British Journal of Nutrition (2023), 129, 2102–2121 doi:10.1017/S0007114522002811

Effects of school-based interventions on Food and Nutrition Literacy (FNLIT) in primary-school-age children: a systematic review

Nasrin Omidvar[1], Azam Doustmohammadian[2]*, Elham Shakibazadeh[3], Cain C. T. Clark[4], Maryam Sadat Kasaii[1] and Maryam Hajigholam-Saryazdi[5]

[1]*Department of Community Nutrition, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[2]*Gastrointestinal and Liver Diseases Research Center, Iran University of Medical Sciences, Tehran, Iran*
[3]*Department of Health Education and Promotion, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran*
[4]*Centre for Intelligent Healthcare, Coventry University, Coventry CV1 5FB, UK*
[5]*Library, National Nutrition and Food Technology Research Institute; and Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

(Submitted 27 November 2021 – Final revision received 3 August 2022 – Accepted 22 August 2022 – First published online 30 September 2022)

Abstract

This study systematically reviewed the evidence on interventions seeking to improve Food and Nutrition Literacy (FNLIT) functional, interactive and critical skills in primary school-aged children. Electronic databases, including PubMed/MEDLINE, SCOPUS, Web of Science, Cochrane, ProQuest and Google Scholar were systematically searched. Randomised and non-randomised controlled trials, pre-/post-test and case–control designs were included. The primary outcomes were three levels of FNLIT: functional, interactive and critical. All citations, full-text articles and abstract data were screened by two independent reviewers. Any conflicts were then resolved through discussion. The quality of the included studies was individually evaluated using the Effective Public Health Practice Project (EPHPP) quality assessment tool. Two reviewers extracted data from the included studies, and a descriptive analysis was performed. The quality of all eligible studies (*n* 19) was rated as moderate/weak. A wide variety of skill-building activities were introduced by programmes, including recipe skills/food preparation, food label literacy, food tasting, gardening harvesting, and supporting cultural practices and ethnic foods. Only four studies measured food literacy (FL) (food label literacy) via a valid measure. Most interventions focused on the functional level of FL, except for two programmes (one scored weak and one scored moderate). In most of the studies, delivery of intervention content was facilitated by teachers (*n* 15). Promising interventions were tailored to the needs and interests of students, incorporated into the existing curriculum and facilitated by teachers. The successful intervention strategies led to improvements in functional, partly interactive and critical skills. Future interventions should focus, holistically, on all aspects of FNLIT, especially interactive and critical skills.

Key words: **Food literacy: Nutrition literacy: School-based interventions: Primary school**

Food/nutrition literacy is an important topic in public health research; indeed, the growing attention towards food/nutrition literacy is because it is considered as bridging the gap between food, nutrition and well-being in communities. In addition, it can serve as a fundamental step towards the capacity building to effectively use nutritional knowledge and skills, specifically in meeting children's current and future health[1].

A myriad of definitions and conceptualisations of food/nutrition literacy are provided in the research; however, a widely cited definition describes food literacy (FL) as a collection of inter-related knowledge, skills, and behaviours required to plan, manage, select, prepare, and eat foods to meet needs and determine food intake. FL is the staging that empowers individuals, households, communities and nations to protect diet quality through change and support dietary resilience over time[2]. Some studies have characterised FL as the ability to search and understand nutrition-related information[3]. In a review of 173 studies, Krause and colleagues[4] classified FL into three conceptual elements of Nutbeam's health literacy definition[5], including functional, interactive and critical FL. Doustmohammadian *et al.* have also previously defined Food and Nutrition Literacy (FNLIT) based on Nutbeam's model of

Abbreviations: FL, food literacy; FNLIT, Food and Nutrition Literacy.

* **Corresponding author:** Azam Doustmohammadian, email doost_mohammadui@yahoo.com

British Journal of Nutrition

health literacy, to which the cognitive and skill domain has been added; indeed, based on this study, the cognitive domain included knowledge and understanding, while skill domains included food choice, functional, interactive and critical skills[6].

Childhood and adolescence are critical periods of life in which many eating habits are formed and generally continue into adulthood[7]. Promoting FNLIT in children empowers them to control the determinants of nutritional health[8]. Available evidence shows that most children and adolescents do not follow dietary guidelines' recommendations. For example, fruit and vegetable consumption in 5–18-year-old children is less than the recommended level, whilst only 15 % of students consume the recommended intake of milk and dairy products[9,10]. A general shift in children's dietary patterns has been noted towards the lower intake of fruit and vegetables, fibre-rich foods, and dairy products[11], as well as increased consumption of high-energy-dense foods[12]. Thus, FNLIT along with other environmental factors may be a crucial factor in promoting food choices and eating behaviours among children and adolescents[1,13].

According to the extant literature, early prevention programmes are recommended to best influence children's learning skills and increase the possibility of more successful behaviour stabilisation to maintain healthy dietary habits into adulthood[13]. Indeed, paying attention to FNLIT promotion among children may be essential in improving dietary patterns, health and well-being. Schools have direct contact with students for about 6 h a day and up to 12 critical years of intellectual, psychological, social and physical development[14]. The WHO identified the school setting as ideal for nutrition education and promoting healthy eating practices in children[15]; however, the lack of documented policies and programmes relating to FNLIT is a preponderant issue in developing countries.

Kelly *et al.* reviewed the efficacy of FL interventions, without focusing on the quality of the studies, in elementary schoolchildren aged 4–12 years old and concluded that few interventions (28 %) addressed critical FL[16]. The other limitation of the aforementioned study was the lack of grey literature searched. Furthermore, the authors just focused on FL and did not consider the wide and multifaceted topic of FNLIT[6,17] in their search strategy and review.

The multi-dimensional nature of the concept of FNLIT necessitates multi-level interventions to improve FNLIT[2,18]. The first step to develop such interventions includes referring to the evidence and successful modelling examples[19]. Unfortunately, most studies in the field of food/nutrition literacy are correlational[20], and there is a lack of convincing studies to demonstrate the change in FNLIT as the outcome of interventions. Therefore, this systematic review aims to identify interventions targeted at promoting children's FNLIT in the school setting. The current study aims to identify: (1) strategies and principal components of FNLIT promotion, (2) the implementation methods of the interventions, and (3) the effectiveness of interventions in promoting FNLIT among primary schoolchildren.

Methods

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[21]. The current systematic review was registered with PROSPERO, the International Prospective Register of Systematic Reviews (CRD42019135118). The authors published a more detailed systematic review protocol in addition to the online registration[22].

Inclusion and exclusion criteria

Eligible study designs were quantitative studies, including case–control studies, pre- and post-interventions, post-test only, randomised and non-randomised controlled trials that allocated students individually or in clusters (i.e. teachers, classrooms and schools), and quasi-randomised trials examining the effectiveness of interventions for FNLIT promotion in primary students aged 5 to 12 years.

Any studies available in full-text and English-featuring interventions that contained one or more dimensions of the skill domain of food/nutrition literacy, including functional, interactive and critical food/nutrition literacy that targeted children aged 5–12 years old in elementary schools, or other equivalent educational settings, were searched for and included accordingly. Nutritional interventions focused on diabetes, obesity and other non-communicable diseases were excluded.

Referring to Nutbeam's model of health literacy[5,23], the primary outcomes in the review consisted of FNLIT in skill domains, including functional, interactive, and critical FNLIT. Based on the available evidence, components of each dimension of the skill domain are presented in Table 1.

We considered interventions whose reported outcomes increased FNLIT skills (functional, interactive and critical) or both dimensions of food/nutrition knowledge and skills.

Interventions that were solely aimed at food and nutrition knowledge improvement were not considered. Successful interventions and those that included theories and hands-on activities to enhance literacy were taken into account.

Secondary outcomes included diet quality improvement (e.g. healthy eating index)[1], nutritional indicators (e.g. dietary diversity score), weight loss[24] and lifestyle health promotion[25].

All positive and negative outcomes were considered in the study.

Search strategy

The review team (AD, NO and MHS) designed a search strategy and implemented the suggested query or search strategy suited to the environment of data banks for multiple databases. According to the PICOS format (Participant, Intervention, Comparison, Outcome and Setting)[26] and the MeSH database, a draft of the search strategy can be found in Supplemental Table S1.

The primary source of literature was a structured search of major electronic databases, up to 1 October 2021, including PubMed/MEDLINE, SCOPUS, Web of Science, Cochrane and Pro-Quest. Google Scholar as a source of grey literature was searched up to page 20 (first 200 results) for title searches using the following keywords and was performed in duplicate: ((FL) or (nutrition literacy) or (health literacy) or (functional literacy) or (critical literacy) or (interactive literacy) or literacy or food or nutrition)) AND (education or school or student or teaching or

Table 1. Study eligibility and exclusion criteria based on the PICOS elements

Inclusion criteria	
Participants	• Children aged 5 to 12 years.
Intervention	• All types of interventions to improve skill domain, including functional, interactive and critical without/alongside cognitive domains (food/nutrition knowledge, attitude and food/nutrition information understanding).
Comparison	• All comparisons, including: different educational interventions; different methods of delivery, educational contents, intervention dosages, or the like; regular classes; and non-intervention.
Outcomes	Main outcomes: (1) Functional food and nutrition literacy: • Food selection (sources, store and quality). • Planning and managing (money, time, food intake and nutrition balance). • Preparing (cooking, preparing food in a new way, and safety)[2,31,75]. • Recognition ability (searching and understanding including information and official recommendations)[3,4]. • Reading and using nutrition facts labels[31]. • Self-efficacy and confidence[76] and trying ethnic and unfamiliar food[36]. (2) Interactive food and nutrition literacy: • Communicating and interacting (e.g. family–child feeding interactions, increasing school community connections)[31,37]. • Emotional skills (e.g. the ability to say 'no' to unhealthy foods)[6]. • Collaborating socially (improving school social environment, helping friends with concerns regarding nutritional issues)[2,4,37]. (3) Critical food and nutrition literacy: • Critically evaluating information (e.g. critically analysed food labels) and recognising social contexts[5,45]. • Media literacy (the ability to critically judge the media and its trustworthiness as a source of information[77,78]. • Ecological factors (food system approaches, e.g. engagement with issues of social justice and equity in food systems, and social determinants of health)[46,76]. Secondary outcomes: • Health outcomes, including improvement in diet quality (e.g. HEI)[1], dietary intake indicators (e.g. DDS), BMI Z-score, weight status[24] and indicators of quality of life/well-being[25].
Study design	• Randomised and non-randomised controlled trials that allocated students individually or in clusters (i.e. teachers, classrooms and schools), quasi-randomised trials, pre- and post-test, post-test only and case–control designs.
Setting	• Primary schools or other equivalent educational institutions.
Exclusion criteria	• Irrelevant participant(s), including interventions aimed at teachers but not measuring relevant student outcomes. • Irrelevant intervention(s), when the educational intervention was part of a comprehensive study, and it was not possible to extract relevant results from irregular health education interventions (e.g. teaching about the advantages of healthy eating or physical activity). • Irrelevant outcome(s), including interventions aimed to increase knowledge without addressing skills (functional, food choice, interactive, critical and food label literacy). • Irrelevant setting(s), including after school club, summer camp, home and community. • Publications, not English. • Books, conference papers, thesis, patents and reviews were excluded.

PICOS, Population, Intervention, Comparison, Outcome, Setting[26]

training or class or curriculum or lesson or instruction) AND (garden or harvest or cook or taste or label or skill).

Hand-searching of the reference lists of included studies, relevant reviews, and documents were conducted to identify other relevant studies.

Study selection

All citations were imported into Endnote X7 citation manager[27] and were systematically de-duplicated, and a merged library was created. The de-duplication process was validated by Systematic Review Assistant-Deduplication Module (SRA-DM)[28]. Based on the pilot-tested inclusion criteria checklist, two review authors (AD and MK) independently screened studies for eligibility by their titles and abstracts. The full texts of all the potentially relevant papers were then retrieved and assessed independently by the two review authors (AD and MK). The final decisions were made according to the inclusion criteria checklist, and the reasons for article discarding were documented (online Supplementary Table S2).

At all stages, disagreements were resolved by seeking a third review author's view (NO). The PRISMA flowchart[21] was used to document the selection process.

Data extraction

A pilot-tested standardised form was used to extract data from each study report. We extracted the following data: author (s), publication year, target group (age, sex and number of participants), intervention description (name, study design, comparison or control groups, components, duration, and follow-up of intervention), FL/nutrition literacy validated tools (if any), theory basis of intervention (if any) and FNLIT outcomes.

Two reviewers (AD and MK) performed data extraction independently, and potential conflicts were resolved through discussion. As necessary, original authors of primary publications were contacted for data clarifications or missing outcome data.

Quality appraisal

Two reviewers separately evaluated the risk of bias in the included reports by the validated quality assessment tool for quantitative studies (online Supplementary Table S3). This tool was developed by the Effective Public Health Practice Project (EPHPP)[29] to assess the quality of included studies in systematic reviews relating to public health topics[30]. Seven elements of the quality assessment tool were included: selection bias, study design, confounders, blinding, data collection methods,

withdrawals/dropouts and analysis, leading to an overall rating of strong, moderate or weak[30]: (a) strong (when there were no weak rating); (b) moderate (when one factor was rated as weak); and (c) weak (when two or more factors were rated as weak).

The quality assessment of all the included studies was conducted by two authors (AD and MK) and was reported in Supplementary Table S3. Potential conflicts were resolved through discussion.

Synthesis of results

The quantitative analysis (meta-analysis or statistical pooling) was not considered due to the lack of sufficient studies with similar outcome measures or similar interventions; therefore, only a descriptive analysis was performed.

Results

Study selection

Our literature search yielded 7809 publications between 1997 and 2020 (PubMed = 1057, SCOPUS = 1880, Web of science = 4535, Cochrane = 98, Pro Quest = 123, and Google Scholar = 116). After removing duplicates, 102 articles were screened based on title and abstract review. Of these, 64 publications were excluded for the following reasons: no full text available (*n* 29), thesis (*n* 26), the paper was not in English (*n* 2), book, conference abstract (*n* 5) and review (*n* 2). The full texts of the remaining thirty-eight publications were retrieved for further assessment, of which nineteen failed to meet the inclusion criteria. The main reason for excluding full texts was that they were not school-based interventions (Fig. 1, online Supplementary Table S2). Finally, nineteen articles were included, such that their characteristics are summarised in Table 2. The quality assessment of each of these studies is depicted in Fig. 2.

Study characteristics

The main theoretical models of behaviour change used in developing food/nutrition literacy interventions were Social Cognitive Theory (*n* 5, 26·31 %)[31–35] and Theory of Planned Behavior (*n* 1, 5·26 %)[36]. Theory-based interventions mainly improved functional food/nutrition literacy (Table 3).

Four studies (21 %) were randomised controlled trials[35,37–39], and four (21 %) used a case–control design[36,40–42]. In three studies (15·78 %), two groups were compared pre- and post-test[33,43,44], but most studies (*n* 8, 42·10 %)[31,32,34,45–49] used the same group tested pre- and post-intervention.

Fifteen out of nineteen studies (78·94 %) had not used a valid scale to measure FNLIT and its components. Only four studies (%) measured food label literacy by valid measures[32,43,48,50]. In one study, a change in knowledge of food labelling was assessed by asking individuals whether a food label was present on a product[32]. Validated multi-item 'food label literacy' tools to evaluate the food label literacy of students were used only by two studies[43,50]. Treu *et al.*[43] evaluated knowledge of healthy food choices in the form of food label literacy in school-aged children by the Food Label Literacy and Nutrition Knowledge (FLLANK) questionnaire, which previously underwent validation testing in the Independence School District (ISD)[51].

Eighteen of the nineteen studies were set in high-income countries, as classified by the World Bank economic classification[52]. Of these, fifteen studies were conducted in the USA[31,33–36,38–40,42–46,48–50,53], two in Australia[33,37], one in the UK[41] and one in Spain[47].

Of the included studies, ten targeted children aged 7–10 years[31,35,37,38,41–44,47,49], four studies targeted children aged 11–15 years[32,33,40,48] and five studies targeted children aged 8–15 years[34,36,39,45,46].

Seven out of nineteen studies (36·84 %) included parents in the interventions[31,35,37,38,42,46,47].

Quality assessment of included studies

The results mainly came from uncontrolled studies and were often based on non-validated outcome measures with no proper adjustment for confounders, which led to the weak global rating for ten studies based on the EPHPP assessment tool[29]. The quality of nine studies was rated as moderate, and none of the studies were judged as strong.

The data collection method was rated weak for most studies (*n* 11), largely because there was no information on the measurement instrument's validity and reliability.

Blinding of students and education providers was generally not possible in the studies. Task outcomes were directly assessed and not likely to be influenced by lack of blinding. Therefore, we assessed blindness as moderate in most studies. The quality assessment of included studies is summarised in Fig. 2 (online Supplementary Table S2).

Strategies and components used in the interventions

Five basic types of strategies were used in interventions aimed at improving FNLIT, including gardening[40], recipes skill building/cooking[31,41,47], food label reading[32,42,43,48,50], food tasting[38] and multi-component interventions[33–37,39,44–46,49,53]. Multi-component interventions included a combination of strategies from gardening/harvesting to food preparation/cooking, recipe skill-building, supporting cultural practices and ethnic foods, food tasting, and food labelling interventions (Table 2).

The variety of skill-building activities introduced by studies is as follows:

Recipe skill building

Two interventions offered recipe skill-building to children and preadolescents (aged 9–15 years)[41,45]. These included interventions that allowed a child to develop competency in recipe reading. Recipes were purposefully written for children with limited food skills and resources and reflected proper considerations, such as low cost, basic ingredients, basic/simple kitchen equipment, standardised format, numbered preparation steps, core recipes with variations, repetition, and progression of skills, exposure to a variety of foods, dietary guidelines principles, and involved local foods. Workstations were provided for an individual child or a team of two persons with the opportunity to skill-build and gain the confidence to perform the task

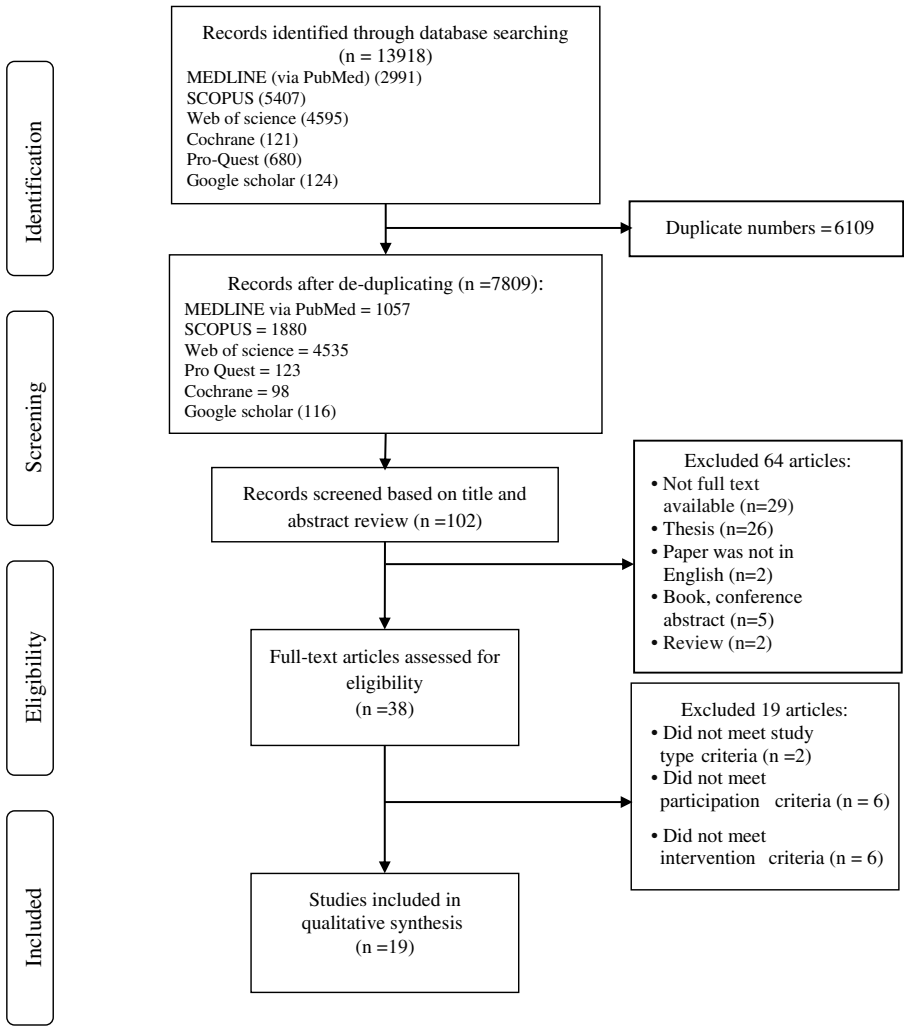

Fig. 1. PRISMA diagram.

independently. Working in a small group provided opportunities for peer-to–peer and supportive adult interactions. Additionally, by providing a 'core' recipe with simple ingredients, the choice was a practice of the learning experience, allowing youths to make food by their selected ingredients. For example, the 'create a-flavor' allowed changes in 'Apple Cinnamon Toast' by variations in the type of fruit, bread and seasonings[45]. In addition, opportunities for conversations about food choices, such as the advantages of whole-grain choices, were provisioned. Overall, these programmes were well received by students.

Food label literacy

Food label literacy interventions were usually part of multi-component school module(s) to promote the skills of use and understanding food label information, as well as informed food choices presented entirely in a one-off session[34,50] or as part of a healthy eating intervention[43]. Food label literacy interventions focused on enabling students to (1) explain topics such as nutrients, balanced diets, harmful effects of high fat, sugar and salt foods, and why making informed food choices can benefit their health; (2) recognise deception on packages of food products; (3) identify mandatory information on the labels, aspects they considered while buying packaged foods, defining DV and calculating DV% with differing serving sizes, and key points to make healthy food choices; (4) demonstrate the location of the nutrition facts panel, the ingredient list on food packages, nutrient content declaration (energy, fat, sugar and salt), manufacture, expiration, and best-before dates, and quality symbols; (5) determine foods' healthfulness according to their labels, nutrition facts panels and the ingredient list on their packages; and (6) grocery store tours[32,34,43,48,50].

Food preparation/cooking classes/clubs

Cooking classrooms and cooking clubs, either embedded into the school curriculum[31,35,37,38,44,45,49,53] or delivered in the form of an after-school food club[34,39,41,47], are another approach used to promote food skills (Table 3). Food clubs were held over several weeks (e.g. 20 weeks). The length of cooking classes or courses varied from a few hours per week to multiple days of training. Classroom-based activities focused on science, health, nutrition, literature and field trips to grocery stores, restaurants, nature centres and cultural events. Children were involved in an

Table 2. Key characteristics of reviewed studies (*n* 19)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
	Gardening-based interventions							
	McAleese & Rankin, 2007, Southeast Idaho[40]	Children aged 12 years, *n* 99 Sex: NS	Garden-based nutrition education, quasi-experimental pre-post design	Three treatment groups: 1 × 12 week nutrition education, 1 × 12 week nutrition education + garden-based activities, 1 × control.	Immediately after	No	NS	Main: Nutrition education + garden-based activities resulted in greater intake of fruit (1·9 (SD 0·6) to 2·6 (SD 1·7)) and vegetables (0·8 (SD 0·8) to 1·0 (SD 1·4)) than other two groups (skill/functional). Nutrition education + garden-based activities group significantly increased their fruit and vegetable servings, V.A, C intake, and fibre intake (skill/functional). Secondary: -
	Recipes skill-building/cooking-based interventions							
	Miller A, *et al.*, 2016, Maine, Nebraska, South Dakota, Tennessee, and West Virginia[31]	Children aged 9–12 years, *n* 35, Sex: NS, and their primary meal preparers, *n* 35	iCook 4-H intervention, 2-year control-treatment intervention study	Six-session curriculum taught through 3 months, focusing on families cooking, eating and playing together.	Immediately after	No	SCT	Main: significant, positive differences, including 11 % increase in cooking skill confidence (from 75 % to 86 %), desire to cook more meals at home and 19 % decrease in fast-food eating (from 23 % to 4 %) (skill/functional). 14 % increase in adult–youth feeding interactions (from 35 % to 49 %) (skill/interactive). Significant increases in 100 % fruit juice, vegetable soup and whole-grain consumption (skill/functional). Secondary: -
	Perez-Rodrigo & Aranceta, 1997, Spain, in Bilbao[47]	children aged 8–12 years, *n* 150, Sex: NS	Nutrition education of school-children living in a low-income area in Spain/pre- and post-test	2-h sessions × 5 weeks, included cooking, education, changes to school lunches and parental involvement + food and nutrition incorporated into the curriculum. implementation duration was 2 years	Immediately after	No	NS	Main: Increased nutrition, food hygiene and food preparation knowledge, increased cooking skills and preparing dishes at home. Increased intake of fruit, salad, fish and dairy products (skill/functional) Secondary: -
	Revill et al, 2004, North east England[41]	10 schools (5 intervention and 5 control group), student aged 11–12 years. *n* 167 Sex: NS	Food club/pre- and post-test	After-school food club. 20-week × 2-h programme aimed to teach cooking skills using inexpensive, healthful ingredients and essential equipment. The education content of food clubs included twenty sessions which as extracurricular to be taught in	Immediately after	No	NS	Main: some limited positive changes to food intake, gains in confidence and skills in cooking and more involved cooking at home (skill/functional). Secondary: -

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
				schools by teachers. The education programme was performed for 20 weeks in the autumn term from September 1999 to April 2000 and was divided into four blocks of 5 weeks duration in order to coincide with the academic half-terms. The intervention schools were asked to provide a suitable teaching room for the after-school cooking clubs. Part of the programme was taking food home for the family to have for dinner. 1 × control.				
	Food labelling interventions							
	Gavaravarapu et al, 2016, Hyderabad, India[32]	Schoolchildren. Aged aged 12–15 years. Females: NS (*n* 175).	Read-B4-U-Eat, Intervention group, and comparison group using pre- and post-intervention questionnaires	READ-B4-U-EAT multi-component school module to improve food label information and informed food choices. Four sessions of 45 min delivered using videos, handouts, presentations, and by teachers. Use of nutrition labels evaluated with five questions (self-reported) and knowledge of nutrition label assessed using one question	Immediately after	Yes	SCT	Main: improvements of the using and understanding of nutrition labels compared to the comparison group (from 12·6 ± 3·2 to 16·6 16·6 ± 3·07) (skill/functional) Secondary: -
	Hawthorne *et al.*, 2006, Houston[48]	Young adolescents. aged 11–14 years, *n* 35, 16 girls and 19 boys	How to read and use a nutrition facts label education programme. Single cohort using pre- and post-tests	Programme including calculating %DV with understanding serving sizes and defining DV.	Immediately after	Yes	NS	Main: Increased in Nutrition label understanding (calculating %DV with understanding serving sizes and defining DV) from 38 % to 74 %, improving serving size modification calculations (skill/critical). Secondary: -
	KATZ, et a, 2011[42] & 2014[50], Missouri.	Second-, third- and fourth-grade primary school students, *n* 1180 (628 intervention and 552 control group), aged 7–9 years old, 577 male and 604 females	Nutrition Detectives™ programme/case–control study	Nutrition Detectives programme including five mini-lessons: Mini-lessons one, two and three convey the link between food choice and health, the struggles of eating well in the modern world, in addition to how and what nutritious foods to choose + mini-lesson 4 was an interactive activity +	Immediately after	Yes	NS	Main: Students' nutrition knowledge improved significantly compared to baseline (knowledge). A significant gain of 15·0 percentage points for the 90-min programme and 16·2 percentage points for the 45-min lesson in scores of food label literacy (ability to distinguish between more and less healthful foods) of

https://doi.org/10.1017/S0007114522002811 Published online by Cambridge University Press

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
				the final mini-lesson including the healthy choice of fresh produce and summarising key points and takeaway messages. This programme was evaluated for a 90-min and 45-min lesson with a presentation and hands-on activity.				students was observed (skill/functional). Nutrition Detectives effectively improved students and their parents' ability to identify more nutritious food choices (skill/functional). Secondary: without any significant improvement in the BMI status of intervention and control group
	Treu *et al.*, 2017, Missouri[43]	School-aged children in grade 3. Mean age 8·7 years, 52 % female, *n* 1487, alongside their family. 17 primary schools (intervention) and 9 primary schools (control)	Nutrition Detectives and ABC for Fitness programmes, Quasi-experimental 3 group design. Schools randomised on the district. Pre- and post-tests.	The standard intervention (SI), including the Nutrition Detectives programme (in 3rd grade) + ABC for Fitness programme (in K-5 grades), provided daily physical activity in classrooms and a programme on making healthful foods, using food labels. The enhanced intervention (EI) provided these + additional components for students and their families, home, and supermarket. 90-min class session. 3-month follow-up, 30-min booster. (Control group received normal curriculum and no pre- and post-tests).	Immediately after	Yes	NS	Main: Both groups increased Food Literacy and Label Nutrition Knowledge (FLLANK) scores (by 23·3 ± 1·0) (skill/functional) compared to baseline values after the first and booster session (without difference between the two intervention groups) Secondary: without significant improvement in BMI Z score and physical fitness
Non-Randomized Controlled trials	Food tasting interventions							
	Gold *et al.*, 2017, North Dakota[38]	Third grade students, *n* 747 (51·8 % girls) from 26 schools, control (12 schools, *n* 369), intervention (14 schools, *n* 378)	Go Wild With Fruits and Veggies! (GWWFV), randomised control and intervention group with pre/post-test study	The GWWFV curriculum was a 7-week school-based intervention comprised of a 7-lesson series including classroom nutrition-based activities, taste testing, classroom movement activities, parent newsletters and take-home challenges.	Immediately after	No	NS	Main: Students tried and consumed more fruits and vegetables. Total fruit consumption increases from 3·1 to 3·7 in the intervention group (skill/functional). Secondary: -
	Multi-component interventions							
	Barnick *et al.*, 2014,	*n* 86 student in 4th grade (treatment = 43, and	School Gardening Program, quantitative, quasi-	The school gardening programme consisted of a single 1-h weekly session and was	immediately after	No	NS	Main: there was no statistically significant change in students' knowledge and attitude scores

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
	Cleveland, Ohio[44]	control = 43), Sex: NS	experimental pre- and post-design	part of the 10-month curriculum. The 1-h session comprised a 20-min lesson + 20-min hands-on activity + a 20-min nutrition piece that might include cooking, taste testing, etc. Topics covered included photosynthesis, germination, soil sampling and transplantation techniques.				(knowledge), but their behaviour scores significantly increased. Students made healthier choices (behaviour scale mean score changed from 12·21 ± 2·55 to 13·45 ± 2·91) (skill/functional) when given options between foods and expressed a higher degree of interest in attending school on the days that the nutrition programme was offered. Secondary: -
	Beckman et all, 2008, Minnesota[36]/ Lautenschlager[53]& Smith, 2007, Minneapolis[53]	Inner-city youth (ages 8–13 years), *n* 40. Sex: NS	Youth Farm Market Project (YFMP), pre- and post-survey	During the 10-week garden project, participants were involved in activities with various aspects of the food system (gardening, harvesting, cooking, and eating) and nutrition education as follows: Nutrition lessons facilitated by a nutrition educator with a new topic in each week (e.g. the food cycle, nutrients, and stewardship), + an activity (e.g. role-playing) to foster participatory learning. Then, youth were assigned to either gardening or cooking groups. At lunch, the entire group was introduced to an ethnic meal prepared by youth cooks. The afternoon was spent doing crafts (e.g. photography) or working in a garden. During the weekends, youth could volunteer to sell their planted products at the market. Youth also went to the ''Farm Camp'' and learned how a small-scale, organic cooperative farm operates.	Immediately after	No	TPB	Main: Increasing in nutrition/gardening knowledge score from 4·00 ± 3·20 to 5·24 ± 3·33 (knowledge) and fruit consumption from 2·01 ± 1·7 to 3·05 ± 2·1 and vegetable consumption from 2·05 ± 1·3 to 3·43 ± 2·5 (servings/d) in boys (functional skills). Garden participants were more willing to eat nutritious food, try ethnic and unfamiliar food, expressed a greater appreciation for individuals and cultures, and were more likely to cook and garden. Secondary: -
	Block *et al.*, 2012, Melbourne[37]	Children in grades three to six (aged 8–12 years), *n* 764 children (475 programmes, 289 comparisons) with 562 parents	Stephanie Alexander Kitchen Garden (SAKG) Program, mixed methods,	The teaching methods comprised enjoyable hands-on food education through gardening, harvesting, preparing, and sharing fresh, seasonal,	Immediately after	No	NS	Main: primary qualitative evaluation showed increasing child willing to try new foods (skill/functional), confidence and skills in relation to cooking and gardening (skill/

https://doi.org/10.1017/S0007114522002811 Published online by Cambridge University Press

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
		(326 programme, 236 comparison) and 93 teachers. Sex: NS	longitudinal, matched comparison trial	healthy, and delicious. The programme included a weekly minimum of 45 min in the garden with a garden specialist + 90 min in the kitchen classroom with a kitchen specialist as an ongoing part of the school curriculum.				functional), improvement school social environment (skill/interactive), and increasing school community connections (skill/interactive). Secondary: -
	Cunningham-Sabo *et al.*, 2014, Santa Fe,[49]	Fourth-grade students (*n* 1230), 50 % female	Cooking With Kids (CWK), pre-post, quasi-experimental, 2 cohorts	Including CWK interventions. Schools with CWK-CT had cooking and tasting lessons. Schools with CWK-T had exposure only to tasting lessons. 25 × 2-hour cooking and/or 5 × 1-hour fruit and vegetable tasting lessons	Immediately after	No	NS	Main: both intervention groups increased fruit and vegetable preferences, especially with vegetables (nearly 2·5 times), the greatest gains in cooking self-efficacy (in boys) without prior cooking experience (more than 2·5 times) (skill/functional). Without a significant change in cooking attitude (skill/functional). Secondary: -
	Morgan *et al.*, 2010, Australia[33]	11–12 years (*n* 127), 54 % boys	Nutrition education with and without a school garden, quasi-experimental pre-post design	10-week intervention with two treatment groups: (4 × 45 mins)/week nutrition education + garden (NE&G) classes, (3 × 1 h)/weeks nutrition education (NE) lessons in the classroom) only and 1 × control groups with their usual class. Food literacy aspects were taste vegetables, identify vegetables, willingness to taste vegetables. Follow-up duration: 4 months	After 4-month follow-up	No	SCT	Main: School gardens can positively improve primary-school students' ability to identify vegetables (knowledge), willingness to taste vegetables(skill/functional) without the significantly increased intake of fruit and vegetables (skill/functional) Secondary: No between-group differences were found for quality of school life (QoSL)
	Public Health Association of British Columbia (PHABC), 2017[46]	In Canadian schools without a control group, *n* 14 000 students enrolled in public schools in BC	Farm to school BC programmes. Pre- and post-test intervention	Farm to School BC included three-component goals of farm to school programmes: bringing healthy, local food into schools + hands-on experiential learning opportunities for students, and + fostering school and community connectedness. A 2-year project	Immediately after	No	NS	Main: The evaluation found that farm to school movement has contributed toward realising goals of food sovereignty through two main mechanisms, including advocacy for local and sustainable foods and mobilising food literacy for increased public engagement with issues of social justice and equity in food systems. (skill/critical). Secondary: -
			Choose Health: Food, Fun, and Fitness (CHFFF), two	CHFFF includes a six-lesson curriculum for third to sixth	Immediately after	No	SCT	Main: Reading of nutrition information increased significantly (skill/

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
	Wolf *et al.*, 2018, New York State[34]	Schoolchildren in grades 3–5 and 6–8. 50 % female. (*n* 1334)	cohort subsamples, across age groups and settings evaluated using pre-and post-surveys (which featured nutrition label items)	graders to enhance knowledge and skills building includes label reading. Session duration: 6-weekly lessons 45–90 min each. Setting: school, clubs and summer camp. Each lesson included hands-on, interactive nutrition education, problem-solving and participatory experiences to expand learning and skills in each lesson. Children were encouraged to prepare or at least taste and easy, healthy, kid-friendly recipes, improving their preferences and cooking skills (behavioural capacity, expectations and self-efficacy).				functional), more than a third of the third to fifth graders improved ≥ 1 point for each fruit and vegetable item, increased in frequency of drinking water, and frequency of choosing healthy snacks (with 40 % improving at least 1 point for each behaviour), increasing their willingness to ask their family to buy a new fruit and vegetable, decreasing in mean frequency for a sweetened drink (37 % to 45 % decreased by at least 1 point) (skill/functional) Secondary: -
	Thonney & Bisogni, 2006, New York[45]	Children aged 9–15 year olds, *n* 128 Sex: NS	Cooking Up Fun (CUF), pre-/post-test intervention	6 × 90 min sessions are designed to help young people acquire independent food skills to support healthy eating and positive youth development. Two adults (adult facilitators) work with 6–8 youth, and young people help plan the cooking sessions. Skill-building activities focused on reading recipes and food labels, kitchen, and food safety, ingredient science, and nutritional choices.	Immediately after	No	NS	Main: Skills were gained in knowledge (knowledge) and food preparation (skill/functional) Secondary: -.
Randomized Controlled trials	Scherr RE *et al.*, 2017, northern and central California[35]	Fourth graders (aged 9–10 years) at two control schools (*n* 179) and two intervention schools (*n* 230) and their parents and teachers. Sex: NS	Shaping Healthy Choices Program (SHCP), a clustered, randomised, controlled intervention	Five overlapping components comprised the SHCP: (1) nutrition education and promotion + (2) family and community partnerships + (3) supporting regional agriculture, + (4) foods available on the school campus, and + (5) school wellness committees and policies. The curriculum contained eight modules (15 classroom	Immediately after	No	SCT	Main: Students at the intervention schools compared to the control group showed significant improvements in nutrition knowledge from 19·4 to 21·6 scores (2·2) and total vegetable identification (1·18) (knowledge), and healthy food choices (skill/functional). Secondary: a significant decrease in BMI percentiles. The percentage of overweight/obese students

https://doi.org/10.1017/S0007114522002811 Published online by Cambridge University Press

Table 2. (*Continued*)

Study designs	Author/lead agency, year, country	Target group (age/sex/N)	Intervention (name and type)	Intervention description (components of intervention/intervention duration/follow-up)	Timing of post-intervention evaluation	FL/NL validate tools	Theory	Outcomes (domain/dimension)
				lessons + 19 take-home activities).				decreased from 55·6 % to 37·8 % from pre- to post-measure.
	Townsend *et al.*, 2006, California[39]	Children aged 9–12 years, *n* 5111, 2521 male (49·3 %)	Youth Expanded Food and Nutrition Education Program (EFNEP), randomised, controlled field trial	Youth programme with seven school-based lessons includes food preparation/cooking, food tasting and food safety.	Immediately after	No	NS	Main: 53 % of children had improved scores for nutrition knowledge (knowledge), 34 % for eating various foods, 31 % for food selection and 68 % for food preparation skills and safety practices (skill/functional). Secondary: -

FL, food literacy; NL, nutrition literacy; NS, not stated; SCT, Social Cognitive Theory; TPB, Theory of Planned Behavior.

in-depth demonstration focused on specific food/ethnic foods[53] or skills, such as preparing delicious foods, identifying food safety and self-efficacy. Students became more confident and independent by learning the importance of healthy nutrition and hands-on skills in a kitchen setting. In the interactive cooking classes, students cook along with a chef and their peers in real time. Designed to look and feel like they were cooking in their own home, each student had his/her own cooking station, complete with sinks, aprons and cookware sets. Interventions offered hands-on skills, along with food-knowledge building[31,37,39,41,44,47,53]. One intervention used cooking demonstrations using the 'Cooking Up Healthy Choices' curriculum. Cooking Up Healthy Choices was a series of five cooking demonstration sessions that allowed students to get familiar with a variety of vegetables, observe cooking methods, understand related nutrition concepts and experience the preparation of recipes using all five senses[35].

Food tasting

Students participated in communal food activities that impacted food knowledge and fostered positive food nature[33,34,38,44]. Students brought new food to the class and talked with each other about how they tasted. They were encouraged to notice and enjoy the sensory characteristics of food and eagerly shared their pleasure with their peers. In the 'Cooking With Kids (CWK)' intervention, students were exposed to tasting lessons[49]. Through these sessions, students would learn to try new food as one of the components of functional skills of FNLIT (Table 3).

Gardening/harvesting

Seven studies specifically focused on gardening/harvesting interventions[33,35,37,40,44,46,53]. These programmes were carried out as gardening lessons in the classroom curriculum. Children assigned to gardening groups received weekly lessons focused on garden activities and the food system. They were engaged in either doing crafts (e.g. photography) or gardening in the afternoons. Volunteer adolescents sold their planted products in the farmers' market during the weekends. They also went to the 'Farm Camp' and learned how a small-scale, organic, cooperative farm operates.[53].

Supporting cultural practices and ethnic foods

Some programmes consisted of strategies to increase children's willingness and cognition towards ethnic and indigenous foods. Students were introduced to an ethnic meal prepared by young cooks in this programme and tried ethnic and unfamiliar foods[46,53]. Understanding diverse ethnic and cultural practices related to meal preparation and consumption is one layer of FL[2].

Implementation methods of the interventions

The educational/training sessions were presented mainly by lectures, pictorial booklets, and posters, accompanied by power points, videos, and short animation films to engage, motivate and inform the students. Also, some group activities were performed, for example, assigning teams of students to search

https://doi.org/10.1017/S0007114522002811 Published online by Cambridge University Press

Fig. 2. Quality assessment (using the EPHPP) of reviewed studies (*n* 19).

through a grocery bag containing food products, such as cereals, crackers, or snack bars, and decide which products are healthful 'clued-in' and which are less healthy 'clue-less'[50]. Other teachings and learning activities included take-home challenges and parents' newsletter, role-playing, playing together, grocery store tours, hands-on activities, doing crafts (photography) and animation film for entertainment education.

Delivery formats of interventions in the fifteen of the nineteen studies (78·94 %) were by teachers[31–33,35,37–44,46,47,49]. Investigators supplemented information only when it was necessary. Some other interventions (*n* 4) were facilitated by community health educators[34], registered dieticians[48], as well as community members involved in the programme[45].

Interventions in the promotion of Food and Nutrition Literacy dimensions

Functional Food and Nutrition Literacy. Fifteen studies (78·94 %)[32–36,38–45,47,49] were interventions to improve health outcomes, which described the specific effects on some components of functional FNLIT and knowledge aspects. These interventions resulted in a significant increase in functional skills of FNLIT, including food preparation (cooking and safety), planning and managing, food selection, recognition ability, reading and using nutrition facts labels, self-efficacy, and confidence, and trying ethnic and unfamiliar food (see Table 3 for details).

Critical Food and Nutrition Literacy. In a study by Hawthorne *et al.*[48], the subjects' scores in serving size modification calculations and nutrition label understanding (calculating %DV with differing serving sizes and defining DV) as critical food/nutrition literacy skills were significantly improved.

The Farm to School programme[46] is comprised of a tailored approach and presented according to students' needs and interests. The intervention evaluation showed an improvement in advocacy for local and sustainable foods and mobilising FL for increased public engagement with issues of social justice and equity in food systems.

Table 3. Summary of intervention description in terms of content, facilitators, cooking course association setting and its effect on the FNLIT dimensions and its components by the quality level of study

Quality	Study	Content/type of intervention	Facilitators	Supervisor	Cooking course association setting	Curriculum	Dimensions affected by the intervention				Components affected by intervention		
							Knowledge	Functional	Interactive	Critical	Functional	Interactive	Critical
	Block *et al.*, 2012[37]	Food preparation/cooking, gardening/harvesting, and food tasting	Teachers	Garden specialist and kitchen specialist	In school	In curriculum	–	√	√	–	Preparing skills (cooking, safety), self-efficacy and confidence, trying ethnic and unfamiliar food	Communicating and interacting	–
	Cunningham-Sabo *et al.*, 2014[49]	Food preparation/cooking, food tasting	Teachers	Food educators	In school	in curriculum	–	√	–	–	planning and managing, self-efficacy and confidence, trying ethnic and unfamiliar food	–	–
Moderate	Gavaravarapu *et al.*, 2016[32]	Food label literacy (reading food labels and informed food choices)	Teachers	Investigators	–	in curriculum	–	√	–	–	reading and using nutrition facts labels	–	–
	Gold *et al.*, 2017[38]	Food tasting	Teachers	School food service professionals	In school	in curriculum	–	√	–	–	planning and managing,	–	–
	McAleese & Rankin, 2007[40]	Gardening/harvesting	Teachers	NS	–	in curriculum	–	√	–	–	planning and managing,	–	–
	Morgan *et al.*, 2010[33]	Gardening/harvesting, food tasting	Teachers	NS	–	in curriculum	√	√	–	–	trying ethnic and unfamiliar food	–	–
	Scherr RE *et al.*, 2017[35]	Recip s skill building, food preparation/cooking, and gardening/harvesting	Teachers	Nutrition educator	In school	in curriculum	√	√	–	–	Food selection	–	–
	Townsend *et al.*, 2006[39]	Food preparation/cooking and food tasting	Teachers	NS	After school	in curriculum	√	√	–	–	Preparing skills (cooking, safety), planning and managing, food selection	–	–
	Treu *et al.*, 2017[43]	Food label literacy (using food labels and grocery store tour)	Teachers	NS	–	in curriculum	√	√	–	–	Reading and using nutrition facts labels	–	–
			Teachers		In school	In curriculum	–	√	–	–		–	–

Table 3. (*Continued*)

Quality	Study	Content/type of intervention	Facilitators	Supervisor	Cooking course association setting	Curriculum	Dimensions affected by the intervention				Components affected by intervention		
							Knowledge	Functional	Interactive	Critical	Functional	Interactive	Critical
	Barnick *et al.*, 2014[44]	Food preparation/cooking, test tasting, and gardening/harvesting		Master gardener volunteers							Planning and managing, food selection		
	Beckman *et al.* l, 2008[36] Lautenschlager & Smith, 2007[53]	Food preparation/cooking, supporting cultural practices and ethnic foods, and gardening/harvesting	Nutrition educator	NS	In school	Extracurricular	√	√	–	–	Preparing skills (cooking, safety), planning and managing, trying ethnic and unfamiliar food	–	–
	Katz, *et al.*, 2011[42] Katz, *et al.*, 2014[50]	Food label literacy (using food labels)	Teachers	NS	–	In curriculum	√	√	–	–	Recognition ability, reading and using nutrition facts labels	–	–
	Miller A, *et al.*, 2016[31]	Food preparation/cooking	Teachers	NS	In school	In curriculum	–	√	√	–	Preparing skills (cooking, safety), planning and managing, self-efficacy and confidence	Communicating and interacting	–
Weak	Hawthorne *et al.*, 2006[48]	Food label literacy (calculating %DV with differing serving sizes)	Registered dietitian	NS	–	Extracurricular	–	–	–	√	–	–	critically evaluating information
	Perez-Rodrigo & Aranceta, 1997[47]	Recipes skill building, and food preparation/cooking	Teachers	NS	After school food club	In curriculum	–	√	–	–	Preparing skills (cooking, safety, planning and managing	–	–
	Public Health Association of BC, 2017[46]	Gardening/harvesting, and supporting cultural practices and ethnic foods	Teachers	NS	–	In curriculum	–	–	–	√	–	–	ecological factors
	Revill *et al.*, 2004[41]	Recipes skill building, and food preparation/cooking	Teachers	NS	After school food clubs	Extracurricular	–	√	–	–	Preparing skills (cooking and safety), planning and managing, self-efficacy and confidence	–	–
			Adult	NS	In school	In curriculum	√	√	–	–		–	–

Table 3. (*Continued*)

Quality	Study	Content/type of intervention	Facilitators	Supervisor	Cooking course association setting	Curriculum	Dimensions affected by the intervention: Knowledge	Functional	Interactive	Critical	Components affected by intervention: Functional	Interactive	Critical
	Thonney & Bisogni, 2006[45]	Food label literacy (reading food labels), food preparation/cooking									Preparing skills (cooking, safety)		
	Wolf *et al.*, 2018[34]	Food preparation/cooking, recipes skill building, and food label literacy (reading food labels)	Community health educators	NS	After school	In curriculum	–	√	–	–	planning and managing, food selection, reading and using nutrition facts labels, trying ethnic and unfamiliar food	–	–

Integrated aspects of Food and Nutrition Literacy (functional and interactive). No intervention included measurement of all FNLIT components or the three emphasised dimensions of Nutbeam's hierarchical model of health literacy; however, two out of nineteen studies (10·52 %)[31,37] did incorporate two dimensions of the skill domain, including functional and interactive literacy. Block *et al.*[37] presented the Stephanie Alexander Kitchen Garden programme results. The following components of FNLIT were improved:

- confidence and skills in relation to cooking and gardening, and increasing child willingness to try new foods (functional skills);
- school social environment, increasing school community connections (interactive skills).

The Stephanie Alexander Kitchen Garden (SAKG) was a national programme based on a health-promoting schools framework that used a multi-level, multi-strategy approach through the school policies, curriculum, staffing and environment sought sustainability[54–56]. The teaching methods comprised enjoyable hands-on food education through gardening, harvesting, preparing, and sharing fresh, seasonal, healthy, and delicious food. Teachers facilitated the programme. The specialist staff planned and supervised each class, and children worked in small groups assisted by adult volunteers[57].

iCook 4-H was a curricular programme focusing on families cooking, eating and playing together. Miller *et al.*[31] reported the following improvements in FNLIT functional and interactive skills in the iCook 4-H intervention:

- cooking skill confidence, desire to cook more meals at home, and fewer fast-food meals, 100 % fruit juice, vegetable soup, and whole-grain consumption (functional skills)
- adult–youth feeding interactions by shared parent–child decision-making related to food choice and effective management in food-related conflicts (interactive skills)

Effectiveness of interventions

Because of the low quality of the studies, we can draw no firm conclusions regarding the effective components of food/nutrition literacy interventions. However, the following common factors were noted within the interventions successful in more than one dimension of FNLIT, especially interactive and critical aspects, which were identified as promising. Four out of nineteen studies included the following factors (21·05 %):

- the interventions which tailored their activities and presented information to the needs and interests of students[37];
- the interventions that were incorporated into the existing curriculum and facilitated by teachers[31,37,46];
- interventions mainly used promising strategies/methods, including pleasurable hands-on food education, school gardening programmes, kitchen classrooms, family cooking, eating and playing together, and supporting cultural practices and ethnic foods[31,37,46,48] that led to improvements in functional, partly interactive and critical skills.

Discussion

In this systematic review, for the first time, interventions aimed at improving food/nutrition literacy were identified and assessed. To our knowledge, there has been no study to have directly examined food/nutrition literacy interventions. However, we looked for relevant studies focused on food skills or functional aspects of FNLIT. All the studies reviewed here effectively improved one or more dimensions of FNLIT skills, especially functional FL. However, the interventions partially considered improved interactive and critical skills and were implemented among students from different grades and through various delivery formats, study designs, FL measurement instruments, and outcomes.

Three factors were identified as promising within the reviewed interventions: (1) those that tailored their activities and presented information to the needs and interests of students; (2) the interventions that were incorporated into the existing curriculum and facilitated by teachers; and (3) the interventions that mainly used strategies/methods such as pleasurable hands-on food education, school gardening programme, kitchen classroom, family cooking, eating, and playing together and supporting cultural practices and ethnic foods that led to improvements in functional, and partly interactive and critical skills (instead of just knowledge). These findings are concordant with those from the review by Berkman *et al.*[58] and other studies[59–61], demonstrating that the effectiveness of interventions could be determined by a combination of tailored activities and appropriate strategies.

Because of the studies' overall low quality, no firm conclusions could be drawn on the effectiveness and the affective component(s) of food/nutrition literacy interventions. Besides, FL was operationalised and measured differently in the interventions, thus impeding the comparability of the results. Furthermore, most studies did not use a validated tool for measuring FL. Due to the novelty of the FL concept, over the preceding decades, a limited number of studies on the development, translation and validation of (both subjective and objective) food/nutrition literacy measurement instruments have been published[6,62–65]. The development of precise tools for measuring FL and taking a unified approach will provide a foundation for developing effective FNLIT programmes[66].

The three most common strategies used by programmes were gardening, food preparation/cooking and food tasting. In a qualitative study on students, Hess and Trexler[67] found that students had limited knowledge of conventional agriculture and emphasised experiential learning (e.g. small-scale farming or gardening) to increase students' understanding of food. Evidence shows that school-based gardening activities positively impact scientific process skills and strengthen interactive, critical, innovative, and creative skills, and all important aspects of FL[68–70]. Indeed, a review of garden-based nutrition education concluded that these interventions improved fruit and vegetable consumption and expanded preference for such foods (functional literacy)[71]. Comparable to the studies on garden-based interventions, school-based cooking initiatives improved the cooking skill elements and related components of FL. Food tasting is also a way to get children excited by trying new foods; indeed, senses make individuals innately equipped to make food choices, and the appearance, smell, and taste of food can influence individuals' food consumption.[68].

Some research treated gardening, cooking and taste testing as targeted interventions designed to develop cognitive and skill domains of FL in this area[68,72]. Although these studies demonstrated positive results in nutrition knowledge, changing food preferences, and increased confidence in cooking and gardening skills, more evidence is needed to document the use of these initiatives as a strategy for promoting FL in school settings.

FNLIT encompasses the knowledge and skills that students need to access, understand, interpret, express ideas and opinions, interact (food and nutrition) information with others (peers, family and nutritionists), analyse and evaluate food and nutrition information, and participate in activities related to health and nutrition in and out of schools[2]. Success in any area requires the use of significant, identifiable, and distinctive FNLIT that is important for learning and representative of the content of that area[2,62]. Evidence has suggested that a teacher-led intervention to improve students' knowledge and skills is effective, while, alongside the primary goal to improve students' outcomes, the impact of professional development activities on teachers' reactions, learning and teaching behaviour should be considered[73].

The collected evidence provides insight into the gaps in intervention to improve children's interactive and critical skills in future research. It should be noted that all components may not always be present in every individual. Conversely, when a component is missing, the relationship with food and nutrition will be weaker and less likely to respond to change in that area.

To better understand how FL improves in the school context, we must ascertain the environments of food education and the characteristics of instruction that appeal to and encourage all school community members to cooperate[74].

To our knowledge, this is the first systematic review related to FNLIT interventions in children. This review rigorously applied a comprehensive search strategy and systematic selection process to include the most up-to-date publications according to inclusion criteria. However, our review has some noteworthy limitations despite the rigorous and novel approach. First, a meta-analysis of the effect size of interventions was not possible due to heterogeneous study designs and outcome measures; therefore, a descriptive analysis was performed. Second, we did not find sufficient numbers of studies to estimate the statistical risk of publication bias. However, publication bias might exist, as it is possible that the studies with higher effects are more likely to be published. This review mainly evaluated non-randomised controlled trials with primary schoolchildren (5–12 years old) and school settings. As a result, interventions among adolescents and in different settings (e.g. after school) were not considered. Finally, other limitations were the inclusion of only English papers and the lack of FNLIT as a unique indexing term.

Future research should evaluate pragmatic cluster-randomised controlled trials in a broader variety of settings in children and adolescents.

Conclusion

None of the interventions reviewed included all effective FNLIT components, and there was much emphasis on the functional

level of FL. There are considerable gaps in the research evidence reviewed; indeed, there was insufficient data on interactive and critical components. Future interventions should focus holistically on all aspects of FNLIT, especially interactive and critical skills, and use stronger designs, for example, in well-reported, large-sampled randomised controlled trials. However, promising interventions were tailored to the needs and interests of students, incorporated into the existing curriculum, facilitated by teachers, used the profitable strategies including pleasurable hands-on food education, school gardening programme, kitchen classroom, family cooking, eating, and playing together and supporting cultural practices and ethnic foods that led to improvements in functional, and partly interactive and critical skills.

Acknowledgements

The authors hereby express their appreciation to Shahid Beheshti University of Medical Sciences, National Nutrition and Food Technology Research Institute (NNFTRI) for funding the study.

This work was approved and funded by Shahid Beheshti University of Medical Sciences, National Nutrition and Food Technology Research Institute (NNFTRI) (grant number. IR.SBMU.NNFTRI.REC.1397·022).

A. D. and N. O. conceived and designed the study. A. D. and E. S. developed the search strategy. A. D. and M. S. performed the search and selection of articles. A. D. and M. S. K. performed the analyses for the articles. N. O. and E. S. contributed to the discussion and conclusions of the study. A. D. is a major contributor in the writing of the manuscript, which N. O. and E. S. revised. All authors read and approved the final paper.

The authors declare that they have no competing interests.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114522002811

References

1. Zoellner J, You W, Connell C, *et al.* (2011) Health literacy is associated with healthy eating index scores and sugar-sweetened beverage intake: findings from the rural Lower Mississippi Delta. *J Am Dietetic Assoc* **111**, 1012–1020.
2. Vidgen HA & Gallegos D (2014) Defining food literacy and its components. *Appetite* **76**, 50–59.
3. Cullen T, Hatch J, Martin W, *et al.* (2015) Food literacy: definition and framework for action. *Can J Diet Pract Res* **76**, 140–145.
4. Krause C, Sommerhalder K, Beer-Borst S, *et al.* (2018) Just a subtle difference? Findings from a systematic review on definitions of nutrition literacy and food literacy. *Health Promot Int* **33**, 378–389.
5. Nutbeam D (2008) The evolving concept of health literacy. *Soc Sci Med* **67**, 2072–2078.
6. Doustmohammadian A, Omidvar N, Keshavarz-Mohammadi N, *et al.* (2017) Developing and validating a scale to measure Food and Nutrition Literacy (FNLIT) in elementary school children in Iran. *PLoS One* **12**, e0179196.
7. Nelson MC, Story M, Larson NI, *et al.* (2008) Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. *Obesity* **16**, 2205–2211.
8. Vidgen HA & Gallegos D (2012) Defining Food Literacy, its Components, Development and Relationship to Food Intake: a Case Study of Young People and Disadvantage. Brisbane: Queensland University of Technology.
9. CDC (2010) Youth risk behavior surveillance—United States, 2009. MMWR 59, 1–42.
10. Hardy LL, Mihrshahi S, Bellew W, *et al.* (2017) Children's adherence to health behavior recommendations associated with reducing risk of non-communicable disease. *Prev Med Rep* **8**, 279–285.
11. Diethelm K, Jankovic N, Moreno LA, *et al.* (2012) Food intake of European adolescents in the light of different food-based dietary guidelines: results of the HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) Study. *Public Health Nutr* **15**, 386–398.
12. Savige GS, Ball K, Worsley A, *et al.* (2007) Food intake patterns among Australian adolescents. *Asia Pac J Clin Nutr* **16**, 738–747.
13. Laska MN, Larson NI, Neumark-Sztainer D, *et al.* (2012) Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. *Public Health Nutr* **15**, 1150–1158.
14. US Department of Education (2010) Institute of Education Sciences. Educational Indicators, Indicator 24: Time in Formal Instruction. Washington, DC: US Department of Education. http://nces.ed.gov/pubs/eiip/eiipid24.asp (accessed September 2019).
15. WHO (1996) World Health Organization. The Status of School Health. http://www.who.int/school_youth_health/media/en/87.pdf?ua=1 (accessed September 2019).
16. Kelly RK & Nash R (2021) Food literacy interventions in elementary schools: a systematic scoping review. *J Sch Health* **91**, 660–669.
17. Vettori V, Lorini C, Milani C, *et al.* (2019) Towards the implementation of a conceptual framework of food and nutrition literacy: providing healthy eating for the population. *Int J Environ Res Public Health* **16**, 5041.
18. Velardo S (2015) The nuances of health literacy, nutrition literacy, and food literacy. *J Nutr Educ Behav* **47**, 385–389.e381.
19. Khan K, Kunz R, Kleijnen J, *et al.* (2011) *Systematic Reviews to Support Evidence-Based Medicine: How to Review and Apply Findings of Healthcare Research*. London: Royal Society of Medicine Press Ltd.
20. Vaitkeviciute R, Ball LE & Harris N (2015) The relationship between food literacy and dietary intake in adolescents: a systematic review. *Public Health Nutr* **18**, 649–658.
21. Moher D, Liberati A, Tetzlaff J, *et al.* (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* **62**, 1006–1012.
22. Doustmohammadian A, Omidvar N & Shakibazadeh E (2020) School-based interventions for promoting food and nutrition literacy (FNLIT) in elementary school children: a systematic review protocol. *Syst Rev* **9**, 1–7.
23. Nutbeam D & Kickbusch I (2000) Advancing health literacy: a global challenge for the 21st century. *Health Promot Int* **15**, 183–184.
24. Davis JN, Ventura EE, Cook LT, *et al.* (2011) LA Sprouts: a gardening, nutrition, and cooking intervention for Latino youth improves diet and reduces obesity. *J Am Dietetic Assoc* **111**, 1224–1230.
25. Colatruglio S & Slater J (2014) *Food Literacy: Bridging the Gap Between Food, Nutrition and Well-Being. Sustainable*

Well-Being: Concepts, Issues, and Educational Practices. Winnipeg, MB: ESWB Press. pp. 37–55.
26. McGowan J, Sampson M, Salzwedel DM, *et al.* (2016) PRESS peer review of electronic search strategies: 2015 guideline statement. *J Clin Epidemiol* **75**, 40–46.
27. Clarivate Analytics (2019) Endnote X7.7.1 for Mac OS X (Computer Software). Philadelphia, PA: Clarivate Analytics.
28. Rathbone J, Carter M, Hoffmann T, *et al.* (2015) Better duplicate detection for systematic reviewers: evaluation of systematic review assistant-deduplication module. *Syst Rev* **4**, 6.
29. Effective Public Health Practice Project (EPHPP) (2009) Quality Assessment Tool for Quantitative Studies. https://www.nccmt.ca/knowledge-repositories/search/14 (accessed June 2019).
30. National Collaboration Center for Methods and Tools (2010) Quality Assessment Tool for Quantitative Studies. http://www.nccmt.ca/registry/view/eng/14.html (accessed August 2019).
31. Miller A, Franzen-Castle L, Aguirre T, *et al.* (2016) Food-related behavior and intake of adult main meal preparers of 9–10 year-old children participating in iCook 4-H: a five-state childhood obesity prevention pilot study. *Appetite* **101**, 163–170.
32. Gavaravarapu SM, Saha S, Vemula SR, *et al.* (2016) Read-B4-U-eat: a multicomponent communication module to promote food label reading skills among adolescents in India. *J Nutr Educ Behav* **48**, 586–589. e581.
33. Morgan PJ, Warren JM, Lubans DR, *et al.* (2010) The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students. *Public Health Nutr* **13**, 1931–1940.
34. Wolfe W & Dollahite J (2018) Choose health: food, fun, and fitness curriculum promotes positive behaviors in youth compared to control period. *J Nutr Educ Behav* **50**, S153–S154.
35. Scherr RE, Linnell JD, Dharmar M, *et al.* (2017) A multicomponent, school-based intervention, the shaping healthy choices program, improves nutrition-related outcomes. *J Nutr Educ Behav* **49**, 368–379. e361.
36. Beckman LL & Smith C (2008) An evaluation of inner-city youth garden program participants' dietary behavior and garden and nutrition knowledge. *J Agric Educ* **49**, 11–24.
37. Block K, Gibbs L, Staiger PK, *et al.* (2012) Growing community: the impact of the Stephanie Alexander Kitchen Garden Program on the social and learning environment in primary schools. *Health Educ Behav* **39**, 419–432.
38. Gold A, Larson M, Tucker J, *et al.* (2017) Classroom nutrition education combined with fruit and vegetable taste testing improves children's dietary intake. *J Sch Health* **87**, 106–113.
39. Townsend MS, Johns M, Shilts MK, *et al.* (2006) Evaluation of a USDA nutrition education program for low-income youth. *J Nutr Educ Behav* **38**, 30–41.
40. McAleese JD & Rankin LL (2007) Garden-based nutrition education affects fruit and vegetable consumption in sixth-grade adolescents. *J Am Dietetic Assoc* **107**, 662–665.
41. Revill SA (2004) *Evaluation of a School-Based Nutrition and Food Preperation Skills Intervention Delivered to Schoolchildren from Deprived Social Backgrounds*. Tyne: Newcastle University.
42. Katz DL, Katz CS, Treu JA, *et al.* (2011) Teaching healthful food choices to elementary school students and their parents: the Nutrition Detectives™ program. *J Sch Health* **81**, 21–28.
43. Treu JA, Doughty K, Reynolds JS, *et al.* (2017) Advancing School and Community Engagement Now for Disease Prevention (ASCEND) a quasi-experimental trial of school-based interventions to prevent childhood obesity. *Am J Health Promot* **31**, 143–152.
44. Barnick A (2014) *The Impact of a School Gardening Program on Nutrition Attitudes, Behaviors and Interests Amongst Fourth Grade Students*. Cleveland: Cleveland State University.
45. Thonney PF & Bisogni CA (2006) Cooking up fun! A youth development strategy that promotes independent food skills. *J Nutr Educ Behavior* **38**, 321–323.
46. Public Health Association of British Columbia (PHABC) (2017) History. Farm to School BC. http://farmtoschoolbc.ca/about-us/history/ (accessed November 2020).
47. Perez-Rodrigo C & Aranceta J (1997) Nutrition education for schoolchildren living in a low-income urban area in Spain. *J Nutr Educ* **29**, 267–273.
48. Hawthorne KM, Moreland K, Griffin IJ, *et al.* (2006) An educational program enhances food label understanding of young adolescents. *J Am Dietetic Assoc* **106**, 913–916.
49. Cunningham-Sabo L & Lohse B (2014) Impact of a school-based cooking curriculum for fourth-grade students on attitudes and behaviors is influenced by gender and prior cooking experience. *J Nutr Educ Behav* **46**, 110–120.
50. Katz DL, Treu JA, Ayettey RG, *et al.* (2014) Peer reviewed: testing the effectiveness of an abbreviated version of the nutrition detectives program. *Prev Chronic Dis* **11**, E57.
51. Reynolds JS, Treu JA, Njike V, *et al.* (2012) The validation of a food label literacy questionnaire for elementary school children. *J Nutr Educ Behav* **44**, 262–266.
52. Fantom NJ & Serajuddin U (2016) The World Bank's Classification of Countries by Income. World Bank Policy Research Working Paper. http://documents1.worldbank.org/curated/en/408581467988942234/pdf/WPS7528.pdf (accessed July 2020).
53. Lautenschlager L & Smith C (2007) Beliefs, knowledge, and values held by inner-city youth about gardening, nutrition, and cooking. *Agric Hum Value* **24**, 245.
54. Association AHPS (2001) A National Framework for Health Promoting Schools (2000–2003). Canberra: Commonwealth Department of Health and Family Services.
55. World, Health, Organization (1996) Regional Guidelines: Development of Health-Promoting Schools-a Framework for Action. Manila: WHO Regional Office for the Western Pacific.
56. St Leger L (2005) Protocols and guidelines for health promoting schools. *Promot Educ* **12**, 145–147.
57. Block K, Johnson B, Gibbs L, *et al.* (2009) *Evaluation of the Stephanie Alexander Kitchen Garden Program*. Melbourne: University of Melbourne.
58. Berkman ND, Sheridan SL, Donahue KE, *et al.* (2011) Health literacy interventions and outcomes: an updated systematic review. *Evid Rep/Technol Assess* **199**, 1–941.
59. Meppelink CS, Smit EG, Buurman BM, *et al.* (2015) Should we be afraid of simple messages? The effects of text difficulty and illustrations in people with low or high health literacy. *Health Commun* **30**, 1181–1189.
60. Meppelink CS, van Weert JC, Haven CJ, *et al.* (2015) The effectiveness of health animations in audiences with different health literacy levels: an experimental study. *J Med Int Res* **17**, e11.
61. Muller I, Rowsell A, Stuart B, *et al.* (2017) Effects on engagement and health literacy outcomes of web-based materials promoting physical activity in people with diabetes: an international randomized trial. *J Med Int Res* **19**, e21.
62. Amouzandeh C, Fingland D & Vidgen HA (2019) A scoping review of the validity, reliability and conceptual alignment of food literacy measures for adults. *Nutrients* **11**, 801.
63. Ashoori M, Omidvar N, Eini-Zeynab H, *et al.* (2020) Development and validation of Food and Nutrition Literacy Assessment Tool (FNLAT) for Iranian High-school graduates. Int J Prev Med 11, 185.

64. Khorramrouz F, Doustmohammadian A, Amini M, *et al.* (2021) Validity of a Modified Food and Nutrition Literacy (M-FNLIT) questionnaire in primary school children in Iran. *Br J Nutr* **127**, 1–28.
65. Stjernqvist NW, Elsborg P, Ljungmann CK, *et al.* (2021) Development and validation of a food literacy instrument for school children in a Danish context. *Appetite* **156**, 104848.
66. Park D, Shin M-J & Song S (2019) Food literacy in South Korea: operational definition and measurement issues. *Clin Nutr Res* **8**, 79–90.
67. Hess AJ & Trexler CJ (2011) A qualitative study of agricultural literacy in urban youth: understanding for democratic participation in renewing the agri-food system. *J Agric Educ* **52**, 151–162.
68. Strohl CA (2015) *Scientific Literacy in Food Education: Gardening and Cooking in School*: Davis, CA: University of California.
69. Nowak AJ, Kolouch G, Schneyer L, *et al.* (2012) Building food literacy and positive relationships with healthy food in children through school gardens. *Childhood Obes* **8**, 392–395.
70. Brooks N & Begley A (2014) Adolescent food literacy programmes: a review of the literature. *Nutr Diet* **71**, 158–171.
71. Robinson-O'Brien R, Story M & Heim S (2009) Impact of garden-based youth nutrition intervention programs: a review. *J Am Dietetic Assoc* **109**, 273–280.
72. Joshi A, Azuma AM & Feenstra G (2008) Do farm-to-school programs make a difference? Findings and future research needs. *J Hunger Environ Nutr* **3**, 229–246.
73. Moore L, Graham A & Diamond I (2003) On the feasibility of conducting randomised trials in education: case study of a sex education intervention. *Br Educ Res J* **29**, 673–689.
74. FAO (2020) School-Based Food and Nutrition Education – A White Paper on the Current State, Principles, Challenges and Recommendations for Low- and Middle-Income Countries. Rome: FAO. https://doi.org/10.4060/cb2064en
75. Edwards CS & Hermann JR (2011) Piloting a cooperative extension service nutrition education program on first-grade children's willingness to try foods containing legumes. *J Ext* **49**, 1–4.
76. Azevedo J, Padrão P, Gregório MJ, *et al.* (2019) A web-based gamification program to improve nutrition literacy in families of 3-to 5-year-old children: the nutriscience project. *J Nutr Educ Behav* **51**, 326–334.
77. Krause CG, Beer-Borst S, Sommerhalder K, *et al.* (2018) A short food literacy questionnaire (SFLQ) for adults: findings from a Swiss validation study. *Appetite* **120**, 275–280.
78. Shriver EK (2008) Media-Smart Youth: Eat, Think, and Be Active! A Workshop Curriculum for Youth Ages 11 to 13. Guide for Training Program Facilitators. National Institute of Child Health and Human Development (NICHD). http://www.nichd.nih.gov/msy (accessed September 2022).

British Journal of Nutrition