A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults[1–3]

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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. *Am J Clin Nutr* 2014;99:181–97.

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).

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

TABLE 1
Inclusion and exclusion criteria for selecting studies

	Population	Exposure	Outcome
Include	Community-dwelling adults, ≥18 y old	Dietary pattern defined by using diet quality scores or indexes or by using statistical exploratory method (eg, pattern analysis)	Depressive disorder or depressive symptoms as primary or secondary outcome
	Study sample must be selected from free-living settings instead of institutional care	Assessment of whole diet (ie, by using food-frequency questionnaire, 24-h dietary recall, food record, diet history, or similar) or whole diet intervention	Depression data must be in a format that can be extracted
	When health status was not specified, the sample was assumed to be broadly representative of the general population	Analysis of association must include all dietary components	
Exclude	Adults with nutritional needs different from the general population (eg, pregnant and lactating women, athletes)	No measure of whole diet or measured only specific dietary components (eg, dietary screeners) or individual nutrients	Depressed mood
		Dieting or disordered eating behaviors (eg, binge eating or other eating disorders)	Postnatal or postpartum depression
	Included only subgroup of the general population with health condition that may confound the diet-depression relation (eg, obese, hypertension, hypercholesterolemia)	Eating patterns or dietary habits (eg, regular meals, meals with diverse foods, snacking habits)	Bipolar disorders, overall mood states, or psychological stress where depression data could not be isolated and extracted

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 SE_{log} OR according to the Hasselblad and Hedges method (12, 13).

Random-effects models were used for the analysis. Heterogeneity was assessed by using the I^2 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 21of 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).
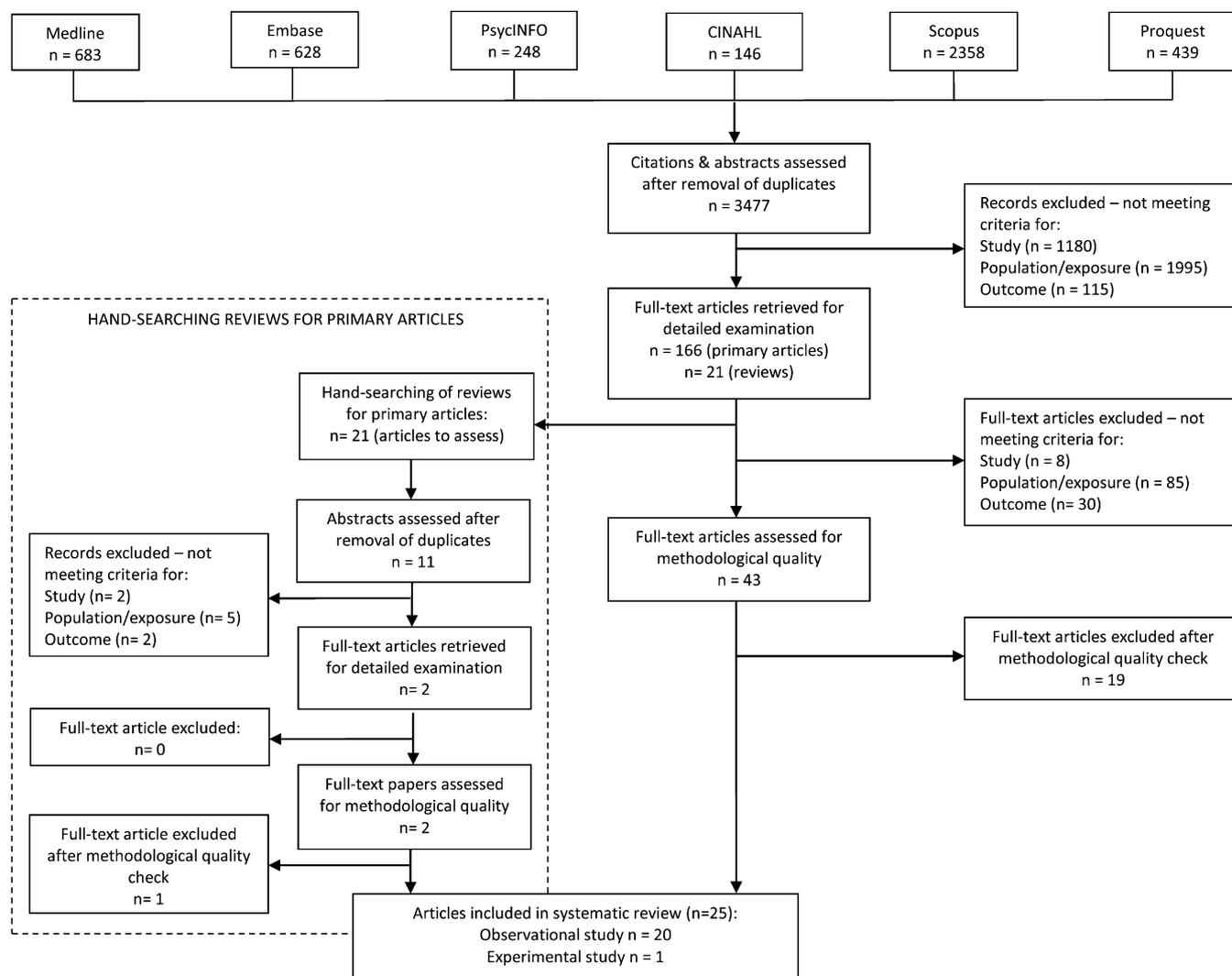
FIGURE 1. Flowchart of the study selection process: Medline, Embase, and PsycInfo (http://www.ovid.com/); CINAHL (http://www.ebscohost.com/cinahl/); Scopus (http://www.scopus.com/); and Proquest (http://www.proquest.com/).

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,

TABLE 2
Characteristics of observational studies that examined the effects of dietary interventions and depression

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Akbaraly, 2009 (38), UK, cohort (5 y)	The Whitehall II Study cohort, civil servants working in London offices (n = 3486; age: 35–55 y; 73.8% men; cases: n = 416)	FFQ, 127 items, validated against 7-d diet diary and biomarkers; measured at baseline	Factor analysis: tertiles of factor scores	Processed food: high intakes of sweetened desserts, chocolates, fried food, processed meat, pies, refined grains, high-fat dairy products, condiments	CES-D, 20 items, measured at baseline and 5-y follow-up; depression >15	Age, sex, energy intake, employment grade, educational level, marital status, smoking, physical activity, hypertension, diabetes, CVD, stroke, antidepressant use, cognitive functioning	Highest tertile of processed food pattern: OR (1.58), 95% CI (1.11, 2.23)
Akbaraly, 2013 (36), UK, cohort (15 y)	(n = 4215; cases = 260)	(as above); measured at baseline and 10 y later	AHEI (0–10): higher scores indicate greater adherence	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	(as above); measured at baseline and 10-y and 15-y follow-up; depression >15 at both follow-ups	Age, ethnicity, energy intake, SES, retirement, marital status, smoking, physical activity, hypertension, coronary artery disease, HDL cholesterol, central obesity	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)
Chocano-Bedoya, 2013 (19), USA, cohort (12 y)	The Nurses' Health Study cohort, female US registered nurses (n = 50,605; age: ~62 y; cases: 6–15%)	FFQ, 131 items, validated against four 1-wk dietary records; measured at baseline and every 4 y	Factor analysis: quintiles of factor scores	Prudent: higher loadings from fruit, vegetables, fish, whole-grain products, low-fat dairy products Western: higher loadings of red and processed meats, French fries, desserts, high-fat dairy products, refined grains	Strict definition: self-reported both a clinical diagnosis of depression and use of antidepressants after baseline Broad definition: self-reported use of antidepressants or clinical diagnosis of depression after baseline	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	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

(Continued)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Rienks, 2013 (30), Australia, cohort (3 y)	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)	FFQ, 80 items, validated against 7-d weighted food records; measured at baseline	Factor analysis: quintiles of dietary factor scores	Cooked vegetables: cauliflower, cabbage, Brussels sprouts, broccoli, green beans Fruit: strawberries, pineapple, melon, apricots, mango Mediterranean: garlic, peppers, mushrooms, salad greens, pasta, red wine Meat and processed meat: pork, bacon, sausages, lamb Dairy: cream cheese, low-fat cheese, yogurt, skim milk High fat and sugar: sweet biscuits, cakes, jam, meat pies, chocolate	CES-D, 10 items, measured at baseline and 3 y follow-up; depression ≥10	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	Cooked vegetables: OR (0.95), 95% CI (0.85, 1.06), P = 0.32 Fruit: OR (1.04), 95% CI (0.94, 1.16), P = 0.44 Mediterranean: OR (0.83), 95% CI (0.75, 0.93) Meat and processed meat: OR (1.06), 95% CI (0.93, 1.21), P = 0.37 Dairy: OR (0.93), 95% CI (0.84, 1.04), P = 0.22 High fat and sugar: OR (1.02), 95% CI (0.92, 1.14), P = 0.73
Sánchez-Villegas, 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)

(*Continued*)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Skarupski, 2013 (33), USA, cohort (12 y)	The Chicago Health & 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)	FFQ, 139 items, validated against multiple 24-h recalls, measured at baseline	MedDiet Score (0–55): higher scores indicate greater adherence; tertiles of adherence	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 serves); Monthly: red meat and meat products (4–5 serves)	CES-D, 10 items, yes/no version, measured at baseline and every 3 y; depression ≥ 4	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	Highest tertile of MedDiet Score compared with lowest tertile: β −0.03, SE 0.01
Tsai, 2012 (35), Taiwan, cohort (4 y)	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%)	FFQ, validated against 14-d food diary, measured at baseline	Food groups analysis: all dietary components examined	Meat and poultry, fish, seafood, eggs, fruit, vegetables, infused camellia tea, grains	CES-D, 10 items, measured at baseline and 4 y follow-up; depression ≥10	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	Consumption of ≥3 times/wk compared with <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 < 0.05; Cereal/grains: OR (0.85), 95% CI (0.58, 1.26), P = 0.425; Tea: OR (0.77), 95% CI (0.51, 1.16), P = 0.211

(*Continued*)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Beydoun and Wang (18), 2010, USA, cross-sectional	The NHANES study cohort (*n* = 2217; age: 20–39 y; sex: *n* = 977 men, *n* = 1240 women; cases: 6.4% men, 9.2% women)	One 24-h recall	Healthy Eating Index-2005 (0–100): higher scores indicate greater adherence to 2005 *Dietary Guidelines for Americans*	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	Composite International Diagnostic Interview for ICD-10	Age, ethnicity, marital status, food insecurity	Men: *β* −3.29, SE 2.12, *P* > 0.05; women: *β* −2.63, SE 1.96, *P* > 0.05
Beydoun, 2010 (17); Kucmarski, 2010 (39); Beydoun, 2009 (40); USA, cross-sectional	The HANDLS Study cohort (*n* = 1681; age: 30–64 y; sex: *n* = 734 men, *n* = 947 women; cases: *n* = 156 men, *n* = 304 women)	Two nonconsecutive 24-h dietary recalls (second recall collected 4–7 d after the first recall)	Healthy Eating Index-2005 (0–100): higher scores indicate greater adherence to 2005 *Dietary Guidelines for Americans*	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	CES-D, 20 items	Age, ethnicity, marital status, education, poverty status, smoking status, illicit drug use, BMI	Women: *β* −0.083, SE 0.023; Men: *β* −0.045, SE 0.024, *P* > 0.05
Crichton, 2013 (20), Australia, cross-sectional	Representative sample of South Australian residents (*n* = 1183; age: 40–65 y; sex: 751 women, 432 men)	FFQ, 215 items, validated against protein and urinary measures	Mediterranean diet score (0–11): higher scores indicate greater adherence; 3 categories of adherence: low (0–3), medium (4–7), high (8–11)	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 lipids	CES-D, 20 items	No adjustment of confounders–no significant differences for all measures of socioeconomic status between categories of Mediterranean diet adherence	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)
Féart, 2009 (21), France, cross-sectional	The Three-City Study, community-dwelling adults (*n* = 1410; age ≥65 y; sex: 60% women)	FFQ, 40 item, validated against dietary recalls	Mediterranean diet score (0–9): higher scores indicate greater adherence; 3 categories of adherence (lowest to highest: 0–3, 4–5, 6–9)	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	CES-D, 20 items	No adjustment for confounders	Depression score for each category of adherence (mean ± SD: low, 8.2 ± 7.4; middle, 7.5 ± 7.5; high, 7.3 ± 6.8)

(Continued)

TABLE 2 (Continued)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Jacka, 2010 (23), Australia, cross-sectional	Geelong Osteoporosis Study cohort of women (n = 1046; age: 20–94 y; cases: n = 60)	FFQ, 74 foods and beverages, validated against 7-d weighed food record	Factor analysis, standardized dietary factor score: higher factor scores indicate greater consumption	Western: meat pies, processed meats, pizza, chips, hamburgers, white bread, sugar, flavored milk drinks, beer Modern: fruit and salads, fish, tofu, beans, nuts, yogurt, red wine Traditional: vegetables, fruit, beef, lamb, fish, whole-grain foods	The Structured Clinical Interview for DSM-IV-TR Research Version, Non-Patient Edition	Age, socioeconomic status, physical activity, alcohol consumption, smoking, energy intake, BMI	Western diet: OR (1.52), 95% CI (0.96, 2.41), P > 0.05 Modern: OR (1.29), 95% CI (0.96, 1.73), P > 0.05 Traditional dietary pattern: OR (0.65), 95% CI 0.43, 0.98), P < 0.05
			Australian Recommended Food Score (0–74): higher scores indicate greater adherence	≥2 servings fruit and ≥4 servings vegetables daily; 1–5 servings red meat/wk; low-fat dairy products, whole-grain foods			ARFS: OR (0.85), 95% CI (0.62, 1.13)
Jacka, 2011 (22), Norway, cross-sectional	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)	FFQ, 169 items, validated against weighed food records	Principal component analysis, standardized dietary factor score: higher factor scores indicate greater consumption	Western: liver, processed meats, pizza, salty snacks, chips, sugars and sweets, soft drinks, cake, ice cream Traditional: fish and shellfish, potatoes, fruit, vegetables, milk, yogurt, bread, pasta, rice, meat spreads, legumes, eggs Healthy: vegetables, fruit, rice, pasta, cereals, fish, wine, nonprocessed meats	HADS, 7 items: Depression ≥8	Sex, age group (47-49 y, 70-74 y), income, education, physical activity, smoking, alcohol, and energy intakes	Western diet: men (OR: 0.68; 95% CI: 0.68, 1.11; women (OR: 1.25; 95% CI: 0.93, 1.68) Traditional diet: men (OR: 0.77; 95% CI: 0.61, 0.96); women (OR: 0.99; 95% CI: 0.76, 1.29) Healthy diet: men (OR: 1.02; 95% CI: 0.87, 1.19; women (OR: .68; 95% CI: 0.57, 0.82)
			Self-developed diet quality score (6–18): higher scores indicate a more healthy diet	High intakes of vegetables, fruit, low-fat dairy products, whole-grain foods, fish; moderate intakes of red meat			Diet quality scores: men (OR: 0.83; 95% CI: 0.7, 0.99); women (OR: 0.71; 95% CI: 0.59, 0.84)

(Continued)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Klassen (24), 2009, USA, cross-sectional	African American women, residing in 11 public housing communities (n = 156; age: 20–50 y; cases: n = 116)	Three nonconsecutive 24-h dietary recalls (2 weekdays/1 weekend), across 21 d	Self-developed cancer prevention index based on dietary recalls	No alcoholic beverage intake; moderate caloric intake (1600–2200 kcal); moderate fat intake (<30% of energy); ≥5 servings of fruit and vegetables; ≥65 on the Healthy Eating Index–2005	CES-D, 20 items; depression >15	Age, depression, life events, smoking, expected future health, food from other sources, shopping transportation, meal planning	OR (0.45), 95% CI (0.22, 0.95), P < 0.05
Krauchi (25), 1988, Switzerland, case-control	Female outpatients with SAD; controls: hospital staff without psychiatric history (n = 28 cases, n = 24 controls; age: 27–73 y)	FFQ at each season, 33 food/drink items and 13 meal items; validation method not reported	Food and drink scores	Starch-rich foods, sugar-rich foods, protein-rich foods, fiber-rich foods, dairy products, alcohol, caffeine-containing drinks	A seasonal screening questionnaire	Age–analysis performed with SAD and controls matched for age	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)
Kronish, 2012 (26), USA, cross-sectional	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%)	FFQ, 109 items, validated against multiple diet records	Self-developed dietary criteria	Fish ≥2 servings/wk; fruit and vegetables ≥4.5 cups/d; sodium <1500 mg/d; sugar <450 kcal/wk; fiber: carbohydrate ratio >0.1	CES-D, 4 items; depression ≥4 points	Age, race, sex, geographic region of residence, education, income	Adjusted prevalence ratios from comparison with and without depressive symptoms: diet (<2 out of 5 Healthy diet criteria) 1.08, 95% CI (1.06, 1.10)
Mamplekou, 2010 (27); Bountziouka, 2009 (41), Greek Islands and Cyprus, cross-sectional	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)	FFQ, 15 food groups, validation method not described	MedDietscore (0–55): higher scores indicate greater adherence	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)	GDS (0-15); depression: mild (6–10), severe (11–15)	Age, sex, education status, BMI, physical activity status, presence and management of hypertension, hypercholesterolemia, and diabetes	OR (1.03), 95% CI (0.976, 1.09), P = 0.99

(*Continued*)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Meyer, 2013 (28), Australia, cross-sectional	The Australian National Nutrition and Health Surveys cohort, national sample of community-dwelling adults ($n = 10,986$; age ≥ 18 y; sex = 52% women; cases: $n = 224$)	24-h dietary recall	Food group analysis: all dietary components examined	Meat, poultry, game; milk products and dishes; vegetables (food groups found to be significant predictors of the logistic regression model)	Self-reported physician diagnosis	Age, sex	Meat, poultry, game: β (−29.9), 95% CI (9.64, 9.6); milk products: β (10.1), 95% CI (3.87, 6.8); vegetables: β (−15.7), 95% CI (6.48, 5.9)
Nanri, 2010 (29), Japan, cross-sectional	Full-time municipal employees ($n = 521$; age: 21–67 y; sex: 59.1% men; cases: $n = 186$)	Diet history questionnaire, 67 items, validated against 16-d weighed dietary records and biomarkers	Factor analysis: tertile of factor scores	Healthy Japanese: fruit, vegetables, soy products, mushrooms, green tea Animal food: fish and shellfish, meat, processed meat, mayonnaise, eggs Westernized breakfast: bread, milk, and yogurt; confectioneries; mayonnaise and eggs; low intakes of rice, alcohol, and fish	CES-D, 20 items; depression ≥ 16	Age, education, income, marital status	Healthy Japanese: OR (0.4), 95% CI (0.22, 0.71) Animal food: OR (0.97), 95% CI (0.61, 1.55) Westernized breakfast: OR (1.27), 95% CI (0.77, 2.1)
Samieri, 2008 (31), France, cross-sectional	The Three-City Study cohort subsample, community-dwelling adults ($n = 1724$; age: ≥ 65 y; sex: $n = 647$ males, $n = 1077$ females)	FFQ, 40 categories of food, validated against dietary recalls	Cluster analysis	Biscuits and snacking: biscuits and cakes, high energy intake Healthy: high intakes of fish in men compared with fruit and vegetables in women Charcuterie, meat, alcohol in men compared with charcuterie and starchy foods in women Pasta eaters (men) compared with pizza, sandwich eaters (women)	CES-D, 20 items	Age, education, income, marital status	Men: biscuits and snacking (β: −0.06; 95% CI: −0.35. 0.23); women: biscuits and snacking (β: 0.13; 95% CI: −0.07, 0.02) Men: healthy (β: −0.12; 95% CI: −0.31, 0.07); women: healthy (β: −0.16; 95% CI: −0.33, 0.007) Men: charcuterie, meat, alcohol (β: 0.03; 95% CI: −0.20, 0.26); women: charcuterie, starchy foods (β: −0.15; 95% CI: 0.32, 0.02); $P = 0.06$ Men: pasta eaters (β: 0.26; 95% CI: 0.06, 0.46; women: pizza, sandwich (β: 0.21; 95% CI: −0.11, 0.53)

(*Continued*)

TABLE 2 (*Continued*)

Author, year, country, study design	Subjects	Dietary assessment	Methods defining dietary patterns	Dietary patterns identified	Depression assessment	Adjustment for confounders	Main findings
Sugawara, 2012 (34), Japan, cross-sectional	Residents of Iwaki district, Japan (n = 791; age: 22–86 y; sex: n = 488 females; cases: n = 97)	Diet history questionnaire, 65 items, validated against 16-d dietary records	Principal component analysis: tertiles of dietary pattern scores	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	CES-D, 20 items; depression ≥16	Age, sex, exercise habits, BMI, education, marital status, current smoking, history of hypertension and diabetes mellitus	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

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.

33–36). Other symptom inventories included the Hospital Anxiety and Depression Scale (22), Geriatric Depression Scale (27), and a self-developed seasonal affective disorder questionnaire (25). Diagnostic interview schedules included the WHO Composite International Diagnostic Interview (18) and the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, 4th edition (23).

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 tool (22, 24–26). 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).

Meta-analysis results

Meta-analyses included a total of 13 observational studies ($n = 4$ cohort, $n = 9$ cross-sectional). For the remaining studies ($n = 1$ case-control, $n = 3$ cohort, $n = 7$ cross-sectional), definitions of dietary patterns were not directly comparable with those included in the meta-analysis.

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,
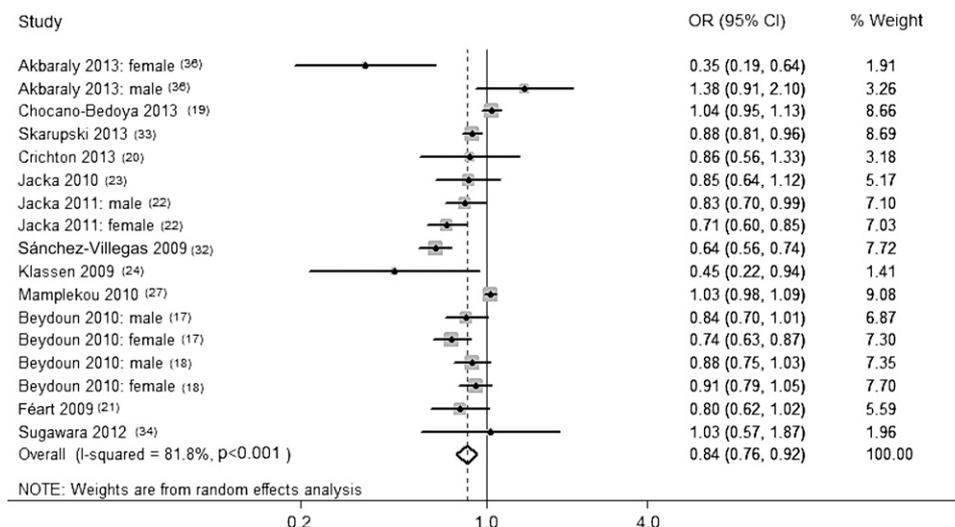
Study	OR (95% CI)	% Weight
Akbaraly 2013: female (36)	0.35 (0.19, 0.64)	1.91
Akbaraly 2013: male (36)	1.38 (0.91, 2.10)	3.26
Chocano-Bedoya 2013 (19)	1.04 (0.95, 1.13)	8.66
Skarupski 2013 (33)	0.88 (0.81, 0.96)	8.69
Crichton 2013 (20)	0.86 (0.56, 1.33)	3.18
Jacka 2010 (23)	0.85 (0.64, 1.12)	5.17
Jacka 2011: male (22)	0.83 (0.70, 0.99)	7.10
Jacka 2011: female (22)	0.71 (0.60, 0.85)	7.03
Sánchez-Villegas 2009 (32)	0.64 (0.56, 0.74)	7.72
Klassen 2009 (24)	0.45 (0.22, 0.94)	1.41
Mamplekou 2010 (27)	1.03 (0.98, 1.09)	9.08
Beydoun 2010: male (17)	0.84 (0.70, 1.01)	6.87
Beydoun 2010: female (17)	0.74 (0.63, 0.87)	7.30
Beydoun 2010: male (18)	0.88 (0.75, 1.03)	7.35
Beydoun 2010: female (18)	0.91 (0.79, 1.05)	7.70
Féart 2009 (21)	0.80 (0.62, 1.02)	5.59
Sugawara 2012 (34)	1.03 (0.57, 1.87)	1.96
Overall (I-squared = 81.8%, p<0.001)	0.84 (0.76, 0.92)	100.00

NOTE: Weights are from random effects analysis

FIGURE 2. Meta-analysis of observational studies quantifying the association between the Healthy dietary pattern and the risk of depression.
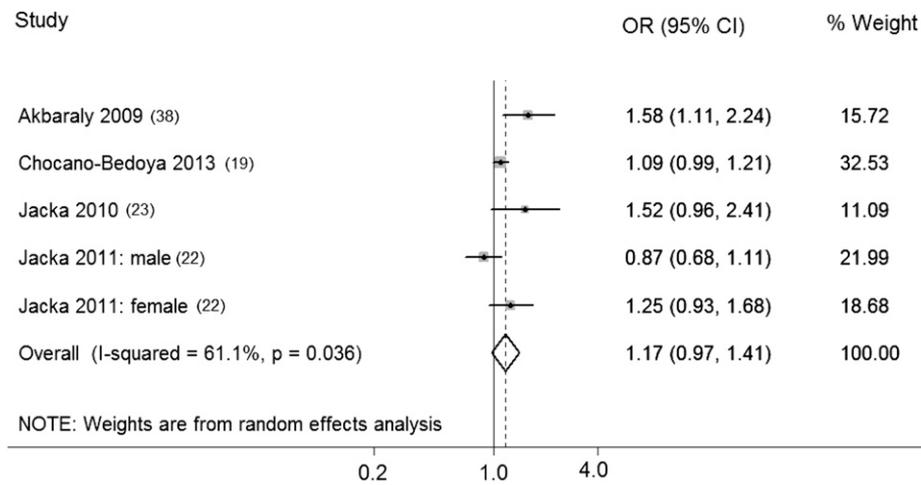
FIGURE 3. Meta-analysis of observational studies quantifying the association between the Western dietary pattern and the risk of depression.

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 (ie, 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).
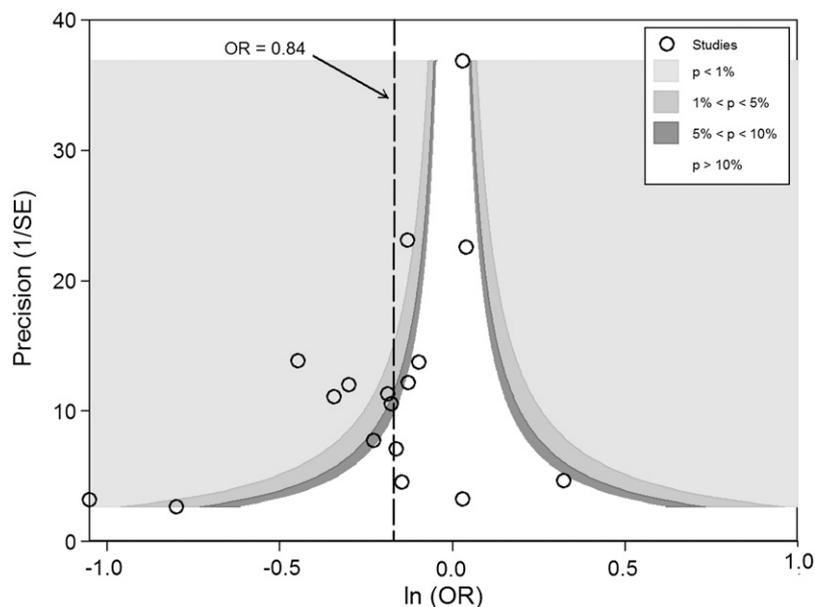

FIGURE 4. Contour-enhanced funnel plot of the observational studies that examined the association between the Healthy dietary pattern and the risk of depression.

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−3) 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 I^2 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.

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