Relationship Between Diet and Mental Health in Children and Adolescents: A Systematic Review

We systematically reviewed 12 epidemiological studies to determine whether an association exists between diet quality and patterns and mental health in children and adolescents; 9 explored the relationship using diet as the exposure, and 3 used mental health as the exposure.

We found evidence of a significant, cross-sectional relationship between unhealthy dietary patterns and poorer mental health in children and adolescents. We observed a consistent trend for the relationship between good-quality diet and better mental health and some evidence for the reverse. When including only the 7 studies deemed to be of high methodological quality, all but 1 of these trends remained.

Findings highlight the potential importance of the relationship between dietary patterns or quality and mental health early in the life span. (*Am J Public Health.* 2014;104:e31–e42. doi:10.2105/AJPH.2014.302110)

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THE ROLE OF HABITUAL DIET IN the development of depressive disorders and symptoms has become a recent research focus over the past decade. Data from adult populations have indicated that better-quality diet is associated with better mental health outcomes.[1–5] In fact, new meta-analyses have confirmed the inverse association between healthy diets and depression.[4,5] A habitually poor diet (e.g., increased consumption of Western processed foods) is also independently associated with a greater likelihood of or risk for depression[1,6,7] and anxiety.[1] Although stress and depression can promote unhealthy eating, recent longitudinal studies have suggested that reverse causality is a less likely explanation for long-term associations.[8]

However, our understanding of these associations earlier in the life span remains unclear. To date, much of the research around this relationship has focused on dietary intake and externalizing behaviors (particularly hyperactivity). For example, poor nutritional quality is independently associated with symptoms of attention-deficit hyperactivity disorder.[9] However, the relationship between dietary intake in childhood and adolescence and internalizing behaviors, which represent depressive symptoms, low mood, or anxiety, has received comparably less attention. Given that the previous literature in adults regarding diet and mental health has focused on the common mental disorders, depression and anxiety, examination of these same mental health parameters in children and adolescents is needed. In terms of what evidence is available to date, findings remain inconsistent. For example, although some studies have observed a dose–response relationship between diet quality and mental health in young adolescents,[10] others have shown no significant association.[11] The evidence is even less comprehensive for the relationship between dietary intake and anxiety symptoms.[12]

To our knowledge, no systematic reviews to date have specifically investigated the association between diet, measured using diet quality scores, dietary pattern analysis, or both and internalizing behaviors that characterize low or depressive mood and anxiety symptoms in child and adolescent populations.

METHODS

Studies considered for inclusion in this review (1) were full-text articles; (2) consisted of epidemiological cohort, case-control, and cross-sectional study designs; (3) examined associations between diet quality or patterns and internalizing disorders that encompassed depression, low mood, depressive symptoms, emotional problems, and anxiety (as distinct from externalizing disorders), assessed via self- or informant report, medical records, or the application of diagnostic measurement tools in children or adolescents who were aged 19 years or younger on enrolment (as per the United Nations[13] definition); and (4) used nonclinical study samples that were population based rather than from acute or institutional settings. We included studies defining dietary patterns using either a priori or a posteriori approaches, as well as studies using proxy measures of diet quality (e.g., studies that derived a diet quality score from food frequency data).

In the absence of a standard definition of diet quality or diet patterns, we defined them as the quality of overall habitual dietary intake or the pattern of overall habitual dietary intake, as previously reported.[1,14,15] Although varying in composition according to the country of origin, healthy or prudent dietary patterns are characterized by a higher intake of nutrient-dense foods, including vegetables, salads, fruits, fish, and other foods groups known to be healthful. Conversely, unhealthy patterns are characterized by a higher intake of foods with increased saturated fat, refined carbohydrates, and processed food products. We excluded studies that

1. examined individual nutrients or supplements,
2. examined the effects of preservatives on mental health,
3. examined emotional or binge eating,
4. examined dietary restraint or restriction (i.e., the restriction of calories or food

consumption for the purpose of weight loss),
5. used trait-based (assessing personality) or measures of stress (as distinct from internalizing behaviors),
6. presented only univariate analyses, and
7. were published in languages other than English.

We also excluded studies that used samples in which the age range overlapped between adolescence and adulthood and studies that presented mental health data only as a composite measure (e.g., overall behavior scores as distinct from internalizing behavior scores) or as a comorbidity only. Furthermore, given that the purpose of this review was to assess whether a relationship exists between diet quality or dietary patterns and mental health (rather than examining dietary intervention effects), we also excluded studies with a randomized controlled trial design.

Search Strategy and Data Extraction

We performed the search strategy using medical, health, psychiatric, and social sciences databases (PubMed, OVID, MEDLINE, CINAHL, PsycINFO) to identify relevant literature published through August 30, 2012. We used the following search terms: (depression OR depressive disorder OR anxiety disorders OR affective symptoms OR anxi* OR mood OR internali* OR psychological symptoms OR psychological distress) AND (diet OR food habits OR dietary OR dietary patterns OR dietary quality OR western diet OR Mediterranean diet) AND (youth OR adolescen* OR child OR infant).

We also searched reference lists of relevant reviews and studies. One author (S. H.) performed the electronic search strategy, and then another author (A. O.) replicated the search. The abstracts or full-text articles of those studies deemed potentially relevant were obtained. We (A. O. and S. H.) conferred to finalize the articles to be included in the review according to the predetermined inclusion and exclusion criteria; where consensus was not reached, the senior author (F. N. J.) was consulted.

Assessment of Methodological Quality and Best-Evidence Synthesis

The heterogeneity between study definitions of dietary and internalizing symptomatology variables precluded formal meta-analysis. As such, we determined a priori that included studies would be analyzed by assessing their methodological quality and performing a best-evidence synthesis of those studies meeting quality standards.

To assess the methodological quality of the reviewed studies, we used a scoring system based on that of Lievense et al.,[16] which has been used in musculoskeletal and obesity research and recently in another review article examining the relationship between dietary variables and depression in adults.[15,17,18] We (S. E. Q. and S. H.) independently scored 14 items relating to the methodological quality of studies in the following areas: study population, assessment of risk factors, assessment of outcomes, study design, and data analysis (see the box on this page). If they endorsed an item, a positive score of 1 was applied; if they did not endorse the item, a score of 0 was applied. In cases in which information was missing or was insufficiently documented, the item was coded as unclear (?), and a score of 0 was subsequently applied. We calculated the total score (percentage) for each of the studies, and those subsequently deemed high quality were those with a score exceeding the mean of all the total scores. The mean score was 83.7% (range = 62.5%–100%). The scoring system is preferential to cohort studies, and this is reflected by cohort studies being eligible for a greater number of criteria (e.g., related to prospective study designs, participation and attrition rates) than case-control and cross-sectional study designs. In the case that we (S. E. Q. and S. H.) did not agree on the ratings, a co-author experienced in best evidence synthesis (S. L. B.) provided the final judgment in 1 consensus meeting.

Our best-evidence synthesis included those studies that met high-quality standards as we have defined them. We performed the synthesis by ranking the findings across all studies into 5 levels of evidence, ranging from strong evidence, moderate evidence, limited evidence, and conflicting evidence to no evidence (Table 1). The synthesis took into account the type of study design used (i.e., strong evidence was defined by generally consistent findings in multiple high-quality cohort studies). This systematic review adhered to the guidelines outlined in the 2009 Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.[19]

Criteria list for the assessment of study quality (modified from Lievense et al.[17])

Study population
1. Selection at uniform point C/CC/CS
2. Cases and controls drawn from the same population CC
3. Participation rate > 80% for cases/cohort C/CC
4. Participation rate > 80% for controls CC

Assessment of risk factor
5. Exposure assessment blinded C/CC/CS
6. Exposure measured identically for cases and controls CC
7. Exposure assessed according to validated measures C/CC/CS

Assessment of outcome
8. Outcome assessed identically in studied population C/CC/CS
9. Outcome reproducibly C/CC/CS
10. Outcome assessed according to validated measures C/CC/CS

Study design
11. Prospective design used C/CC
12. Follow-up time > 12 months C
13. Withdrawals < 20% C

Analysis and data presentation
14. Appropriate analysis techniques used C/CC/CS
15. Adjusted for at least age, and gender C/CC/CS

Note. C = applicable to cohort studies; CC = applicable to case-control studies; CS = applicable to cross-sectional studies. Studies were scored as positive (1), negative (0), or unclear (?), and 100% represented the maximum possible score.

RESULTS

Applying the initial search strategy identified 1255 citations; we subsequently excluded 242 because of duplication, leaving 1013 potentially relevant studies. Of those, we excluded 991 on the basis of information available

TABLE 1—Criteria for Ascertainment of Evidence Level for Best-Evidence Synthesis

Level of Evidence	Criteria for Inclusion in Best Evidence Synthesis
Strong evidence	Generally consistent findings in multiple high-quality cohort studies
Moderate evidence	Generally consistent findings in 1 high-quality cohort study and > 2 high-quality case-control studies
Limited evidence	Generally consistent findings in single cohort study, 1 or 2 case-control studies, or multiple cross-sectional studies
Conflicting evidence	Inconsistent findings in < 75% of the studies
No evidence	No studies found

Note. Adapted from Lievense et al.[20]

from the abstract and title. We obtained the full texts of the remaining 22 articles to assess eligibility. Additionally, we manually examined reference lists and citations for further relevant studies, revealing 7 new full-text articles (n = 29). On examination of the full-text articles, 14 studies did not fulfill inclusion criteria and were subsequently excluded. We (A. O. and S. H.) achieved a high level of consensus (89%); decisions surrounding the remaining articles were reached in consultation with the senior author (F. N. J). As a result, a further 3 articles were excluded (investigated stress or neuroticism or parental restrictions on foods), thus leaving 12 articles for inclusion in this review. Figure 1 displays a summary of the results of the systematic search.

The most common reasons for exclusion were (1) "diet" defined as skipping meals, caloric control, or binge eating; (2) results taken from participants enrolled in an intervention study, community- or school-based program, or both; (3) study explored the role of stress or well-being as opposed to psychological outcomes; or (4) study investigated the impact of parental practices or attitudes related to provision of food.

Population and Design

We extracted the following key information from those articles eligible for inclusion: author, country, sample, diet measure, mental health measure, statistical presentation of results (including exposure variable), covariates, and key findings. Key characteristics of included articles are displayed in Table 2. Briefly, studies were from Australia,[10,22–24,27] the United States,[21,26] the United Kingdom,[20] Germany,[25] China,[12] Canada,[11] and Norway.[28]

Collectively, studies included 82 779 participants (Oddy et al.[22] [n = 1324] and Robinson et al.[24] [n = 1860] used the same data set). Data were derived predominantly from cross-sectional studies and 3 prospective cohort studies. For the latter, follow-up assessment periods ranged from 2 to 4 years. Age of participants ranged from 4.5 to 18 years in all studies (Table 2).

Measures of Mental Health

Table 2 displays the instruments used to measure outcome and exposure variables. We present studies in which mental health was treated as the exposure variable separately from studies exploring diet as the exposure. The most commonly used instruments

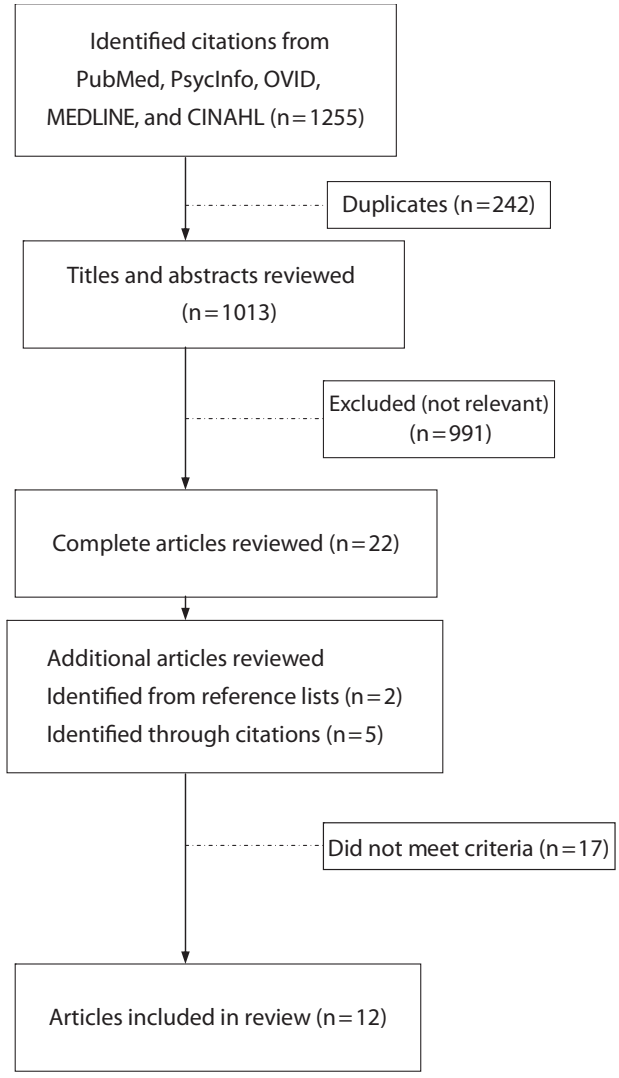

FIGURE 1—Flowchart summary of search results.

to measure mental health were subscales of the Child Behavior Checklist[22,24,28] and the Strengths and Difficulties Questionnaire.[20,25,27] Other instruments included the Short Mood and Feelings Questionnaire (n = 1)[23]; the Depression Self-rating Scale for Children (n = 1)[12]; physician diagnosis using health records (applying the *International Classification of Diseases, Ninth Revision*; n = 1)[11]; a 6-item checklist (n = 1) consisting of symptoms of depression including feeling tired, having trouble sleeping, feeling unhappy, sad, depressed, hopeless, nervous or tense, and worrying too much about things[26]; the Pediatric Quality of Life Inventory (n = 1)[10]; and a questionnaire about frequency of feeling depressed (n = 1).[21]

Measures of Diet Quality and Patterns

Dietary intake was most commonly measured using variations of a Food Frequency Questionnaire (FFQ),[12,20,25] including the Harvard Youth/Adolescent

TABLE 2—Characteristics of 12 Included Studies, Grouped by Study Design, Author, and Exposure of Interest

Author and Country	No. Participants, Sex (%), and Follow-Up Period (If Applicable)	Age at Recruitment, Years, Mean (SD) or Range	Dietary Measure	Mental Health Measure	Questionnaire Respondent
Cohort, prospective studies					
Wiles et al.,[20] United Kingdom	4541,[a] 2.5 y	4.5[b]	FFQ; principal components analysis to identify junk food dietary pattern	Emotional Symptoms subscale of SDQ	Mother
Jacka et al.,[10] Australia	3040, 56% male, 2 y	11–18	Dietary questionnaire used to construct "healthy diet" score based on National Healthy Eating Guidelines, "unhealthy diet" score constructed by summing consumption of unhealthy foods	Emotional Functioning subscale of the PedsQL	Adolescent
McMartin et al.,[11] Canada	3757, 48% male, 3 y	10–11	Harvard Youth/Adolescent FFQ, overall DQI-I score (0–100), variety component score of the DQI-I	Health records of physician-diagnosed internalizing disorders (*ICD-9*)	Child
Cross-sectional studies					
Brooks et al.,[21] United States	2224, 52% male	16.2[b]	Dichotomized question: "Do you eat a healthy diet?"	Frequency of feeling depressed or distressed in the past 30 d, dichotomized cutoff score ≥10	Adolescents
Oddy et al.,[22] Australia	1324, 51.2% male	14.1 (0.2)	CSIRO FFQ, healthy and Western dietary patterns based on factor analysis	Internalizing subscale of CBCL	Parent
Jacka et al.,[23] Australia	7114, 47.2% male	11.6 (0.81)	Dietary questionnaire adapted from Amherst Health and Activity Study Adult Survey of Child Health; diet quality score divided into quintiles for unhealthy and healthy diets	SMFQ; dichotomized cutpoint score of ≥8 defined as symptomatic	
Jacka et al.,[10] Australia	3040, 56% male	11–18	Dietary questionnaire, healthy diet and unhealthy diet scores constructed on the basis of National Healthy Eating Guidelines	Emotional functioning subscale of the PedsQL	Adolescent
Robinson et al.,[24] Australia	1598,[a] 51.3% male	~14[b]	CSIRO FFQ; food groups: cereals and grains, fruit, dairy products, meat and meat alternatives, vegetables, and extras based on Australian dietary recommendations	Internalizing subscale of CBCL	Parent

Continued

TABLE 2—*Continued*

Weng et al.,[12] China	5003, 52.09% male	13.21 (0.99)	FFQ, 38 items, principal component analysis produced snack, animal, and traditional dietary patterns, divided into quintiles	DSRS (Chinese version), cutoff score of 15 defined as screening positive for depressive symptoms; SCARED (Chinese version), cutoff score of > 23 defined as screening positive for an anxiety disorder	Adolescent
Kohlboeck et al.,[25] Germany	3361, 62.8% male	11.15 (0.5)	FFQ, 82 items, constructed diet quality score based on the concept of the German OMD for children and adolescents, food categories defined according to the Codex General Standard for Food Additives food category system	Emotional Symptoms subscale of SDQ	Parent
Fulkerson et al.,[26] United States	4734,[b] 50.2% male	Boys: 14.9[b] Girls: 14.7[b]	YAQ, FFQ, 149 items	Constructed 6-item scale of the following symptoms: feeling tired; having trouble sleeping; feeling unhappy, sad, depressed, hopeless, nervous or tense, worrying too much about things, stratified depressive symptom groups (low, moderate, high)	Adolescent
Renzaho et al.,[27] Australia	3370, 51.8% male	4–12	Questionnaire about fruit and vegetable consumption according to Australian Guide to Healthy eating	Emotional Symptoms subscale of SDQ	Parent or caregiver
Vollrath et al.,[28] Norway	42 451	~1.5[b]	Dietary questionnaire, questionnaire consisting of 4 items based on consumption of cakes, waffles, or sweet cookies; desserts or ice cream; chocolate; and other sweets, jellybeans, or confectionary; summary score dichotomized at 85th percentile	Internalizing subscale of CBCL, 14 items; EAS, 11 items; mean score derived from 25 items of combined scales	Mother

Note. CBCL = Child Behavior Checklist; CSIRO = Commonwealth Scientific and Industrial Research Organization; DQI-I = Diet Quality Index–International; DSRS = Depression Self-Rating Scale for Children; EAS = Emotionality Activity and Sociability Questionnaire; FFQ = Food Frequency Questionnaire; *ICD-9* = *International Classification of Diseases, 9th Revision*; OMD = optimized mixed diet; PedsQL = Pediatric Quality of Life Inventory; SCARED = Screen for Child Anxiety Related Emotional Disorders; SDQ = Strengths and Difficulties Questionnaire; SMFQ = Short Mood and Feelings Questionnaire; YAQ = Youth and Adolescent Food Frequency Questionnaire.
[a]Number of participants for which data are available on both mental health measure and dietary measure,
[b]Data not provided.

Questionnaire (n = 2)[11,26] and the Commonwealth Scientific and Industrial Research Organization FFQ (n = 2).[22,24] Other measures included a 14-item questionnaire based on the Amherst Health and Activity Study Adult Survey of Child Health Habits (n = 1),[23] the German optimized mixed diet concept for children and adolescents (n = 1),[25] the Australian Guide to Healthy Eating by Questionnaire (n = 2),[1,27] 4 questions about frequency of sweet consumption (n = 1),[28] a self-report questionnaire about nutrition (n = 1),[10] and the question "Do you eat a healthy diet?" (n = 1).[21]

Key Findings Including Data From All Studies

Key results of the 12 studies reviewed are provided in Table 3; cross-sectional and prospective analyses performed within a study are presented separately. Of the 12 studies, 9 explored the relationship between diet quality and mental health using diet as the exposure variable[1,10–13, 20–25]; of these 9 studies with diet as the exposure, 5 explored the relationship between dietary patterns and mental health and 3 explored the relationship between diet quality and mental health; 1 explored both diet quality, dietary patterns and mental health.[25] Of those examining dietary patterns as the exposure, the majority of studies (n = 4) consistently demonstrated significant relationships between unhealthy dietary patterns and poorer mental health. Evidence of an association between healthy dietary patterns and better mental health was less consistent, with significant positive associations observed in only half of the 6 studies. Of the 5 studies exploring the association between diet quality, measured using diet quality scores, and mental health, all demonstrated a significant relationship between higher diet quality (i.e., higher intakes of healthy, nutrient-dense foods) and better mental health (Brooks et al.[21] for females only). Of the 3 studies that looked specifically at the association between lower diet quality (i.e., higher intake of unhealthy foods) and poorer mental health outcomes, 2 also reported significant relationships.

A paucity of available prospective studies (n = 3) investigated the association between dietary patterns or quality and mental health[1,10,11,20]; where evidence was available, findings were conflicting (Table 3).

When the relationship between mental health and diet quality was explored using mental health as the exposure variable, data were also limited. However, 2 of 3 of these studies (66%) demonstrated that children and adolescents with worse mental health reported significantly poorer dietary patterns.[27,28] No data were available on the relationship between mental health as an exposure and its relationship to measures of healthy dietary habits.

Best-Evidence Synthesis

When we applied criteria for the best-evidence synthesis, the mean score was 83.7% (range = 62.5%–100%, where 100% is the maximum obtainable score). Methodological quality ratings of each study are displayed in Table 3. The 7 studies exceeding the mean were subsequently included in a best-evidence synthesis. When we applied the criteria for ascertainment of evidence level for best-evidence synthesis, we deemed the level of evidence for all of these associations as limited.

DISCUSSION

Our aim was to review and synthesize the existing literature to determine whether an association exists between diet quality and mental health in childhood or adolescence, with a focus on internalizing disorders including depression, low mood, and anxiety. We observed consistent cross-sectional associations between unhealthy dietary patterns and worse mental health in childhood or adolescence. In contrast, we found inconsistent trends for the relationships between healthy diet patterns or quality and better mental health. We also found inconsistent trends for unhealthy diet quality and worse mental health. Overall, best-evidence criteria confirmed that this area had a limited level of evidence, largely attributable to a dearth of prospective and case-control data, which thereby precludes us from inferring causal associations about these relationships.

These findings add to the existing literature that has attempted to elucidate the relationship between diet quality and mental health in adult populations.[6,7,15,29] To our knowledge, this is the first review of its kind in this area to focus specifically on children and adolescents. Although this review generated insufficient evidence to elucidate the directionality of the relationship, several potential explanations exist for the relationship between diet and mental health in this population.

It may be the case that children and adolescents with internalizing disorders or symptoms eat more poorly as a form of self-medication. However, it is equally as conceivable that the influence of early eating habits and nutritional intake has an important impact on affect. Indeed, there are numerous potential biological pathways by which diet quality may have an impact on mental health in children and adolescents. First, a poor quality diet that is lacking nutrient-dense foods may lead to nutrient deficiencies that have been associated with mental health issues. For example, the dietary intake of folate, zinc, and magnesium is inversely associated with depressive disorders,[30] whereas dietary long-chain omega-3 fatty acids are inversely related to anxiety disorders.[31]

Dietary intake may also have a direct impact on various biological systems and mechanisms that underpin depression, including oxidative processes, the functioning of the immune system, and levels of salient brain proteins. For example, in patients with depression, markers of systemic inflammation are often significantly greater than in controls, which is indicative of immune system dysregulation.[32] Studies have indicated that markers of inflammation are positively correlated with components of a poor diet, and a healthy diet is associated with reduced inflammation.[33] The available evidence also suggests that high-fat, high-sugar diets can affect proteins that are important in brain development, such as the signaling molecule brain-derived neurotrophic factor.[34] Brain-derived neurotrophic factor is often reduced in patients with depression,[35] and when its synthesis is increased, symptoms of depression can improve.[36] It is important to note that consistent evidence has shown that higher quality diets (i.e., those higher in nutrient-dense foods) and diets high in saturated fats and refined carbohydrates are each independently related to depression, suggesting the possibility of different operant pathways. The

TABLE 3—Key Results of Included Articles, Including Summary, Covariates, and Methodological Quality Score

Author	Results		Covariates	Quality Score, %
	Key Results	Summary		
Cohort, Prospective Studies				
Wiles et al.[20]	OR = 1.01 (CI = 0.94, 1.09)	No association between junk food dietary pattern at age 4.5 and emotional problems at age 7 (dietary pattern)	Sex, SDQ total difficulties or subscale score at age 4.5 y, maternal smoking, maternal age at birth of child, number of siblings, socioeconomic markers, birth weight and gestational age, maternal depression and anxiety, maternal enjoyment score, and single-parent household	75
Jacka et al.[10]	C2: b = 0.11* (CI = 0.01, 0.21) C3: b = 0.14* (CI = 0.02,0.27) C2: b = 0.05 (CI = –0.04,0.27) C3: b = –0.07 (CI = –0.18, 0.03)	Dose–response prospective association between higher baseline healthy diet quality scores and higher PedsQL scores at 2-y follow-up (dietary quality) No prospective association between higher unhealthy diet quality scores and lower PedsQL (dietary quality) after controlling for baseline mental health	Age, sex, area-level SES, dieting behaviors, BMI, physical activity, baseline PedsQL scores	75
McMartin et al.[11]	IRR = 1.09 (CI = 0.73, 1.63) IRR = 0.45* (CI = 0.25–0.82)	No association between "overall" DQI-I diet quality scores and rates of internalizing disorders (dietary quality) Greater "variety" component DQI-I diet quality scores associated with lower rates of internalizing disorders over 3-y follow-up period (dietary quality)	Sex, energy intake, household income, parental marital status and education, body weight status, physical activity level, geographic area	91.7
Cross-Sectional Studies				
Brooks et al.[21]	Males: OR = 1.07 (CI = 0.98,1.18); Females: OR = 0.89* (CI = 0.83,0.96)	No association between a healthy diet and feeling depressed or stressed for males Eating a healthy diet was associated with reduced odds of feeling depressed or stressed for females	Age, race	62.5
Oddy et al.[22]	b = 1.25* (CI = 0.15, 2.35) b = 0.17 (CI = –0.54, 0.88)	A Western dietary pattern was associated with higher CBCL internalizing scores (dietary pattern) No association between healthy dietary pattern and CBCL internalizing scores (dietary pattern)	Sex, total energy intake, BMI category, physical activity, screen use, family structure, family income, family functioning at age 14 and maternal education at pregnancy	100

Continued

TABLE 3—*Continued*

Jacka et al.[23]			Age, sex, physical activity, parental work and educational status, household level, SES, dieting behaviors, family conflict and poor family management, BMI, smoking, and physical activity	75
Unhealthy diet	Q2: OR = 1.03 (CI = 0.87, 1.22) Q3: OR = 1.22 (CI = 1.03, 1.44) Q4: OR = 1.29 (CI = 1.12, 1.50) Q5: OR = 1.79 (CI = 1.52, 2.11)	Dose–response association between higher unhealthy diet scores and higher odds of being depressed (SMFQ score; dietary quality)		
Healthy diet	Q2: OR = 0.61 (CI = 0.45, 0.84) Q3: OR = 0.58 (CI = 0.43, 0.79) Q4: OR = 0.47 (CI = 0.35, 0.64) Q5: OR = 0.55 (CI = 0.40, 0.77)	Dose–response association between higher scores on healthy diet scores and lower odds of being depressed (SMFQ score; dietary quality)		
Jacka et al.[10]			Age, sex, area level, SES, dieting behaviors, BMI, and physical activity	75
Healthy diet score (least healthy)	C2: b = 0.31* (CI = 0.22, 0.39) C3: b = 0.42* (0.31, 0.53)	Dose–response associations between higher healthy diet quality scores and higher PedsQL scores (dietary quality)		
Unhealthy diet score	C2: b = –0.14* (CI = –0.23, –0.06) C3: b = –0.29* (CI = –0.38, –0.20)	Dose–response associations between higher unhealthy diet quality scores and lower PedsQL (dietary quality)		
Robinson et al.[24]	b = 0.32* (CI = 0.03, 0.60)	"Extras" food group associated with higher internalizing CBCL scores (dietary pattern)	Sex, sociodemographic factors (family income, father not at home, and maternal employment), family functioning, physical activity, screen use, smoking, alcohol, marijuana use, and early sexual activity	87.5
Vegetable food group	b = 0.14 (CI = –0.41, 0.69)	No association between the vegetable, fruit, dairy, cereal, or meat and meat alternatives food groups and internalizing CBCL scores (dietary pattern)		
Fruit food group	b = 0.09 (CI = –0.39, 0.21)			
Dairy food group	b = 0.11 (CI = –0.36, 0.59)			
Cereal food group	b = –0.09 (CI = –0.57, 0.39)			
Meat and meat alternatives food group	b = 0.01(CI = –0.62, 0.63)			
Weng et al.[12]			Age, sex, maternal education, paternal education, family income, BMI, physical activity	87.5

Continued

TABLE 3—*Continued*

Snack dietary pattern and pure depression, pure anxiety, and coexisting depression and anxiety	Pure depression: T2: OR = 0.98 (CI = 0.77, 1.25) T3: OR = 1.64* (CI = 1.30, 2.06) Pure anxiety: T2: OR = 1.38* (CI = 1.08, 1.65) T3: OR = 1.87* (CI = 1.51, 2.31) Coexisting depression and anxiety: T2: OR = 1.27 (CI = 1.00, 2.43) T3: OR = 1.93* (CI = 1.54, 2.43)	Highest tertile of snack dietary pattern associated with higher odds of pure depression, anxiety, and coexisting depression and anxiety (dietary pattern)		
Animal dietary pattern and pure depression, pure anxiety, and coexisting depression and anxiety	Pure depression: T2: OR = 1.08 (CI = 0.86, 1.37) T3: OR = 1.21 (CI = 0.95, 1.53) Pure anxiety: T2: OR = 1.34* (CI = 1.08, 1.65) T3: OR = 1.87* (CI = 1.51, 2.32) Coexisting depression and anxiety: T2: OR = 1.10 (CI = 0.88, 1.39) T3: OR = 1.71* (CI = 1.37, 2.15)	Highest tertile of animal dietary pattern associated with higher odds of pure anxiety and coexisting depression and anxiety, but not pure depression (dietary pattern)		
Traditional dietary pattern and pure depression, pure anxiety, and coexisting depression and anxiety	Pure depression: T2: OR = 0.61* (CI = 0.49, 0.79) T3: OR = 0.38* (CI = 0.30, 0.49) Pure anxiety: T2: OR = 0.98 (CI = 0.79, 1.23) T3: OR = 0.85 (CI = 0.69, 1.04) Coexisting depression and anxiety: T2: OR = 0.74* (CI = 0.60, 0.92) T3: OR = 1.50* (CI = 0.39, 0.63)	Highest tertile of traditional dietary pattern associated with reduced odds of pure depression and coexisting depression and anxiety, but not pure anxiety (dietary pattern)		
Kohlboeck et al.[25]	OR = 0.89* (CI = 0.80, 0.98) OR = 1.19* (CI = 1.08,1.32)	Higher diet quality score associated with lower emotional SDQ scores (dietary quality) Increased confectionary food group associated with higher emotional SDQ scores (dietary pattern) No association between dairy, fats and oils, fruits and vegetables, confectionary, cereals, bakery wares, meat products, egg products, or ready-to-eat savories and emotional SDQ scores (dietary pattern)	Sex, study center, total energy intake, parental background (education, income, single-parent family), BMI, physical activity, TV viewing or video game use	87.5

Continued

TABLE 3—Continued

Fulkerson et al.[26]				
Daily vegetable intake	Males: 1.8 (low), 1.9, (moderate), and 1.9 (high) Females: 2.0 (low), 1.9 (moderate), and 2.3 (high)	No association between depressive symptoms and daily servings of vegetables or fruits for either sex (dietary pattern)	Race, grade level; all analyses stratified by sex	100
Daily fruit intake	Males: 2.3 (low), 2.2 (moderate), and 2.3 (high) Females: 2.5 (low), 2.3 (moderate), and 2.3 (high)			
Renzaho et al.[27]			Household income, family structure, child age and sex, parental educational level, language spoken at home, financial stress, food security, and social support	87.5
Fruit consumption	Males: b = −0.054* (CI = −0.095, −0.012) Females: b = −0.064* (CI = −0.112, −0.015)	Emotional SDQ scores associated with lower fruit consumption for males and females (dietary pattern)		
Vegetable consumption	Males: b = −0.014 (CI = −0.054, 0.025) Females: b = −0.050* (CI = −0.088, −0.012)	Emotional SDQ scores associated with lower vegetable consumption for females but not males (dietary pattern)		
Vollrath et al.[28]	OR = 1.47* (CI = 1.32, 1.65)	Internalizing scores associated with higher consumption of sweet foods (dietary pattern)	Maternal characteristics (negative affectivity, completed education in years, duration of breastfeeding), child sex, temperament, and weight for length at 1 y	75

Note. BMI = body mass index; C = category; CBCL = Child Behavior Checklist; CI = confidence interval; IRR = incident rate ratio; OR = odds ratio; PedsQL = Pediatric Quality of Life Inventory; Q = quartile; SES = socioeconomic status; SDQ = Strengths and Difficulties Questionnaire; SMFQ = Short Mood and Feelings Questionnaire; T = tertile.
*Significant results.

correlation between healthy and unhealthy dietary patterns is also weak (e.g., Jacka et al.[37]). However, we acknowledge that these interpretations remain speculative in view of the limited evidence for causality currently available.

Limitations

The studies acquired through the systematic search have various methodological strengths and weaknesses that might have influenced the outcomes reported. A strength of this review was the inclusion of a range of studies conducted across several countries and settings. However, the way in which diet was measured varied greatly between the studies. Many used FFQs, a common validated tool, to assess dietary quality. The FFQs were completed by the child or adolescent in some cases[26] and by the primary caregiver in others.[28] The Youth and Adolescent Food Frequency Questionnaire, a validated measure, was also used,[26] and some studies did not use a validated tool.[21] A number of these articles were secondary analyses from larger health studies (e.g., Robinson et al.[24]). In such studies, statistical techniques were used to score the available data to create diet-quality scores. Techniques of this kind are deemed an appropriate method to rank individuals in terms of their diet quality when available data are limited.[10,23] Owing to the length and complexity of FFQs, they are not always used in health studies.

Aside from the quality of the tools used to assess diet, other issues surrounding reporting may have influenced the results obtained for habitual food intake in the reviewed articles. Studies rely on accurate reporting; however, reporting biases can occur for many reasons, including recall ability and

social desirability biases,[38] in which respondents are more likely to report healthier food intake as a result of knowledge about healthy eating guidelines. Reporting biases may differ between children and adults, making the comparison of results additionally challenging because FFQs were completed by the adults, or children, or both. Moreover, differential reporting might also occur in those with depressive symptoms in comparison with those without. Moreover, we acknowledge the potential influence of the file-drawer effect, in which positive studies are overrepresented in the literature because studies containing null findings remain unpublished.[39]

Finally, it is important to note that although many studies have taken into account many of the common confounding variables, other studies have not. For example, socioeconomic status is considered an important potential confounder that must be considered because it is associated with both diet[40] and mental health.[41] Several studies in this review did not take socioeconomic status into account; results from such studies should be viewed with caution because the relationships observed may possibly be explained by socioeconomic status or other related variables rather than by diet or mental health alone. Similarly, several studies did not account for physical activity. Unavoidable residual confounding may also explain the associations observed. For example, certain complex variables, such as socioeconomic status, are difficult to measure and are therefore likely to result in residual confounding. This type of confounding cannot be ruled out as an explanatory factor in the associations observed in the studies reviewed.

To our knowledge, this is the first review of its kind to explore the association between diet quality and patterns and mental health in children and adolescents. Findings from the cross-sectional studies included in this review highlight the potential importance of the relationship between dietary patterns or quality and the mental health of young people; however, we acknowledge that further studies that contribute to a stronger level of evidence are required. We recommend that the relationships between both poor diet and poorer mental health and good diet and better mental health be examined using longitudinal study designs. Moreover, the need for studies explicating specific biological mechanisms of action, as well as data from well-designed randomized controlled trials to support or refute direct biologically causal relationships, is clear.[42]

Conclusions

Despite a paucity of data, our findings highlight the potential importance of the relationship between dietary patterns or quality and mental health early in the life span. Prospective and intervention studies are now required to improve the level of evidence. Given that the average age of onset for anxiety and mood disorders is 6 years and 13 years, respectively,[43] the potential for early intervention using strategies targeted at improving dietary intake at a population level may be of substantial public health benefit. However, this would require policy action to improve the global food environment.[44] ■

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This article was accepted May 31, 2014.

Contributors

A. O'Neil and F. N. Jacka conceptualized the article. A. O'Neil and S. Housden developed the search strategy and conducted the review. S. E. Quirk and S. Housden performed the quality assessment and assisted A. O'Neil in the development of the 1st draft of the article and subsequent revisions. S. L. Brennan oversaw the methodology. F. N. Jacka oversaw the writing of the article. L. J. Williams, J. A. Pasco, and M. Berk contributed to drafts of the article.

Acknowledgments

A. O'Neil, S. L. Brennan, and F. N. Jacka are recipients of National Health and Medical Research Council (NHMRC) Fellowships (1052865, 1012472, and 628912). L. J. Williams is the recipient of an NHMRC Career Development Award and was supported by an Alfred Deakin Postdoctoral Fellowship while undertaking this work. M. Berk is supported by an NHMRC Senior Principal Research Fellowship (1059660).

A. O'Neil, M. Berk, and F. N. Jacka have received project funding from Meat and Livestock Australia. M. Berk has received grant and research support from the National Institutes of Health, Cooperative Research Centre, Simons Autism Foundation, Cancer Council of Victoria, Stanley Medical Research Foundation, Medical Benefits Fund, NHMRC, Beyond Blue, Rotary Health, Geelong Medical Research Foundation, Bristol Myers Squibb, Eli Lilly, Glaxo SmithKline, Organon, Novartis, Mayne Pharma, and Servier; has been a speaker for Astra Zeneca, Bristol Myers Squibb, Eli Lilly, Glaxo SmithKline, Janssen Cilag, Lundbeck, Merck, Pfizer, Sanofi Synthelabo, Servier, Solvay, and Wyeth; and served as a consultant to Astra Zeneca, Bristol Myers Squibb, Eli Lilly, Glaxo SmithKline, Janssen Cilag, Lundbeck Merck, and Servier. F. N. Jacka has received grant and research support from the Brain and Behaviour Research Institute, NHMRC, Australian Rotary Health, Geelong Medical Research Foundation, Ian Potter Foundation, Eli Lilly, and The University of Melbourne and has been a paid speaker for Sanofi-Synthelabo, Janssen Cilag, Servier, Pfizer, Health Ed, Network Nutrition, and Eli Lilly. L. J. Williams has received grant and research support from Eli Lilly, Pfizer, The University of Melbourne, Deakin University, and NHMRC.

Human Participant Protection

Institutional review board approval was not needed because data were obtained from secondary sources.

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