A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults$^{1-3}$

Jun S Lai, Sarah Hiles, Alessandra Bisquera, Alexis J Hure, Mark McEvoy, and John Attia

ABSTRACT

Background: Studies of single nutrients on depression have produced inconsistent results, and they have failed to consider the complex interactions between nutrients. An increasing number of studies in recent years are investigating the association of overall dietary patterns and depression.

Objective: This study aimed to systematically review current literature and conduct meta-analyses of studies addressing the association between dietary patterns and depression.

Design: Six electronic databases were searched for articles published up to August 2013 that examined the association of total diet and depression among adults. Only studies considered methodologically rigorous were included. Two independent reviewers completed study selection, quality rating, and data extraction. Effect sizes of eligible studies were pooled by using random-effects models. A summary of the findings was presented for studies that could not be meta-analyzed.

Results: A total of 21 studies were identified. Results from 13 observational studies were pooled. Two dietary patterns were identified. The healthy diet pattern was significantly associated with a reduced odds of depression (OR: 0.84; 95% CI: 0.76, 0.92; \( P < 0.001 \)). No statistically significant association was observed between the Western diet and depression (OR: 1.17; 95% CI: 0.97, 1.68; \( P = 0.094 \)); however, the studies were too few for a precise estimate of this effect.

Conclusions: The results suggest that high intakes of fruit, vegetables, fish, and whole grains may be associated with a reduced depression risk. However, more high-quality randomized controlled trials and cohort studies are needed to confirm this finding, specifically the temporal sequence of this association.


INTRODUCTION

Depression is a common mental health disorder and is estimated to affect 350 million people worldwide (1). It is expected to be the world’s second leading cause of disease burden by the year 2020. Depression is associated with decreased productivity, poor psychosocial outcomes, and decreased quality of life and well-being (2). In addition, health care services to manage this condition cost governments billions of dollars each year (1). In view of its public health impacts, there is a need for new approaches to prevent depression or to delay its progression.

There has been much debate within the past few years regarding the development of universal interventions to prevent those at high risk of developing depression and those with current depressive symptoms from developing major depressive disorder (3, 4). However, most research for depression has been devoted to tertiary treatment, including individualized pharmacologic and psychological treatments (5). There is a need for more research focused on the prevention of depression among community-dwelling individuals.

An emerging body of evidence has suggested that nutrition plays an important role in mental health (6, 7). In the past, most studies have focused on the association of depression with specific nutrients or foods (6). However, the effect of nutrition on health is complex and often involves interactions between different nutrients and a variety of food components in addition to health behaviors. In view of this, there has been a shift in focus from the study of single nutrients toward total diet and dietary patterns in recent years (8). Two main approaches have been used to identify patterns of dietary intake. The a priori approach uses diet quality scores or indexes, based on dietary guidelines, to assess an individual’s adherence to a predefined dietary pattern (8). The a posteriori approach makes use of statistical exploratory methods to identify major dietary patterns based on dietary intake reported by a population (8).

As new studies investigating the association of dietary patterns with depression emerge, a systematic collection and evaluation of these findings will provide a better understanding of the role of total diet on the risk of depression. This systematic review aimed to critically appraise current literature and conduct meta-analyses to synthesize the results of studies on dietary patterns and depression among the general population.

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic reviews and Meta-Analyses statement was used for writing up this systematic review (9).

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Search strategy

An electronic literature search was conducted of 6 databases: Medline, Embase and PsycInfo via Ovid (http://www.ovid.com/); Cumulative Index to Nursing and Allied Health Literature via EBSCO (http://www.ebscohost.com/cinahl/); Scopus (http://www.scopus.com/); and Proquest (http://www.proquest.com/), for articles published up to August, 2013. The following keywords and index terms were used: “nutrition” or “diet*” or “dietary pattern” or “diet quality” or “food habits” or “nutrition surveys” or “diet surveys” or “food-frequency questionnaire” or “diet records” AND “depression” or “depressive disorder” or “affect*” or “psychological stress” or “depressive symptoms.” All searches were limited to human studies published in the English language.

Study selection

Titles and abstracts of all articles retrieved in the initial search were evaluated independently by 2 reviewers (JSL and SH). Articles not meeting the eligibility criteria were excluded by using a hierarchical approach based on study design, population or exposure, and outcome. The reference lists of relevant review articles identified during this process were also examined to include additional studies. Full-text articles were retrieved if the citation was considered eligible, and subjected to a second evaluation for relevance by the same reviewers. Any disagreements were discussed and resolved by consensus or by a third independent reviewer (AJH) if necessary.

Eligibility criteria

Relevant articles were obtained and included in this review if they 1) examined whole diet (regardless of methods used to define dietary patterns) and included measurements of all dietary components by using a 24-h dietary recall, food record, food-frequency questionnaire (FFQ), or similar instruments; 2) included depressive symptoms, depressive disorder, or dysthymia as an outcome measure; and 3) enrolled community-dwelling adults. Articles were excluded if they 1) examined only individual nutrients or did not examine all dietary components, 2) did not report depression data in a format that could be extracted, or 3) comprised study samples that were not population based or only focused on a subgroup of individuals with nutritional needs that are different from the general population or individuals with health conditions that may confound the diet-depression relation. The inclusion and exclusion criteria for the selection of studies based on 3 main items—population, exposure, and outcome—are outlined in Table 1.

Quality assessment

Articles considered for inclusion after the second evaluation were assessed for methodologic quality independently by 2 reviewers (JSL and SH or AJH). The quality of all articles was assessed by using the American Dietetic Association Quality Criteria Checklist for primary research (10). The articles were rated based on 4 questions addressing relevance to practice and 10 validity questions addressing scientific soundness. The articles were subjected to validity assessment only if the answers to all relevance questions were “Yes.” For each validity question, the reviewers assigned “Yes” if the criterion was met, “No” if the
criterion was not met, “Unclear” if the criterion was not clearly described, or “N/A” (not applicable) if the criterion did not apply to the study. The answers for each article were tabulated, and a rating of positive, negative, or neutral was assigned. Any disagreements that arose between the reviewers were resolved through discussion. Positive articles with ≥6 of the answers to the validity questions being “Yes,” including all 4 priority questions, were considered methodologically rigorous and were included. Negative articles with ≥6 of the answers to the validity questions being “No” or “Unclear,” did not meet the criteria of a strong quality study and were therefore excluded. If at least one of the answers to the priority validity questions was “No” or “Unclear,” the articles were rated “Neutral,” and these were subjected to a second quality assessment. This second stage assessed the quality of the dietary assessment tool used in each “Neutral” article. All “Neutral” articles used an FFQ to assess dietary intake. If the FFQ was validated, the full text of the validation study was retrieved and assessed by using the European Micronutrient Recommendations Aligned Network of Excellence scoring system (11). Dietary assessment tools scoring >5 were rated “excellent,” scoring 3.5–5 were rated “good,” scoring 2.5–3.5 were rated “acceptable,” and scoring <2.5 were rated “poor.” If the FFQ was not validated, it was rated “poor.” Neutral articles that used a “poor” dietary assessment tool were excluded.

Data extraction

Data extractions were performed by 2 independent reviewers (JSL and SH, or E Gresham) and entered into a predefined data extraction form. Discrepancies in data extraction were discussed and resolved by consensus. If there were multiple publications originating from the same study cohort, the article reporting the largest sample for the diet and depression measures was chosen.

The following information was extracted: first author, publication year and country, study design, study duration (for cohort studies), sampling frame, sample size, number of cases and controls (if available), dietary assessment tool and validation method (if applicable), method of identifying dietary patterns, dietary patterns identified, depression assessment tool, confounders adjusted for in analysis, and main findings, including the estimates of association. When a study provided several estimates with adjustment for different confounders, results were reported for the one adjusting for the largest number of factors.

Data synthesis

Only the most common patterns of dietary intake or dietary interventions were considered for meta-analysis. Because the labeling of dietary patterns varied across studies, as long as the selected patterns were similar with regards to the most frequently consumed foods, these studies were grouped and analyzed together regardless of their original label. For example, most studies examined dietary patterns with a high intake of fruit and vegetables, fish, and whole grains, and these studies were pooled and analyzed together and the corresponding dietary pattern was labeled “Healthy.” Studies not eligible for inclusion in the meta-analysis were summarized in a narrative review.

Statistical analysis

The original studies reported the results of dietary pattern either as categories of dietary factor scores, as continuous diet-quality scores, or standardized dietary factor scores. To combine the results, a meta-analysis was conducted in which we evaluated depression outcomes for higher compared with lower intakes of dietary patterns: highest compared with lowest categories of dietary pattern or standardized dietary factor scores. For observational studies with depression as a binary outcome, ORs, and 95% CIs from individual studies were combined. If studies reported RR instead of OR, it was treated the same as OR if the reported incident depression was ≤20%. If studies treated depression as a continuous variable by way of regression coefficients or as a mean difference in depression score between categories of dietary pattern, standardized coefficients or standardized mean difference and their corresponding SEs were multiplied by 1.81 to convert them to log ORs and the corresponding SEused OR according to the Hasselblad and Hedges method (12, 13).

Random-effects models were used for the analysis. Heterogeneity was assessed by using the I² statistic (14). If results showed significant heterogeneity, potential sources of heterogeneity were explored by using meta-regression and subgroup analysis, with the following covariates: age (as continuous variable and age groups: <65 or ≥65 y), sex, country (United States or European countries), study design, methods used to identify dietary patterns (a posteriori or a priori), dietary intake assessment (FFQ or dietary recalls), depression measure (symptom inventories or diagnostic), percentage of depression cases at baseline (as continuous variable and <20% or ≥20%), and methodologic quality (“Positive” or “Neutral”). Publication bias was examined through a contour-enhanced funnel plot to look for asymmetry (15). All statistical analyses were conducted by using Stata version 11 (StataCorp) (16).

RESULTS

Search results

A flowchart detailing the process of study selection is shown in Figure 1. The search yielded 3477 citations (excluding duplicates, n = 1025). Initial screening of title and abstract excluded 3290 citations. Hand-searching of a reference list of review articles further identified 11 references. Full texts for eligible citations were obtained for further evaluation. Assessment of methodologic quality was performed on 45 full-text articles. The final number of articles eligible for inclusion in this review was 25. However, data from only 21 of the articles was included, to avoid duplicating the results of any individual participant (ie, there were 4 articles that duplicated data from 3 cohorts). In total, there were 20 observational studies (17–36) and 1 randomized controlled trial (RCT) (37). Because of a lack of RCTs, subsequent results focus on the observational studies.

Quality

All 45 full-text articles scored “Yes” to all the relevance questions and were subjected to validity assessment. Out of a maximum of 10 “Yes” answers for the validity questions, the highest score was 9 and the lowest score was 2 (see Supplemental Table 1 under “Supplemental data” in the online issue).
Eleven studies were rated negative, scoring ≤5 “Yes,” and were excluded. Thirteen studies were rated “Neutral.” These neutral studies were subjected to the European Micronutrient Recommendations Aligned Network of Excellence scoring system (results not shown). Nine of the neutral studies used a non-validated FFQ to assess dietary intake and were therefore eliminated from this review. These 9 eliminated studies used either a self-constructed FFQ with no mention of whether they were validated or a modified versions of validated FFQs that were not revalidated. The FFQs in the remaining 4 studies were rated “good,” scoring between 3.5 and 5.

Description of studies

The characteristics of the studies included in this review are presented in Table 2. Six studies were conducted in European countries (21–23, 25, 31, 32), 6 in the United States of America (17–19, 24, 26, 33), 4 in Australia (20, 23, 28, 30), 2 in Japan (29, 34), one in Taiwan (35), and 1 in the United Kingdom (36). The total number of participants ranged from 52 to 50,605. Participants’ ages ranged from 20 to 94 y at the time of study. Five studies were restricted to female subjects (19, 20, 23–25). The remaining 15 examined both sexes with 5 examining men and women separately (17, 18, 22, 31, 36) and 10 in combination (20, 21, 26–29, 32–35). Most of the observational studies were cross-sectional (n = 13) and measured dietary intake and depression concurrently (17, 18, 20–24, 26–29, 31, 34). Four were prospective cohorts that measured dietary intake at baseline and used repeated measures of depression outcomes at baseline and at each follow-up (30, 32, 33, 35). Another 2 prospective cohort studies used repeated measure of dietary intake and depression outcomes at baseline and at every follow-up (19, 36). There was one case-control study of dietary patterns in people with and without seasonal affective disorder (25). Dietary variables were measured by using a variety of instruments. Most studies used validated FFQs (n = 16) (19–23, 25–27, 29–36), whereas the remaining studies used 24-h dietary recalls (n = 4) (17, 18, 24, 28). Depression was assessed by using depressive symptom inventories (n = 15) (17, 20–22, 24–27, 29–31, 33–36), diagnostic interview schedules (n = 2) (18, 23), or self-reported clinical diagnosis (n = 3) (19, 28, 32). The Centre for Epidemiologic Depression Scale was the most commonly (n = 12) used symptom inventories to assess depressive symptoms (17, 20, 21, 24, 26, 29–31, 33–35).
### TABLE 2
Characteristics of observational studies that examined the effects of dietary interventions and depression

<table>
<thead>
<tr>
<th>Author, year, country, study design</th>
<th>Subjects</th>
<th>Dietary assessment</th>
<th>Methods defining dietary patterns</th>
<th>Dietary patterns identified</th>
<th>Depression assessment</th>
<th>Adjustment for confounders</th>
<th>Main findings</th>
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<tbody>
<tr>
<td>Akbaraly, 2009 (38), UK, cohort (5 y)</td>
<td>The Whitehall II Study cohort, civil servants working in London offices (n = 3486; age: 35–55 y; 73.8% men; cases: n = 416)</td>
<td>FFQ, 127 items, validated against 7-d diet diary and biomarkers; measured at baseline</td>
<td>Factor analysis: tertiles of factor scores</td>
<td>Processed food–high intakes of sweetened desserts, chocolates, fried food, processed meat, pies, refined grains, high-fat dairy products, condiments</td>
<td>CES-D, 20 items, measured at baseline and 5-y follow-up; depression &gt;15</td>
<td>Age, sex, energy intake, employment grade, marital status, smoking, physical activity, hypertension, diabetes, CVD, stroke, antidepressants use, cognitive functioning</td>
<td>Highest tertile of processed food pattern: OR (1.58), 95% CI (1.11, 2.23)</td>
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<td>Akbaraly, 2013 (36), UK, cohort (15 y)</td>
<td>(n = 4215; cases = 260) (as above); measured at baseline and 10 y later</td>
<td>AHEI (0–10); higher scores indicate greater adherence</td>
<td>(as above); measured at baseline and 10-y and 15-y follow-up; depression &gt;15 at both follow-ups</td>
<td>High intake of fruit and vegetables (except potatoes), nuts and soy, cereal fiber; higher fish/poultry; red/processed meat ratio; PUFA:MUFA ratio; low intake of trans fat; moderate alcohol intake; long term multivitamin use</td>
<td></td>
<td>Age, ethnicity, energy intake, SES, retirement, marital status, smoking, physical activity, hypertension, coronary artery disease, HDL cholesterol, central obesity</td>
<td>Women who maintained a high AHEI score compared with women who maintained a low score over 10 y: OR (0.35), 95% CI (0.19, 0.64) Men who maintained a high AHEI score compared with men who maintained a low score over 10 y: OR (1.38), 95% CI (0.91, 2.11)</td>
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<tr>
<td>Chocano-Bedoya, 2013 (19), USA, cohort (12 y)</td>
<td>The Nurses' Health Study cohort, female US registered nurses (n = 50,605; age: ~62 y; cases: 6–15%)</td>
<td>FFQ, 131 items, validated against four 1-wk dietary records; measured at baseline and every 4 y</td>
<td>Factor analysis: quintiles of factor scores</td>
<td>Prudent–higher loadings from fruit, vegetables, fish, whole-grain products, low-fat dairy products</td>
<td>Strict definition: self-reported both a clinical diagnosis of depression and use of antidepressants after baseline</td>
<td>Age, total caloric intake, BMI, smoking status, physical activity, menopause status, use of hormonal replacement therapy, marital status, multivitamin use, retired, participation in community groups, caffeine intake, diagnosis of cancer, diabetes, hypertension, hypercholesterolemia, heart disease, psychological stress, or well-being at baseline</td>
<td>Strict definition incident depression: Prudent: RR (1.05), 95% CI (0.91, 1.20), P = 0.73; Western: RR (1.05), 95% CI (0.89, 1.23), P = 0.50 Broad definition incident depression: Prudent: RR (1.04), 95% CI (0.95, 1.13), P = 0.79; Western: RR (1.09), 95% CI (0.99, 1.21), P = 0.08</td>
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<td>Rienks, 2013 (30), Australia, cohort (3 y)</td>
<td>The Australian Longitudinal Study of Women’s Health cohort, national sample of Australian women ( n = 6060 ); age: 45–50 y; cases: ( n = 873 ) at 3 y follow-up</td>
<td>FFQ, 80 items, validated against 7-d weighted food records; measured at baseline</td>
<td>Factor analysis: quintiles of dietary factor scores</td>
<td>Cooked vegetables—cauliflower, cabbage, Brussels sprouts, broccoli, green beans&lt;br&gt;Fruit: strawberries, pineapple, melon, apricots, mango&lt;br&gt;Mediterranean—garlic, peppers, mushrooms, salad greens, pasta, red wine&lt;br&gt;Meat and processed meat—pork, bacon, sausages, lamb&lt;br&gt;Dairy—cream cheese, low-fat cheese, yogurt, skim milk&lt;br&gt;High fat and sugar—sweet biscuits, cakes, jam, meat pies, chocolate</td>
<td>CES-D, 10 items, measured at baseline and 3 y follow-up; depression ≥10</td>
<td>Age, area of residence, ability to manage on available income, occupation, education, marital status, smoking, physical activity, BMI, total energy intake, history of non-insulin-dependent diabetes mellitus, hypertension, heart disease, stroke, mean stress score</td>
<td>Cooked vegetables: OR (0.95), 95% CI (0.85, 1.06), ( P = 0.32 )&lt;br&gt;Fruit: OR (1.04), 95% CI (0.94, 1.16), ( P = 0.44 )&lt;br&gt;Mediterranean: OR (0.83), 95% CI (0.75, 0.93)&lt;br&gt;Meat and processed meat: OR (1.06), 95% CI (0.93, 1.21), ( P = 0.37 )&lt;br&gt;Dairy: OR (0.93), 95% CI (0.84, 1.04), ( P = 0.22 )&lt;br&gt;High fat and sugar: OR (1.02), 95% CI (0.92, 1.14), ( P = 0.73 )</td>
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Sanchez-Villages, 2009 (32), Spain, cohort (4.4 y) | The Seguimiento Universidad de Navarra’ Study cohort, alumni of the University in Spain \( n = 10,094 \); age: 21–85 y; sex: 58.5% women; cases: \( n = 480 \) | FFQ, 136 items, validated against nonconsecutive 4-d food records, measured at baseline | Mediterranean-diet score (0–9): higher scores indicate greater adherence; 5 categories of adherence (lowest – highest): 0–2, 3, 4, 5, 6–9 | High ratio of MUFA to SFA; high intakes of legumes, cereal, fruit and nuts, vegetables, fish; low intake of meat and meat products; moderate intake of dairy products, alcohol | Self-reported physician diagnosis, and/or use of antidepressant at baseline and 4.4 y follow-up | Age, sex, marital status, no. of children, employment status, no. of work hours, BMI, energy intake, physical activity, smoking, health consciousness/ proxies of overall healthier lifestyle | Highest compared with lowest adherence: HR (0.5), 95% CI (0.33, 0.74) |
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<td>Skarupski, 2013 (33), USA, cohort (12 y)</td>
<td>The Chicago Health &amp; Aging Project cohort, black and White residents in 3 southside Chicago neighborhoods ($n = 3502$; age ≥65 y; sex: 41% male; cases: 13.7%, 10.7%, 13.4% at each follow-up, respectively)</td>
<td>FFQ, 139 items, validated against multiple 24-h recalls, measured at baseline</td>
<td>MedDiet Score (0–55): higher scores indicate greater adherence; tertiles of adherence</td>
<td>CES-D, 10 items, yes/no version, measured at baseline and every 3 y; depression ≥ 4</td>
<td>Age, sex, race, education, yearly personal income, widowhood, total calorie intake, BMI, smoking, alcohol consumption, myocardial infarction, stroke, cancer, diabetes, high blood pressure, Parkinson disease, shingles, thyroid disease, hip fracture, global cognitive function, physical disability</td>
<td>Highest tertile of MedDiet Score compared with lowest tertile: $\beta = 0.03$, SE 0.01</td>
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<td>Tsai, 2012 (35), Taiwan, cohort (4 y)</td>
<td>The Survey of Health and Living Status of the Elderly in Taiwan cohort, national sample of Taiwanese ($n = 1609$; age ≥60 y; sex: 57.6% men; cases ~ 21%)</td>
<td>FFQ, validated against 14-d food diary, measured at baseline</td>
<td>Food groups analysis: all dietary components examined</td>
<td>CES-D, 10 items, measured at baseline and 4 y follow-up; depression ≥10</td>
<td>Age, sex, years of formal education at baseline, economic status, living setting, smoking status, alcohol drinking, betel-nut chewing, functional status, physical exercise, hypertension, diabetes, heart disease, cancer, stroke, chronic kidney disease, gout, joint pain/arthritis, gallbladder/liver disease, hip fracture, lower-back pain, cognitive status</td>
<td>Consumption of ≥3 times/wk compared with &lt;3 times/wk: Meat and poultry: OR (1.31), 95% CI (0.90, 1.91), $P = 0.158$; Eggs: OR (0.73), 95% CI (0.50, 1.03), $P = 0.069$; Seafood: OR (0.92), 95% CI (0.51, 1.65), $P = 0.773$; Fish: OR (0.91), 95% CI (0.62, 1.14), $P = 0.622$; Fruit: OR (0.77), 95% CI (0.50, 1.17), $P = 0.215$; Vegetables: OR (0.40), 95% CI (0.17, 0.95), $P &lt; 0.05$; Cereal/grains: OR (0.85), 95% CI (0.58, 1.26), $P = 0.423$; Tea: OR (0.77), 95% CI (0.51, 1.16), $P = 0.211$</td>
<td>(Continued)</td>
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<td>Beydoun and Wang (18), 2010, USA, cross-sectional</td>
<td>The NHANES study cohort (n = 2217; age: 20–39 y; sex: n = 977 men, n = 1240 women; cases: 6.4% men, 9.2% women)</td>
<td>One 24-h recall</td>
<td>Healthy Eating Index 2005 (0–100): higher scores indicate greater adherence to 2005 Dietary Guidelines for Americans</td>
<td>High intakes of fruit, vegetables, legumes, whole grains, low-fat dairy products; moderate intakes of lean meat/poultry; low intakes of SFAs, sodium, alcohol, added sugars</td>
<td>Composite International Diagnostic Interview for ICD-10</td>
<td>Age, ethnicity, marital status, food insecurity</td>
<td>Men: β = 3.29, SEE 2.12, P &gt; 0.05; women: β = 2.63, SEE 1.96, P &gt; 0.05</td>
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<td>Beydoun, 2010 (17); Kucmarski, 2010 (39); Beydoun, 2009 (40); USA, cross-sectional</td>
<td>The HANDLS Study cohort (n = 1681; age: 30–64 y; sex: n = 734 men, n = 947 women; cases: n = 156 men, n = 304 women)</td>
<td>Two nonconsecutive 24-h dietary recalls (second recall collected 4–7 d after the first recall)</td>
<td>Healthy Eating Index 2005 (0–100): higher scores indicate greater adherence to 2005 Dietary Guidelines for Americans</td>
<td>High intakes of fruit, vegetables, legumes, whole grains, low-fat dairy products; moderate intakes of lean meat/poultry; low intakes of SFAs, sodium, alcohol, added sugars</td>
<td>CES-D, 20 items</td>
<td>Age, ethnicity, marital status, education, poverty status, smoking status, illicit drug use, BMI</td>
<td>Women: β = –0.083, SE 0.023; Men: β = –0.045, SE 0.024, P &gt; 0.05</td>
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<td>Crichton, 2013 (20), Australia, cross-sectional</td>
<td>Representative sample of South Australian (n = 1183; age: 40–65 y; sex: 751 women, 432 men)</td>
<td>FFQ, 215 items, validated against protein and urinary measures</td>
<td>Mediterranean diet score (0–11): higher scores indicate greater adherence; 3 categories of adherence: low (0–3), medium (4–7), high (8–11)</td>
<td>High intakes of vegetables, fruit and nuts, legumes, cereals, olive oil, fish; moderate intakes of dairy products, red wine; low intakes of meat, poultry, saturated fats</td>
<td>CES-D, 20 items</td>
<td>No adjustment of confounders—no significant differences for all measures of socioeconomic status between categories of Mediterranean diet adherence</td>
<td>Average depression score for each category of diet score (mean ± SD: low, 33.4 ± 9.7; medium, 32.9 ± 9.9; high, 32.6 ± 9.9)</td>
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<td>Feart, 2009 (21), France, cross-sectional</td>
<td>The Three-City Study, community-dwelling adults (n = 1410; age ≥65 y; sex: 60% women)</td>
<td>FFQ, 40 item, validated against dietary recalls</td>
<td>Mediterranean diet score (0–9): higher scores indicate greater adherence; 3 categories of adherence (lowest to highest: 0–3, 4–5, 6–9)</td>
<td>High ratio of MUFA to SFA; high intakes of legumes, cereal, fruit and nuts, vegetables, fish; low intakes of meat and meat products; moderate intakes of dairy products, alcohol</td>
<td>CES-D, 20 items</td>
<td>No adjustment for confounders</td>
<td>Depression score for each category of adherence (mean ± SD: low, 8.2 ± 7.4; middle, 7.5 ± 7.5; high, 7.3 ± 6.8)</td>
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<td>Jacka, 2010 (23), Australia, cross-sectional</td>
<td>Geelong Osteoporosis Study cohort of women (n = 1046); age: 20–94 y; cases: (n = 60)</td>
<td>FFQ, 74 foods and beverages, validated against 7-d weighed food record</td>
<td>Factor analysis, standardized dietary factor score: higher factor scores indicate greater consumption</td>
<td>Western–meat pies, processed meats, pizza, chips, hamburgers, white bread, sugar, flavored milk drinks, beer</td>
<td>The Structured Clinical Interview for DSM-IV-TR Research Version, Non-Patient Edition</td>
<td>Age, socioeconomic status, physical activity, alcohol consumption, smoking, energy intake, BMI</td>
<td>Western diet: OR (1.52), 95% CI (0.96, 2.41), (P &gt; 0.05)</td>
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<td>Australian Recommended Food Score (0–74): higher scores indicate greater adherence</td>
<td>Modern–fruit and salads, fish, tofu, beans, nuts, yoghurt, red wine</td>
<td>Traditional–vegetables, fruit, beef, lamb, fish, whole-grain foods ≥2 servings fruit and ≥4 servings vegetables daily; red meat 1–5 serving/wk, low-fat dairy products, whole-grain foods</td>
<td>Traditional dietary pattern: OR (0.65), 95% CI 0.43, 0.98, (P &lt; 0.05)</td>
<td>ARFS: OR (0.85), 95% CI (0.62, 1.13)</td>
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<td>Jacka, 2011 (22), Norway, cross-sectional</td>
<td>The Hordaland Health Study cohort, community-dwelling adults (n = 5731); age: 46–49 y and 70–74 y; sex: (n = 2477) men, (n = 3254) women; cases: (n = 240) men, (n = 281) women</td>
<td>FFQ, 169 items, validated against weighed food records</td>
<td>Principal component analysis, standardized dietary factor score: higher factor scores indicate greater consumption</td>
<td>Western–liver, processed meats, pizza, salty snacks, chips, sugars and sweets, soft drinks, cake, ice cream</td>
<td>HADS, 7 items: Depression ≥8</td>
<td>Sex, age group (47-49 y, 70-74 y), income, education, physical activity, smoking, alcohol, and energy intakes</td>
<td>Western diet: men (OR: 0.87; 95% CI: 0.68, 1.11); women (OR: 1.25; 95% CI: 0.93, 1.68)</td>
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<td>Self-developed diet quality score (6–18): higher scores indicate a more healthy diet</td>
<td>Traditional–fish and shellfish, potatoes, fruit, vegetables, milk, yoghurt, bread, pasta, rice, meat spreads, legumes, eggs</td>
<td>Traditional dietary: men (OR: 0.77; 95% CI: 0.61, 0.96); women (OR: 0.99; 95% CI: 0.76, 1.29)</td>
<td>Healthy diet: men (OR: 1.02; 95% CI: 0.87, 1.19); women (OR: 0.68; 95% CI: 0.57, 0.82)</td>
<td>Diet quality scores: men (OR: 0.83; 95% CI: 0.7; 0.99); women (OR: 0.71; 95% CI: 0.59, 0.84)</td>
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<td>Klassen (24), 2009, USA, cross-sectional</td>
<td>African American women, residing in 11 public housing communities ($n = 156$; age: 20–50 y; cases: $n = 116$)</td>
<td>Three nonconsecutive 24-h dietary recalls (2 weekdays/1 weekend), across 21 d</td>
<td>Self-developed cancer prevention index based on dietary recalls</td>
<td>No alcoholic beverage intake; moderate caloric intake (1600–2200 kcal); moderate fat intake (&lt;30% of energy); ≥5 servings of fruit and vegetables; ≥65 on the Healthy Eating Index–2005</td>
<td>CES-D, 20 items; depression &gt;15</td>
<td>Age, depression, life events, smoking, expected future health, food from other sources, shopping transportation, meal planning</td>
<td>OR (0.45), 95% CI (0.22, 0.95), $P &lt; 0.05$</td>
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<td>Krauchi (25), 1988, Switzerland, case-control</td>
<td>Female outpatients with SAD; controls: hospital staff without psychiatric history ($n = 28$ cases, $n = 24$ controls; age: 27–73 y)</td>
<td>FFQ at each season, 33 food/drink items and 13 meal items; validation method not reported</td>
<td>Food and drink scores</td>
<td>Starch-rich foods, sugar-rich foods, protein-rich foods, fiber-rich foods, dairy products, alcohol, caffeine-containing drinks</td>
<td>A seasonal screening questionnaire</td>
<td>Age–analysis performed with SAD and controls matched for age</td>
<td>Food and drink scores (mean ± SD): starch-rich foods (cases = 61.7 ± 15.5; controls = 50.3 ± 15.1), fiber-rich foods (cases = 82.8 ± 27.9; controls = 61.6 ± 12.7)</td>
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<td>Kronish, 2012 (26), USA, cross-sectional</td>
<td>The REGARDS study cohort, population study of white and African American adults residing in 8 Southern US states ($n = 20,093$; age: ≥45 y; sex: 56% women; cases: 9.8%)</td>
<td>FFQ, 109 items, validated against multiple diet records</td>
<td>Self-developed dietary criteria</td>
<td>Fish ≥2 servings/wk; fruit and vegetables ≥4.5 cups/d; sodium &lt;1500 mg/d; sugar &lt;450 kcal/wk; fiber: carbohydrate ratio &gt;0.1</td>
<td>CES-D, 4 items; depression ≥4 points</td>
<td>Age, race, sex, geographic region of residence, education, income</td>
<td>Adjusted prevalence ratios from comparison with and without depressive symptoms: diet (&lt;2 out of 5 healthy diet criteria) 1.08, 95% CI (1.06, 1.10)</td>
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<td>Mamplekou, 2010 (27); Bountziouka, 2009 (41), Greek Islands and Cyprus, cross-sectional</td>
<td>The MEDIS Study cohort, community-dwelling adults ($n = 595$; age ≥65 y; sex: $n = 553$ men, $n = 637$ women; cases: $n = 161$ mild depression, $n = 246$ severe depression)</td>
<td>FFQ, 15 food groups, validation method not described</td>
<td>MedDietscore (0–55); higher scores indicate greater adherence</td>
<td>Daily: nonrefined cereals; vegetables (2–3 servings); fruit (6 servings); olive oil (main added lipid); weekly: fish (4–5 servings); poultry (3–4 servings); olives, pulses, and nuts (3 servings); potatoes; eggs (3–4 servings); Monthly: red meat and meat products (4–5 servings)</td>
<td>GDS (0-15); depression: mild (6–10), severe (11–15)</td>
<td>Age, sex, education status, BMI, physical activity status, presence and management of hypertension, hypercholesterolemia, and diabetes</td>
<td>OR (1.03), 95% CI (0.976, 1.09), $P = 0.99$</td>
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<td>Meyer, 2013 (28), Australia, cross-sectional</td>
<td>The Australian National Nutrition and Health Surveys cohort, national sample of community-dwelling adults ($n = 10,986$; age $\geq 18$ y; sex $= 52%$ women; cases: $n = 224$)</td>
<td>24-h dietary recall</td>
<td>Food groups analysis: all dietary components examined</td>
<td>Meat, poultry, game; milk products and dishes; vegetables (food groups found to be significant predictors of the logistic regression model)</td>
<td>Self-reported physician diagnosis</td>
<td>Age, sex</td>
<td>Meat, poultry, game: $\beta$ ($-29.9$), 95% CI (9.64, 9.6); milk products: $\beta$ (10.1), 95% CI (3.87, 6.8); vegetables: $\beta$ ($-15.7$), 95% CI (6.48, 5.9)</td>
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<td>Nanri, 2010 (29), Japan, cross-sectional</td>
<td>Full-time municipal employees ($n = 521$; age: 21–67 y; sex: 59.1% men; cases: $n = 186$)</td>
<td>Diet history questionnaire, 67 items, validated against 16-d weighed dietary records and biomarkers</td>
<td>Factor analysis: tertile of factor scores</td>
<td>Healthy Japanese–fruit, vegetables, soy products, mushrooms, green tea</td>
<td>CES-D, 20 items; depression $\geq 16$</td>
<td>Age, education, income, marital status</td>
<td>Healthy Japanese: $\text{OR (0.4), 95% CI (0.22, 0.71)}$ Animal food: $\text{OR (0.97), 95% CI (0.61, 1.55)}$ Westernized breakfast: $\text{OR (1.27), 95% CI (0.77, 2.1)}$</td>
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<td>Samieri, 2008 (31), France, cross-sectional</td>
<td>The Three-City Study cohort subsample, community-dwelling adults ($n = 1724$; age: $\geq 65$ y; sex: $n = 647$ males, $n = 1077$ females)</td>
<td>FFQ, 40 categories of food, validated against dietary recalls</td>
<td>Cluster analysis</td>
<td>Biscuits and snacking–biscuits and cakes, high energy intake</td>
<td>CES-D, 20 items</td>
<td>Age, education, income, marital status</td>
<td>Men: biscuits and snacking ($\beta = -0.06$; 95% CI: $-0.35, 0.23$); women: biscuits and snacking ($\beta = 0.13$; 95% CI: $-0.07, 0.02$)</td>
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<td>Sugawara, 2012 (34), Japan, cross-sectional</td>
<td>Residents of Iwaki district, Japan (n = 791; age: 22–86 y; sex: n = 488 females; cases: n = 97)</td>
<td>Diet history questionnaire, 65 items, validated against 16-d dietary records</td>
<td>Principal component analysis: tertiles of dietary pattern scores</td>
<td>Healthy–vegetables, seaweeds, tofu, fruit, fish Western–beef/pork, processed meats, mayonnaise/dressing, ice cream, bread, spaghetti and macaroni Bread and confectionery –confectioneries and bread, low intakes of vegetables Alcohol and accompanying–noodles, squid/ octopus/shrimp/shellfish, alcoholic beverages</td>
<td>CES-D, 20 items; depression ≥16</td>
<td>Age, sex, exercise habits, BMI, education, marital status, current smoking, history of hypertension and diabetes mellitus</td>
<td>Healthy: OR (1.03), 95% CI (0.57, 1.88), P = 0.920 Western: OR (0.71), 95% CI (0.39, 1.27), P = 0.246 Bread and confectionery: OR (1.02), 95% CI (0.59, 1.78), P = 0.941 Alcohol and accompanying: OR (0.94), 95% CI (0.55, 1.59), P = 0.807</td>
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1 AHEI, Alternative Healthy Eating Index; CES-D, Centre for Epidemiologic Depression Scale; CVD, cardiovascular disease; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; FFQ, food-frequency questionnaire; GDS, Geriatric Depression Scale; HADS, Hospital Anxiety and Depression Scale; HANDLS, Healthy Aging in Neighborhoods of Diversity across the Life Span; ICD, International Classification of Diseases; MEDIS, Mediterranean Islands Elderly; REGARDS, REasons for Geographic and Racial Differences in Stroke; SAD, seasonal affective disorder; SES, socioeconomic status.
The a priori approach (diet quality scores or indexes) was the most common method used to define dietary patterns (n = 13) (17, 18, 20–27, 32, 33, 36). Diet quality scores or indexes included the Mediterranean diet score (20, 21, 27, 32, 33), the USDA Healthy Eating Index (17, 18), the Alternative Healthy Eating Index (36), the Australian Recommended Food Score (23), and various other self-developed diet quality rating tools (22, 24, 25, 26). Included in this were 3 studies that used both the a priori and a posteriori method of defining dietary patterns (22, 23, 36), but only results for the a priori method were pooled for meta-analysis of the Healthy diet because it was the most commonly used method in other studies. Five studies used the a posteriori approach, which included factor analysis (n = 4) (19, 29, 30, 34) and cluster analysis (n = 1) (31). Although dietary patterns observed across studies varied according to country and methods used for defining dietary patterns, it was possible to identify 2 dietary patterns with similar characteristics that were common to most of the studies. The Healthy dietary pattern was characterized by high intakes of fruit, vegetables, fish, and whole grains. A second dietary pattern, the Western diet, was identified in studies using the a posteriori method. The Western diet generally consisted of refined grains, processed meat foods or snacks, and high-sugar and high-fat products. The remaining 2 studies performed separate analyses for each food group and depression (28, 35).

**Healthy diet**

The results of all studies that examined the association between higher compared with lower consumption of the Healthy diet and the odds of depression are shown in Figure 2. Subjects with higher consumption of the Healthy diet were shown to have a lower odds of depression (OR: 0.84; 95% CI: 0.76, 0.92; P < 0.001). There was strong evidence of heterogeneity (I^2: 81.8%; P < 0.001), which was further explored in meta-regression. All covariates investigated in the meta-regression provided a poor explanation of the heterogeneity (ie, negative-adjusted R^2, P > 0.05) (see Supplemental Table 2 under “Supplemental data” in the online issue). In addition, the analysis was repeated stratified according to each covariate. The results were consistent with that observed in meta-regression. The OR for each subgroup did not significantly change compared with the combined estimate of 0.84 (OR: 0.78–0.92), which indicated that the estimate is fairly robust. The CIs were largely overlapping for the subgroups compared. Considerable heterogeneity remained even after stratification (I^2 res > 70%).

**Western diet**

Results from the meta-analysis of the Western diet are presented in Figure 3. A trend toward a positive association between higher consumption of the Western diet and the odds of depression was observed, but this relation was not significant (OR: 1.17; 95% CI: 0.97, 1.41; P = 0.094). Further studies that examined this dietary pattern are needed to allow a robust interpretation of these results. Sources of heterogeneity were not investigated in studies that examined the Western diet because they are essentially the same studies that investigated the Healthy diet.

**Publication bias**

The contour-enhanced funnel plot of studies that examined the Healthy diet and the corresponding meta-analysis pooled estimate (OR: 0.84) are shown in Figure 4. Visual inspection of the plot suggests little evidence of publication bias. Study estimates were equally distributed in the middle and the left of the plot,
which indicated that studies of high statistical significance and nonsignificant studies were included. There is a suggestion of missing studies to the right of the plot, mainly in the area of statistical significance. It is unlikely that studies of statistical significance with results in the opposite direction (i.e., a Healthy diet increasing the risk of depression) would not be published, if methodologically sound (15).

**Narrative review**

Data from 8 observational studies could not be pooled and thus are included in this narrative section (25, 26, 28–31, 34, 35). One study found that participants with lower intakes of fruit and vegetables have higher odds of depression, which is consistent with the meta-analysis finding (26). Similarly, one study found an inverse association between high intakes of fruit and vegetables and depression, but this association was significant only among women (31). Two Japanese studies observed an inverse association between the healthy Japanese diet (which includes high intakes of green tea, soy products, fruit, and vegetables) and depression (29, 34). Another study found that high intakes of vegetables were inversely associated with depression, but found no significant association between consumption of fruit, fish, or grains and depression (35). An Australian study found that in addition to vegetable consumption, intakes of meat and poultry and dairy products are inversely associated with odds of depression (28), but another Australian study found no significant association between consumption of fruit, cooked vegetables, or dairy products with depression (30).

There were conflicting results for studies that investigated foods similar to the Western diet: one study showed that consumption of processed meat was associated with decreased odds of depression among women (31), but 3 studies found no significant association between depression and processed meats, sweet biscuits, cakes, meat pies, or confectioneries (29, 30, 34).
In addition, there may be an association between frequent consumption of starch-rich foods and odds of depression. Samieri et al (31) found that a high intake of starchy foods in women and pasta among men were associated with higher depressive symptoms. Another study also found that patients with seasonal affective disorder had a higher consumption of starch-rich foods, including pasta, rice, bread, and potatoes (25). This suggests a possibility that other types of dietary patterns are also relevant to depression. More research is needed to define the effect of other dietary patterns.

**DISCUSSION**

This systematic review and meta-analysis provides a comprehensive evaluation of current evidence of the association between dietary patterns and depression. The results indicate that the Healthy dietary pattern is associated with a reduced odds of depression. On the other hand, no association was found between the Western dietary pattern and the odds of depression, but this may have resulted because of too few studies.

The Healthy diet is consistent with current dietary guidelines recommending high intakes of fruit, vegetables, whole grains, poultry, fish, and reduced-fat dairy products (42). Many reviews confirm that dietary patterns similar to the Healthy diet found in this study are associated with a reduced morbidity and all-cause mortality (43, 44). Several potential mechanisms underlying this association have been discussed in other studies. The antiinflammatory properties of foods in the Healthy diet were shown to influence concentrations of monoamines, which are thought to play a role in the regulation of emotions and cognition (45). The antioxidant compounds in fruit and vegetables could reduce oxidative-stress induced neuronal damage, particularly neurons in the hippocampus (46, 47). Evidence also suggests that a high consumption of long-chain omega-3 (n=4) PUFAs (48), which is found in high concentrations in oily fish, reduces depression risk. It could also be the cumulative effect of all these nutrients and their biochemical properties that influence depression risk (7, 49).

Note, however, that most of the evidence presented here are cross-sectional in nature, which poses limitations in determining causality. With cross-sectional designs, it is not known whether a poor dietary pattern precedes the development of depression or if depression causes poor dietary intake. Indeed, some studies have shown that depressed individuals seek to self-medicate with high-fat and high-sugar food (50, 51). However, the subgroup analysis by study design showed that the cohort studies (n = 4) have a remarkably similar OR to cross-sectional studies (n = 9) and overlapping 95% CIs, which suggests that this is a robust finding. Whereas the association with cohort studies was not significant, it was likely the result of the lack of studies. All cohort studies tested the possibility of reverse causality of the diet-depression relation by excluding from the analysis participants who reported depressive symptoms at baseline, or through other statistical methods, and excluded this as an explanation. In addition, 2 cohort studies used repeated measures of dietary intakes, which provided a stronger test of cumulative dietary exposures on depression. Further longitudinal studies assessing the incidence of depression using repeated measures of dietary intakes and depression are required to confirm this finding.

The inclusion of RCTs in this review was intended to provide the highest level of evidence regarding the association of dietary patterns and depression. However, only one RCT met our inclusion criteria (37). This RCT used a short intervention period of 2 wk and had a small sample size (ie, <15 participants per group).

In the investigation of possible reasons for heterogeneity, several factors were identified and further explored by using meta-regression and subgroup analysis. Dietary habits may be culturally related and location specific. The use of different dietary measurements could potentially influence the association between dietary patterns and depression. The 24-h dietary recall has higher precision in assessing diet but only measures actual dietary intake on one or several days instead of long-term intake (52). The FFQ, on the other hand, measures dietary intake over a longer period of time but is subjected to many errors introduced as a result of restrictions to a fixed list of foods, memory, and perception of portion sizes (52). Similarly, the strength of the association between dietary patterns and depression may vary depending on whether a diagnostic schedule or whether symptom inventories were used. Symptom inventories generally have poorer criterion validity compared with diagnostic schedules and may result in stronger association (53). The meta-regression and subgroup analysis results, however, showed that none of the covariates explained the observed heterogeneity. Additional sources of heterogeneity are likely to exist but were not explored due to a lack of studies. Although foods commonly consumed within each dietary pattern were matched as closely as possible, the actual foods within the same dietary pattern were never identical between studies, because these are dependent on the methods used to define dietary patterns. For example, factor analysis involves subjective techniques such as the consolidation of food items into food groups and the number of factors extracted (8). The use of diet quality scores or indexes also varied in scoring methods. Likewise, depressive symptoms inventories have different ways of scoring depressive symptoms and classifying depression cases. The inconsistent adjustment for potential confounders among the included studies could also have contributed to heterogeneity. Some of the studies included in our analyses provided crude estimates of association. There are likely to remain potentially important confounding differences that could substantially affect the results. For example, it is also possible that adoption of the Healthy diet is a marker of other healthy lifestyle factors responsible for the lower odds of depression. Some studies found individuals with healthy dietary behaviors are also more likely to be nonsmokers, sensible alcohol drinkers, and more physically active (54, 55).

Meta-analyses studies examining the Western diet yielded pooled estimates that suggested a trend toward increased odds of depression but were not statistically significant, likely because of insufficient power as a result of the small number of high-quality studies included. Although we identified 3 additional cross-sectional studies that could be pooled, they had low methodologic quality and were excluded because of the risk of bias. We chose to err on the side of having imprecise but unbiased estimates rather than having precise but potentially misleading estimates.

The current review has systematically identified, appraised, and synthesized current evidence and provided a quantification of the association of dietary patterns and depression. The existing literature suggests that consumption of a diet high in fruit, vegetables, whole grains, and fish may reduce depression risk, which indicates that dietary interventions have the potential to be included as a primary prevention strategy for depressive disorder.
However, the limitations mentioned should be considered. Significant heterogeneity is found in our analysis, which makes it difficult to achieve a reliable combined estimate of the association between dietary patterns and depression. However, we have applied strict inclusion criteria to limit heterogeneity to a minimum. In proceeding with a meta-analysis despite the heterogeneity, it allows the conflicting results between studies to be formally assessed and more accurately quantified (14). We were also able to explore potential sources of heterogeneity through meta-regression and subgroup analysis, which further justified that our study finding is robust. A further issue to consider is that when there are many studies with large sample sizes, the 𝑓 test may detect heterogeneity that may be statistically significant but clinically unimportant, which could be the case in our study (56). In conclusion, there is a need for more RCTs and prospective cohort studies to clarify whether true causal associations exist between dietary patterns and depression.

We are grateful to Ellie Gresham for her help with data extraction and to Debbie Booth for her assistance with developing the literature search strategy. Thanks are also extended to the corresponding authors of the original articles included in this review, who provided additional information as required. The authors’ responsibilities were as follows—JSL, AJH, MM, and JA: were involved in the overall design and development of the research; JSL and SH: conducted the research, including the literature search, quality assessment, and data extraction; AJH: assisted with the quality assessments; JSL and AB: performed the statistical analysis; and JSL: wrote the manuscript and had primary responsibility for the final content. All authors contributed to the editing and proofreading of the final manuscript. No conflicts of interest were reported.

REFERENCES


