Lead Article

Associations of maternal stress and/or depressive symptoms with diet quality during pregnancy: a narrative review

Alycia K. Boutté, Gabrielle M. Turner-McGrievy, Sara Wilcox, Jihong Liu, Jan M. Eberth, and Andrew T. Kaczynski

Background: *Pregnancy can be a stressful time for many women; however, it is unclear if higher stress and depressive symptoms are associated with poorer diet quality during pregnancy.* ***Objective:*** *The aims for this narrative review were to (1) synthesize findings of original, peer-reviewed studies that examined associations of stress and/or depressive symptoms with diet quality during pregnancy; (2) review the measurement tools used to assess stress, depressive symptoms, and diet quality; (3) identify current gaps in the extant literature; and (4) offer recommendations for future research.* ***Methods:*** *A search strategy was used to identify peer-reviewed manuscripts published between January 1997 and October 2018, using the following databases: PubMed, CINAHL Complete, PsycINFO, Academic Search Complete, and Psychology & Behavioral Sciences Collection. The search was updated December 2019. Two reviewers independently assessed title, abstract, and full-text of the studies that met the inclusion criteria. Data were extracted and a quality assessment was conducted.* ***Results:*** *Twenty-seven observational studies were identified in this review (21 cross-sectional and 6 longitudinal). In 22 studies, higher stress and/or depressive symptoms were associated with poorer diet quality or unhealthy dietary patterns; 5 studies found no association. Findings are mixed and inconclusive regarding the relationship among stress, depressive symptoms, and food groups related to diet quality and frequency of fast-food consumption.* ***Conclusions:*** *The current data suggest stress and depressive symptoms may be a barrier to proper diet quality during pregnancy; however, variability in the assessment tools, timing of assessments, and use of covariates likely contribute to the inconsistency in study findings. Gaps in the literature include limited use of longitudinal study designs, limited use of comprehensive diet-quality indices, underrepresentation of minority women, and lack of multilevel theoretical frameworks. Studies should address these factors to better assess associations of stress and/or depressive symptoms with diet quality during pregnancy.*

Affiliation: *A. K. Boutté* is with the Department of Health Promotion, Education, and Behavior, Graduate Trainee, Prevention Research Center, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA. *G. M. Turner-McGrievy* is with the Department of Health Promotion, Education, and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA. *S. Wilcox* is with the Department of Exercise Science, Director, Prevention Research Center, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA. *J. Liu* is with the Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA. *J. M. Eberth* is with the Department of Epidemiology and Biostatistics, Deputy Director, SC Rural Health Research Center, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA. *A. T. Kaczynski* is with the Department of Health Promotion, Education, and Behavior, Co-Investigator, Prevention Research Center, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, USA.

Correspondence: *A. K. Boutté*, Department of Health Promotion, Education, and Behavior, Graduate Trainee, Prevention Research Center, Arnold School of Public Health, University of South Carolina, 915 Greene Street, Discovery 1 Room 529, Columbia, SC 29208, USA. Email: Alycia.boutte@gmail.com.

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INTRODUCTION

Almost one-half (46%) of pregnant women in the United States (US) exceed the Institute of Medicine's 2009 gestational weight gain (GWG) recommendations,[1,2] and this has become a significant public health challenge. Excessive GWG is associated with adverse maternal outcomes (eg, increased risk of preeclampsia and cesarean delivery)[3] and poor infant health. Maternal diet quality, or overall eating pattern during pregnancy influences infant development and can help prevent excessive GWG, making it an important modifiable factor to address during pregnancy.[4,5]

Depression is the primary cause of disease-related disability among women worldwide, with the prevalence of depression reaching its peak during the childbearing years.[6] Depression during pregnancy has been associated with excessive GWG[7] and suicidal ideation,[8] among other adverse health outcomes, highlighting the importance of screening for depressive symptoms during pregnancy to intervene.[9] Stress, defined as generalized perceived stress,[10] is inextricably linked with depression by increasing one's risk for depression,[11] and depression, in turn, also increases one's susceptibility to stressful events,[12] creating a feedback loop for chronic stress.[12] Measuring perceived stress is beneficial because it captures one's experience of stress independent of the source of stress, compared to stressful life events scales.[10]

Stress has been associated with consuming energy-dense, nutrient-poor foods (eg, less fruit and vegetable intake[13]; more fast-food intake[14]; more intake of sweets and snacks) among pregnant women.[15] Stress is thought to disrupt the hypothalamic-pituitary-adrenal axis system, which elevates cortisol levels, encouraging increased consumption of energy-dense foods,[16,17] which may negatively affect diet quality. Depressive symptoms are important to investigate in the context of dietary intake because depressive symptoms may exacerbate the negative effect of maternal stress on diet quality.[18]

Proper diet quality involves consuming foods from a variety of different food groups, such as those that compose diet-quality indices (eg, fruits, vegetables, grains).[19] Dairy is the primary source of dietary calcium in the US,[20] making it an important component of overall diet quality.[19] Emerging research is now examining the relationship between the consumption of fermented foods (eg, yogurt, cheese, fermented milk) and mental health during pregnancy,[21] with conflicting results to date. In addition, soy product consumption has been gaining attention because of the multiple health benefits of isoflavones (eg, prevention of hormone-dependent cancers and cardiovascular diseases)[22]; however, the mental health benefits of soy consumption in pregnancy have not received much attention.[23] Furthermore, epidemiologic data indicate consuming more fish is associated with a lower occurrence of depressive symptoms among the general population[24–26]; however, these associations have not been thoroughly examined during pregnancy. Fast-food consumption is also important to examine because it is associated with excess energy intake and eating behaviors related to poor diet quality (eg, higher sodium and added-sugar intake).[27]

Previous reviews that have explored the relationship between stress and/or depressive symptoms and diet quality during pregnancy have been limited in 3 main ways: (1) having a predominant focus on the impact of nutrient deficiencies (eg, zinc, iron, omega-3 fatty acids)[28,29]; (2) compiling studies that examined outcomes during the entire perinatal period (including pregnancy and up to 1-year postpartum)[29–31]; and (3) focusing on how diet quality affects child health and dietary outcomes (eg, height; blood pressure; fruit and vegetable intake).[32–35] These previous approaches leave important gaps in the literature as it pertains to maternal physical and mental health during pregnancy. Limited research has examined associations of maternal mental health factors (ie, stress, depressive symptoms) with overall diet quality in pregnancy exclusively.[15]

The aims for conducting this narrative literature review were to: (1) synthesize findings of original, peer-reviewed studies that examined associations of stress and/or depressive symptoms with diet quality during pregnancy; (2) review the measurement tools used to assess stress, depressive symptoms, and diet quality; (3) identify gaps in the extant literature; and (4) offer recommendations for future research.

METHODS

This narrative review was conducted using a systematic literature search strategy. In October 2018, the following databases were searched: PubMed, CINAHL Complete, PsycINFO, Academic Search Complete, and Psychology & Behavioral Sciences Collection. The search was updated in December 2019. Free text and controlled vocabulary were developed in conjunction with a librarian who validated the search strategy for all databases. The following filters were used: English articles and articles published since January 1, 1997. This date was chosen because Kant's 1996 review[36] acknowledged that it was common to examine individual nutrients or foods with health outcomes at that time, an approach that had many limitations. Kant's review helped signify a more widespread shift in assessing diet quality comprehensively. In addition, a search yielded

Table 1 **PubMed search strategy for the narrative review investigating associations of stress and/or depressive symptoms with diet quality in pregnancy**

Concept	Search terms
Concept 1: Stress	1. Hydrocortisone [MESH]
	2. Stress, physiological [MESH]
	3. Stress, psychological [MESH]
	4. Cortisol [tw]
	5. Hydrocortisone [tw]
	6. Stress [tw]
	7. Stressed [tw]
	8. Stresses [tw]
	9. Stressful [tw]
	10. Stressor [tw]
	11. Stressors [tw]
	12. Psychosocial [tw]
	13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12
Concept 2: Depression	14. Depression [MESH]
	15. Depressive disorder [MESH]
	16. Mental health [MESH]
	17. Depressed [tw]
	18. Depression [tw]
	19. Depressive [tw]
	20. Mental health [tw]
	21. Mental wellbeing [tw]
	22. Emotional wellbeing [tw]
	23. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22
Concept 3: Diet quality	24. Diet [MESH]
	25. Diet records [MESH]
	26. Feeding behavior [MESH]
	27. Food [MESH]
	28. Maternal nutritional physiological phenomena [MESH]
	29. Nutrition assessment [MESH]
	30. Nutrition surveys [MESH]
	31. Nutritional status [MESH]
	32. Diet [tw]
	33. Diets [tw]
	34. Dietary behavior[c][tw]
	35. Dietary guideline[c] [tw]
	36. Dietary intake[c] [tw]
	37. Dietary pattern[c] [tw]
	38. Dietary quality [tw]
	39. Eating behavior[c] [tw]
	40. Eating habit[c] [tw]
	41. Eating pattern[c] [tw]
	42. Food group[c] [tw]
	43. Food habit [tw]
	44. Food habits [tw]
	45. Fruit [tw]
	46. Healthy diet[c] [tw]
	47. Healthy eating [tw]
	48. Nutrition assessment [tw]
	49. Nutrition index[c] [tw]
	50. Nutrition survey[c] [tw]
	51. Vegetable [tw]
	52. 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46 OR 47 OR 48 OR 49 OR 50 OR 51
Concept 4: Pregnancy	53. Maternal health [MESH]
	54. Pregnancy [MESH]
	55. Pregnant women [MESH]
	56. Antenatal [tw]
	57. Maternal [tw]
	58. Perinatal [tw]
	59. Pregnancy [tw]

(continued)

Table 1 **Continued**

Concept	Search terms
	60. Pregnant [tw] 61. Prenatal [tw] 62. 53 OR 54 OR 55 OR 56 OR 57 OR 58 OR 59 OR 60 OR 6163. 13 OR 23 AND 52 AND 62

Abbreviations: MESH, medical subject headings; tw, text word.
[a]English-language articles published between January 1997 and December 2019.
[b]Truncated term.

no relevant articles before 1997. The PubMed search strategy is detailed in Table 1.

Inclusion and exclusion criteria

Inclusion and exclusion criteria were determined a priori. Studies were included if they: (1) were full-text articles; (2) were of cohort, cross-sectional, or randomized design; and (3) examined associations of stress and/or depressive symptoms with diet quality in pregnancy. Stress was defined as self-reported perceived stress or stressful life events.[10,37] Depressive symptoms were self-reported or assessed by diagnostic measurement tools.[38,39] Diet quality was defined as the quality of one's typical food intake determined by a diet quality score,[18] alignment with healthy eating guidelines,[40] adherence to a specific dietary pattern (eg, "Western" diet),[41] or intake of food groups related to diet quality.[15] Diet quality was the main outcome of interest; however, cross-sectional studies were included if they examined diet quality as the exposure or the outcome, because the direction of the relationship is unclear. Cohort studies were included if they examined diet quality as the outcome.

Studies were excluded if they only: (1) examined individual nutrients or micronutrients (eg, omega-6 fatty acids); (2) examined disordered eating or gestational diabetes; (3) measured associations in prepregnancy or postpartum; (4) assessed diet in relation to malnutrition or food insecurity; (5) used animal models; (6) used qualitative methods; (7) focused on child outcomes; (8) were pilot studies (sample size <20 women); (9) were review articles; (10) measured stress biomarkers; or (11) were dissertations or unpublished works.

Selection process

All records were uploaded into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia); duplicates were automatically removed. Two reviewers independently screened titles and abstracts to identify studies that met the inclusion criteria. A calibration exercise, which involved screening 50 titles and abstracts, was conducted to clarify the eligibility criteria. After agreement was achieved, reviewers identified relevant articles and a full-text screening was conducted by 2 reviewers. Discrepancies were resolved through consensus.

Data extraction and quality assessment

The lead reviewer extracted data from included studies and a second reviewer independently checked the extraction to ensure accuracy. The extracted data included study characteristics (sample size, study design, study location, participants' racial composition, and inclusion of a theoretical framework); diet quality assessment (measures used, time of completion, and method for assessing diet quality); stress and depressive symptoms assessment (measures used, time of completion, and cutoff scores); statistical analyses; covariates; and a summary of relevant findings. If information needed to be added, reviewers had a discussion and came to an agreement. The same 2 reviewers independently assessed the quality of the studies using the Grading of Recommendations Assessment, Development and Evaluation 4 guidelines, which evaluate observational studies against 4 criteria: developing and including eligibility criteria, unflawed measurement of exposure and outcome, controlling for confounding, and incomplete follow-up.[42]

RESULTS

Study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart provides an overview of the search process (Figure 1). The initial search occurred in October 2018. Out of 7058 identified records, Covidence removed 1848 duplicates, resulting in 5210 records that were screened by title and then by abstract. From these, 5158 records were excluded because they were irrelevant to the topic (eg, animal models, examined individual nutrients, examined child outcomes, examined associations either prepregnancy or postpartum, focused on eating disorders). The full-text

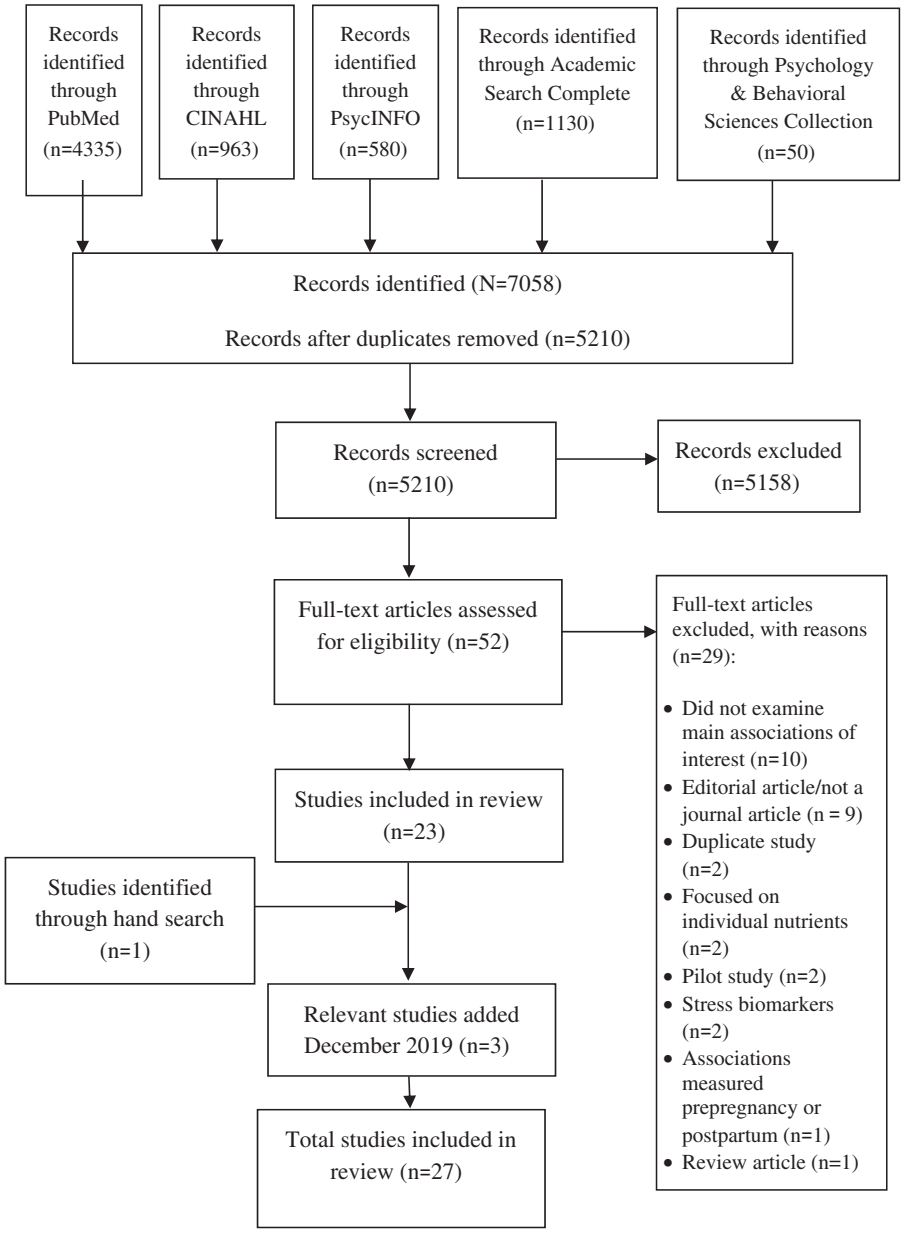

Figure 1 **Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart for article selection process for narrative review assessing stress and/or depressive symptoms with diet quality in pregnancy.**

for the resulting 52 studies were read and an additional 29 articles were excluded. Reasons for exclusion are detailed in Figure 1. There were 23 articles that met the inclusion criteria and their reference lists were reviewed for additional relevant articles. One article was identified from reference lists. The search was updated in December 2019 to check for new relevant articles and 3 were added, for a total of 27 articles.

Study characteristics

The characteristics of included studies are reported in Table 2. All studies were observational and used a survey methodology. There were 21 cross-sectional studies[13–15,18,21,23,40,43–56] and 6 prospective cohort studies.[41,57–61]

Setting. The studies were conducted in multiple countries. Nine studies were conducted in the US[13–15,18,43,52,54,55,57], 6 studies were conducted in Japan,[21,23,46,50,51,56] 4 studies were conducted in the United Kingdom,[41,45,49,60] 2 took place in Australia,[40,59] and 1 study was conducted in each of the following countries: Brazil,[47] New Zealand,[48] Pakistan,[58] Canada,[44] China,[61] and Iran.[53]

Table 2 **Summary of 27 studies evaluating associations of stress and/or depressive symptoms with diet quality during pregnancy**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
Dietary patterns (nonindices)								
Barker (2013)[45]	United Kingdom	Cross-sectional	6979 British women ALSPAC cohort White: 94.4%	Depressive symptoms EPDS, 10 items; score range, 0–30	Diet pattern FFQ, 43 items Factor analysis 2 diet patterns: healthy, unhealthy	32	Path analysis Police involvement, substance use, partner cruelty, inadequate living conditions and housing, housing defects, poverty, single caregiver, early parenthood, and low education	Adjusted: Higher depressive symptoms were associated with higher "unhealthy" dietary pattern scores ($d = 0.096$; $P < 0.05$) and lower "healthy" dietary pattern scores ($d = -0.059$; $P < 0.05$)
Baskin (2017)[59]	Australia	Cohort study	167 Australian women No racial breakdown	Depressive symptoms EPDS, 10 items; score range 0–30	Diet quality FFQ, 100 items Factor analysis 2 diet patterns: healthy, unhealthy	T1: 16 T2: 32	Path analysis (examined relationships in both directions) Age, prepregnancy BMI, education, income, parity, history of depression, exercise	Adjusted: Higher depressive symptoms at 16 wk significantly predicted lower "unhealthy" dietary pattern scores at 32 wk ($\beta = -0.17$; 95%CI, −0.32 to −0.02; $P < 0.05$) Adjusted: Higher "unhealthy" dietary pattern scores were related to higher depressive symptoms at 32 wks ($\beta = 0.19$; 95%CI, 0.04–0.34); $PP < 0.05$)
Jiang (2018)[61]	China	Cohort study, cross-sectional analysis	T1: 3698 T2: 2343 T3: 2162 Chinese women Zhoushan Pregnant Women Cohort	Dietary Diversity Scale Dietary recall questionnaire, 21-items 9 food groups: Cereal, soybean products, meat, egg, dairy products, fish/seafood, fat/oil, fruits, vegetables Score range, 0−9 (aggregate score of all consumed food groups) Low dietary diversity: < 6	SDS, 20 items; score range, 20–80 Score > 53 indicates depressed	T1: 10 T2: 28 T3: 36	*t*-test; χ^2 test Multiple linear and logistic regression models for each trimester Education, per capita income, occupation, BMI, maternal age, marital status, physical exercise, sleep quality, family care, morning sickness, medical problems in pregnancy, cigarette smoking and	Adjusted: Dietary diversity scores were inversely associated with depressive symptoms (higher dietary diversity scores were associated with lower depressive symptoms). T1: β(SE) = −1.16 (0.12); $P < 0.001$ T2: β(SE) = −1.12 (0.21); $P \leq 0.001$ T3: β(SE) = −1.01 (0.22); $P \leq 0.001$ High dietary status (> 6) was negatively associated with depression status

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
				High dietary diversity: > 6			drinking before pregnancy, parity, and gravidity	T1: OR (95%CI), 0.56 (0.46–0.69) T2: OR (95%CI), 0.55 (0.36–0.84) T3: OR (95%CI), 0.45 (0.31–0.65)
Lobel (2008)[57]	United States	Cohort study	279 White: 65.2% AA: 11.8% Hispanic: 11.8%	Pregnancy-specific stress Prenatal Distress Questionnaire, score range, 0−18 Prenatal Life Events Scale: No. of life events, score range, 0−28 Life events distress, score range, 0−84	Diet quality Prenatal Health Behaviors Scale, 6 items Healthy, unhealthy eating subscales, score range, 0−12	T1: 10−20 wk T2: 21−30 wk T3: ≥ 30 wk	Structural equation modeling Obstetric risk	Adjusted: Higher pregnancy-specific stress scores were associated with higher "unhealthy" dietary pattern scores ($\beta = 0.29$; $P < 0.05$), and associated with lower "healthy" dietary pattern scores ($\beta = -.14$; $P < 0.05$)
Miyake (2018)[46]	Japan	Cross-sectional study	1744 KOMCHS cohort Japanese women	Diet patterns Diet History Questionnaire, 145 items Factor analysis 3 diet patterns: Healthy, Japanese, and Western	Depressive symptoms CES-D (Japanese version), 20 items Score range, 0−60 Score > 16 indicates presence of depressive symptoms	5−39 wk	Poisson regression Age, gestation, region of residence, no. of children, family structure, history of depression, family history of depression, smoking, second-hand smoke exposure, employment, household income, education, and BMI	Adjusted: Compared with the lowest quartile of the healthy dietary pattern scores, those in the second, third, or fourth quartiles of the healthy pattern were associated with a lower prevalence of depressive symptoms (PR, 0.56; 95%CI, 0.43–0.73; $P = 0.001$) Compared with the lowest quartile of the Japanese dietary pattern scores, those in the third and fourth quartiles were associated with a lower prevalence of depressive symptoms (PR, 0.76, 95%CI, 0.58–0.99; and PR, 0.72, 95%CI, 0.55–0.94), respectively; $P = 0.01$

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
Molyneaux (2016)[41]	United Kingdom	Cohort study	13 314 ALSPAC cohort British women White: 97.3%	Depressive symptoms EPDS, 10 items, score range, 0−30 Score > 12 at both 18 and 32 wk of gestation indicated high depressive symptoms	Diet patterns FFQ, 43 items Principal component analysis 5 diet patterns: Health conscious, traditional, processed, confectionary, vegetarian	Depressive symptoms: 18 wk, 32 wk Diet: 32 wk	Linear regression; multiple logistic regression Age, ethnicity, marital status, occupation, education, parity, singleton or multiple pregnancy, stressful life events, social support, alcohol consumption, tobacco smoking, drug use, physical activity	Adjusted: High depressive symptoms at 18 and 32 wk were significantly associated with higher confectionary dietary pattern scores only ($\beta = 0.10$; 95%CI, 0.02–0.17; $P = 0.01$)
Omidvar (2018)[53]	Iran	Cross-sectional study	445 Iranian women	Pregnancy-specific stress Prenatal Distress Questionnaire, 12-items, score range, 0−48 Depressive symptoms Beck Depression Inventory-II, 21-items, score range, 0−63	Healthy nutrition Health-Promoting Lifestyle Profile (Persian version, nutrition domain), 9-items, Scores 9−36	Anytime in pregnancy (range, < 13 to 42 wk)	ANOVA; Pearson correlation Linear regression (unadjusted and adjusted models) Age, education, and gestational age	Adjusted: Neither depressive symptoms nor pregnancy-specific stress were significantly associated with healthy nutrition scores in adjusted models ($P > 0.05$)
Paskulin (2017)[47]	Brazil	Cross-sectional study	712 Brazilian women	Diet patterns FFQ, 88 items Cluster analysis 3 diet patterns: restricted, varied, and common Brazilian Food groups that align with Food Guide for the Brazilian Population (fruit, beans, and sweets/sugars)	Prevalence of major depressive disorder PRIME-MD, diagnosis of major depressive disorder	16–36 wk	Poisson regression models Age, municipality of residence, violence in pregnancy, and monthly family income	Adjusted: Women with high common Brazilian dietary pattern scores had 43% higher prevalence of major depressive disorder compared with those with high scores on the varied dietary pattern (PR, 1.43; 95%CI, 1.01–2.02) Adjusted: Women with low fruit and high sweets/sugars intake had a higher prevalence of major depressive disorder (PR, 1.43, 95%CI, 1.04–1.95, $P = 0.03$; and PR,

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
								1.91, 95%CI, 1.91–3.07, $P = 0.01$), compared with those with high fruit and low sweets/sugar intake
Pina-Camacho (2015)[60]	United Kingdom	Prospective cohort study	7814 British women ALSPAC cohort White: 95%	Depressive symptoms EPDS, 10 items; score range, 0—30	Diet patterns FFQ, 43 items, used to create unhealthy diet score Unhealthy diet: Continuous score (higher = worse)	Depressive symptoms: 18 wk, 32 wk Diet: 32 wk	Pearson correlation Summed into an index: parity, birth complications, police involvement, substance use, cruelty from partner, inadequate basic living conditions, inadequate housing, housing defects, poverty, being a single caregiver, early parenthood, and low educational attainment	Correlation: Higher depressive symptoms at 18 wk were associated with higher unhealthy dietary pattern scores at 32 wk ($r = 0.024$; $P < 0.05$)
Wall (2016)[48]	New Zealand	Cross-sectional study	5664 New Zealand women in the Growing up in New Zealand cohort European: 56% Maori: 13.2% Pacific: 12.8% Asian: 14.2% Other: 3.8%	Diet patterns FFQ, 44 items Principal components analysis 4 diet patterns: junk, health-conscious, traditional/white bread, and fusion/protein	Depressive symptoms EPDS, 10 items, score range, 0—30 Score > 13 indicates likely to have symptoms of depression	29—40 wk	Multivariable linear regression Ethnicity, household deprivation, prepregnancy BMI, prepregnancy self-rated health, folic acid supplementation, smoking and alcohol consumption, physical activity before and during pregnancy, and dieting prepregnancy	Adjusted: Higher "junk" dietary pattern scores were associated with having an EPDS score > 13 ($\beta = 0.14$; 95%CI, 0.06–0.23; $P = 0.001$).
Diet quality (indices)								
Berube (2019)[54]	United States	Cross-sectional study	519 All Hispanic, low income	Depressive symptoms Patient Health Questionnaire-9, score range, 0—27	Diet quality FFQ, 118 items Healthy Eating Index-2015, score range, 0—100	28—32 wk	Independent *t* tests, 1-way ANOVA, and linear regression Maternal age, marital status, parity, employment	Depressive symptoms were not associated with diet quality

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
				No depressive symptoms: total score range, 0−4 Mild or greater depressive symptoms: total score range, 5−27			status, education level, and prepregnancy BMI	
Fowles (2011)[18]	United States	Cross-sectional study	118 Hispanic: 46.6% AA: 12.7% Low income	Distress (index of stress and depressive symptoms) Prenatal Psychosocial Profile-Stress subscale, score range, 11–44 EPDS score > 10 indicate possible depression	Diet quality 24-h recall (3×) DQI-P, score range, 0−80 Score > 70 indicates desirable diet quality	<14 wk	Path analysis Age, education	Adjusted: Higher distress scores were significantly associated with higher poor eating habits scores ($\beta = 0.36$; $P < 0.01$), and directly ($\beta = -0.23$; $P < 0.05$) and indirectly associated with lower diet-quality index scores ($\beta = -0.30$; $P < 0.05$)
Fowles (2012)[43]	United States	Cross-sectional study	71 Hispanic: 48% AA: 14% Low income	Stress, depressive symptoms Prenatal Psychosocial Profile-Stress subscale, score range, 0−33 EPDS score > 10 indicates possible depression Score > 13 indicates probable depression	Diet quality 24-h recall (3×) DQI-P, score range, 0−80 Score > 70 indicates desirable diet quality	<14 wk	Student *t* tests None (sample size too small)	Unadjusted: Women with diet quality scores below the median (DQI-P score, 53.3) had higher depressive symptoms (mean ± standard deviation, 9.6 ± 5.1 vs 6.7 ± 5.1; $P = 0.02$) and stress scores (22.1 ± 5.4 vs 19.3 ± 4.8; $P = 0.03$) than women with diet-quality scores above the median
Saeed (2016)[58]	Pakistan	Cohort study	82 Pakistani women, middle income	Depressive symptoms EPDS, 10 items, score range, 0−30 Score > 9 indicates "depressed"	Diet quality 24-h recall (1×) Food frequency checklist, modified for cultural context HEI (modified)—only adequacy components, score range, 0−50 (> 40 indicates good diet)	Depressive symptoms: 13 wk Diet: 13 wk, 36 wk	Correlations; relative risk and attributable risk None (potential confounders: age, weight, BMI, and parity did not differ between depressed and nondepressed women)	Unadjusted: Women with higher depressive symptoms had an increased risk of poor diet quality compared with women with lower depressive symptoms (RR, 2.58; 95%CI, 1.60–5.23; $P < 0.001$ 62% of poor diet quality could be attributed to

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
								exposure to high depressive symptoms
Food groups								
Chang (2015)[13]	United States	Cross-sectional study	213 White: 48% AA: 47% Other: 5% Overweight/obese, low-income, and WIC-enrolled women	Stress, depressive symptoms Perceived Stress Scale, 9 items, score range, 9−36 EPDS, 10 items, score range, 0−30 Score range, 11−12 possible minor depression Score > 13 indicates potential major depression	Fat, fruit, and vegetable intake Rapid food screener, 17 items Higher score indicates higher fat intake or more fruit and veggie intake	Any time during pregnancy (women in all 3 trimesters)	ANOVA, χ^2, Pearson correlation, path analysis None	Unadjusted: Higher stress was associated with lower fruit and vegetable intake in the first trimester ($\beta = -0.56$; $P < 0.05$) Higher depressive symptoms were associated with higher fat intake in the first trimester ($\beta = 0.67$; $P < 0.05$)
Chang (2016)[52]	United States	Cross-sectional study	332 White: 58% AA: 42% Overweight/obese, low-income, and WIC-enrolled women	Stress, depressive symptoms Perceived Stress Scale, 9 items, score range, 9−36 EPDS, 10 items, score range, 0−30	Fast food, fat, fruit, and vegetable intake Brief fast-food screener, 12 items, score range, 0−96 Rapid food screener, 24 items (fruit, vegetables, fat)	Any time during pregnancy (women in all 3 trimesters)	*t* Test, χ^2, path analysis None	Unadjusted: Among overweight women, those who reported more depressive symptoms were more likely to eat fast foods, which led to more vegetable intake ($P = 0.01$) and partially higher fat intake than women with fewer depressive symptoms ($P = 0.003$)
Chang (2019)[55]	United States	Cross-sectional study	353 White: 58% AA: 42% Overweight/obese, low-income, and WIC-enrolled women	Stress Perceived Stress Scale, 9 items, score range, 9−36 > 30 indicates high stress < 30 indicates low stress	Fat, fruit, and vegetable intake Rapid food screener, 24 items Fat score range, 0−68 Fruit score range, 0−10 Vegetable score range, 0−25	Any time during pregnancy (women in all 3 trimesters)	χ^2, analysis of variance, multiple linear regression Trimester, gravidity, age, race, education, employment status, and smoking status	Adjusted: There was no relationship between stress and fat intake. Women with high stress reported significantly lower fruit and vegetable intake but not fat intake than women with low stress
Fowles (2011)[14]	United States	Cross-sectional study	50 Hispanic: 50% White: 32% AA: 18%	Frequency of fast-food consumption 24-h recall (3×)	Stress, depressive symptoms Prenatal Psychosocial Profile-Stress	< 14 wk	*t* tests None	Unadjusted: Eating from fast-food restaurants ≥3 times in the past week was associated with having higher

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
					subscale, score range, 11−44 EPDS, 10 items, score range, 0−30 Score > 10 indicates possible depression			stress (mean ± standard deviation, 23.7 ± 6.8 vs 18.9 ± 4.1; 95%CI, −7.87 to −1.70; $P < 0.05$) and depressive symptoms (10.4 ± 6.0 vs 6.8 ± 4.1; 95%CI, −6.45 to −0.71; $P < 0.05$) compared with eating at fast-food restaurants 0−2 times in the past week
Golding (2009)[49]	United Kingdom	Cross-sectional study	14 541 British women ALSPAC cohort Majority white (breakdown not provided)	Seafood intake FFQ, 13 food groups Fish, 3 items: white fish, dark or oily fish, and shellfish	Depressive symptoms EPDS, 10 items, score range, 0−30 Score > 13 indicates "high levels of depressive symptoms"	32 wk	Logistic regression Age, parity, outcome of immediately preceding pregnancy, education, housing tenure, crowding, mothers' life events in childhood scale, chronic stress, smoking, alcohol use, ethnicity, energy intake	Adjusted: Compared with women consuming > 1.5 g of omega-3 from seafood/wk, those consuming none were more likely to have higher depressive symptoms at 32 wk' gestation (adjusted OR, 1.54; 95%CI (1.25, −1.89); $P < 0.001$)
Hurley (2005)[15]	United States	Cross-sectional study	134 85% white Well-educated, middle-class	Stress, depressed mood Perceived Stress Scale Profile of Mood States–Depression subscale	Intake of food groups FFQ, frequencies for 7 food groups	Stress, depressive symptoms: 24 wk Diet: 28 wk	Pearson correlations (adjustment via residual approach) Maternal age, parity, BMI, and education	Adjusted: Higher stress at 24 wk was associated with higher intake of breads (r 0.23; $P < 0.01$) and foods from the fats, oils, sweets, and snack group at 28 wk ($r = 0.18$; $P < 0.05$). No significant relationship between depressed mood and food group intake
Malek (2017)[40]	Australia	Cross-sectional study Theory of Planned Behavior	455 Australian women	Stress Perceived Stress Scale, 4 items, score range, 0−16	Adherence to food group recommendations FFQ, 6 items	13−30 wk	Hierarchical multiple linear regression Metro area, education, household income, parity, third trimester,	Adjusted: Perceived stress was not a significant predictor of adherence to food group recommendations ($\beta = 0.04$, $P > 0.05$)

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
					Adherence to 5 food-group recommendations		prepregnancy overweight/obesity, prepregnancy exercise, smoking during pregnancy, nutrition knowledge, and use of folic acid and iodine supplements during pregnancy	
Miyake (2013)[50]	Japan	Cross-sectional study	1745 KOMCHS cohort Japanese women	Fish intake Diet History Questionnaire, 150 items Fish intake (g)	Depressive symptoms CES-D (Japanese), 20 items, score range, 0−60 Score > 16 indicates depressive symptoms present	Any time during pregnancy Mean, 19 wk 92% in first or second trimester	Multiple logistic regression Age, gestation, region of residence, no. of children, family structure, history of depression, family history of depression, smoking, secondhand smoke exposure at home and at work, job type, household income, education, and BMI	Adjusted: Compared with being in the lowest quartile, being in the highest quartile for fish intake was associated with a lower prevalence of depressive symptoms during pregnancy (adjusted OR between extreme quartiles, 0.61; 95%CI, (0.42–0.87); $P = 0.01$)
Miyake (2015)[51]	Japan	Cross-sectional study	1745 KOMCHS cohort Japanese women	Dairy intake Diet History Questionnaire, 150 items Dairy, 4 items: Full-fat milk, low-fat milk, yogurt, cheese, and cottage cheese	Depressive symptoms CES-D (Japanese), 20 items, score range, 0−60 Score > 16 indicates depressive symptoms present	Any time during pregnancy Mean, 19 wk 92% in first or second trimester	Multiple logistic regression Age, gestation, region of residence, no. of children, family structure, history of depression, family history of depression, smoking, secondhand smoke exposure at home and at work, job type, household income, education, BMI, and fish intake	Adjusted: Compared with being in the lowest quartile, being in the highest quartile for yogurt intake was independently associated with a lower prevalence of depressive symptoms during pregnancy Adjusted OR between extreme quartiles, 0.69; 95%CI, 0.48–0.99); $P = 0.03$)

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
Miyake (2018)[23]	Japan	Cross-sectional study	1745 KOMCHS cohort Japanese women	Soy product intake Diet History Questionnaire, 150 items Total soy product intake: sum of tofu, tofu products, fermented soybeans, boiled soybeans, miso, miso soup, and soymilk	Depressive symptoms CES-D (Japanese), 20 items, score range, 0−60 Score > 16 indicates depressive symptoms present	Any time during pregnancy Mean, 19 wk 92% in first or second trimester	Poisson regression Age, gestation, region of residence, no. of children, family structure, history of depression, family history of depression, smoking, secondhand smoke exposure at home and at work, job type, household income, education, and BMI, intake of fish, yogurt, and seaweed	Adjusted: Higher intake total soy products, tofu, tofu products, fermented soybeans, boiled soybeans, and miso soup was independently related to a lower prevalence of depressive symptoms during pregnancy: Adjusted PRs (95%CI), *P* for trend between extreme quartiles were: 0.63 (0.47–0.85), 0.002; 0.72 (0.54–0.96), 0.007; 0.74 (0.56–0.98) 0.04; 0.57 (0.42–0.76; < 0.001), 0.73 (0.55– 0.98), 0.03; and 0.65 (0.49–0.87), 0.003, respectively
Sontrop (2008)[44]	Canada	Cross-sectional study	2394 Prenatal Health Project (cohort) Canadian women (no racial breakdown)	Fish intake FFQ, 106 items Fish: 4 items (canned tuna; dark meat fish; other fish; and shrimp, lobster, or scallops)	Depressive symptoms CES-D, 20 items, score range, 0−60 Score > 16 indicates probable depression	10−22 wk	Sequential multiple regression Age, marital status, education, household income, occupational status, smoking, physical activity, meeting Canada Food Guide to Healthy Living guidelines, and total energy intake	Adjusted: No relationship between fish intake and depressive symptoms after controlling for confounders ($\beta = -0.2$; 95%CI, −0.9 to 0.4; $P > 0.05$)
Takahashi (2016)[21]	Japan	Cross-sectional study	9030 Japan Environment and Children's Study cohort Japanese women	Fermented food consumption FFQ, 66 items Focused on intake of probiotics, prebiotics, and other fermented foods (eg, yogurt, lactic acid beverages, fermented milk,	Psychological Distress Kessler Psychological Distress Scale, 6 items, score range, 0−24	13−40 wk	Multivariate logistic regression analysis Parity, BMI, marital status, family structure, number of childbirths, mood after pregnancy was confirmed, history of infertility	Adjusted: The consumption of yogurt and other fermented foods was not associated with lower prevalence of psychological distress in pregnant women ($P > 0.05$)

(continued)

Table 2 **Continued**

First author (year)	Country	Study design	Sample size, racial composition	IV, assessment tool(s)	DV, assessment tool(s)	Week of pregnancy	Statistical tests, covariates	Findings
				cheese, milk, Japanese pickles, miso soup, fermented soybeans, beans)			treatment, history of mental health disorders, age, gestation, academic history, employment, household income, physical activity, smoking status, husband's smoking status, secondhand smoking status, alcohol consumption, total intake, tea consumption, presence of health complications or disease, intimate partner violence, and social capital	
Takei (2019)[56]	Japan	Cross-sectional study	273 Japanese women	Depressive symptoms EPDS, 10 items, score range, 0–30	Vegetable intake Brief-type, self-administered diet history questionnaire	19–23 wk	Spearman correlation coefficient analysis, Mann-Whitney U test, Kruskal-Wallis analysis, multiple linear regression analysis Not mentioned	There was no association between depressive symptoms and vegetable intake

Abbreviations: AA, African American; ALSPAC, Avon Longitudinal Study of Parents and Children; BMI, body mass index; CES-D, Center for Epidemiologic Studies–Depression Scale; DQI-P, Diet Quality Index for Pregnancy; DV, dependent variable; EPDS, Edinburgh Postnatal Depression Scale; FFQ, food frequency questionnaire; HEI, Healthy Eating Index; IV, independent variable; KOMCHS, Kyushu Okinawa Maternal and Child Health Study; OR, odds ratio; PR, prevalence ratio; PRIME-MD, Primary Care Evaluation of Mental Disorders; RR, relative risk; SDS, Self-Rating Depression Scale; WIC, Women, Infants, & Children.

Population. Sample sizes ranged from 82[58] to 13 314[41] women in cohort studies and from 50[14] to 14 541[49] in cross-sectional studies. Eight cross-sectional studies included targeted populations: low-income women[13,14,18,43,52,54,55]; women with a prepregnancy body mass index (BMI) of overweight or obese [13,52,55]; and well-educated, middle-class women.[15] One cohort study included a targeted population of middle-income women.[58]

Dietary assessment. Dietary intake was assessed through a variety of tools. Dietary intake was most commonly assessed through food frequency questionnaires (FFQs), which were used in 12 studies.[15,21,40,41,44,45,47–49,54,59,60] FFQs estimate one's usual intake, typically over the previous month.[62] The level of detail of FFQs varied among these studies: One study used a 3-item version,[49] 1 study used a 4-item version,[44] 1 study used a 6-item version,[40] and the remaining studies used detailed FFQs, ranging from 43[41] to 118 items.[54] Three studies used 24-hour dietary recalls[14,18,43]; 1 study used a 21-item dietary recall questionnaire[61]; 5 studies used diet history questionnaires[23,46,50,51,56]; 3 studies used a rapid food screener[13,52,55]; 1 study used a prenatal health behaviors scale[57]; 1 study used a combination of 24-hour dietary recalls and a food frequency checklist modified to fit the cultural context of Pakistan[58]; and 1 study used a health-promoting lifestyle profile (Persian version).[53]

Comprehensive diet quality index scores were estimated in 4 studies[18,43,54,58] and were derived from 24-hour dietary recalls or a detailed FFQ. The Diet Quality Index for Pregnancy was used in 2 studies[18,43] and consisted of 8 components: grains; fruit; vegetables; percentage of recommended intake for folate, calcium, and iron; percentage of energy from fat; and meal/snack pattern.[63] Scores for each component ranged from 0 to 10, with total scores ranging from 0 to 80. A composite score ≥ 70 indicated the most desirable diet quality.[63] The third study modified the traditional Healthy Eating Index (HEI) to assess only the adequacy components (ie, areas where typical consumption is too low) such as whole grains, whole fruit, and total vegetables.[58] The overall score of the modified HEI was reduced to 50, with a score > 40 indicating good diet quality. The fourth study used the traditional HEI-2015, with scores ranging from 0 to 100.

Eight studies identified dietary patterns through factor analysis,[45,46,59,60] other statistical techniques,[41,47,48] or "healthy" or "unhealthy" subscales.[57] Standardized scores for each dietary pattern were calculated for study participants, with higher scores indicating greater similarity to that dietary pattern.[41] Some of the identified patterns include "healthy" vs "unhealthy"[45,59]; "Japanese"[46]; "health conscious"[41,48]; "common Brazilian"[47]; "junk"/"processed"/"confectionary"/"Western"[41,46,48]; and "vegetarian."[41] One study assessed diet quality by examining dietary diversity across 9 food groups and creating a composite score, with higher scores indicating greater dietary diversity and better diet quality.[61] In addition, 9 studies assessed food groups (eg, fruit, vegetables, fish, dairy)[13,15,40,44,49–51,55,56] and 1 assessed fast-food intake.[14]

Mental health assessment. Mental health was assessed through multiple tools. A total of 23 studies assessed depressive symptoms during pregnancy.[13–15,18,23,41,43–54,56,58–61] Of these, 13 studies used the Edinburgh Postnatal Depression Scale (EPDS),[13,14,18,41,43,45,48,49,52,56,58–60] a validated self-report screening tool used in clinical and research settings to identify depressive symptoms during pregnancy and postpartum.[38] Scores from this scale can be used as a continuous variable, with higher scores indicating more depressive symptoms or categorized into levels of depressive symptoms using validated cutoff scores.[38] Of these, 5 studies analyzed depressive symptoms as a continuous variable[45,52,56,59,60] and 8 studies used cutoff scores ranging from ≥ 9 to ≥ 13 to identify high levels of depressive symptoms.[13,14,18,41,43,48,49,58] Five studies used the Center for Epidemiologic Studies–Depression Scale to assess depressive symptoms,[23,44,46,50,51] which is a research screening tool to identify high depressive symptoms and has been validated in community samples.[64] Of these 5, 1 study used a cutoff score of > 16[46] and 4 studies used a cutoff of ≥ 16[23,44,50,51] to identify depressive symptoms. One study used the Primary Care Evaluation of Mental Disorders,[47] a valid tool designed to facilitate the diagnosis of major depressive disorder by primary care physicians.[39] One study used the Profile of Mood States–Depression subscale,[15] a continuous measure that assesses depressed mood, with higher scores reflecting more-negative mood[65]; another study used the Self-Rating Depression Scale,[61] a previously validated screening tool used to evaluate one's mood in the past 7 days, with higher scores indicating higher depressive symptoms (score range, 20–80; cutoff, ≥ 53)[66]; and 1 study used the Beck Depression Inventory–II,[53] which is a widely used and valid instrument for detecting depression in normal and clinical populations. Higher scores indicate more severe depressive symptoms.[67] Last, 1 study used the Patient Health Questionnaire–9, a validated tool that includes 9 items related to depression; higher scores indicate higher depressive symptoms.[68]

Eleven studies assessed self-reported stress or psychological distress during pregnancy.[13–

[15,18,21,40,43,52,53,55,57] Three studies used the Prenatal Psychosocial Profile–Stress subscale,[14,18,43] a validated continuous measure of stress during pregnancy.[69] Two studies used the full-length (14-item) Perceived Stress Scale,[15,55] 2 studies used the 9-item version,[13,52] and 1 study used the brief 4-item version,[40] with all versions measuring general perceived stress.[10] Two studies assessed pregnancy-specific stress; 1 used the original Prenatal Distress Questionnaire, and 1 used a revised version.[57] The Prenatal Distress Questionnaire is a continuous measure of pregnancy-specific stress.[70] One study examined stressful life events in conjunction with prenatal distress by using the Prenatal Life Events Scale, which is a count of stressful life events during pregnancy and resulting level of distress.[37] Last, 1 study used the 6-item Kessler Psychological Distress Scale,[21] which is a widely used screening tool for identifying psychological distress in the general population.[71] On all stress measures, higher scores indicated higher levels of stress or distress.

Methodological quality. The results of the Grading of Recommendations Assessment, Development and Evaluation 4 quality assessment are summarized in Table 3.[42] Ten studies provided adequate and appropriate information regarding eligibility criteria, including exclusion for health conditions that could affect diet quality.[14,15,18,43,44,53,54,56,58,61] Most of the studies provided unflawed measurement of exposure and outcome.[14,15,18,21,23,40,41,43–51,54–56,58–61] Only 5 studies failed to adequately control for potential confounding factors or did not specify their control variables,[13,14,43,52,56] and only 6 studies had complete follow-up or results for multiple points during pregnancy.[41,57–61] Two studies had the strongest methodological design[42] relative to the other included studies. These studies found significant associations of mental health with diet quality in pregnancy.[58,61] There was variation in the covariates included across studies. Sociodemographic factors such as age, education, income, and marital status were controlled for in nearly half of the studies.[15,18,21,23,40,41,46,47,49,53–55,59,61] Parity was controlled for in 9 studies,[15,21,23,40,41,49,54,59,61] gestational age (weeks) was controlled for in 7 studies,[21,23,46,50,51,53,55] history of depression was controlled for in 6 studies,[21,23,46,50,51,59] and BMI was controlled for in 11 studies.[15,21,23,40,46,48,50,51,54,59,61]

Study findings (Table 2) were grouped into 3 categories on the basis of the way diet quality was assessed: (1) dietary patterns, such as healthy or Western patterns, (2) diet quality determined from standardized diet quality indices (eg, Diet Quality Index for Pregnancy, HEI), and (3) dietary diversity, consumption of fast food, or specific food groups commonly included in diet quality indices (eg, fruit, vegetable, seafood).

Stress and depressive symptoms: studies assessing dietary patterns (nonindices).

Cohort. There are mixed findings regarding the relationship between depressive symptoms in early pregnancy (ie, 16 or 18 weeks) and dietary pattern scores at 32 weeks (eg, "unhealthy," "confectionary," "health conscious").[41,59,60] For example, Baskin et al[59] found that higher depressive symptoms at 16 weeks significantly predicted lower "unhealthy" dietary pattern scores at 32 weeks ($\beta = -0.17$; 95%CI, −0.32 to −0.02; $P < 0.05$).[59] Molyneaux et al[41] found that consistently elevated depressive symptoms were significantly associated with higher "confectionary" dietary pattern scores [$\beta = 0.10$; 95%CI, 0.02–0.17); however, they found no relationship between elevated depressive symptoms and 4 other dietary patterns (ie, health conscious, traditional, processed, or vegetarian). Stress, specifically pregnancy-specific stress, was assessed in only 1 cohort study.[57] Lobel et al[57] found that higher pregnancy-specific stress was significantly associated with higher unhealthy dietary pattern scores ($\beta = 0.29$; $P < 0.05$) and lower healthy dietary pattern scores ($\beta = -0.14$; $P < 0.05$) in a majority white sample of US women (n = 279).

Cross-sectional. Two cross-sectional studies examined stress and/or depressive symptoms as the exposure and dietary patterns as the outcome.[45,53] The authors reported mixed findings. For example, Barker et al[45] found that higher depressive symptoms were associated with higher unhealthy dietary pattern scores ($\beta = -0.01$; 95%CI, −0.015 to −0.006) and lower healthy dietary pattern scores [$\beta = -0.005$; 95%CI, −0.009 to −0.003) at 32 weeks. Alternatively, Omidvar et al[53] found that neither depressive symptoms nor pregnancy-specific stress were significantly associated with healthy nutrition scores.

Four cross-sectional studies examined dietary patterns or dietary diversity as the exposure and level of depressive symptoms[46,48,61] or diagnosis of major depressive disorder as the outcome.[47] Overall, findings indicated an inverse relationship between dietary pattern and depressive symptoms or major depressive disorder. For example, Miyake et al[46] found that Japanese women (n = 1744) who scored in the upper quartiles of the healthy dietary pattern (second, third, or fourth quartiles) had a lower prevalence of depressive symptoms, indicated by Center for Epidemiologic Studies–Depression Scale scores > 16 (adjusted prevalence ratio, 0.56; 95%CI, 0.43–0.73), compared with those in the

Table 3 **Risk-of-bias summary**[a]

First author (year)	Appropriate eligibility criteria	Appropriate measurement of exposure and outcome	Adequately controlled confounding	Complete follow-up
Barker (2013)[45]	—	+	+	—
Baskin (2017)[59]	—	+	+	+
Berube (2019)[54]	+	+	+	—
Chang (2015)[13]	—	—	[c]	—
Chang (2016)[52]	—	—	[c]	—
Chang (2019)[55]	—	+	+	—
Fowles (2011)[18]	+	+	+	—
Fowles (2011)[14]	+	+	—	—
Fowles (2012)[43]	+	+	—	—
Golding (2009)[49]	—	+	+	—
Hurley (2005)[15]	+	+	+	—
Jiang (2018)[61]	+	+	+	+
Lobel (2008)[57]	—	—	+	+
Malek (2017)[40]	—	+	+	—
Miyake (2013)[50]	—	+	+	—
Miyake (2015)[51]	—	+	+	—
Miyake (2018)[46]	—	+	+	—
Miyake (2018)[23]	—	+	+	—
Molyneaux (2016)[41]	—	+	+	+
Omidvar (2018)[53]	+	—	+	—
Paskulin (2017)[47]	—	+	+	—
Pina-Camacho (2015)[60]	—	+	+	+
Saeed (2016)[58]	+	+	+	+
Sontrop (2008)[44]	+	+	+	—
Takahashi (2016)[21]	—	+	+	—
Takei (2019)[56]	+	+	?	—
Wall (2016)[48]	—	+	+	—

Abbreviations: —, high risk of bias (criteria not met in the study design); +, low risk of bias (criteria met in the study design).
[a]Authors' judgments about each risk-of-bias item were reviewed for each included study according to Grading of Recommendations Assessment, Development, and Evaluation–4 guidelines.
[b]Unclear risk of bias; authors did not report whether criteria were met.

lower quartile. In terms of diagnosed depression, Paskulin et al[47] found that Brazilian women with high "common Brazilian" dietary pattern scores had a 43% higher prevalence of major depressive disorder compared with those with high scores on the varied dietary pattern (adjusted prevalence ratio, 1.43; 95%CI, 1.01–2.02).

Overall, higher depressive symptoms were generally associated with higher scores on unhealthy and confectionary dietary patterns in pregnancy. In addition, higher depressive symptoms and pregnancy-specific stress were both cross-sectionally related to higher unhealthy dietary pattern scores and lower healthy dietary pattern scores. A similar inverse relationship was observed for depressive symptoms, where higher healthy and Japanese dietary pattern scores were associated with lower prevalence of depressive symptoms.

Stress and depressive symptoms: studies assessing diet quality scores (indices).

Cohort. Three studies investigated associations of stress and/or depressive symptoms with diet quality during pregnancy, using a standardized diet quality index score,[18,43,58] and only 1 used a cohort study design.[58] Saeed et al[58] found that middle-income women with higher depressive symptoms (EPDS score ≥ 9) at 13 weeks had lower HEI scores at 36 weeks (relative risk, 2.58; 95%CI, 1.60–5.23) compared with women who had lower depressive symptoms. Depressive symptoms explained 62% of the variance in diet quality during pregnancy, highlighting the importance of mental well-being in relation to diet quality during pregnancy.[58]

Cross-sectional. Fowles et al[43] examined the independent relationships between stress and depressive symptoms on diet quality using the Diet Quality Index–Pregnancy. In a sample of majority Hispanic, low-income women (n = 71), they found that women with diet quality scores below the median (Diet Quality Index–Pregnancy = 53.3) had higher depressive symptoms (mean ± standard deviation, 9.6 ± 5.1 vs 6.7 ± 5.1; $P = 0.02$) and stress scores (22.1 ± 5.4 vs 19.3 ± 4.8, $P = 0.03$) than did women with diet quality scores above the median.[43] Fowles et al[18] built on their

previous study by recruiting additional women (n = 118) and combining stress and depressive symptoms into an index called "distress" to examine their synergistic effects on diet quality. They found that higher distress scores were significantly associated with higher poor eating habits scores ($\beta = 0.36$; $P < 0.01$), and were directly ($\beta = -0.23$; $P < 0.05$) and indirectly ($\beta = -0.30$; $P < 0.05$) associated with lower scores on the Diet Quality Index–Pregnancy in their sample of low-income, majority Hispanic women.[18] Alternatively, Berube et al[54] examined the relationship between depressive symptoms on diet quality using the HEI-2015 and they found no association.

Overall, there is limited reported research on the relationship between stress, depressive symptoms, and diet quality in pregnancy using a standardized diet quality index. Emerging research indicates there are mixed results regarding the relationship between stress and/or depressive symptoms on overall diet quality.[18,43,54,58]

Stress and depressive symptoms: studies assessing food group and fast-food consumption. Thirteen articles examined associations of stress and/or depressive symptoms with the consumption of food groups[13,15,21,23,40,44,49–51,55,56] or fast-food in pregnancy.[14,52] All articles used a cross-sectional design.

Five studies investigated associations of mental health with the consumption of food groups relevant to diet quality or adherence to food-group recommendations as the outcome.[13,15,40,55,56] Chang et al[13] found that women with higher levels of stress were less likely to eat fruits and vegetables during their first trimester ($\beta = -0.56$; $P \leq 0.05$); however, this association was not significant in the second or third trimesters. Similarly, women with higher depressive symptoms (EPDS score-≥ 13) were more likely to have higher levels of fat intake during the first trimester ($\beta = 0.67$; $P \leq 0.05$), but the association was not significant in the second or third trimesters. These findings highlight the importance of measuring stress, depressive symptoms, and dietary intake multiple times throughout pregnancy, because associations may change.

Malek et al[40] investigated the relationship between maternal stress and adherence to the Australian food-group recommendations in Australian pregnant women (n = 455) and found that perceived stress was not a significant predictor of adherence to food-group recommendations ($\beta = 0.04$; $P > 0.05$). This was the only study that was informed by an evidence-based theory (ie, Theory of Planned Behavior); however, the researchers did not assess depressive symptoms.

Seven studies examined the relationship between dairy/fermented foods, fish/seafood intake, or soy products on stress, psychological distress, or depressive symptoms in pregnancy.[14,21,23,44,49–51] Miyake et al[51] found that scoring in the highest quartile for yogurt intake was associated with a lower prevalence of depressive symptoms (Center for Epidemiologic Studies–Depression Scale score ≥ 16) during pregnancy (adjusted odds ratio, 0.69; 95%CI, 0.48–0.99). Alternatively, Takahashi et al[21] found no relationship between the consumption of fermented foods (eg, yogurt, lactic acid beverages, and fermented soybeans) and psychological distress in a large sample of Japanese women (n = 9030).

Only 3 studies examined the relationship between fish or seafood intake and the presence of depressive symptoms in pregnancy,[44,49,50] and findings conflicted. For example, Miyake et al[50] found that pregnant women who scored in the highest quartile of fish intake had a significantly lower prevalence of depressive symptoms (adjusted odds ratio, 0.61; 95%CI, 0.42–0.87) compared with those in the lowest quartile among a sample of Japanese women (n = 1745). Alternatively, Sontrop et al[44] found no relationship between fish intake and depressive symptoms after adjusting for confounders.

Miyake et al[23] found that higher intake of total soy products, tofu, tofu products, fermented soybeans, boiled soybeans, and miso soup were independently associated with a lower prevalence of depressive symptoms between extreme quartiles. Adjusted prevalence ratios (95% CI; *P* for trend) were 0.63 (0.47–0.85; 0.002), 0.72 (0.54–0.96; 0.01), 0.74 (0.56–0.98; 0.04), 0.57 (0.42–0.76; < 0.001), 0.73 (0.55–0.98; 0.03), and 0.65 (0.49–0.87; 0.003), respectively.[23]

Two studies examined the relationship between fast-food intake and mental health in pregnancy. Overall, these studies found that higher stress and/or higher depressive symptoms were significantly associated with more fast-food intake among pregnant women, which negatively affected their diet quality.[14,52] For example, Fowles et al[14] found that eating fast food ≥ 3 times in the past week was associated with having significantly higher stress levels (mean $\pm$ standard deviation, 23.7 ± 6.8 vs 18.9 ± 4.1; 95%CI, −7.87 to −1.70) and higher depressive symptoms (10.4 ± 6.0 vs 6.8 ± 4.1; 95%CI, −6.45 to −0.71) compared with eating fast food less frequently in a largely Hispanic sample (n = 50) of pregnant women.

Overall, study findings suggest higher depressive symptoms and pregnancy-specific stress were associated with higher unhealthy dietary pattern scores and lower healthy dietary pattern scores. Regarding comprehensive diet quality, higher stress levels and higher depressive symptoms were mostly associated with lower diet quality scores in pregnancy; however, evidence is very limited, and 1 study found no association. Associations of mental health with the consumption of specific food

groups were inconclusive. Higher stress levels and higher depressive symptoms may be associated with lower fruit and vegetable consumption and greater quantity of fat intake. There was limited evidence in support of greater quantity of yogurt consumption and lower prevalence of depressive symptoms, and associations of fish/seafood consumption with depressive symptoms were conflicting. Poor mental health was consistently associated with more fast-food consumption. Last, there was a predominant focus on depressive symptoms, with fewer studies investigating stress in relation to diet quality.

DISCUSSION

In this study, we aimed to examine associations of stress and/or depressive symptoms with diet quality during pregnancy; review the measurement tools used to assess stress, depressive symptoms, and diet quality; identify current gaps in the literature; and offer recommendations for future research. Higher stress and higher depressive symptoms were associated with higher unhealthy dietary pattern scores and lower diet quality index scores in pregnancy. Similarly, lower stress and lower depressive symptoms were associated with higher healthy dietary pattern scores. We found limited and inconclusive evidence for associations of stress and/or depressive symptoms with the consumption of specific food groups (ie, fruits, vegetables, dairy, fish/seafood) and fast-food consumption. Overall, there was a dominant focus on depressive symptoms, with fewer studies investigating stress in relation to diet quality in pregnancy.

Conflicting findings could be influenced by sample characteristics, assessment tools used, and timing of assessments. Most studies were conducted with samples outside of the US and with factor analysis to identify dietary patterns, making it difficult to compare specialized patterns (ie, Japanese, common Brazilian, and Western) across populations.[46,47] Other authors have highlighted the need for high-quality studies that use standard definitions and methods of assessing diet quality and dietary patterns.[30,72,73] Studies that analyze dietary-intake data as a comprehensive diet quality score allow for a more standardized approach to compare findings across different populations. Although many studies used the EPDS to measure depressive symptoms, studies varied in their use of a continuous score or varying cutoff scores,[41,59] as evidenced in Table 2. Stress was assessed in multiple ways, including general and pregnancy-specific stress, limiting the ability to compare results across studies. In addition, studies varied in the number of covariates that were controlled for, with 4 studies not adjusting for any covariates[13,14,43,58]; however authors either found no significant differences in sample characteristics that could pose as confounding factors[14,58] or were unable to include covariates, due to small sample sizes.[13,43] In terms of timing of assessments, only 1 study reported findings across all 3 trimesters,[13] demonstrating varying results as pregnancy progressed.

The majority of the studies in this review were cross-sectional studies; a few were cohort studies. Thus, the direction of the relationship between mental health and diet quality is unclear. A bidirectional association is plausible for the relationship between depressive symptoms and diet quality during pregnancy.[41] Nutrition plays a role in influencing biological processes that underlie depressive illnesses,[74] such as inflammation,[75] the stress response system,[76] and oxidative processes.[77] Deficiencies in folate, vitamin B_{12}, iron, selenium, zinc, and polyunsaturated fatty acids are associated with depression in the general population.[78] Because pregnant women have increased nutrient needs for proper fetal development, they may be more susceptible to the effects of poor nutrition on depression.[29] More large-scale, prospective cohort studies are needed that assess stress, depressive symptoms, and diet quality across multiple times to help determine the direction of the relationship.[30]

A recent feasibility study found that 2 novel, 8-week, stress-reduction interventions facilitated meaningful reductions in stress and depressive symptoms and improved eating behaviors among a sample of multiethnic, low-income, pregnant women with overweight and obesity.[79] Future studies could also investigate the effectiveness of stress management interventions in improving diet quality during pregnancy on a larger scale through randomized controlled trials. In addition, because fast-food consumption contributes to poor diet quality, addressing fast-food consumption may be a leverage point for future dietary interventions in pregnancy. Given the wide variability in the way diet quality was assessed, studies should use standardized diet quality indices to enhance consistency in measurement. There is also room for improvement in the racial diversity of study samples.

When considering the racial and ethnic diversity of women in the US studies, 3 studies consisted primarily of Hispanic women (> 45%),[14,18,43] and only 2 studies had participant samples of which > 20% were African American.[13,52] This is a major gap in the literature, because African American women have disproportionately high rates of obesity,[80] worse diet quality,[81] increased risk of excessive GWG,[82] and are more likely to retain excess weight after delivery[1,82–85] compared with their white counterparts. Given the racial disparities related to obesity, GWG, and diet quality between white and African American US women, it is imperative that African American and minority women overall are adequately represented in studies to better understand

the contextual factors influencing diet quality and to develop culturally relevant interventions to improve diet quality.

A 2010 Institute of Medicine report specified the need to investigate multiple levels of influence on eating to inform systems-level approaches for obesity prevention in the US[86] In only 1 study[40] in this review did authors report a specific framework that informed their research (ie, Theory of Planned Behavior), which focused on individual-level factors. Examining multiple levels of influence (eg, intrapersonal-, interpersonal-, and environmental-level factors) can help improve our understanding of these complex relationships and inform policy-, systems-, and environmental-level initiatives to improve health.[87]

A major strength of this study is that it synthesizes literature on associations of stress and/or depressive symptoms with diet quality during pregnancy, which has not been thoroughly researched. Also, the review is exhaustive because it involved multiple reviewers, involvement of a research librarian, 5 databases, and a thorough review of the measurement tools used to assess stress, depressive symptoms, and diet quality during pregnancy. This study also highlights important gaps in the literature that need to be addressed to achieve health equity. This review identified the following gaps: (1) limited use of longitudinal study designs assessing variables at multiple times throughout pregnancy; (2) paucity of studies that have examined overall diet quality using comprehensive indices; (3) underrepresentation of minority women in samples; and (4) lack of theoretical frameworks that bridge multiple levels of influences to explain diet quality in pregnancy beyond individual-level factors.

Regarding limitations, only English-language papers were included, which may limit the generalizability of findings. Because this is a growing area of research, there are limited sources of data. For example, 4 studies came from the Avon Longitudinal Study of Parents and Children cohort in England,[41,45,49,60] 4 studies came from the Kyushu Okinawa Maternal and Child Health Study cohort in Japan,[23,46,50,51] and 3 studies came from the same research group in Texas.[14,18,43] This may limit the generalizability to other study populations. In addition, the exclusion of broad search terms (eg, health behavior) could have excluded studies that examined eating within assessments of other health behaviors. Search terms were not cross-referenced with the tools used to operationalize eating, which may have inadvertently excluded potentially relevant studies from the search results. Furthermore, interrater reliability was not calculated, so the exact agreement between raters is unknown. Depressive symptoms can coexist or overlap with other mental health conditions (eg, anxiety, generalized negative affect); however, this study is limited to 2 aspects of mental health. Future studies should examine how other mental health concerns could be associated with diet quality. There also could potentially be a confounding variable explaining the associations between mental health and diet quality (eg, poverty, food insecurity, unplanned pregnancy, intimate partner violence) that should be explored in future research.

CONCLUSION

In this review, we highlight the limited amount of research that has been conducted on associations of stress and/or depressive symptoms with diet quality during pregnancy. Overall, the findings suggest that higher stress levels and higher depressive symptoms are associated with unhealthy dietary patterns. Pregnancy-specific stress should be further investigated but is associated with higher scores on unhealthy dietary patterns and lower scores on healthy dietary patterns. Few studies have examined mental health in relation to diet quality indices in pregnancy; however, findings show that higher stress levels and higher depressive symptoms are associated with poorer diet quality index scores. During pregnancy, women have an increased risk of experiencing stress and depressive symptoms, both of which have been associated with poor diet quality.[30] In general, diet quality during pregnancy is inadequate,[88] and nutrition is very important during pregnancy.[5,89] Thus, there is a need to identify and examine factors that contribute to poor diet quality in pregnancy. Clinical health professionals should consider implementing standardized screening practices to identify women with high stress levels and high depressive symptoms during prenatal care visits who may need targeted dietary or mental health interventions or referral to additional resources. Pregnancy is an important time to optimize maternal diet quality and mental well-being to increase chances of positive health outcomes for mothers and children.

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