Ranisavljev et al. Nutrition Journal (2025) 24:69
https://doi.org/10.1186/s12937-025-01136-2

Nutrition Journal

REVIEW

Open Access

Community-based interventions addressing multiple forms of malnutrition among adolescents in low- and middle-income countries: a scoping review

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Abstract

Background Community-based interventions hold promise for addressing adolescent malnutrition, but there is limited knowledge of their nature and impact on adolescent nutrition outcomes in low- and middle-income countries (LMICs). This scoping review aimed to characterize community-based adolescent nutrition interventions in LMICs and summarize their effects on adolescent nutrition outcomes.

Methods We systematically searched MEDLINE via PubMed, Embase, and CENTRAL through the Cochrane Library for studies published between 2000 and 2023. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews guidelines. Eligible studies included randomized controlled trials and quasi-experimental studies addressing adolescent malnutrition in LMIC community settings, involving adolescents aged 10–19 years. A narrative synthesis was employed to analyze and describe the evidence.

Results Our review included 37 records from 36 studies conducted in 27 countries. Interventions included micronutrient supplementation, nutrition education, food supplementation and fortification, physical activity education, and multicomponent approaches. The intervention duration ranged from 3 weeks to 2 years, with limited studies grounded in theoretical frameworks. Fifty-seven percent of interventions (n = 21) targeted adolescent girls, indicating a gap in programs for boys and other vulnerable groups, such as out-of-school adolescents and migrants. The intervention delivery agents included research staff and healthcare professionals. The majority of interventions were delivered in person; few utilized social media strategies. Among the studies reviewed, nine out of ten evaluating micronutrient supplementation, six out of seven assessing nutrition education, and seven out of eight examining multicomponent interventions reported improvement in at least one nutrition or diet-related outcome.

Conclusions Community-based interventions hold promise for improving adolescent nutritional status in LMICs. However, our review highlights gaps in the evidence base, marked by significant variability in intervention design,

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delivery, and implementation platforms. This underscores the need for integrated approaches and rigorous evaluations of their implementation outcomes, including acceptability, relevance, feasibility, effectiveness, and sustainability, in addressing adolescent nutrition challenges.

Registration The review protocol was registered prospectively with the Open Science Framework on 19 July 2023 (https://osf.io/t2d78).

Keywords Community interventions, Malnutrition, Adolescents, Review, Low- and middle-income countries

Introduction

Approximately 1.3 billion adolescents aged 10–19 years constitute 16% of the global population [1], and of these, 90% reside in low- and middle-income countries (LMICs) [2]. Because adolescence is characterized by rapid body growth and physiological changes, proper nutrition is critical as it lays the foundation for well-being in adulthood [3]. However, adolescents in LMICs face significant nutritional challenges, including the double burden of malnutrition (DBM). This condition is characterized by the coexistence of persistent underweight and widespread micronutrient deficiencies—particularly iron deficiency—alongside rising rates of overweight and obesity [4]. For example, in Southeast Asia, thinness is prevalent among 11.7% of boys and 8.9% of girls, while overweight is prevalent among 19.5% of boys and 15.0% of girls [5]. Furthermore, in northern Africa, 5.8% of boys and 3.6% of girls are affected by thinness, while 30.1% of boys and 32% of girls are overweight and 12.8% of boys and 14.6% of girls are obese [5]. Lastly, iron deficiency anaemia among adolescents is a leading cause of disability-adjusted life years globally, with prevalence rates reaching up to 50% among girls and 30% among boys in some countries [6–8]. The COVID- 19 pandemic could have further exacerbated these rates due to food crises and inflation. Moreover, data on dietary diversity and quality among adolescents in LMICs is limited, posing significant challenges for monitoring and evaluating existing programs and developing effective interventions to address the DBM in this population [9].

Undernutrition and micronutrient deficiencies during adolescence lead to numerous adverse health consequences, including poor cognitive skills and academic performance, increased susceptibility to infectious diseases, stunted bone growth, diminished vision, complications during pregnancy and birth, and decreased economic productivity [10]. Conversely, overweight and obesity contribute to noncommunicable diseases (NCDs), including hypertension, coronary heart disease, stroke, diabetes, and certain cancers [10]. Therefore, addressing all forms of malnutrition among adolescents in LMICs is a public health priority. The recent rise in the DBM has sparked increased interest in interventions, policies, and programs that address multiple forms of malnutrition simultaneously, often referred to as double-duty actions [11]. These actions help address common drivers of undernutrition and overweight/obesity at once and are advantageous given the limited public health and policy resources available to address nutrition-related challenges and diseases.

Nutrition interventions for adolescents in LMICs include health education, dietary and nutritional programs, and multicomponent strategies. These interventions can be categorized into nutrition-specific interventions, which address the immediate causes of malnutrition, or nutrition-sensitive interventions, which target the underlying causes. [12, 13]. Despite the existence of these interventions, significant gaps remain in our understanding of the DBM among adolescents in LMICs. Historically, most interventions have been delivered through schools, which are considered promising platforms for addressing the nutritional needs of adolescents [12]. Consequently, there is limited evidence on community-based nutrition programs targeting out-of-school and vulnerable adolescents, such as migrants, those engaged in work to support their families, and those living with HIV. Furthermore, many interventions focus primarily on older adolescent girls, leaving a gap in knowledge about their effectiveness for younger adolescent girls and adolescent boys.

To address these gaps, we conducted a scoping review to characterize community-based interventions targeting various forms of malnutrition among adolescents in LMICs and to describe their effects on nutrition and health outcomes. Within this review, community-based interventions encompass all initiatives implemented in community settings, excluding schools, aiming to improve the health and nutrition of both in- and out-of-school adolescents within specific local communities. Examples of such settings include, but are not limited to, homes, religious centres, clubs, and youth centres.

Methods

This scoping review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist [14], summarized in Online File 1. The review protocol has been published elsewhere [15], with registration on Open Science Framework (https://osf.io/t2d78).

Eligibility criteria

Eligibility criteria were determined using the participants, concept, and context (PCC) model without any restrictions on outcomes for a broad search. We included both quantitative and qualitative data from randomized controlled trials (RCTs) of individuals or clusters, quasi-experimental studies, and controlled before-after studies addressing adolescent malnutrition in community settings within LMICs (according to the World Bank's classification in 2022–2023) [16]. Studies were eligible if they focused on adolescent boys and/or girls aged 10–19 years and included interventions such as micronutrient supplementation, feeding interventions, nutrition education, physical education, or other relevant interventions aimed at improving adolescent health and nutrition [15]. The criteria did not impose restrictions on language, sample size, or intervention duration. The exclusion criteria included quasi-experimental studies without comparator groups, observational studies, editorials, commentaries, opinions, and review articles. Additionally, studies exclusively focusing on individuals with specific conditions, including malnourished individuals, were excluded [15]. We also excluded school-based interventions because of their extensive coverage and synthesis in the literature [12, 17, 18]. We focused on community-based interventions that are less common, less understood, and more challenging to implement than school-based interventions and yet hold promise for reaching the most vulnerable groups of adolescents [15].

Information sources and search

We conducted a comprehensive search of MEDLINE via PubMed, Embase, and CENTRAL through the Cochrane Library to identify relevant studies published between January 1, 2000, and July 14, 2023. Additionally, we carefully examined the references and bibliographies of the included studies and relevant reviews to identify additional sources of information. We employed keyword search terms pertaining to the adolescent population, interventions (nutrition education, physical activity, food supplements and fortification, micronutrient supplements, community gardens, and WASH), types of studies (RCTs and quasi-experimental studies), and settings (LMICs). The search strategy was not restricted by predefined outcomes, enabling the review to capture the full range of outcomes addressed by community-based nutrition interventions for adolescents and to identify trends in their effectiveness. The detailed search strategy for all the databases is provided in Online File 2. We exported the final search results into Covidence (Veritas Health Innovation, Melbourne, Australia), where duplicates were removed [15].

Selection of sources of evidence

Initially, two researchers independently screened titles/abstracts and later progressed to full-text screening. Disagreements were resolved through discussion. We documented and summarized the study exclusions using the PRISMA flow diagram for scoping reviews [14].

Data extraction process and data items

Using a prespecified Excel form for all eligible studies, we extracted publication details and study methods, including study type, age, sex, country, sample size, and inclusion criteria. For the intervention strategy, we collected data on the timing, duration, and frequency of the intervention, guiding theories, intervention topics, delivery mechanisms, and selection and training of delivery agents. We also extracted outcome data, details of the measures used, and qualitative findings.

Critical appraisal of individual sources of evidence

We used the Cochrane Collaboration's revised tool for assessing the risk of bias in randomized trials (RoB2) [19]. For the risk of bias in clustered trials, we used the risk of bias 2 for the cluster-randomized trials tool (RoB2 CRT) [20]. Finally, we used the Risk of Bias in Nonrandomized Studies of Interventions (ROBINS-I) tool [21] to assess the risk of bias for controlled before-after studies and nonrandomized controlled trials.

Synthesis of evidence

We systematically synthesized the findings from all included studies, both in textual form and in tabular format, following the Synthesis Without Meta-analysis (SWiM) guidelines [22]. Where reported, the impact of interventions was described through mean differences for continuous variables and percentage or percentage point changes for binary outcomes. We presented simple frequency counts to summarize the overall direction of effects for each outcome. We analyzed qualitative studies using thematic analysis, with narrative descriptions provided for each identified theme.

Results

Study description

Our initial search generated 28,315 records (Fig. 1). Following title and abstract screening, 20,985 records were excluded. We reviewed 149 full-text records for eligibility. Ultimately, 37 records from 36 studies met the eligibility criteria and were included in the review. Table 1 summarizes the study characteristics, including study type, intervention content and delivery mechanism,

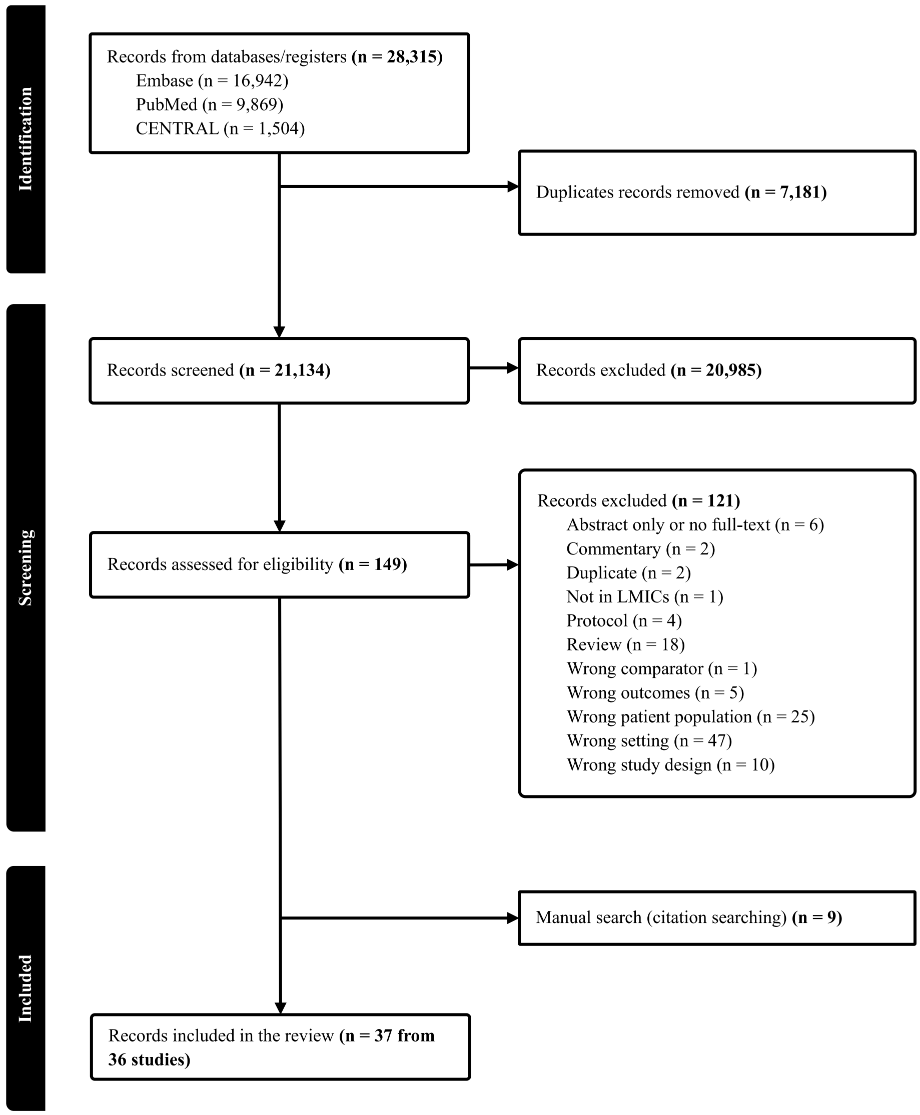

Fig. 1 Scoping literature review flow chart

comparator group, outcomes, and overall evidence quality.

Study design, setting, and population

Of the 37 records from 36 studies included in the review, 18 were RCTs, 10 were cluster RCTs (cRCTs), 2 were mixed-methods evaluations, 5 were non-RCTs, and 2 were qualitative assessments (Table 1). The included studies were conducted in 27 different countries. A significant proportion of the studies (47.2%) were conducted in Asia (nine in India, two each in Bangladesh and Malaysia, and one each in Indonesia, Iran, Pakistan, and Thailand), 22.2% were conducted in Africa (two in Tanzania, and one each in Benin, Ethiopia, Ghana, Niger, Uganda, and Zambia), 13.9% were conducted in South America (two each in Brazil and Peru, and one in Colombia), 5.6% were conducted in North America and the Caribbean (one each in Jamaica and Mexico), Oceania (one each in Fiji and Tonga), and 2.8% were conducted in Europe (one in Bulgaria, Croatia, and Romania). One study was conducted across four countries in Asia and Africa—the Philippines, Sri Lanka, Madagascar, and Tanzania. Overall, the participants' ages ranged from 5–44 years across the studies. Specifically, 20 interventions focused on adolescents aged 10–19 years, two interventions targeted children and younger adolescents aged 5–14 years, five interventions were aimed at children and adolescents aged 5–19 years, two interventions focused

Table 1 Characteristics of the included studies on community-based interventions targeting nutrition and physical activity for adolescents

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
Micronutrients supplementation								
1	Ahmed (2001), Bangladesh [23]	RCT	**Participants:** *n* = 480 **Age range:** 14–19 years **Gender:** women	Multimicronutrient supplementation Intervention I: vitamin A (2.42 mg) tablets Intervention II: iron (120 mg) and folic acid (3.5 mg; IFA) tablets Intervention III: IFA *plus* vitamin A tablets **Duration:** 12 weeks **Frequency:** weekly **Follow-up:** immediately postintervention	Supplements are given in garment factories either before or after lunch **Delivery agent(s):** Field staff	Placebo	- Significant increase in haemoglobin in the IFA supplement group than in the placebo group - Significant increase in haemoglobin concentration in the IFA *plus* vitamin A supplements group versus the IFA supplement group	Low
2	Bansal (2016), India [24]	RCT	**Participants:** *n* = 446 **Age range:** 11–18 years **Gender:** women	Multimicronutrient supplementation (IFA (100 mg iron and 500 mcg folate) and 500 mcg cyanocobalamin for 6 weeks and 15 mcg for 20 weeks) tablets **Duration:** 26 weeks **Frequency:** weekly **Follow-up:** immediately postintervention	Door-to-door weekly delivery of supplements **Delivery agent(s):** Investigator	IFA and a placebo	- Prevalence of vitamin B12 deficiency reduced in the intervention group; no change in the B12 deficiency in the control group - A significant reduction in the prevalence of serum ferritin deficiency in the intervention group, compared to the control group	Low
3	Beasley (2000), Tanzania [25]	RCT	**Participants:** *n* = 119 **Age range:** 12–18 years **Gender:** women	Iron (400 mg ferrous sulfate) tablets **Duration:** 16 weeks **Frequency:** weekly **Follow-up:** immediately postintervention	Not reported	Cyanocobalamin tablets	- Significant increase in serum ferritin, but not in haemoglobin in the intervention group compared to the control group	Some concerns
4	Correia-Santos (2011), Brazil [26]	RCT	**Participants:** *n* = 36 **Age:** mean age 16 years in the control group and 17 years in the intervention group **Gender:** women	Multimicronutrient supplementation (18 mg iron, 15 mg zinc, 2 mg copper, 162 mg calcium, and other vitamins and minerals) tablets **Duration:** 15 weeks **Frequency:** daily **Follow-up:** at 7, 11, and 15 weeks	Not reported	Placebo	- Significant increase in haemoglobin and zinc concentrations in the intervention group at 11 and 15 weeks compared to the control group - Significant increase in plasma calcium in the intervention group at 11 weeks compared to the control group - Reduction in copper concentration in the placebo group at 7 and 11 weeks	High

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
5	Gunaratna (2015), Tanzania [27]	RCT	**Participants:** *n* = 561 **Age range:** 15–29 years **Gender:** women	Multimicronutrient supplementation Intervention I: IFA (iron 30 mg and folic acid 0.4 mg) tablets Intervention II: Multivitamin (vitamin A 2500 IU, vitamin B1 1.4 mg, vitamin B2 1.4 mg, vitamin B6 1.9 mg, vitamin B12 2.6 mg, niacin 18 mg, vitamin C 70 mg, vitamin E 10 mg) and IFA tablets **Duration:** 6 months **Frequency:** daily **Follow-up:** immediately postintervention	Supplements are dispensed during monthly home visits **Delivery agent(s):** Research staff	Folic acid tablets	- No difference in haemoglobin levels across study arms - Compared to the folic acid regimen, a lower risk of hypochromic microcytic anaemia in the two intervention groups	Low
6	Handiso (2021), Ethiopia [28]	RCT	**Participants:** *n* = 226 **Age range:** 10–19 years **Gender:** women	IFA tablets (60 mg iron and 0.4 mg folic acid) **Duration:** 3 months **Frequency:** weekly **Follow-up:** immediately postintervention	IFA tablets are provided every weekend through household visits **Delivery agent(s):** Nurses and supervisors	No intervention	- Significant increase in haemoglobin, serum ferritin, and serum folate concentrations in the intervention group compared to the control group after 3 months of supplementation	Low
7	Kumar (2023), India [29]	RCT	**Participants:** *n* = 520 **Age range:** 11–18 years **Gender:** women	Micronutrient supplementation Intervention I: weekly IFA (100 mg iron, 500 mg folate) tablets Intervention II: weekly IFA and vitamin C (25 mg) tablets **Duration:** 6 months **Frequency:** weekly **Follow-up:** midpoint and immediately postintervention	Community health workers provided tablets to the participants at the healthcare center **Delivery agent(s):** Healthcare workers	Daily IFA tablets	- Significant increase in haemoglobin levels in the weekly IFA supplementation group compared to the daily IFA supplementation group - A higher increase in haemoglobin levels with vitamin C supplementation than with only IFA supplementation	High
8	Kanani (2000), India [30]	CRCT	**Participants:** *n* = 203 (from 3 clusters) **Age range:** 10–18 years **Gender:** women	IFA tablets (60 mg iron and 0.5 mg folic acid) **Duration:** 3 months **Frequency:** daily **Follow-up:** immediately postintervention	Tablets delivered through community-based youth project **Delivery agent(s):** Researchers	Placebo	- An increase in haemoglobin levels in the intervention group and a slight decrease in the placebo group - A significant weight gain (0.83 kg) among girls in the intervention group	Some concerns

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
9	Lopez-de-Romana (2006), Peru [31]	CRCT	**Participants:** *n* = 866 households **Age range:** 12–44 years **Gender:** women	Multi-micronutrient supplementation by Nutrivit capsules (iron 30 mg, zinc 20 mg, vitamin A 4 mg, vitamin C 60 mg, and folic acid 0.7 mg) **Duration:** 8 weeks **Frequency:** 2 RDAs **Follow-up:** immediately postintervention	Distribution of blister packs of four capsules to households **Delivery agent(s):** Healthcare staff and facilitators	No intervention	- No significant increase in the mean haemoglobin concentration among adolescents and women in the intervention group - Significantly lower haemoglobin concentration among adolescents and women in the control group - No effect of supplementation on the mean BMI between groups	Some concerns
10	Sharieff (2008), Benin [32]	CRCT	**Participants:** *n* = 339 (from 161 households) **Age range:** 11–15, 15–44 years **Gender:** women	The use of two different forms of iron cooking pots on anaemia Intervention I: cast iron pots Intervention II: blue steel pots **Duration:** 6 months **Frequency:** Not reported **Follow-up:** 12 follow-up visits (once every two weeks)	Home visits **Delivery agent(s):** Fieldworkers and trained technicians	Daily iron tablets (60 mg iron for 3 months and 30 mg iron for another 3 months)	- No significant differences in haemoglobin concentrations among groups - Higher serum ferritin concentrations in the control group compared with the groups using iron pots	Low
Nutrition education, workshop, or training								
11	Creed-Kanashiro (2000), Peru [33]	RCT	**Participants:** *n* = 121 **Age range:** 12–17 years **Gender:** women	An education campaign to improve the menus of the community kitchens and to provide low-cost heme sources of iron and dietary enhancers **Duration:** 9 months **Frequency:** Not reported **Follow-up:** immediately postintervention	Training sessions, distribution of education materials including school folders, pencil cases, T-shirts, posters, recipe booklets, and mobile promoting iron-rich foods **Delivery agent(s):** Community Kitchen leaders and members	No intervention	- Significant increase in total daily iron intake, intake of heme iron, and total ascorbic acid in the intervention group compared to the control group - No significant change in anaemia prevalence among the intervention group participants in post-intervention	High

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
12	Ferguson (2021), Jamaica [34]	RCT	**Participants:** n = 92 **Age range:** 12 years **Gender:** men and women	JUS Media programme: a food-focused media literacy intervention comprising a workshop on a healthy diet, remote acculturation, and media literacy principles related to food advertising **Duration:** 6 months **Frequency:** 90 min and weekly workshop **Follow-up:** T1 – T4 (baseline, after workshop 1, after workshop 2, immediately following SMS phase)	Face-to-face interactive workshops and SMS messages to reinforce workshop content **Delivery agent(s):** Jamaican institution	No intervention	- Significant increase in nutrition knowledge among intervention group participants compared to control group participants - Participants in the intervention group were more prepared to eat vegetables and fruits daily than the control group participants	High
13	Wiafe (2023a)[a], Ghana [35]	RCT	**Participants:** *n* = 137 **Age range:** 10–14 years **Gender:** men and women	Nutrition education and counseling related to the importance of iron in adolescent health, sources of iron-rich foods, iron-enhancing foods, iron-inhibiting foods, and proper hygiene **Duration:** 6 months **Frequency:** monthly for 45 min (education) or every two/three weeks for 30 min (counseling) **Follow-up:** immediately postintervention	Home visits (counseling), face-to-face interactions, and telephone calls (education and counseling) **Delivery agent(s):** Registered dietitians and nutritionists	No intervention	- No statistically significant difference between the study groups in terms of underweight, haemoglobin, and dietary iron intake except for vitamin C intake - Reduced prevalence of anaemia, low ferritin levels, inadequate dietary iron, and vitamin C in all groups, with the most significant improvements observed in the intervention group - Higher mean dietary iron in the intervention group compared with the control group - Higher mean haemoglobin and vitamin C levels in the control group than in the intervention group	Some concerns

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
14	Hewett (2020), Zambia [36]	CRCT	**Participants:** *n* = 2660 (from 10 clusters) **Age range:** 10–19 years **Gender:** women	Adolescent Girl's Empowerment Program with nutrition curriculum education: nutrition needs for adolescent girls, the role of food in the body, anaemia in adolescent girls, nutrition for pregnant adolescents, infant feeding from birth through six months, and young child feeding and growth monitoring **Duration:** 2 years **Frequency:** 1–2 h weekly **Follow-up:** 1 year after the program was completed	Group meetings with illustrative vignettes, role play, and participatory methods at local community space **Delivery agent(s):** Older and young women as mentors	Without nutrition curriculum	- Exposure to the nutritional curriculum had limited influence on nutritional knowledge, behavior, or outcomes	Low
15	Inacio (2022), Brazil [37]	CBA	**Participants:** *n* = 245 **Age range:** 5–14 years **Gender:** men and women	Using 'Intuitive Method' to conduct interventions that focused on four main topics: (1) classifying food choices, (2) promoting adequate and healthy eating through a cooking workshop, (3) eating and commensality through dramatization, and (4) identifying and overcoming barriers to maintaining a healthy and adequate diet using film session **Duration:** 3 months (institution A) and 6 months (institution B) **Frequency:** ranging from 40–120 min for each activity **Follow-up:** immediately postintervention	Lectures with slides in a classroom **Delivery agent(s):** Not reported	Standard education	- Decreased ultra-processed food intake and greater self-efficacy with cooking among the intervention group participants compared to control group participants	Serious

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
16	Jefrydin (2020), Malaysia [38]	CBA	**Participants:** $n = 125$ **Age range:** 13–14 years **Gender:** men and women	Instagram-based nutrition labeling education **Duration:** 12 weeks **Frequency:** weekly **Follow-up:** immediately postintervention	Instagram messages using infographics and short videos **Delivery agent(s):** Researchers	No intervention	- Significant changes in intervention participants' attitudes and practices on nutrition labels but no significant effect on nutrition knowledge	Serious
17	Wiafe (2023b)[a], Ghana [39]	CBA	**Participants:** $n = 137$ **Age range:** 10–14 years **Gender:** men and women	Nutrition education and counseling program: Nutrition education focused on the importance of iron in adolescent health, sources of iron-rich foods, and proper hygiene and included 30-min counseling sessions on dietary habits for adolescents and guardian **Duration:** 6 months **Frequency:** monthly for 30–45 min **Follow-up:** immediately postintervention	Nutrition education delivered through group discussions, leaflets, charts, and posters **Delivery agent(s):** Dieticians and nutritionists	No intervention	- Nutrition education improved the knowledge of iron and iron-rich food intake practices of participants in the intervention group compared to the control group	Moderate
18	Dyke (2021), Madagascar, Philippines, Sri Lanka, Tanzania [40]	Formative evaluation (qualitative)	**Participants:** $n = 303$ **Age range:** 6–19 years **Gender:** women	Girl-Powered Nutrition program: nutrition education (curriculum) through a nutrition badge activity and community mobilization through community action initiatives **Duration:** 2 years **Frequency:** varies in each country, mostly twice a month, with meetings lasting 1–2 h **Follow-up:** not reported	Multi-mode strategy, including education, advocacy, and events **Delivery agent(s):** Advocacy champions, community members, local partners, adult leaders, and regional commissioner of the World Association of Girl Guides and Girl Scouts	Not applicable	- Intervention activities perceived as helpful to keep the girls' focus (especially the younger group) and their interest and enhance their understanding of nutrition and diet quality, physical activity, and healthy lifestyle	-
19	Januraga, (2020) Indonesia [41]	Qualitative evaluation	**Participants:** $n = 37$ **Age range:** 16–19 years **Gender:** women	Pretty and Picky social media campaign: an online and offline campaign (articles, recipes, and photos) to promote healthy food choices **Duration:** 2 months **Frequency:** 40–90 min each interview **Follow-up:** not reported	Social media campaign (website, Instagram, Facebook, Line, and YouTube), focus group discussion, and in-depth interviews **Delivery agent(s):** Not mentioned	Not applicable	- Intervention perceived as beneficial for increasing participants' knowledge and awareness of healthy diets and the health risks of unhealthy diets, as well as improving their motivation to change their behavior and avoid foods containing salt, sugar, and excess fat	-

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
Physical activity education								
20	Sriramatr (2014), Thailand [42]	RCT	**Participants:** *n* = 220 **Age range:** 18–24 years **Gender:** women	Internet-based intervention to promote physical activity: Use of a website to record physical activity, set physical activity goals, and identify self-efficacy and outcome expectations on those goals **Duration:** 3 months **Frequency:** weekly **Follow-up:** postintervention and 3 months after intervention ended	Intervention content delivered via website and emails **Delivery agent(s):** Not reported	No intervention	- Higher steps/day, a greater leisure time activity score, and a lower resting heart rate among participants in the intervention group than those in the control group - Significantly higher self-efficacy, outcome expectations, and self-regulation among intervention group participants than those in the control group	Some concerns
21	Van Bavel (2014), Bulgaria [43]	RCT	**Participants:** *n* = 1,200 **Age range:** 16–24 years **Gender:** men and women	Using online social-normative messages to measure intention to engage in physical activity Intervention I: Positive normative messages Intervention II: Negative normative messages **Duration:** one-time survey **Frequency:** one-time survey **Follow-up:** not reported	Online administration of the questionnaire **Delivery agent(s):** Study staff	Without being exposed to social-normative messages	- Significant and positive - effect on intention to be physically active among both the positive and negative normative messages group participants - No difference between the effects of the messages	Some concerns
Food supplementation and fortification								
22	Adewusi (2006), Niger [44]	RCT	**Participants:** *n* = 55 **Age range:** 15–30 years **Gender:** men and women	A diet incorporating 15% and 25% of *Acacia colei* seed flour was mixed with millet, sorghum, and maize flour were given to the participants **Duration:** 3 weeks **Frequency:** 3 meals were served each day **Follow-up:** not reported	Three groups were housed and ate separately but adjacent to one another for the duration of the trial **Delivery agent(s):** supervisors	0% of *Acacia colei* seed flour	- Significant increase in BMI and mid-arm circumference for volunteers on acacia-incorporated diets but not for the control diet	High

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
23	Chopra (2018), India [45]	RCT	**Participants:** $n = 167$ **Age range:** 14–35 years **Gender:** women	A cooked snack containing green leafy vegetables (25 g), dried fruits (4 g), and whole milk powder (12 g) **Duration:** 12 weeks **Frequency:** daily **Follow-up:** immediately postintervention	Snacks were administered in centers close to the participants' homes **Delivery agent(s):** Study kitchen workers	A snack containing foods of lower micronutrient content, such as potato and onion	- No statistically significant differences in the change of intakes of green leafy vegetables, pulses, and legumes or total ALA-rich food between study groups	Some concerns
24	Gupta (2022), Pakistan [46]	CRCT	**Participants:** $n = 517$ (from 486 households and 34 clusters) **Age range:** 10–16 years **Gender:** women	Providing zinc-biofortified wheat flour (Zincol- 16) **Duration:** 25 weeks **Frequency:** every 15 days **Follow-up:** midpoint and immediately postintervention	Participants collected the flour from a distribution point **Delivery agent(s):** Not reported	Non-biofortified wheat flour	- Increase in zinc intake among the intervention group but no significant effect on plasma zinc concentration	Some concerns
25	Kehoe (2015), India [47]	RCT	**Participants:** $n = 222$ **Age range:** 14–35 years **Gender:** women	Snack supplementation contained green leafy vegetables (25 g), dried fruit (10 g), and whole milk powder (12 g) **Duration:** 12 weeks **Frequency:** daily **Follow-up:** immediately postintervention	Participants visited the local community center six times per week to receive snacks **Delivery agent(s):** Local community center	Control snack group containing potato, sago, or tapioca	- Significant increase in β-carotene concentrations in the intervention group compared to the control group - No differences in concentrations of ferritin, retinol, ascorbate, folate, or vitamin B12 between the intervention and control groups	Some concerns
26	Mendez (2012), Mexico [48]	RCT	**Participants:** $n = 131$ **Age range:** 12–17 years **Gender:** women	Fortified milk with zinc (11 mg/100 g) and other micronutrients **Duration:** 27 days **Frequency:** 2 servings of 250 mL per day **Follow-up:** immediately postintervention	Not reported **Delivery agent(s):** Study staff	Consumed regular diet	- No significant differences in energy and protein intake between groups - High intake in zinc intake and plasma zinc in the intervention group than the control group	High
27	Villamor (2023), Colombia [49]	RCT	**Participants:** $n = 80$ **Age range:** 12–14 years **Gender:** men and women	Fortified skim milk with cholecalciferol (2400 IU or 60 µg) **Duration:** 6 weeks **Frequency:** daily **Follow-up:** midpoint and immediately postintervention	Milk was packed in plastic bags of 1-L capacity with light-blocking overwrap and distributed through home visits **Delivery agent(s):** Research assistants	Unfortified skim milk	- Significant increase in total 25(OH)D concentrations in the intervention group and a decrease in the control group	Low

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
28	Rahman (2015), Bangladesh [50]	CRCT	**Participants:** *n* = 334 (from 44 households) **Age range:** 6–15 years **Gender:** men and women	Supplementation via wheat flour chapatti fortified with micronutrients (including 66 mg hydrogen-reduced elemental iron and 3030 mg retinol equivalent as retinyl palmitate per kilogram of flour) **Duration:** 6 months **Frequency:** weekly **Follow-up:** midpoint and immediately postintervention	Project staff distributed the flour to the "clusters", and"mothers"prepared the chapatti for the children."Adults in clusters"checked the consumption and compliance **Delivery agent(s):** Project staff, mothers, and adults in clusters	Wheat flour without micronutrients	- Micronutrient-fortified wheat flour chapatti increased serum retinol concentration post-intervention - No demonstrable effect of fortified chapatti consumption on iron status, haemoglobin levels, and anaemia	Some concerns
Behavior (lifestyle) intervention								
29	Richard (2014), Uganda [51]	Mixed methods	**Participants:** *n* = 1,350 **Age range:** 11–14 years **Gender:** men and women	Competitive football league to promote physical activity **Duration:** 11 weeks **Frequency:** weekly for 40 min **Follow-up:** immediately postintervention	All intervention activities took place at the two most central sports fields **Delivery agent(s):** six paid staff and 32 volunteer adults as coaches	Waitlist control group and non-registered for the intervention control group	- No impact of the intervention on fitness and a negative effect on - the mental health of participating boys - No significant effect of the intervention on any outcomes for girls	Low
Multi-component intervention								
30	Ahmad (2018), Malaysia [52]	RCT	**Participants:** *n* = 134 **Age range:** 8–11 years **Gender:** men and women	REDUCE (REorganise Diet, Unnecessary sCreen time and Exercise) intervention: Family-based intervention using social media with the topics of nutrition, physical activity, and behavior modification techniques **Duration:** 4 months **Frequency:** weekly training for 4 weeks and 3 months of weekly boosters **Follow-up:** 3 months and 6 months postintervention	Sessions delivered Face-to-face, via Facebook, and WhatsApp messaging **Delivery agent(s):** Public health physicians, sports medicine specialists, and trained research assistants	Waitlist group	- Significant reduction in BMI z-scores among all children (overweight and obese) and obese subgroup - Significant reduction in waist circumference percentile and body fat percentage among overweight and obese subgroup of the intervention arm compared with the wait-list arm	Low

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
31	Kumar (2014), India [53]	CRCT	**Participants:** *n* = 646 (from 3 villages) **Age range:** 5–15 years **Gender:** Not reported	Intervention I: deworming, salt fortification Intervention II: deworming, health education **Duration:** 8 months **Frequency:** monthly **Follow-up:** immediately postintervention	Salt and education were provided each month **Delivery agent(s):** Not reported	No intervention, but received deworming	- Non-significant increase in haemoglobin in the intervention groups compared with the control group - Improved ferritin, body iron stores, and retinol in the intervention groups compared to the control group	Some concerns
32	Kumar (2021), India [54]	CRCT	**Participants:** *n* = 212 (from 6 villages) **Age range:** 5–17 years **Gender:** men and women	Deworming, educational film on the role of micronutrients in human health, and salt enriched with micronutrients (10 g of the fortified salt contained 10 mg of chelated iron, 400 µg iodine, 4 µg vitamin B12, 100 µg folic acid, and 10 mg of zinc) **Duration:** 8 months **Frequency:** monthly **Follow-up:** immediately postintervention	Salt and education were provided each month **Delivery agent(s):** Health workers	Deworming and conventional iodized salt	- Significant increase in haemoglobin, serum zinc, ferritin, and body iron stores in the intervention group, compared to the control group - Decrease in the prevalence of anaemia and the burden of zinc deficiency in the intervention group relative to the control group	Some concerns
33	Bhatia (2023), India [55]	CRCT	**Participants:** *n* = 1,478 (from 38 clusters) **Age range:** 10–19 years **Gender:** women	Participatory learning and action (PLA) activities on education, nutrition, gender equity, and health; youth leadership sports activities; and practical livelihood promotion **Duration:** 33 months **Frequency:** PLA is held monthly, youth leadership is held every two months, and livelihood promotion is held every three months **Follow-up:** immediately postintervention	In-person meetings and training **Delivery agent(s):** Female and male peer facilitators called *yuva saathi* (friend of youth)	Practical livelihood promotion only	- No intervention effects on the dietary diversity score - No change in the prevalence of anthropometric status of the study participants	High

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
34	Parvin (2022), Iran [56]	CRCT	**Participants:** $n = 2,145$ (from 3 clusters) **Age range:** 4–18 years **Gender:** men and women	Lifestyle intervention related to diet, physical activity, and smoking **Duration:** 3 years **Frequency:** multiple times a year **Follow-up:** continuous for 17 years	Family-based through group sessions, education, consultation, slides and video presentation, newsletter, and pamphlets/booklets Community-based through social and religious gatherings **Delivery agent(s):** Health liaisons	No intervention	- Significant impact of the intervention on young overweight adults and at-risk obese young children	High
35	Fotu (2011), Tonga [57]	CBA	**Participants:** $n = 2,479$ **Age range:** 11–19 years **Gender:** men and women	Used social marketing approaches, community capacity building, and grassroots activities to promote healthy behaviors, including eating breakfast, increasing water, fresh fruit, and vegetable consumption, participation in organized sports and physical activity during and after school, and reducing sweet drink consumption and sedentary activities **Duration:** 3 years **Frequency:** varied between community **Follow-up:** 12 months postintervention	Coaching sessions in the community **Delivery agent(s):** Project committee	No intervention	- Similar and large increase in the prevalence of overweight and obesity in both intervention and control groups - Small decrease in the percentage of body fat in the intervention group and no differences in other anthropometric outcomes between groups	Serious
36	Kremer (2011), Fiji [58]	CBA	**Participants:** $n = 2,948$ **Age range:** 13–18 years **Gender:** men and women	Capacity building to promote healthy eating, breakfast, regular physical activity, and reduce overweight and obesity **Duration:** 3 years **Frequency:** not reported **Follow-up:** immediately postintervention	In settings such as road traffic control offices and religious institutions **Delivery agent(s):** Local admin (e.g. road traffic control officers, staff in religious institutions)	No intervention	- No significant differences in weight or BMI between groups - Significant reduction in the percentage of body fat among intervention group participants compared to the control group	Serious

Table 1 (continued)

No	Author (year), country	Study design	Participants characteristics	Description of intervention	Delivery mechanism	Comparator	Summary findings	ROB
37	Rao (2014), India [59]	Mixed methods	**Participants:** $n = 317$ **Age range:** 15–35 years **Gender:** women	Health and nutrition education and counseling (related to anaemia, the importance of macro- and micronutrients, seasonal fruits rich in vitamin C), iron-rich recipe demonstration, distribution of green leafy vegetables, deworming tablets, and iron supplementation **Duration:** 1 year **Frequency:** once/fortnight for meetings, monthly for demonstration, and weekly for home visits **Follow-up:** immediately postintervention	In-person meetings, recipe demonstrations, and home visits **Delivery agent(s):** Physicians, nutritionists, study technicians, and community health workers	Same intervention but without iron supplementation	- Significant increase in haemoglobin among participants who attended more than 50% of the meetings or repeated more than 50% of the recipes at home in the non-supplemented group; smaller haemoglobin increase in the supplementation group than non-supplemented group	High

ALA Alpha-Linolenic Acid, *BMI* Body Mass Index, *CBA* Controlled Before-After Study, *CRCT* Clustered Randomized Controlled Trial, *IFA* Iron and Folic Acid, *JUS media* Jamaican and United States media, *PLA* Participatory Learning and Action, *REDUCE* REorganise Diet, Unnecessary sCreen time and Exercise; *RCT* Randomized Controlled Trial

[a] Publication from the same study

on adolescents and young adults aged 15–24 years, and seven interventions targeted a wider age range of the population (aged 12–44 years). The total number of participants involved in these studies ranged from 36 to 2,948.

Intervention characteristics

Intervention duration

The interventions varied in duration, ranging from three weeks to over two years, with eighteen interventions spanning from three weeks to six months, thirteen interventions lasting from six months to one year, and one extending for an entire year, whereas five interventions were implemented over periods exceeding two years.

Theoretical framework

Seven studies used eight distinct theoretical frameworks to support their interventions. Specifically, social cognitive theory was applied in three studies [36, 42, 52]. Additionally, one study combined the asset-building framework with social cognitive theory [36]. The theory of planned behaviour and the model of goal-directed behaviour were used in another study [43], whereas a separate study employed the social media and technology acceptance model [41]. Another study utilized social learning theory [56]. Lastly, one study developed a theory of change framework involving adolescent groups and incorporated youth leadership activities, livelihood promotion, and community engagement and support [55].

Intervention focus

Ten studies provided micronutrient supplementation, whereas eight focused on nutrition education, workshops, or training. Another eight studies implemented multicomponent interventions. Furthermore, seven studies incorporated food supplementation and food fortification, two focused on physical education, and one addressed behavioural changes through a lifestyle modification intervention.

Delivery platform

Seventeen studies utilized diverse delivery platforms to implement their interventions. Home visits were the most commonly used approach, reported in seven studies [23, 27, 28, 32, 35, 49, 59]. Supplements were delivered either door-to-door or at community health centres in four studies [24, 28, 29, 47]. Educational interventions were delivered through face-to-face interactions, group sessions, and multimedia content in nine studies [26, 33, 34, 39, 41, 42, 52, 56, 59]. Social media platforms, such as Instagram, Facebook, and WhatsApp, were leveraged in three studies [38, 41, 52]. Other platforms included youth project centres [30], sports fields [51], and community-based distribution points for fortified foods [46, 50]. Additionally, one study integrated interactive workshops and SMS messaging to reinforce intervention content [34], while another used innovative approaches like illustrative vignettes and participatory methods in in-person workshops [36].

Intervention content

The goal of micronutrient supplementation interventions, which lasted eight to 26 weeks, was to address multiple forms of malnutrition and improve the nutritional status of adolescents. Of the ten micronutrient supplementation interventions, three were administered daily [26, 27, 30], while six were administered weekly [23–25, 28, 29, 31] and one study [32] did not report the frequency of administration. Among the ten micronutrient supplementation studies, nine provided iron supplements, either alone or in combination with other micronutrients. For example, one study administered 400 mg of ferrous sulfate weekly [25], whereas others provided it in combination with folic acid and different vitamins and minerals [23, 24, 26–30]. Additionally, one study provided a multi-micronutrient supplement [31], whereas another investigated the impact of two types of cooking pots (i.e., cast iron or blue steel) on anaemia over six months [32]. Micronutrient supplements were administered by investigators and research staff [24, 27] and community workers in collaboration with other healthcare workers [23, 28–32].

Nutrition education interventions have aimed to motivate adolescents to adopt healthy eating habits [33–41]. These studies employed diverse methods for nutrition education, such as face-to-face workshops, lectures, counselling, and interviews, complemented by digital interactions via SMS, phone calls, Facebook, WhatsApp, email, and websites. Educational materials were also disseminated through posters, recipe booklets, leaflets, pencil cases, t-shirts, and school folders. The delivery agents for the intervention varied across the studies and included healthcare workers, community kitchen staff, peers, and research and study personnel.

Two studies incorporated a physical activity education component to promote exercise among participants. They focused on setting specific goals such as daily step counts and active minutes, identifying self-efficacy and outcome expectations related to these goals, and presenting both positive and negative messages about physical activity [42, 43]. Three studies supplied participants with flour fortified with *acacia colei*, zinc, vitamin A, and iron [44, 46, 50]. Additionally, two studies provided snacks made from leafy green vegetables, dried fruits, and whole milk [45, 47], whereas another two studies supplied fortified milk containing zinc, vitamin D, and additional micronutrients [48, 49]. The interventions, which lasted from three weeks to six months, were implemented by community kitchen workers, mothers of adolescents, and researchers.

Eight studies incorporated multicomponent interventions, including fortification, nutrition and/or physical activity education, deworming, and behaviour modification. Among these, five studies focused on nutrition and physical activity education [52, 55–58], two studies implemented deworming, health education, and fortified salt [53, 54], and one study evaluated the year-long effects of iron supplementation, accompanied by educational materials, cooking demonstrations, and deworming [59]. These interventions varied in duration from four months to three years and were implemented by health workers, peer facilitators, project committees, and study technicians. Finally, only one study focused on a physical activity intervention [51], conducted over nine weeks, which included a football league for adolescent boys and girls. Each week, the participants engaged in a 40-min football game and peace-building activities designed to promote physical activity and improve their body mass index scores.

Risk of bias

Quantitative outcomes were reported for 35 records, for which the risk of bias was assessed. On the basis of the risk of bias assessment, nine studies were rated as having a high risk of bias, twelve as having some concern, and nine as having a low risk of bias. Among non-randomized RCTs, four were judged as having a serious risk of bias, and one had a moderate risk of bias.

Main findings of the interventions

Table 2 summarizes the intervention effects on the basis of the direction of the effects by intervention type. The studies assessing micronutrient supplementation focused on nutritional status outcomes, with all ten studies measuring haemoglobin, five measuring serum ferritin, and three measuring anthropometric outcomes. Nine studies reported positive results for at least one nutritional indicator. Six out of ten studies reported significant improvements in haemoglobin in the intervention group following supplementation [23, 24, 26, 28–30], whereas four reported no improvements [25, 27, 31, 32]. Analysis of the serum ferritin levels in five studies revealed significant improvements in the intervention group [23–25, 28, 32]. Furthermore, two studies reported a significant increase in folic acid concentrations [24, 28], one study noted a significant improvement in vitamin A levels [23], and another reported a significant increase in the zinc status of the intervention group participants compared with the control group participants [26]. Two micronutrient supplementation studies also reported significant weight gain in experimental group participants [25, 30], whereas one study reported no changes in participants'BMI across study groups [31].

Studies on multicomponent interventions primarily assessed anthropometric outcomes such as BMI and body fat percentage, whereas three studies analyzed nutritional status and dietary outcomes. Seven of the eight multicomponent interventions yielded significant results in terms of at least one nutritional outcome. Three biomarkers, namely haemoglobin, serum ferritin, and zinc concentration were measured. One study reported significant improvements only in haemoglobin levels [59]. In contrast, two studies reported significant improvements in all measured biomarkers in experimental group participants compared with control group participants [53, 54]. None of the three studies examining dietary intake and other nutritional variables noted improvements [55, 57, 59]. Four studies evaluated anthropometric indicators, with two reporting improved body mass index [52, 56], while the remaining two reported positive changes in body fat percentage among the participants in the intervention groups [57, 58].

Nutrition education studies have predominantly evaluated dietary outcomes, especially nutritional knowledge, attitudes and practices, and micronutrient intake. Six out of seven studies reported improvements in at least one nutritional outcome. Four studies assessed outcomes related to nutrition knowledge, attitudes, behaviours, and understanding of nutrition labels. Of these, two studies reported significant improvements across all measured outcomes, including nutrition knowledge, attitudes, and behaviour, as well as food-focused media literacy among the participants in the intervention group [34, 39]. However, two studies reported improvements only in attitudes toward and practices related to nutrition labels among participants in the intervention groups, without any gains in nutrition knowledge outcomes [36, 38]. Regarding dietary intake, two studies reported significant improvements in all outcomes [33, 37], whereas another study reported improved vitamin C intake, with no improvements in other intake outcomes between study groups [35]. Additionally, two studies reported no significant changes in anthropometric indicators between the study arms [35, 36].

Food fortification studies have largely investigated nutritional status alongside dietary outcomes, particularly intake practices. All seven studies reported at least one positive nutritional outcome. These studies primarily assessed blood biomarkers, such as zinc, haemoglobin, ferritin, and folate concentrations, and dietary outcomes. One study reported a significant increase in zinc concentrations in intervention group participants compared

Table 2 Summary of quantitative studies of included studies on community-based interventions targeting nutrition and physical activity for adolescents

Community-based health and nutrition interventions																		
Outcome	**Micronutrient supplementation (*n* = 10)**			**Multi-component intervention (*n* = 8)**			**Nutrition education, workshop, or training (*n* = 7)**			**Food fortification (*n* = 7)**			**Physical activity education (*n* = 2)**			**Behavior (lifestyle) intervention (*n* = 1)**		
	# of studies assessing outcome	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**
Anthropometry																		
Weight	2	-	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
BMI	1	1	-	4	2	2	1	1	-	1	-	1	-	-	-	-	-	-
BMI z-score	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
Height z-score	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Waist circumference	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Mid-arm circumference	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Percentage of body fat	-	-	-	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Overweight	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Nutritional status																		
Haemoglobin	10	4	6	3	-	3	1	1	-	1	1	-	-	-	-	-	-	-
Serum ferritin	5	-	5	2	-	2	1	1	-	2	2	-	-	-	-	-	-	-
Serum retinol	1	-	1	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-
Serum zinc	1	-	1	1	-	1	-	-	-	2	1	1	-	-	-	-	-	-
Copper	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calcium	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TAC	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Body iron stores	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Serum folate	2	-	2	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Vitamin B12	1	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Vitamin C	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Beta-carotene	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
DHA	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Total 25(OH)D	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Free 25(OH)D	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Prevalence of Vitamin B12 deficiency	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2 (continued)

Community-based health and nutrition interventions																				
Outcome	**Micronutrient supplementation ($n = 10$)**			**Multi-component intervention ($n = 8$)**			**Nutrition education, workshop, or training ($n = 7$)**			**Food fortification ($n = 7$)**			**Physical activity education ($n = 2$)**			**Behavior (lifestyle) intervention ($n = 1$)**				
	# of studies assessing outcome	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**		
Prevalence of serum ferritin deficiency	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Anaemia prevalence	-	-	-	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-		
Iron deficiency	-	-	-	-	-	-	1	1	-	1	-	1	-	-	-	-	-	-		
Zinc deficiency	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-		
Dietary outcomes																				
Nutritional knowledge	-	-	-	-	-	-	4	2	2	-	-	-	-	-	-	-	-	-		
Nutrition label knowledge	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-		
Attitudes and practices on nutrition labels	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Attitude toward nutrition[a]	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Nutrition behavior	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Dietary diversity	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
Diet quality	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-		
Self-efficacy	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Intake of leafy green vegetables	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-		
Intake of fruit	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-		
Intake of processed foods	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Dietary habits	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-		
Food-focused media literacy	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-		
Energy intake	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-		
Protein intake	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-		

Table 2 (continued)

Community-based health and nutrition interventions																		
Outcome	**Micronutrient supplementation ($n = 10$)**			**Multi-component intervention ($n = 8$)**			**Nutrition education, workshop, or training ($n = 7$)**			**Food fortification ($n = 7$)**			**Physical activity education ($n = 2$)**			**Behavior (lifestyle) intervention ($n = 1$)**		
	# of studies assessing outcome	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**	**# of studies assessing outcome**	**# of studies with no effect**	**# of studies with evidence of effect**
Vitamin C intake	-	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-
Zinc intake	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Iron intake	-	-	-	-	-	-	3	1	2	-	-	-	-	-	-	-	-	-
Heme iron intake	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Absorbable iron intake	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Knowledge of iron	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Hunger level[b]	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physical activity																		
Intention to do physical activity	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Steps per day	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Leisure time activity score	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Resting heart rate	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Physical and sedentary behavior	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-

BMI Body Mass Index, *DHA* Docosahexaenoic acid, *TAC* Total Antioxidant Capacity

[a] Attitudes toward nutrition – stage of change toward healthy eating using questionnaires and focus groups.

[b] Hunger level – questionnaire and visual analogue scale to evaluate self-reported levels of hunger

with control group participants [48]. In contrast, others reported no significant changes in haemoglobin, ferritin, folate, or ascorbate levels between intervention and control groups [46, 47, 50]. Another study reported an increased total of 25(OH)D levels in the intervention group due to supplementation with fortified milk, but free 25(OH)D levels did not change [49]. With respect to dietary outcomes, one study reported no change in energy or protein intake but reported greater zinc intake in the intervention group than in the control group [48], and another study reported no significant differences in the consumption of green leafy vegetables, pulses, legumes, or ALA-rich foods [45] between the intervention and control groups. One study reported significant increases in BMI and mid-arm circumference in the intervention group compared with the control group [44].

Physical activity education and behaviour (lifestyle) interventions investigated only physical activity outcomes and anthropometric outcomes, respectively. Two studies focusing on physical activity education demonstrated significant improvements in physical activity outcomes, reporting substantial improvements in the intervention groups in outcomes such as daily steps, resting heart rate, leisure activity score, and intent to engage in physical activity [42, 43]. A study focusing on behavioural changes and physical activity reported no significant changes in BMI-for-age-z scores between the intervention and control groups [51].

Of the 37 records from 36 studies, we grouped seven reported qualitative findings across five key themes: stakeholders' acceptability of the intervention, their satisfaction with the intervention activities, the perceived effectiveness of the intervention, challenges encountered in participating in the intervention, and suggestions for improving the intervention [34, 38, 49, 52, 55]. The qualitative findings from each study are summarized in Table 3.

Six studies that documented the acceptability of interventions [38, 40, 41, 49, 52, 55] reported moderate to high acceptability among stakeholders, including adolescents and young adults. However, one study noted challenges in engaging adolescents in intervention discussions. One study reported that parents were more accepting of online intervention activities than face-to-face interactions [55]. Two studies reported satisfaction with the type of intervention [34, 52]. Parents generally supported the interventions, whereas adolescents expressed satisfaction with the workshops and SMS communications.

Four studies highlighted the perceived effectiveness of the interventions, indicating positive impacts on knowledge and behaviours [34, 38, 52]. We identified challenges in adolescent participation in five studies [34, 38, 40, 41, 55]. These included limited engagement due to involvement in household economic activities, examination preparations, and embarrassment related to literacy levels and school dropout [55]. A social media intervention faced issues such as insufficient phone credit, message failure, and limited response time [34], whereas another study identified barriers such as limited time, lack of cooking skills, and low self-efficacy affecting healthy eating [41]. A nutrition program highlighted tight academic schedules, cultural norms, poverty, and patriarchal practices as hurdles for girls' nutritional intake [40].

To improve interventions, adolescents in two studies suggested using trending songs and vibrant graphics to capture attention and shorter discussions to increase participation [38]. They also expressed a desire for more detailed nutritional information, updated statistics, and longer training sessions to gain a better understanding of nutrition-related issues [40].

Discussion

This review analyzed 37 reports from 36 studies on community-based interventions addressing various forms of malnutrition among adolescents in LMICs. The interventions covered a range of approaches: micronutrient supplementation, nutrition education, physical activity education, food fortification, behavioural interventions, and multicomponent interventions, with durations ranging from three weeks to more than two years. The frequency of intervention delivery varied: micronutrient supplementation was typically administered weekly, nutrition education was offered either weekly or monthly, and food fortification occurred daily. Demographically, 21 interventions (57%) targeted adolescent girls, 16 (43%) aimed at both genders, and one did not specify the target gender. This finding reveals a gap in interventions specifically designed for adolescent boys and other vulnerable groups, such as out-of-school adolescents and migrants. Notably, it is also crucial to focus on adolescent boys, who face high rates of iron-deficiency anaemia, similar to adolescent girls [60]. Additionally, most interventions targeted a wide range of age groups (11–18 years), indicating a need for more tailored approaches that cater to adolescents'distinct developmental and nutritional needs.

Our findings highlighted a diverse range of delivery agents and platforms for these community-based interventions addressing adolescent malnutrition in LMICs. The delivery agents included frontline health workers, community kitchen staff, dietitians, nutritionists, peers, and mothers of adolescents. Platforms for delivery vary by intervention type and include door-to-door outreach, healthcare centres, community kitchens, and digital channels such as SMS, phone calls, websites, and emails. Some interventions also involved social and religious

Table 3 Key themes and their corresponding results of qualitative evaluations of included studies

Author (year)	Theme	Summary results
Ahmad (2018) [52]	Satisfaction Effectiveness Acceptability	• One-quarter of the parents expressed support for the program • One-fifth of the parents shared their child's progress in eating habits and physical activity • Parents were more accepting of online interventions compared to face-to-face ones
Bhatia (2023) [55]	Acceptability Challenges	• Older adolescents, boys, from poor households, and out-of-school adolescents attended group activities less frequently • Younger adolescents found it hard to understand the questions arising in the discussion • Health workers and schoolteachers positively participated in collaborative or supportive actions initiated by the community youth team
Dyke (2021) [40]	Acceptability Effectiveness Challenges Suggestion for improvement	• Cocreation team members played a critical role in program activities testing • Intervention activities were perceived as age-appropriate and acceptable by the participants • Confusion among some participants regarding a few nutrition messages • Cultural norms, poverty, and patriarchy prevented in practice the messages regarding nutritional meals • Girls perceived a gain in knowledge on nutrition and diet quality, physical activity, and healthy lifestyle • Limitations in participating in program activities due to competing interests such as schoolwork and household chores • Adolescents expected more training and educational sessions along with statistics
Ferguson (2021) [34]	Satisfaction Effectiveness Challenges	• Participants found the workshop enjoyable • Use of local dialect, appropriate frequency and timing of SMS, and a consistent morning send-time for SMS improved participants'satisfaction • Participants reported the intervention has increased healthy eating, decreased unhealthy eating, balanced diet, catalyzed parent-adolescent communication, and improved physical health and fitness. In addition, participants also reported an indirect impact on individuals around them through the transmission of nutritional information and behavioral changes, which encouraged those around them to eat healthier • Lack of phone credit, failure to receive project SMS, phone crashes, limited time to respond to SMS, and forgetting to respond were the main challenges of the intervention
Januraga (2020) [41]	Acceptability Challenges	• The quality, simplicity, and clarity of messages were considered facilitators of the acceptability of a health education campaign • The program improved participants' intention to initiate behavioral change earlier rather than later and attitudes toward healthier food • Good visual presentation, not being data heavy, and having complete information were perceived to have a positive influence on the ease of use of a social media campaign • Participants with tight academic schedules or a lack of cooking skills found it difficult to experiment with the recipes suggested by the campaign • A lack of perceived self-efficacy, interpersonal barriers, and dependence on dishes prepared by parents prevented adolescents from choosing healthier food
Jefrydin (2020) [38]	Acceptability Effectiveness Suggestions for Improvement	• Adolescents reported positive acceptance and viewed the program as motivating and effective • Participants indicated that the program enhanced their knowledge of nutrition labels and helped them choose and eat healthier food • Participants suggested using trending and current songs and bright-color graphics to attract more viewers and, at the same time, decrease the length of discussion
Villamor (2023) [49]	Acceptability	• Stakeholders reported a high level of acceptability for the intervention activities and content

gatherings. This diversity underscores the potential to leverage various platforms and community members to effectively reach adolescents with specific needs. The increasing use of digital technology, including social media, gaming environments, educational websites, and mobile applications, reflects a trend toward enhancing the reach and effectiveness of nutrition interventions. Additionally, exploring platforms such as adolescent sports clubs and recreational areas, where adolescents typically congregate, warrants further investigation. Diversifying platforms for delivering nutrition and physical activity interventions might increase the likelihood of engaging adolescents in manners that resonate with their interests and needs.

The geographic distribution of studies reveals significant gaps, particularly in Africa, where only a small proportion of studies were conducted, highlighting the need for more research in sub-Saharan Africa. Additionally, regions such as Oceania, Europe, and the Americas are underrepresented, with limited studies from countries like Fiji, Tonga, and several Latin American nations. Cross-regional studies are sparse, suggesting an opportunity to explore diverse contexts and nutrition challenges across regions. Expanding research in these underserved areas could provide valuable insights into region-specific adolescent nutrition issues [61]. To address these diverse needs effectively, high-quality data are critical to accurately define them [61]. Such data should inform the development of contextually driven and culturally appropriate interventions, ensuring that nutrition strategies effectively respond to the complex needs of adolescents.

Our findings also highlight the importance of using theoretical frameworks to develop interventions for addressing adolescent malnutrition, as recommended by global guidelines [62–64]. Initiatives such as the World Health Organization's Global Accelerated Action for the Health of Adolescents (AA-HA!), the Global Strategy for Women's, Children's and Adolescents'Health, and the Sustainable Development Goals (SDGs) encourage countries to invest in adolescent health and nutrition [65]. The AA-HA! Guidance specifically emphasizes tailoring interventions to meet adolescents' unique developmental stages and challenges. Seven studies included in this review, published between 2014 and 2022, were based on theories. While no major differences in outcomes or success were observed between interventions with and without theoretical frameworks, these frameworks were instrumental in guiding evaluations, particularly identifying constructs such as self-efficacy, and self-regulation using social cognitive theory for internet-based physical activity interventions [42] or shaping the evaluation process for interventions based on the technology acceptance model in a social media campaign intervention [41]. Overall, theoretical frameworks seem to enhance the design of evidence-based interventions, facilitate outcome evaluation, and provide structured approaches for tackling complex health challenges [66]. Their careful consideration might be useful during intervention development, implementation, and evaluation.

Nutritional challenges among adolescents are often addressed through isolated strategies, leading to fragmented efforts [4]. Our review reflects this trend, with most studies focusing on single aspects of nutrition. However, there is a growing recognition of the need for integrated approaches that address multiple forms of malnutrition simultaneously [67]. Double-duty actions, for example, aim to combat all forms of malnutrition by reducing the risks or burdens of both undernutrition (including wasting, stunting, and micronutrient deficiency or insufficiency) and overweight or obesity, as well as diet-related NCDs simultaneously [67]. These actions are particularly relevant in countries undergoing rapid nutrition transitions, where focusing solely on undernutrition might inadvertently increase the risks of obesity and NCDs [67]. Our findings also indicate that most interventions have a narrow focus, with few addressing body weight as a nutritional indicator. To address the intertwined issues of undernutrition and overweight/obesity effectively, a holistic approach that integrates healthy diets, physical activity, and accessible services is necessary.

Despite the clear need for integrated nutritional strategies, community-based interventions incorporating physical activity are notably rare. This is a significant issue given the effects of globalization and urbanization on reducing available spaces for physical activity, particularly for adolescents [68]. Additionally, no interventions included a multisectoral approach, underscoring the need for strategies that involve schools, families, and communities [69]. Integrating adolescent nutrition programs within multisectoral systems—such as food, health, water and sanitation, urban planning, education, and social protection— is critical [70]. While progress has been made in identifying effective strategies, their implementation remains constrained, highlighting the need for convergent approaches that consider broader socioeconomic and environmental contexts, especially for vulnerable adolescents [10, 71, 72].

Community-based interventions enable engagement with diverse adolescent groups and foster collaboration across local entities, from nongovernmental organizations and religious groups to local businesses, self-help groups, and recreational clubs [73]. Such approaches can enhance local food environments and choices, tailoring support to adolescent needs. In high-income countries, many of the most effective obesity prevention interventions often account for the social context and are implemented within community settings. For example, mentoring conducted by African American community members in the U.S. increased the impact of nutrition interventions on African American young people [74]. These approaches can also influence social norms, support vulnerable populations, and address the environmental factors affecting nutritional challenges [75, 76].

Evidence suggests that longer-duration interventions tend to facilitate better integration and a more comprehensive approach, supporting sustainable behaviour changes and providing ongoing support critical for maintaining gains [73, 77]. However, the evidence on the actual effects on malnutrition-related outcomes favours shorter and medium-duration interventions. In our review, eighteen interventions lasted less than six months, with fifteen showing significant results in at least one outcome, and nine demonstrating positive results in most or all outcomes measured. All twelve interventions lasting between six months and a year showed improvements in at least one measured outcome. In contrast, of the seven interventions lasting a year or longer, only four showed significant results for at least one outcome, and three included a broader age range, not exclusively adolescents, limiting the ability to ascertain conclusions specific to adolescent populations. Furthermore, few studies have included implementation science indicators. Evidence on implementation indicators such as acceptability, appropriateness, feasibility, adoption, fidelity, cost, penetration, and sustainability is crucial to ensure that interventions are both effective in practice and relevant to local contexts [78]. Researchers should consider including these metrics in their evaluation processes.

To our knowledge, this is the first review to synthesize evidence of community-based approaches addressing multiple forms of malnutrition among adolescents in LMICs. Our extensive search covered various interventions, settings, and contexts. However, our review has several limitations, including the incorporation of only English-language databases and engines, which potentially omits significant research in other languages. Furthermore, owing to the diverse nature of interventions and outcomes, conducting a meta-analysis was not feasible within our scoping review approach. Our focus was on summarizing existing evidence about the interventions and identifying gaps in knowledge. The searches for relevant studies were conducted in July 2023, and while we aimed to capture all available data at the time of the search, it is possible that significant findings published since then are not included in this scoping review. A total of seven studies [31, 32, 42, 43, 45, 47, 59] included an overlapping age range than only adolescents, with participants up to 45 years of age. We decided to include these studies to ensure that data specific to adolescents was not excluded from our review.

Despite the limited evidence on community-based nutrition interventions for adolescents, our review highlights the need for tailored, multifaceted community-based nutrition programs, especially for vulnerable groups such as out-of-school adolescents. Future efforts should integrate dietary, physical activity, and educational strategies to ensure sustainable behavioural changes. Research should develop context-specific, intervention designs based on a human-centred approach, and theory-based interventions that integrate various public health sectors and employ multiplatform and multisectoral approaches for comprehensive malnutrition solutions. Additionally, long-term studies focused on specific age groups are crucial for assessing the effectiveness and sustainability of these interventions over time.

Conclusion

In conclusion, our scoping review identified evidence of community-based nutrition interventions for adolescents in LMICs, with most studies focusing on micronutrient deficiencies. The available evidence suggests that community-based interventions may hold significant potential for improving adolescent health and nutrition in LMICs. However, substantial gaps remain in documenting and understanding these interventions. Given the complexity of the double burden of malnutrition and the various determinants of adolescent health, especially for the most vulnerable adolescents, there is a critical need for integrated, context-specific interventions. Leveraging diverse delivery platforms and agents is essential to ensure effective, acceptable, feasible, and sustainable nutrition programs addressing multiple forms of adolescent malnutrition.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12937-025-01136-2.

Supplementary Material 1.

Supplementary Material 2

Acknowledgements

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Author's contributions

MR, ALK, EF, SS, UP, and SZ contributed to the methods and supported the drafting, editing, and finalizing of the manuscript. SS conceived the idea and developed the methods. MR and ALK contributed meaningfully to the design of the search strategy. MR, ALK, EF, SS, UP, NM, NCD, EA, and HYB screened titles and abstracts. MR, ALK, EF, SS, UP, and SZ screened full texts and extracted data. ALK, MR, EF, and SZ wrote the manuscript. CN, SL, SMO, DOA, WWF, FW, TB, and ARISE-NUTRINT collaborators supervised and reviewed the manuscript. All authors approved the final manuscript.

Funding

This study was under the ARISE-NUTRINT project and was funded by the European Union Horizon 2022 (Nr. 101095616). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests

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Received: 6 August 2024 Accepted: 14 April 2025
Published online: 30 April 2025

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