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EDITED BY
Jonathan Glazzard,
University of Hull, United Kingdom

REVIEWED BY
Omer Horovitz,
Tel-Hai College, Israel

*CORRESPONDENCE
Christle Coxon
✉ christle.coxon@roehampton.ac.uk

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Diet and mental health in school-aged children: a mini review of school-based dietary intervention studies

Christle Coxon* and E. Leigh Gibson

School of Psychology, Whitelands College, University of Roehampton, London, United Kingdom

School-based dietary interventions are implemented to improve health outcomes in children and adolescents, yet their impact on mental health and wellbeing remains underexplored. This mini-review synthesized findings from seventeen interventions assessing behavioral functioning and mental health symptoms in children (6–12 years) or adolescents (13–18 years). Most studies were conducted across multiple sites, enabling recruitment of large, diverse populations. More studies were conducted in children compared to adolescents. Behavioral outcomes such as hyperactivity, inattention, and oppositional behavior were commonly assessed in younger children via parent or teacher reports, while adolescent studies more frequently measured mental health symptoms, including depression and anxiety, through self-report. Supplementation, particularly in the context of nutrient deficiencies, was associated with modest improvements in behavioral functioning in children and mental health symptoms in adolescents. However, outcomes varied by the assessor (parent or teacher), and some studies showed placebo effects. In contrast, food reformulation interventions showed no significant impact on mental health outcomes. Despite the use of validated tools, methodological limitations, and variation in participants' nutritional status limit interpretation. Overall, school-based dietary interventions show potential to improve mental health by reaching large, diverse populations. Further research is needed using standardized, age-appropriate measures and incorporating assessment of nutritional status to understand how diet can support and improve mental health in children and adolescents.

KEYWORDS

diet, mental health, nutrition, depression, anxiety, schools, children

Introduction

Poor mental health among children and adolescents is an increasingly urgent global concern: mental disorders are among the leading causes of disability in young people worldwide, with onset typically peaking at about age 14 (Kieling et al., 2024). Growing evidence suggests rising trends in anxiety, depression and psychological distress among school-aged children (Baranne and Falissard, 2018). In the UK, happiness among 10–15-year-olds has declined since 2013 (Collet et al., 2024), and globally mental health in children further declined because of the Covid-19 pandemic (Racine et al., 2021). In 2022, the UK had the highest proportion (25%) of 15-year-olds reporting low life satisfaction among

27 European countries (Collet et al., 2024). These challenges not only compromise individual wellbeing but also affect academic achievement, social relationships, productivity, and long-term health outcomes (Zhang et al., 2025).

Diet and nutrition play a vital role in the physical growth and cognitive development of children and adolescents (Moore Heslin and McNulty, 2023; Norris et al., 2022). Recent research has also highlighted the importance of diet for mental health (Khalid et al., 2016; O'Neil et al., 2014). A high-quality diet, characterized by the consumption of nutrient-dense foods such as fresh fruits and vegetables, whole grains, legumes, and lean sources of protein, has been associated with lower levels of depression, anxiety, and stress (Jiménez-López et al., 2024; Sinclair et al., 2016). In contrast, a low-quality diet, characterized by a high intake of highly processed, energy-dense foods, has been associated with poor mental health outcomes (Mesas et al., 2022). In fact, adherence to healthy Mediterranean-style dietary patterns appears to have a protective effect, with studies showing associations with reduced symptoms of inattention, hyperactivity, depression, and anxiety (Camprodón-Boadas et al., 2025).

Similarly, deficiencies in key micronutrients may impact mental health outcomes (Kris-Etherton et al., 2021). In children and adolescents, for instance, inadequate levels of omega-3 fatty acids and Vitamin D have been linked to increased risk of depression (Föcker et al., 2017; Saji Parel et al., 2022). Low iron status is associated with internalizing symptoms among adolescents (Fiani et al., 2024), while zinc deficiency has been implicated in both child and maternal mental health (DiGirolamo and Ramirez-Zea, 2009). Furthermore, deficiencies in iron and zinc have been associated with higher severity of inattention and hyperactive symptoms in children with Attention Deficient Hyperactivity Disorder (ADHD) (Granero et al., 2021).

These issues are compounded by poor dietary behaviors which are observed in children and adolescents. These include a high intake of confectionery, high-sugar beverages, fats, processed meats, refined grains, and ready meals (Moore Heslin and McNulty, 2023). Recent evidence has demonstrated dose-response relationships between diet and common mental health symptoms, where individuals who reported healthier dietary behaviors, such as high consumption of fruit and vegetables and low consumption of sugar-sweetened beverages, alongside other positive lifestyle habits, reported lower levels of mental health symptoms (Smout et al., 2023). Furthermore, low consumption of fruits and vegetables has been consistently associated with depressive symptoms in low-middle income countries (Liu et al., 2020), while unhealthy dietary patterns have been found more commonly among adolescents reporting psychological distress (Shawon et al., 2023). Poor mental health can also influence eating behaviors, where female adolescents experiencing depression or anxiety were found to be more likely to consume higher amounts of sweet and fatty foods (Aparicio et al., 2017). Taken together, these findings highlight the importance of targeting diet, nutrition, and eating behaviors as key strategies for improving mental health outcomes in children and adolescents.

Schools play a vital role in shaping children's health and offer an ideal setting for delivering nutrition interventions to diverse student populations. As key platforms for health promotion, they can scale interventions to improve diet quality and reduce health inequalities (Woodside et al., 2024, 2021). Evidence indicates that

school-based interventions can yield physical and psychosocial benefits, especially for disadvantaged groups (Kristjansson et al., 2015) and may generate long-term cost savings for health and education systems (Wellander et al., 2016). This approach aligns with global strategies outlined by the World Health and Organization (2021).

School-based dietary interventions are diverse and widely implemented. Interventions include the provision of universal school meals (Cohen et al., 2021; Kristjansson et al., 2015), or school breakfast programs (Adolphus et al., 2017; Cueto, 2001), micronutrient supplementation (Kedir et al., 2024; Samson et al., 2022) food fortification (De-Regil et al., 2017), and nutrition education (Medeiros et al., 2022; Peralta et al., 2021). Collectively, these studies show that school-based dietary interventions can improve physical health, cognitive function, and academic performance, particularly among disadvantaged children and adolescents.

Despite the breadth of these interventions, the focus has been on understanding how dietary interventions can impact cognitive and/or academic outcomes. While these outcomes are important, there is a growing recognition of the mental health challenges faced by school-aged children, including anxiety, stress and depression (Fu et al., 2024; Sood et al., 2024). Poor nutrition may also affect cognitive health, behavioral outcomes, and social functioning, which can influence overall school performance and long-term wellbeing (Bellisle, 2004; Benton, 2008; Taras, 2005).

There is a growing recognition of the link between nutrition and mental health, yet current research rarely includes validated assessments of mental health. Therefore, it is unclear how these interventions may influence emotional and behavioral wellbeing of children and adolescents. This mini-review aims to address this gap by synthesizing evidence from school-based dietary interventions that have assessed cognitive, emotional, behavioral, or psychological outcomes. This literature review evaluates what has been measured, how studies have been designed and implemented, and what findings have emerged. It is guided by the following research questions:

- (1) What types of mental health-related cognitive, emotional, behavioral, and psychological outcomes have been assessed in school-based dietary interventions, and how have these outcomes been measured across different study designs, populations, and intervention types?
- (2) What findings have been reported, and what limitations or methodological issues have been identified?
- (3) What gaps exist in the current evidence base, and how can these inform the development of future school-based nutrition interventions that aim to support mental health and wellbeing in children and adolescents?

Methods

The present review followed the PRISMA-ScR framework (Tricco et al., 2018) and employed a systematic search across five electronic databases: PsycINFO, CINAHL, PsycARTICLES, Academic Search Complete (via EBSCOhost), and PubMed.

The search was limited to peer-reviewed articles published from 2000 to 2025.

The search was completed on 8th March 2025. Titles and abstracts were screened using Rayyan (Ouzzani et al., 2016). Screening followed predefined inclusion and exclusion criteria.

Articles were included if they met the following criteria:

- Population: School-aged children or adolescents (6–18 years)
- Exposure: Dietary or nutritional interventions, including but not limited to diet, nutrition, food intake, dietary patterns, school meals, eating habits, micronutrient supplementation, sugar intake, fortified or functional foods, meal/diet reformulation, overall dietary quality, and or school food policy or nutrition programs changes
- Outcome: Mental health outcomes, including but not limited to internalizing symptoms (e.g., anxiety, depression, stress) emotional wellbeing, and behavioral functioning (e.g., hyperactivity, inattention, oppositional behavior)
- Context: Intervention delivered in a school-based or educational settings

Studies were excluded if they

- Focused on clinical, early-childhood (<6 years) or adult populations
- Were conducted outside of school environments or focused on non-dietary interventions or broader lifestyle interventions without a dietary component
- Did not assess mental health outcomes
- Were not intervention studies (e.g., observational or cross-sectional studies, or were reviews, editorials, dissertations, or non-peer-reviewed materials)

A PRISMA flow diagram summarizes the screening process (Figure 1). Initial screening yielded 2,499 records; after duplicate removal and full-text review, 17 intervention studies were retained for analysis. Risk of bias was not formally assessed, consistent with scoping review methodology (Tricco et al., 2018). For this review, outcomes were grouped into two categories: behavioral outcomes and mental health symptoms. Behavioral outcomes refer to observable behaviors and emotional functioning, such as hyperactivity, inattention, impulsivity, emotional lability, and oppositional behavior, typically assessed through teacher or parent ratings using tools like the Strengths and Difficulties Questionnaire (SDQ) or Conners Comprehensive Behaviour Rating Scales (CBRS). Mental health symptoms refer specifically to internalising symptoms such as depression, anxiety, and stress, assessed using validated scales such as the Beck Depression Inventory (BDI-II) or adapted anxiety and stress inventories. A narrative synthesis was then conducted and structured into two thematic categories: (1) Dietary intervention types and outcomes assessed, (2) patterns and trends across intervention, outcomes, and study contexts. Table 1 presents key study characteristics, including author and date, country and setting, study design, population characteristics (including sample size and gender), intervention type, outcomes assessed (cognitive, physiological, academic, and mental health), and the tools used to assess mental health outcomes. Table 2 summarizes findings by author,

population group (children/adolescents), geographic region and country income level, intervention type, outcomes assessed, main findings and interpretative notes.

Results

Study characteristics: intervention types, study designs and outcomes assessed

The studies included in this review investigated school-based nutrition interventions for children and adolescents across a wide range of countries and regions (see Table 1). Many studies were conducted across multiple sites, and there was a noticeable trend toward targeting rural areas or low-income areas. For instance, Mhurchu et al. (2013) and Murphy et al. (2011) targeted schools in low-income regions, while Neumann et al. (2007), Sigman et al. (2005), Satyanarayana et al. (2024), and Zhang et al. (2013) targeted schools in rural settings. This enabled recruitment from diverse populations, particularly in settings where diet quality is likely to be poor and where interventions may yield the greatest potential benefits (Pradeilles et al., 2019). Eleven studies focused on children aged 6–12 years and typically recruited larger sample sizes ranging from around 100 to over 2000 participants. In contrast, studies involving adolescents were fewer ($n = 6$) and generally smaller in scale, with sample size of approximately 20–200 participants. This pattern may reflect a broader preference for targeting younger populations, who may be more vulnerable to nutritional deficiencies and more responsive to early dietary interventions (Ares et al., 2024).

Interventions included micronutrient supplementation, food reformulation, and school meal provision, each targeting a specific nutrition concern. Supplementation was used to address nutritional deficiencies, such as iron (Zhang et al., 2013), vitamin D (Satyanarayana et al., 2024), or zinc (DiGirolamo et al., 2010; Üçkardeş et al., 2009), or examine the effects of specific nutrients such as omega-3 fatty acids (Al-Ghannami et al., 2019; Kirby et al., 2010; Parletta et al., 2013; Richardson et al., 2012; Tammam et al., 2016). Food reformulation studies aimed to improve dietary intake through varied approaches, such as aligning meals with national dietary guidelines (Healthy New Nordic Diet; Sørensen et al., 2015), modifying the type of grain provided at breakfast (Kim et al., 2021), offering mixed grain diets (Chung et al., 2012), or enriching a local vegetable stew with either meat, milk or vegetable oil (Neumann et al., 2007; Sigman et al., 2005). School meal programs focused on improved nutrition, improved school attendance and addressing consequences of food insecurity (Mhurchu et al., 2013; Murphy et al., 2011).

Of the 17 studies, supplementation was the most common intervention ($n = 10$) with a preference for double-blind, placebo Randomized Controlled Trial (RCT) design ($n = 6$). In contrast, food reformulation ($n = 5$) and school meal interventions ($n = 2$) were less common and typically used cluster RCT designs (see Table 1). The emphasis on supplementation and RCT study designs reflects its alignment with nutrition research, where RCTs offer the strongest method for establishing cause-and-effect relationships (Weaver and Miller, 2017).

TABLE 1 Study design, country and setting, population, intervention type, outcomes assessed, and measurement tools related to mental health of reviewed studies.

References	Country, setting	Population characteristics	Study design	Intervention type and details	Outcome assessed	Assessment tools
Al-Ghannami et al., 2019	Oman, Muscat Primary schools	9–10 years, males and females	Open label	Participants randomized into receiving fish oil capsule (500 mg DHA) (<i>n</i> = 66) or 100 g grilled fish (<i>n</i> = 66) daily, 12 weeks	Physiological, cognitive, mental health: emotional and behavioral functioning	Vanderbilt assessment scales, teacher assessment
Bin Sayeed et al., 2014	Bangladesh, Rangpur Boarding school	14–17 years, males only	RCT – double-blind/placebo	Participants randomized to receive intervention (<i>n</i> = 24) 500 mg Nigella sativa capsule or control (<i>n</i> = 24) Psyllium seed husk daily, 4 weeks	Cognitive, mental health: state and trait anxiety, mood	State-trait anxiety inventory (STAI), bond-lader scale, self-assessment
Chung et al., 2012	Korea Jeonju One high school	16–17 years, males only	RCT (Standard)	Participants randomized to receive mixed grain diet (<i>n</i> = 28) vs. regular diet (<i>n</i> = 28). Mixed grain product (germinated non-glutinous and glutinous brown rice, polished rice, black rice, kidney beans, walnuts) 120 g of mixed-grain product or regular diet (control) served 3 times per day daily, 9-weeks	Physiological, cognitive, mental health: symptoms of Stress	Stress arousal checklist (SACL), self-assessment
DiGirolamo et al., 2010	Guatemala, Guatemala City Five public schools in low-income areas	6–11 years, males and females	RCT – Double-blind/placebo	Participants randomized to receive intervention (<i>n</i> = 378) 10 mg Zinc or control (<i>n</i> = 372) 10 mg glucose daily (5 days/week), 6 months	Physiological, mental health: symptoms of depression and anxiety	Spanish version of the children's depression inventory, Spanish version of the revised children's manifest anxiety scale, parent-reported child Behavior assessment system for children (BASC)
(Kim et al., 2021)	Korea, Jeonju-si Wanju-gun, Jeollabuk-do regional middle and high schools	12–18 years, males and females, participants consumed breakfast less than 3× per week	Open, randomized, parallel group	Participants randomized to rice-based (<i>n</i> = 35), wheat-based (<i>n</i> = 35), or general meal (<i>n</i> = 35, control) breakfast. Diet based on the 2015 Korean dietary reference intake daily, 12-weeks	Physiological, cognitive, mental health: symptoms of stress	Adapted stress tool, self-assessment

(continued)

TABLE 1 (continued)

References	Country, Setting	Population characteristics	Study design	Intervention type and details	Outcome assessed	Assessment tools
Kirby et al., 2010	United Kingdom, Wales Primary schools in Newport area	8–9 years, males and females	RCT – double-blind/placebo	Participants randomized to receive active ($n = 225$) Omega-3 + multivitamin supplements (DHA (200 mg), EPA (28 mg), vitamin A (400 μ g RE), vitamin C (30 mg), vitamin D (2.5 μ g), and vitamin E (1.5 mg α -TE), or placebo ($n = 225$) capsules filled with olive oil matched for appearance and flavor daily, 16 weeks	Academic, cognitive, mental health: emotional and behavioral functioning	Swanson, Nolan, and Pelham-IV (SNAP-IV), strengths and difficulties questionnaire (SDQ), parents and teachers' assessment
Mhurchu et al., 2013	New Zealand 14 schools in low socioeconomic areas	mean (SD) age 9 ± 2 years, males and females	RCT – Cluster, Stepped Wedge	Schools randomized to cross over from control to intervention in different terms during the school year. Total $n = 424$. Number of participants per cluster ranged from 69–146. Free school daily breakfast program. Breakfast provision varied between schools daily, from 1 term to 1 year (depending on cluster)	Academic, mental health: emotional and behavioral functioning	Strengths and difficulties questionnaire (SDQ), teacher's assessment
Murphy et al., 2011	United Kingdom, Wales 56 schools targeted low-income areas first	9–11 years, males and females,	RCT – Cluster, with repeat cross-section design and 12-month follow-up	Schools randomized into control ($n = 2425$) and intervention ($n = 2463$). school breakfast meals provided during academic years 2004–2005 and 2006–2007 breakfast provided daily, 1 year	Cognitive, mental health: emotional and behavioral functioning	Strengths and difficulties questionnaire (SDQ), teacher's assessment
Neumann et al., 2007	Kenya, rural Embu District 12 schools	Same cohort as Sigman et al. (2005)	RCT - Cluster	same as Sigman et al. (2005)	Physiological, academic, cognitive, mental Health: Behavioral functioning	Subjective behavioral observation of leadership, percentage time spent in high and low physical activity, and initiative during free play by trained assessors

(continued)

TABLE 1 (continued)

References	Country, setting	Population characteristics	Study design	Intervention type and details	Outcome assessed	Assessment tools
Parletta et al., 2013	Australia, Northern Territory four schools	6–12 years, males and females	RCT – Crossover/Within-Subjects	Participants randomized to receive placebo ($n = 202$; palm oil) or fish oil capsules ($n = 206$; 750 mg DHA + EPA and 60 mg gamma-linolenic acid per school day). Phase 1 lasted 20 school weeks, followed by a one-way crossover in Phase 2 where all participants received fish oil Daily, 20 school weeks + crossover phase	Academic, cognitive, mental health: emotional and behavioral functioning	Conners comprehensive Behavior rating scales (CBRS), teachers' assessment
Richardson et al., 2012	United Kingdom, Oxfordshire Recruitment from 74 schools	7–9 years, male and females	RCT – double-blind/placebo	Participants randomized to receive active ($n = 180$) 600 mg DHA (algal oil) or placebo ($n = 182$) corn/soybean oil Daily, 16 weeks	Physiological, cognitive, mental health: emotional and behavioral functioning	Conners comprehensive Behavior rating scales (CBRS), teachers and parent's assessment
Satyanarayana et al., 2024	India, Rural Kolar 20 schools randomly selected	14–19 years, males and females	RCT – Cluster	Schools randomized to Intervention ($n = 235$) 60,000 IU vitamin D ₃ once/month for 2 months followed by daily supplementation with 250 IU vitamin D ₃ + 500 mg calcium for 9 weeks, or Control ($n = 216$) daily supplementation with 250 IU vitamin D ₃ + 500 mg calcium for 9 weeks.	Physiological, mental health: symptoms of depression	Beck Depression inventory (BDI-II). clinician-administered interview
Sigman et al., 2005	Kenya, rural 12 schools	7–8 years, males and females	RCT – Cluster	Schools randomized to one of four breakfast interventions: githeri + meat (meat; $n = 126$), githeri + milk (milk; $n = 143$), githeri only (Energy, $n = 130$), or no supplementation (Control, $n = 141$) daily, 21 months	Physiological, mental health: behavioral functioning	Subjective behavioral observation of activity levels, emotional state (positive, negative, neutral), social interactions (peer involvement, leadership, solitary play, aggression) during free play by trained assessors

(continued)

TABLE 1 (continued)

References	Country, setting	Population characteristics	Study design	Intervention type and details	Outcome assessed	Assessment tools
Sørensen et al., 2015	Denmark 9 Danish municipal schools	8–11 years, males and females	RCT – Cluster, with cross-over design	Cluster randomization of year group within schools. Intervention-Control group ($n = 398$) received intervention, followed by control. control-Intervention group ($n = 425$) received control, followed by intervention. Intervention diet: healthy new nordic diet school meals provided during school hours. Control diet was child's habitual lunch/snacks Daily, 3 months,	Academic, cognitive, mental health: emotional and behavioral functioning	Learning rating scale (Danish) teachers and self-assessment
Tammam et al., 2016	United Kingdom, London Large comprehensive secondary school	13–16 years, male and female	RCT – double-blind/placebo	Participants randomized to receive active ($n = 98$) condition: 1 × multivitamin/mineral tablet and 2 × n -3 PUFA capsules (EPA 165 mg; DHA 116 mg) or placebo ($n = 98$) tablet containing dicalcium phosphate with potato starch and placebo capsule containing sunflower oil matched for color, odor and flavor daily, 12 weeks	Physiological, mental health: emotional and behavioral functioning	Conners comprehensive Behavior rating scales (CBRS), teachers' assessment
Üçkardeş et al., 2009	Turkey Low-income district 1 primary school	8–9 years, males and female	RCT – double-blind/placebo	Participants randomized to receive study condition ($n = 109$) 15 mg/day elemental zinc syrup or placebo ($n = 109$) syrup containing no zinc Daily, 10 weeks	Physiological, mental health: emotional and behavioral functioning	Conners comprehensive Behavior rating scales (CBRS), teachers and parent's assessment
Zhang et al., 2013	China, rural Shaanxi Province 54 schools of the poorest regions were selected	10–12 years, male and female	RCT - Cluster	Schools randomized to intervention ($n = 1446$) or control ($n = 1757$). Intervention participants received multinutrient tablet containing 20 vitamins and minerals including 5 mg iron as ferrous sulfate. Control school participants received no intervention or placebo Daily, 5 months	Physiological, mental health: symptoms of anxiety	Adapted general anxiety test

TABLE 2 Population characteristics, region, country and income level, intervention type, outcomes assessed, main findings and interpretative notes of reviewed studies.

Author	Population	Region/country income level	Intervention type	Outcomes assessed	Main findings	Interpretative notes
Al-Ghannami et al. (2019)	Children (6–12 y)	Asia, High-income	Supplementation	Behavioral functioning	Improvements in Teacher rated behavior scores for both groups, however large effects observed in fish meal group compared to supplement group	No control group. Low levels not reported, however significant increases in red cell omega-3 fatty levels in both groups
Bin Sayeed et al. (2014)	Adolescents (13–18 y)	Asia, Lower-middle income	Supplementation	Anxiety	Supplementation was associated with improvements in mood and trait anxiety within the treatment group; however, no statistically significant differences were observed between the treatment and control groups.	Conducted only in males, small sample size and short duration.
Chung et al. (2012)	Adolescents (13–18 y)	Asia, High-income	Food Reformulation	Stress	No effect	
DiGirolamo et al. (2010)	Children (6–12 y)	Latin America & Caribbean, upper-middle income	Supplementation	Depression, Anxiety	No significant group differences in mental health outcomes, however, increases in serum zinc were associated with reductions in depression, anxiety, and internalizing symptoms.	Zinc deficiency in ~20% of population
Kim et al. (2021)	Adolescents (13–18 y)	Asia, Upper-middle income	Food Reformulation	Stress	No significant changes over time. Following treatment, WMG (wheat) group had higher stress scores compared to other groups. No differences at baseline	Participants habitually skipped breakfast
Kirby et al. (2010)	Children (6–12 y)	Europe, High-income	Supplementation	Behavioral functioning	Differences between group in parent rated prosocial behavior: remained steady in treatment but declined in control group. Not confirmed in teacher ratings. Placebo effect observed.	Measured cheek cell sampling. EPA and DHA levels increased in treatment and control groups

(continued)

TABLE 2 (continued)

Author	Population	Region/country income level	Intervention type	Outcomes assessed	Main findings	Interpretative notes
Mhurchu et al. (2013)	Children (6–12 y)	Oceania, High-income	School Meals	Behavioral functioning	No effect	
Murphy et al. (2011)	Children (6–12 y)	Europe, High-income	School Meals	Behavioral functioning	No effect	
Neumann et al. (2007)	Children (6–12 y)	Africa, Lower-middle income	Food Reformulation	Behavioral functioning	Meat group showed largest gains in physical activity, leadership, initiative behaviors (compared to other groups)	Vitamin B12 deficiency, anemia, stunting and underweight
Parletta et al. (2013)	Children (6–12 y)	Oceania, High-income	Supplementation	Behavioral functioning	Behavioral data could not be analyzed	Evidence of poor-quality diet
Richardson et al. (2012)	Children (6–12 y)	Europe, High-income	Supplementation	Behavioral functioning	Placebo effect observed, however parent rated improvements in hyperactivity, oppositional behavior, mood swings and impulsivity were reported (ITT analyses)	Study targeted children performing below the 33rd percentile on a UK-standardized word reading test
Satyanarayana et al. (2024)	Adolescents (13–18 y)	Asia, Lower-middle income	Supplementation	Depression	Significant reduction in depression scores	Vitamin D deficiency reported in both groups. Only 2000 IU/day treatment group showed clear improvement in Vitamin D status. Blinding not explicitly stated.
Sigman et al. (2005)	Children (6–12 y)	Africa, Lower-middle income	Food reformulation	Behavioral functioning	Over time meat group had less of a decline in leadership and initiative. All supplemented children demonstrated more leadership and initiative. Meat group showed smallest decline in high activity compared to other groups.	Stunting and underweight reported for between 15%–30% of population

(continued)

TABLE 2 (continued)

Author	Population	Region/country income level	Intervention type	Outcomes assessed	Main findings	Interpretative notes
Sørensen et al. (2015)	Children (6–12 y)	Europe, High-income	Food Reformulation	Behavioral functioning	No effect	
Tammam et al. (2016)	Adolescents (15–18 y)	Europe, High-income	Supplementation	Behavioral functioning	Supplementation improved teacher assessment of disruptive behavior in treatment group but worsened in control group. High-misbehavior subset appeared to improve after treatment, but not sig different.	Baseline levels of EPA, DHA, total n-3 fatty acids, and the n-3 index were low, while the total n-6 fatty acids and the n-6 to n-3 ratio were elevated. Baseline disciplinary offence rate was 2.5 × higher in control group than active group
Üçkardeş et al. (2009)	Children (6–12 y)	Europe, Upper-middle income	Supplementation	Behavioral functioning	Behavior improvements found in both treatment and control groups. Zinc supplementation significantly reduced the prevalence of clinically significant parent-rated symptoms of attention deficit and hyperactivity. Effects were stronger in children of mothers with low education. No significant changes in teacher-rated scores.	No zinc deficiency was observed in the study; however, this may be due to limitations in the testing methodology. The authors noted a potential risk of zinc deficiency amongst broader population
Zhang et al. (2013)	Children (6–12 y)	Asia, Upper-middle income	Supplementation	Anxiety	Significant reduction in self-reported anxiety scores	Multiple nutrients may impact outcomes. High anemia rate ~ 45% at baseline

Geographic regions are defined according to the classifications provided by Our World in Data (<https://ourworldindata.org/world-region-map-definitions>) Income levels are based on the World Bank's country classification by income (<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519>). ITT: intention-to-treat analyses; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid.

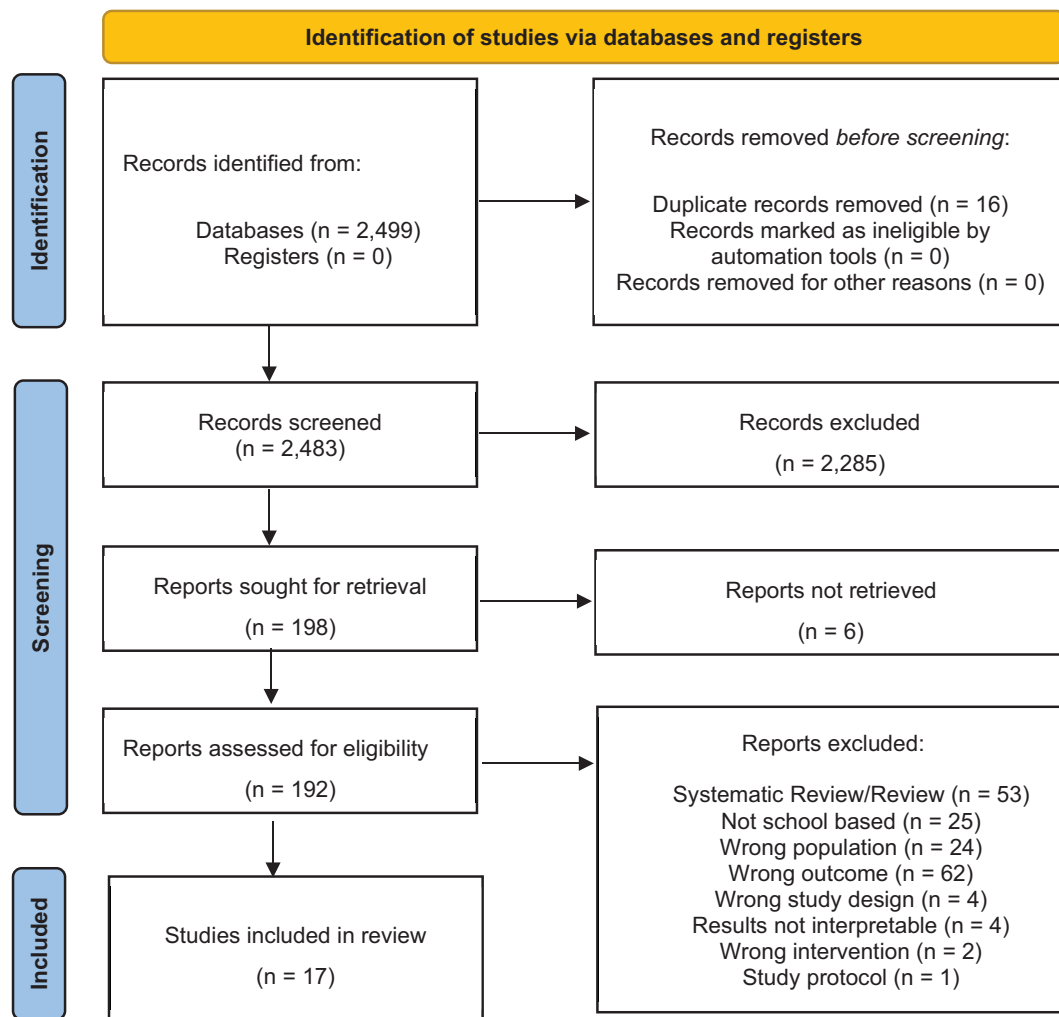


FIGURE 1
PRISMA-ScR flow diagram illustrating the screening and selection process for school-based dietary intervention studies assessing mental health symptoms in children and adolescents.

Across studies, mental health outcomes were assessed using standardized measures, although the approach varied by age group. In children, behavioral outcomes, such as hyperactivity, attention, and conduct, were commonly assessed via parent and teacher reports using tools such as the Strengths and Difficulties Questionnaire (SDQ) (Mhurchu et al., 2013; Murphy et al., 2011), Conners Rating Scales (Richardson et al., 2012; Tammam et al., 2016; Üçkardeş et al., 2009), and the SNAP-IV for ADHD and oppositional symptoms (Kirby et al., 2010). In contrast, adolescent studies focused on internalizing symptoms, such as anxiety and depression, relying on self-report questionnaires such as the State-Trait Anxiety Inventory (STAI) (Bin Sayeed et al., 2014), an adapted stress scale (Kim et al., 2021), and an adapted General Anxiety Test (Zhang et al., 2013) (see Table 1). Only one study employed clinician-administered interviews (Satyanarayana et al., 2024). This trend may reflect developmental differences in assessment practices, where younger children may be less able to self-report reliably (Johnston and Murray, 2003).

Overall, the studies reflect a strong emphasis on early intervention in younger, at-risk populations, particularly using

supplementation strategies. This may indicate a preference for targeted and controlled nutritional intervention approaches. More broadly, these patterns also reflect evidence that schools are a critical setting for addressing nutritional concerns and promoting healthy eating behaviors in children and adolescents, enabling access to large, diverse populations (O'Brien et al., 2021).

Patterns and trends in findings

Across the studies, findings varied depending on outcome type and participant age group. Below, an overview of the findings are presented by outcome type; a summary is included in Table 2.

Behavioral outcomes

Improvements in behavioral and emotional functioning were reported following supplementation and food reformulation interventions. In supplementation studies, parents reported improvements in symptoms such as hyperactivity, emotional lability, oppositional behavior, and impulsivity following

supplementation with omega-3 (Kirby et al., 2010; Richardson et al., 2012), or zinc (Üçkardeş et al., 2009). Following omega-3 supplementation, teachers' reported reductions in disruptive behavior (Tammam et al., 2016), enhanced attention and reduced hyperactivity (Al-Ghannami et al., 2019). However, discrepancies between parent and teacher reports were common, and several studies demonstrated placebo effects. For example, the improvements reported by parents following omega-3 supplementation in studies by Kirby et al. (2010) and Richardson et al. (2012) were not corroborated by teacher assessments, and some improvements were also evident in the control groups, indicating potential placebo effects. A similar pattern was observed for zinc supplementation, where parents reported reductions in symptoms of inattention and hyperactivity; however, these improvements were not confirmed in teacher ratings (Üçkardeş et al., 2009). These patterns highlight the challenges of relying on subjective behavioral assessments and potential influence of expectations and contextual factors (Lapalme et al., 2020).

Behavioral improvements were also observed in food reformulation studies conducted in low-income countries, where children showed improvements in activity levels, leadership, and initiative behaviors (Neumann et al., 2007; Sigman et al., 2005). These populations had high rates of stunting and underweight, suggesting that the intervention may have addressed moderate to severe nutritional deficiencies, which likely contributed to the observed improvements. In contrast, no measurable behavioral improvements were reported after one year of school breakfast programs in high-income countries, despite targeting low-socioeconomic regions (Mhurchu et al., 2013; Murphy et al., 2011). These patterns indicate that interventions may have greater impact in settings where undernutrition and poor diet quality are more prevalent.

Mental health symptoms

In studies assessing mental health symptoms, improvements were reported for symptoms of depression and anxiety following supplementation. Satyanarayana et al. (2024) reported significant reductions in depressive symptoms among adolescents following daily Vitamin D₃ supplementation (2,000 IU) over 2 months. Similarly, Zhang et al. (2013) found reduced self-reported anxiety in children following supplementation with a multinutrient formulation containing 5 mg iron as ferrous sulfate. However, findings were not consistent across all studies. DiGirolamo et al. (2010) found no group-level differences in mental health symptoms between zinc-supplemented and control groups, although increased serum zinc was linked to improved parent-rated symptoms. Bin Sayeed et al. (2014) observed within-group improvements in mood and trait anxiety following supplementation with *Nigella Sativa*, but no differences between treatment and control groups, suggesting possible placebo effects or time-related changes. Importantly, supplementation appeared to address nutritional deficiencies reported in several studies (Vitamin D deficiency, anemia), suggesting that improvements in mental health symptoms may be more likely when interventions are targeting underlying deficiencies.

Food reformulation studies did not report improvements in mental health symptoms. However, this finding is based on two studies, one with a small sample size (Chung et al., 2012), and

the other comparing multiple breakfast types rather than testing against a true control condition (no intervention) (Kim et al., 2021). This limits the strength of the conclusion that can be drawn.

Overall, findings suggest that supplementation may offer modest benefits for behavioral and mental health outcomes, particularly in populations with nutritional deficiencies. However, inconsistencies across studies and methodological limitations highlight the need for more rigorous and context-sensitive research to clarify the impact of dietary interventions on mental health.

Research gaps and future directions

School-based dietary interventions show promise in supporting the mental health and wellbeing of children and adolescents. This review highlights the unique role schools can play in recruiting large, diverse populations and targeting at-risk groups. It also demonstrates that rigorous research designs, including RCTs, can be successfully implemented in school settings across varying contexts. However, several important gaps remain.

The evidence is weighted toward studies in children, with adolescents underrepresented overall. This leaves a gap in understanding how school-based dietary interventions may impact adolescent mental health and wellbeing, especially as adolescents may be vulnerable to poor dietary habits and the mental health consequences of inadequate nutrition (Chaudhary et al., 2020; Devine et al., 2023; Samad et al., 2024). Furthermore, relatively few studies assessed mental health symptoms such as depression, anxiety, and stress, and inconsistencies in outcome measurement limit comparability across trials. Given the rising prevalence of these conditions, future research should prioritize the assessment of mental health outcomes in child and adolescent populations using validated, standardized, and age-appropriate measures (Deighton et al., 2014).

Overall, fewer studies included routine assessment of dietary intake or biomarkers of nutritional status, limiting conclusions about whether interventions effectively addressed nutrient deficiencies or the pathways through which nutrition may influence mental health (Gillies et al., 2025; Young et al., 2020). Notably, positive outcomes were more common in studies involving participants with baseline nutritional deficiencies or in those using broad-spectrum formulations (DiGirolamo et al., 2010; Satyanarayana et al., 2024; Zhang et al., 2013). Evidence also suggests that multinutrient approaches may be more effective than single-nutrient supplementation, suggesting that strategies aimed at improving overall nutritional adequacy hold greater potential (Rucklidge et al., 2021).

Despite the popularity of supplementation, few studies investigated whole-diet approaches, even though these have become a major focus in broader nutrition research (Bamber et al., 2007; Chopra et al., 2021; Staudacher et al., 2025). Furthermore, fewer studies employed longitudinal designs or included follow-up data, limiting understanding of the long-term impact of these interventions (Langford et al., 2014). Whole-diet interventions may be more closely aligned with the principles of health-promoting schools, as they are better positioned to address the complex social

and contextual factors shaping dietary intake (Woodside et al., 2024, 2021). These approaches may offer more sustainable and meaningful improvements in mental health and wellbeing.

In conclusion, research is needed to evaluate the impact of school-based dietary interventions on mental health across both child and adolescent populations (Zhao et al., 2025). Future work should prioritize whole-diet strategies within school settings, incorporate measures of nutritional status, and include long-term follow-up to capture their sustained potential for improving mental health and wellbeing.

Author contributions

CC: Conceptualization, Resources, Formal analysis, Writing – original draft, Writing – review & editing, Project administration, Visualization, Supervision, Methodology, Validation, Data curation, Investigation, Software. EG: Supervision, Methodology, Conceptualization, Software, Writing – review & editing, Investigation, Writing – original draft, Formal analysis, Visualization, Project administration, Validation, Data curation, Resources.

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