanic and Asian/Pacific Islander women. A sensitivity analysis was conducted restricting the overall sample to participants who had a PHQ-9 screen and followed the same analytic methods described for the main analysis. Differences in the means of the 12 individual HEI-2010 between women with and without prenatal depression were assessed using *t* tests. Linear regression models were conducted to estimate the relationship between prenatal depression and each component of the HEI-2010 after adjusting for covariates. To compare women in the final analytic sample to women who were excluded, χ^2 tests were employed. A *P* value <0.05 was considered statistically significant. Data were extracted from the EHR and merged with survey data using SAS version 9.4[44] and analyzed using R version 3.4.4.[45]

RESULTS

Among the 1,810 pregnancies in the PEAPOD study, the second pregnancy of any woman in the study period was excluded to avoid nonindependent observations (n=13). In addition, to ascertain depression status during pregnancy and before completing the FFQ, women who did not have at least one of the following were excluded: a PHQ-9 screen administered through the perinatal depression screening program, a clinical depression diagnosis, or an antidepressant medication fill after the start of pregnancy and before completing the FFQ (n=578). Finally, women whose response on the FFQ resulted in a food energy intake that was not considered plausible, defined as <800 kcal (n=38) or >3,500 kcal (n=21) were excluded. The final sample

Table 3. Demographic characteristics of 1,160 pregnant women by diet quality in a study to assess the relationship between prenatal depression and diet quality among participants in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery Cohort Study conducted in Kaiser Permanente Northern California between 2011 and 2013

Characteristic	Poor Diet Quality[a] (n=291)	Good Diet Quality[a] (n=869)	*P* value[b]
	←n(%)→		
Maternal age at pregnancy start (y)			
<35	194 (66.7)	510 (58.7)	0.044
>35	94 (32.3)	352 (40.5)	
Missing	3 (1.0)	7 (0.8)	
Marital status			
Single/divorced/separated	14 (4.8)	26 (3.0)	0.288
Married/living with partner	277 (95.2)	842 (96.9)	
Missing	0 (0.0)	1 (0.1)	
Maternal education			
Less than college	25 (8.6)	36 (4.1)	0.003
College or beyond	265 (91.1)	833 (95.9)	
Missing	1 (0.3)	0 (0.0)	
Race/ethnicity			
Non-Hispanic white	156 (53.6)	475 (54.7)	0.900
Hispanic	53 (18.2)	160 (18.4)	
Asian/Pacific Islander	53 (18.2)	142 (16.3)	
Other/unknown[c]	29 (10.0)	92 (10.6)	
Parity			
1+	182 (62.5)	550 (63.3)	0.874
0	109 (37.5)	319 (36.7)	
Prepregnancy body mass index[d]			
Underweight	7 (2.4)	25 (2.9)	0.006
Normal weight	138 (47.4)	488 (56.2)	
Overweight	69 (23.7)	201 (23.1)	
Obese	77 (26.5)	150 (17.3)	
Missing	0 (0.0)	5 (0.6)	
Alcohol use during pregnancy			
Yes	59 (20.3)	181 (20.8)	0.906
No	232 (79.7)	688 (79.2)	
Smoking during pregnancy			
Yes	11 (3.8)	10 (1.2)	0.008
No	280 (96.2)	859 (98.8)	
Prenatal vitamin use			
Yes	277 (95.2)	852 (98.0)	0.016
No	14 (4.8)	17 (2.0)	

[a]Diet quality was assessed using the Healthy Eating Index 2010 score calculated fro self-report dietary intake using a modified Block food frequency questionnaire. Poor diet quality was defined by scores that ranged in the lowest quartile (≤68.3). Good quality was defined by scores that ranged in the top three quartiles.
[b]χ^2 test *P* value.
[c]Other/unknown category represents non-Hispanic black, Native American/Alaskan Native, multiple races, other, unknown, or not reported.
[d]Body mass index calculated as kg/m^2. Body mass index categories were defined as underweight <18.5, normal weight 18.5 to <25, overweight 25 to <30, and obese ≥30.

Table 4. Crude odds ratio (cOR) and adjusted odds ratio (aOR) for the relationship between prenatal depression and poor diet quality, overall and by race/ethnicity, in a sample of 1,160 pregnant women participants of the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery study conducted in Kaiser Permanente Northern California between 2011 and 2013

	Poor Diet Quality[a]					
Sample	n	%	cOR	95% CI	aOR	95% CI
Full sample (N=1,160)[b]						
Depression (n=159)	58	36.5	1.89	1.32-2.69	1.80	1.23-2.60
No depression (n=1,001)	233	23.3	1		1	
Non-Hispanic white (n=631)[c]						
Depression (n=89)	28	31.5	1.48	0.90-2.40	1.29	0.76-2.15
No depression (n=542)	128	23.6	1		1	
Hispanic (n=213)[c]						
Depression (n=30)	13	43.3	2.73	1.21-6.09	2.66	1.15-6.06
No depression (n=183)	40	21.9	1		1	
Asian/Pacific Islander (n=195)[c]						
Depression (n=17)	7	41.2	2.25	0.76-6.38	2.32	0.77-6.70
No depression (n=179)	46	25.7			1	

[a]Diet was assessed using the Healthy Eating Index score calculated from self-report dietary intake using a modified Block food frequency questionnaire. Poor quality diet was defined by scores that ranged in the lowest quartile. Good quality diet was defined by scores that ranged in the top three quartiles.

[b]A total of 1,143 women were included in the adjusted analysis due to missing data. The analyses were adjusted for maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking status during pregnancy, prenatal vitamin use during pregnancy, and race/ethnicity.

[c]Due to some missing covariate data, the total sample size for the adjusted analyses for each of the race/ethnicity categories were as follows: n=623 for Non-Hispanic white, n=210 for Hispanic, and n=191 for Asian. The analyses were adjusted for maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking status during pregnancy, prenatal vitamin use during pregnancy, and an interaction term for race/ethnicity and prenatal depression status.

included 1,160 women (see the Figure). The median gestational age at FFQ completion was 25 weeks and more than 75% of the women completed the FFQ at 16 weeks gestation or later. Women excluded from the sample were more likely to have not taken prenatal vitamins during pregnancy compared with women in the sample (3.9% vs 2.7%; $P<0.05$). There were no other significant differences between women in the study and women excluded from the study sample (Table 1).

Characteristics of the Study Population

Descriptive characteristics of women with and without prenatal depression are presented in Table 2. Overall, 159 study participants (14%) had prenatal depression. Women with prenatal depression were less likely to have a college education, less likely to already have a child(ren), and more likely to report alcohol use or smoking during pregnancy compared with women without prenatal depression (all P values <0.05).

HEI-2010 Total Scores

The overall mean score for the HEI-2010 was 74.6±10.0; the minimum score was 37.1 and the maximum score was 95.8. The cutoff for the first quartile (poor diet quality) was 68.3. Several characteristics were significantly associated with poor diet quality (Table 3). Women with poor diet quality were more likely to be younger (age <35 years), have less than a college education, and to be obese compared with women with good diet quality.

Prenatal Depression and Diet Quality

Overall, women with prenatal depression had nearly twice the odds of poor diet quality (crude OR 1.89, 95% CI 1.32 to 2.69) (Table 4) compared with women without prenatal depression. This relationship held after adjusting for potential confounders (adjusted OR 1.80, 95% CI 1.23 to 2.60).

For Hispanic women, prenatal depression was significantly associated with an increase in the odds of poor diet quality. After adjusting for potential confounding, Hispanic women with prenatal depression had over two and a half times the odds of poor diet quality compared with those without prenatal depression (adjusted OR 2.66, 95% CI 1.15 to 6.06). The P value for the likelihood ratio test of the interaction was 0.11.

Prenatal Depression and HEI-2010 Component Scores

The mean scores for each component are listed in Table 5 for the total sample. Women with prenatal depression had a significantly lower mean HEI-2010 component score for empty calories compared with women without depression indicating a higher consumption of foods with solid fats, alcohol, and added sugars (14.38±3.95 vs 15.27±3.71; $P<0.05$). In addition, women with prenatal depression had a significantly lower mean HEI-2010 component score for greens and beans (3.49±1.60 vs 3.79±1.48; $P<0.05$), total

Table 5. Mean score and standard error (SE) for each of the 12 Healthy Eating Index 2010 (HEI-2010) components, overall and by depression status, and β coefficient for the multivariable linear regression model assessing the association between prenatal depression and each of the 12 HEI-2010 components in a sample of 1,160 pregnant women in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery study conducted in Kaiser Permanente Northern California between 2011 and 2013

	Overall (N=1,160)		Depression (n=159)		No Depression (n=1,001)			Multivariable Model[b] (n=1,160)	
HEI-2010 component	Mean	SE	Mean	SE	Mean	SE	*P* value[a]	β	*P* value
Total vegetables[c]	3.62	1.19	3.56	1.18	3.63	1.19	0.47	−.06	0.55
Greens and beans[c]	3.74	1.50	3.49	1.60	3.79	1.48	0.03	−.28	0.03
Total fruit[c]	4.39	1.04	4.16	1.19	4.43	1.01	<0.01	−.24	<0.01
Whole fruit[c]	4.66	0.81	4.45	1.05	4.70	0.76	<0.01	−.24	<0.01
Whole grains[d]	7.23	2.75	6.92	2.77	7.28	2.74	0.13	−.40	0.09
Dairy[d]	7.30	2.51	7.30	2.51	7.30	2.52	0.99	−.11	0.62
Total protein foods[c]	4.62	0.67	4.56	0.75	4.63	0.66	0.27	−.08	0.20
Seafood and plant proteins[c]	4.54	0.93	4.45	1.05	4.55	0.91	0.27	−.08	0.32
Fatty acids[d]	6.34	2.77	6.15	2.82	6.38	2.77	0.35	−.05	0.81
Sodium[d]	4.01	2.49	4.34	2.59	3.96	2.47	0.09	.19	0.35
Refined grains[d]	9.01	1.78	8.82	2.07	9.04	1.73	0.20	−.29	0.06
Empty calories[e]	15.15	3.75	14.38	3.95	15.27	3.71	0.01	−.59	0.06

[a]*t* test *P* value.
[b]A total of 1,143 women were included in the adjusted analysis due to missing data. The analysis adjusted for maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking status during pregnancy, prenatal vitamin use during pregnancy, and race/ethnicity.
[c]Component score ranges from 0 to 5.
[d]Component score ranges from 0 to 10.
[e]Calories from solid fats, alcohol, and added sugar; threshold for counting alcohol is >13 g/1,000 kcal. Component score ranges from 0 to 20.

Table 6. Sensitivity analysis: Crude odds ratio (cOR) and adjusted odds ratio (aOR) for the relationship between prenatal depression and poor diet quality, overall and by race/ethnicity, in a subsample of 1,140 pregnant women with a Patient Health Questionnaire-9 screening score and who participated in the Prepregnancy and Pregnancy Lifestyle Influences the Outcome of Delivery study conducted in Kaiser Permanente Northern California between 2011 and 2013

Sample	cOR	95% CI	aOR	95% CI
Full sample (N=1,140)[a]				
Depression (n=139)	1.91	1.31-2.77	1.76	1.19-2.59
No depression (n=1,001)	1		1	
Non-Hispanic white (n=616)[b]				
Depression (n=74)	1.55	0.90-2.60	1.36	0.77-2.34
No depression (n=542)	1		1	
Hispanic (n=210)[b]				
Depression (n=27)	2.86	1.22-6.60	2.66	1.12-6.30
No depression (n=183)	1		1	
Asian/Pacific Islander (n=195)[b]				
Depression (n=16)	2.25	0.76-6.38	2.35	0.78-6.80
No depression (n=179)	1		1	

[a]Adjusted for maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking status during pregnancy, prenatal vitamin use during pregnancy, and race/ethnicity.
[b]Adjusted for maternal age, marital status, maternal education, parity, prepregnancy body mass index, alcohol use during pregnancy, smoking during pregnancy, prenatal vitamin use during pregnancy, and interaction term for race/ethnicity and prenatal depression status.

fruit (4.16±1.19 vs 4.43±1.01; $P<0.05$), and whole fruit (4.45±1.05 vs 4.70±0.76; $P<0.01$), indicating a lower dietary intake compared with women without prenatal depression. After adjusting for potential confounders the relationship between prenatal depression and solid fats, alcohol, and added sugars approached statistical significance ($P=0.06$), whereas significant relationships remained with prenatal depression and greens and beans, total fruit, and whole fruit. No other significant relationships emerged between prenatal depression and any of the other eight HEI-2010 component scores even after adjusting for potential confounders.

Sensitivity Analysis

Similar results emerged in the sensitivity analysis assessing the relationship between prenatal depression and diet quality restricting the sample to women with a PHQ-9 score. A total of 1,140 women received a PHQ-9 screening during routine prenatal care. Women with prenatal depression had greater odds of poor diet quality (crude OR 1.91, 95% CI 1.31 to 2.77) compared with women without prenatal depression. Although slightly attenuated, this relationship remained significant after adjusting for potential confounders (adjusted OR 1.76, 95% CI 1.19 to 2.59). Similar patterns emerged in the sensitivity analysis assessing the interaction between race/ethnicity and prenatal depression on diet quality when compared to the main analysis. Hispanic women with a positive PHQ-9 score (≥10) had a significant increased odds of poor diet quality compared with women without prenatal depression (adjusted OR 2.66, 95% CI 1.12 to 6.30) (Table 6).

DISCUSSION

Findings from this study suggest women with prenatal depression or high prenatal depressive symptoms may have a higher risk of poor diet quality compared with women without prenatal depression, and that the relationship may be stronger in Hispanic women. The findings remained significant after restricting the sample to women with a PHQ-9 screening score, suggesting that depressive symptoms at or above a threshold of moderate depression may be as important as a clinical depression diagnosis in the relationship with diet quality. Although an inverse association between depression and diet quality has been found previously in pregnant women, the limited research to date has been conducted in small samples (fewer than 120) of low-income women.[15,42] This study adds to the literature findings from a large, racially/ethnically diverse sample of pregnant women.

Findings from this study are consistent with the majority of the limited studies in nonpregnant populations evaluating the relationship between depression and diet quality. In a study of breast cancer survivors, depressive symptoms and HEI scores were inversely related.[46] Similarly, Appelhans and colleagues[47] observed an association between higher depressive severity and lower diet quality in a sample of obese participants with major depressive disorder. An inverse association between depressive symptoms and diet quality was also noted in a representative sample of US adults.[48] In a sample of overweight and obese rural-dwelling adults, depressive symptoms predicted poor overall diet quality among the overweight participants; however, findings did not replicate in the obese participants.[49] Three other studies documented mixed findings as well. For example, Rahe and colleagues[40] did not find a significant relationship between depression as a homogenous entity, but did find a relationship between distinct subtypes of depression such that participants with atypical depression (depression with improved mood in response to positive events) reported the lowest diet quality scores. Two additional studies, one in a sample of obese and overweight women from disadvantaged neighborhoods[50] and another in sample of middle-aged adults,[51] did not find a relationship between depressive symptoms and overall dietary quality. However, similar to the current study findings, the study of obese and overweight women from disadvantaged neighborhoods documented a significant relationship between depressive symptoms and greater saturated fats and total sugar intake.[50]

The underlying mechanisms that link depression and eating behavior may include psychological as well as sensory and physiological pathways. For example, several studies have demonstrated an association between the presences of depressive symptoms and emotional eating.[50,52,53] Emotional eating is the propensity to choose to eat energy-dense sweet and high-fat foods in response to negative effects and stress.[52] Findings from the current study suggest that women with prenatal depression had a significantly lower HEI-2010 empty calories component score compared with women without prenatal depression. The HEI-2010 empty calorie component score is inversely related to dietary intake of empty calories; thus, in this study women with prenatal depression consumed a diet higher in solid fats, alcohol, and added sugars (threshold for counting alcohol >13 g/1,000 kcal) compared with women without prenatal depression. These findings suggest that women with prenatal depression may benefit from nutrition counseling targeted at limiting dietary intake from empty calories from solid fats, alcohol, and added sugars. This study also found that women with prenatal depression consumed less overall greens and beans, total fruit, and whole fruit compared with women without prenatal depression suggesting that nutrition counseling for women with prenatal depression may also target increasing consumption of fruit, greens, and beans. Given that poor maternal diet quality during pregnancy has been linked to poor outcomes of both the offspring into adulthood[1-3] and to the woman's health,[5-8,54-57] further research is needed to understand the extent to which depression may contribute to these outcomes by influencing diet quality. This study is the first to our knowledge to assess the relationship between prenatal depression and individual HEI components.

Strengths and Limitations

Dietary intake was assessed using a validated instrument that allowed us to construct a reliable and internally valid index of diet quality (as assessed with the HEI-2010) that represents a comprehensive assessment of a woman's diet during pregnancy. Further, the HEI-2010 was designed to reflect the 2010 DGA[9] and the use of this a priori diet score would allow comparability across studies in the United States, in contrast to the use of other data-driven study specific dietary scores. In addition, prenatal depression was defined using a combination of clinical diagnoses, antidepressant medications, and PHQ-9 scores all ascertained from EHR data. The sensitivity

analyses restricting the sample to women uniformly screened for depression with the PHQ-9 during the study period demonstrates that symptom severity may be as important as a clinical diagnosis of prenatal depression in the relationship with diet quality. Finally, the authors acknowledge that the study was limited to English-speaking women and thus the associations observed among the Hispanic women may not be representative of non-English speaking Hispanic women.

This study offers some unique insights into the relationship between depression, including depressive symptoms and diet quality in pregnant women; however, the findings and implications of this study should be interpreted with consideration of the limitations. Maternal dietary intake was self-reported using the FFQ, with potential recall bias and subsequent exposure misclassification.[58] There is no evidence that women with prenatal depression may recall their dietary intake differentially from women without prenatal depression. The mean HEI-2010 total score in the current study sample (ie, 74.6) was a little higher in comparison to some previous studies of pregnant women that have ranged from 54.2 to 64,[12,59] yet similar to others (mean HEI-2010 score of 67[60]), including a study conducted in pregnant women in Northern California (mean HEI-2010 score=71.3[28]). Causality cannot be inferred given the cross-sectional study design. Despite defining prenatal depression before the completion of the FFQ, the FFQ asks for dietary intake during the previous 3 months and thus there may be overlap of the timing of prenatal depression and dietary intake. Thus, the ability to determine the direction of the relationship is limited. It is plausible that the relationship between depression and diet is bidirectional. Observational studies have found that adherence to higher quality diets is associated with reduced future onset of depressive symptoms.[61] In addition, recent clinical trials[62,63] suggest dietary interventions may have a modest influence on reducing depressive symptoms. It is possible that depressive symptoms may be related to dietary misreporting, although research assessing this is insufficient.[64] The use of a validated and reliable instrument to assess dietary intake may diminish this possibility; however, previous validation studies in women did not report information on inclusion or exclusion of pregnant women with depression.[32,33] The study sample excluded more than a quarter of the participants recruited into the PEAPOD study because they did not have any evidence of being assessed for depression. There were very few significant differences between the final study sample and those who were excluded. Finally, the relationship between prenatal depression and diet quality among non-Hispanic black women was not able to be assessed given the sample size.

CONCLUSIONS

Findings from this study suggest that women with prenatal depression and or prenatal depressive symptoms are at a higher risk of poor diet quality compared with women without prenatal depression, and the relationship is stronger among Hispanic women. Nutrition counseling interventions for women with depression may consider the use of culturally sensitive material; target limiting empty calories from solid fats, alcohol, and added sugars; and encourage eating more greens, beans, and fruit. Additional prospective studies are needed to clarify the direction of the relationship.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

M. M. Hedderson collected the data, L. A. Avalos conceptualized the manuscript with input from B. Caan, M. M. Hedderson, Y. Zhu, D.-K. Li, and N. Nance, and R. J. Hyde conducted the analysis with oversight from L. A. Avalos and C. Quesenberry. L. A. Avalos drafted the manuscript. All authors reviewed and commented on subsequent drafts of the manuscript.