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Author post-print (accepted) deposited by Coventry University's Repository

Original citation & hyperlink:

Nasrin, O, Doustmohammadian, A, Elham, S, Clark, CCT, Kasaii, MS & Saryazdi, MH 2022, 'Effects of school-based interventions on Food and Nutrition Literacy (FNLIT) in primary-school-age children: a systematic review', *British Journal of Nutrition*, vol. (In-press), pp. (In-press). <https://doi.org/10.1017/S0007114522002811>

DOI 10.1017/S0007114522002811

ISSN 0007-1145

ESSN 475-2662

Publisher: Cambridge University Press

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

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Code: 1449614535.



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10.1017/S0007114522002811

The British Journal of Nutrition is published by Cambridge University Press on behalf of The Nutrition Society

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, Pro-Quest, and Google Scholar were systematically searched. Randomized and non-randomized 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 programs, 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 (food label literacy) via a valid measure. Most interventions focused on the functional level of food literacy, except for two programs (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 food and nutrition literacy, especially interactive and critical skills.

Keywords: food literacy, nutrition literacy, school-based interventions, primary school

Introduction

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 toward 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 conceptualizations of food/nutrition literacy are provided in the research; however, a widely-cited definition describes food literacy 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. Food literacy 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 characterized food literacy as the ability to search and understand nutrition-related information ⁽³⁾. In a review of 173 studies, Krause and colleagues ⁽⁴⁾ classified food literacy into three conceptual elements of Nutbeam's health literacy definition ⁽⁵⁾, including functional, interactive, and critical food literacy. Doustmohammadian et al. have also previously defined FNLIT based on Nutbeam's model of 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 food and nutrition literacy 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 toward the lower intake of fruit and vegetables, fiber-rich foods, and dairy products ⁽¹¹⁾, as well as increased consumption of high-energy-dense foods ⁽¹²⁾. Thus, food and nutrition literacy 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 programs are recommended to best influence children's learning skills and increase the possibility of more successful behaviour stabilization to maintain healthy dietary habits into adulthood ⁽¹³⁾. Indeed, paying attention to food and nutrition literacy promotion among children may be essential in improving dietary

patterns, health, and well-being. Schools have direct contact with students for about six hours a day and up to 12 critical years of intellectual, psychological, social, and physical development⁽¹⁴⁾. The World Health Organization (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 programs relating to food and nutrition literacy is a preponderant issue in developing countries.

Kelly et al. reviewed the efficacy of food literacy (FL) interventions, without focusing on the quality of the studies, in elementary school children 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 focussed on food literacy, and did not consider the wide and multifaceted topic of food and nutrition literacy^(6; 17) in their search strategy and review.

The multi-dimensional nature of the concept of food and nutrition literacy necessitates multi-level interventions to improve food and nutrition literacy^(2; 18). The first step to developing such interventions includes referring to the evidence and successful modeling 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 food and nutrition literacy as the outcome of interventions. Therefore, this systematic review aims to identify interventions targeted at promoting children's food and nutrition literacy in the school setting. The current study aims to identify: 1) strategies and principal components of food and nutrition literacy promotion, 2) the implementation methods of the interventions, and 3) the effectiveness of interventions in promoting FNLIT among primary school children.

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-post interventions, posttest only, randomized and non-randomized controlled trials that allocated students individually or in clusters (i.e., teachers, classrooms, and schools), and quasi-randomized trials examining the effectiveness of interventions for food and nutrition literacy 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 food and nutrition literacy in skill domains, including functional, interactive, and critical food and nutrition literacy. Based on the available evidence, components of each dimension of the skill domain are presented in Table 1.

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

Inclusion criteria	
Participants	<ul style="list-style-type: none"> • children aged 5 to 12 years
Intervention	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • all comparisons, including different educational interventions; different methods of delivery, educational contents, intervention dosages, or the like; regular classes; nonintervention
Outcomes	<p>main outcomes:</p> <ol style="list-style-type: none"> 1) functional food and nutrition literacy: <ul style="list-style-type: none"> • food selection (sources, store, quality) • planning and managing (money, time, food intake, nutrition balance) • preparing (cooking, preparing food in a new way, safety) ^(2; 24; 25), • recognition ability (searching & understanding including information & official recommendations) ^(3; 4) • reading and using nutrition facts labels ⁽²⁵⁾ • self-efficacy and confidence⁽²⁶⁾ and trying ethnic and unfamiliar food⁽²⁷⁾

	<p>2) Interactive food and nutrition literacy:</p> <ul style="list-style-type: none"> • communicating & interacting (e.g., family-child feeding interactions, increasing school community connections) ^(25; 28) • 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; 28) <p>3) critical food and nutrition literacy:</p> <ul style="list-style-type: none"> • critically evaluating information (e.g., critically analyzed food labels) and recognizing social contexts ^(5; 29) • media literacy (the ability to critically judge the media and its trustworthiness as a source of information) ^(30; 31) • ecological factors (food system approaches, e.g., engagement with issues of social justice and equity in food systems, social determinants of health) ^(26; 32) <p>secondary outcomes:</p> <ul style="list-style-type: none"> • health outcomes, including improvement in diet quality (e.g., HEI) ⁽¹⁾, dietary intake indicators (e.g., DDS), BMI Z-score, weight status ⁽³³⁾, and indicators of quality of life/wellbeing ⁽³⁴⁾.
Study design	<ul style="list-style-type: none"> • randomized and non-randomized controlled trials that allocated students individually or in clusters (i.e., teachers, classrooms, schools), quasi-randomized trials, pre-post-test, post-test only, and case-control designs
Setting	<ul style="list-style-type: none"> • primary schools or other equivalent educational institutions
Exclusion criteria	<ul style="list-style-type: none"> • 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

	<p>increase knowledge without addressing skills (functional, food choice, interactive, critical, and food label literacy).</p> <ul style="list-style-type: none"> • irrelevant setting(s), including after school club, summer camp, home, and community • publications, not English • books, conference papers, thesis, patents, and reviews were excluded
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PICOS: Population, Intervention, Comparison, Outcome, Setting ⁽³⁵⁾

We considered interventions whose reported outcomes increased food and nutrition literacy 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 ⁽³³⁾, and lifestyle health promotion ⁽³⁴⁾.

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) ⁽³⁵⁾ 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: ((food literacy) 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 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 ⁽³⁶⁾, were systematically de-duplicated, and a merged library was created. The de-duplication process was validated by Systematic Review Assistant-Deduplication Module (SRA-DM) ⁽³⁷⁾. 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 (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 standardized form was used to extract data from each study report. We extracted the following data: author (s), publication year, target group (age, gender, number of participants), intervention description (name, study design, comparison or control groups, components, duration, and follow up of intervention), food literacy/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 (Supplementary Table S3). This tool was developed by the Effective Public Health Practice Project (EPHPP) ⁽³⁸⁾ to assess the quality of included studies in systematic reviews relating to public health topics ⁽³⁹⁾. 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 ⁽³⁹⁾: (a) strong (when there were no weak rating); (b) moderate (when one factor was rated as weak); (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 & 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, 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 38 publications were retrieved for further assessment, of which 19 failed to meet the inclusion criteria. The main reason for excluding full-texts was that they were not school-based interventions (Figure 1, Supplementary Table S2). Finally, 19 articles were included, such that their characteristics are summarized in Table 2. The quality assessment of each of these studies is depicted in Figure 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%)^(25; 40; 41; 42; 43) and Theory of Planned Behavior (n=1, 5.26%)⁽²⁷⁾. Theory-based interventions mainly improved functional food/nutrition literacy (Table 3).

Four studies (21%) were Randomized Controlled Trials (RCT)^(28; 42; 44; 45), and four (21%) used a case-control design^(27; 46; 47; 48). In three studies (15.78%), two groups were compared pre- and post-test^(41; 49; 50), but most studies (n= 8, 42.10%)^(25; 29; 32; 40; 43; 51; 52; 53) used the same group tested pre- and post-intervention.

Fifteen out of nineteen studies (78.94%) had not used a valid scale to measure food and nutrition literacy and its components. Only four studies (%) measured food label literacy by valid measures^(43; 50; 52; 54). In one study, a change in knowledge of food labeling was assessed by asking individuals whether a food label was present on a product.⁽⁴³⁾ Validated

multi-item “food label literacy” tools to evaluate the food label literacy of students were used only by two studies^(50; 54). Treu et al.⁽⁵⁰⁾ evaluated knowledge of healthy food choices in the form of food label literacy in school-age children by the Food Label Literacy and Nutrition Knowledge (FLLANK) questionnaire, which previously underwent validation testing in the Independence School District (ISD)⁽⁵⁵⁾.

Eighteen of the nineteen studies were set in high-income countries, as classified by the World Bank economic classification⁽⁵⁶⁾. Of these, fifteen studies were conducted in the USA^(25; 27; 29; 32; 40; 41; 42; 44; 45; 46; 47; 49; 50; 52; 53; 54; 57), two in Australia^(28; 41), one in the United Kingdom⁽⁴⁸⁾, and one in Spain⁽⁵¹⁾.

Of the included studies, ten targeted children aged 7-10 years^(25; 28; 42; 45; 46; 48; 49; 50; 51; 53), four studies targeted children aged 11-15 years^(41; 43; 47; 52), and five studies targeted children aged 8-15 years^(27; 29; 32; 40; 44).

Seven out of nineteen studies (36.84%) included parents in the interventions^{(42) (25) (51) (46) (45) (28) (32)}.

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⁽³⁸⁾. 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 summarized in Figure 2 (see supplementary Table S2).

Strategies and components used in the interventions

Five basic types of strategies were used in interventions aimed at improving food and nutrition literacy, including; gardening⁽⁴⁷⁾, recipes skill building/cooking^(25; 48; 51), food label reading^(43; 46; 50; 52; 54), food tasting⁽⁴⁵⁾, and multi-component interventions^(27; 28; 29; 32; 40; 41; 42; 44; 49; 53; 57). 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 labeling 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 old) ^(29; 48). 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, standardized 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 2-persons with the opportunity to skill build and gain the confidence to perform the task 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⁽²⁹⁾. In addition, opportunities for conversations about food choices, such as the advantages of whole-grain choices, were provisioned. Overall, these programs 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 ^(40; 54) or as part of a healthy eating intervention ⁽⁵⁰⁾. 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 (HFSS) foods, and why making informed food choices can benefit their health; 2) recognize 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, quality symbols.; 5) determine foods' healthfulness according to their labels, nutrition facts panels, the ingredient list on their packages; and 6) grocery store tours ^(40; 43; 50; 52; 54).

Food preparation/cooking classes/clubs

Cooking classrooms and cooking clubs, either embedded into the school curriculum ^(25; 28; 29; 42; 45; 49; 53; 57) or delivered in the form of an after-school Food Club ^(40; 44; 48; 51), 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 centers, and cultural events. Children were involved in an in-depth demonstration focused on specific food/ethnic foods ⁽⁵⁷⁾ 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 ^(25; 28; 44; 48; 49; 51; 57). One intervention used cooking demonstrations using the “Cooking Up Healthy Choices” curriculum. Cooking Up Healthy Choices was a series of 5 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 ⁽⁴²⁾.

Food tasting

Students participated in communal food activities that impacted food knowledge and fostered positive food nature ^(40; 41; 45; 49). 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 ⁽⁵³⁾. Through these sessions, students would learn to try new food as one of the components of functional skills of food and nutrition literacy (Table 3).

Gardening/ harvesting

Seven studies specifically focused on gardening/harvesting interventions ^(28; 32; 41; 42; 47; 49; 57). These programs 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. ⁽⁵⁷⁾.

Supporting cultural practices and ethnic foods

Some programs consisted of strategies to increase children's willingness and cognition toward ethnic and indigenous foods. Students were introduced to an ethnic meal prepared by young cooks in this program and tried ethnic and unfamiliar foods ^(32; 57). Understanding diverse ethnic and cultural practices related to meal preparation and consumption is one layer of food literacy ⁽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, e.g., assigning teams of students to search 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”⁽⁵⁴⁾. 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 ^(25; 28; 32; 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 53). Investigators supplemented information only when it was necessary. Some other interventions (n=4) were facilitated by community health educators ⁽⁴⁰⁾, registered dietitians ⁽⁵²⁾, as well as community members involved in the program ⁽²⁹⁾.

Interventions in the promotion of FNLIT dimensions

1) Functional FNLIT

Fifteen studies (78.94%) ^(27; 29; 40; 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 53) were interventions to improve health outcomes, which described the specific effects on some components of functional food and nutrition literacy and knowledge aspects. These interventions resulted in a significant increase in functional skills of food and nutrition literacy, including food preparation (cooking, safety), planning & managing, food selection, recognition ability, reading and using nutrition facts labels, self-efficacy, and confidence, trying ethnic & unfamiliar food (see Table 3 for details).

2) Critical FNLIT

in a study by Hawthorne et al. ⁽⁵²⁾, 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 program ⁽³²⁾ 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 mobilizing food literacy for increased public engagement with issues of social justice and equity in food systems.

3) Integrated aspects of FNLIT (functional and interactive)

No intervention included measurement of all food and nutrition literacy components or the three emphasized dimensions of Nutbeam's hierarchical model of health literacy; however, two out of nineteen studies (10.52%) ^(25; 28) did incorporate two dimensions of the skill domain, including functional and interactive literacy. Block et al. ⁽²⁸⁾ presented the Stephanie Alexander Kitchen Garden program results. The following components of food and nutrition literacy 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 program 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 ^(58; 59; 60). The teaching methods comprised enjoyable hands-on food education through gardening, harvesting, preparing, and sharing fresh, seasonal, healthy, and delicious food. Teachers facilitated the program. The specialist staff planned and supervised each class, and children worked in small groups assisted by adult volunteers ⁽⁶¹⁾.

iCook 4-H was a curricular program focusing on families cooking, eating, and playing together. Miller et al. ⁽²⁵⁾ 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 ⁽²⁸⁾;
- the interventions that were incorporated into the existing curriculum and facilitated by teachers ^(25; 28; 32);
- interventions mainly used promising strategies/methods, including pleasurable hands-on food education, school gardening programs, kitchen classrooms, family cooking, eating and playing together, and supporting cultural practices and ethnic foods ^(25; 28; 32; 52) 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 food and nutrition literacy. All the studies reviewed here effectively improved one or more dimensions of food and nutrition literacy skills, especially functional food literacy. 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, food literacy 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; 3) the interventions that mainly used strategies/methods such as pleasurable hands-on food education, school gardening program, 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.⁽⁶²⁾

and other studies ^(63; 64; 65), 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, food literacy was operationalized and measured differently in the interventions, thus impeding the comparability of the results. Furthermore, most studies did not use a validated tool for measuring food literacy. Due to the novelty of the food literacy 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; 66; 67; 68; 69). The development of precise tools for measuring food literacy and taking a unified approach will provide a foundation for developing effective food and nutrition literacy programs ⁽⁷⁰⁾.

The three most common strategies used by programs were gardening, food preparation/cooking, and food tasting. In a qualitative study on students, Hess and Trexler ⁽⁷¹⁾ found that students had limited knowledge of conventional agriculture and emphasized 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 food literacy^(72; 73; 74). 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)⁽⁷⁵⁾. Comparable to the studies on garden-based interventions, school-based cooking initiatives improved the cooking skill elements and related components of food literacy. 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. ⁽⁷²⁾.

Some research treated gardening, cooking, and taste testing as targeted interventions designed to develop cognitive and skill domains of food literacy in this area. ^(72; 76). 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 food literacy in school settings.

Food and nutrition literacy 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), analyze 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 food and nutrition literacy that is important for learning and representative of the content of that area ^(2; 66). 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 ⁽⁷⁷⁾.

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 food literacy 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.

⁽⁷⁸⁾.

To our knowledge, this is the first systematic review related to food and nutrition literacy 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-randomized controlled trials with primary school children (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 food and nutrition literacy as a unique indexing term.

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

Conclusion

None of the interventions reviewed included all effective food and nutrition literacy components, and there was much emphasis on the functional level of food literacy. 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 food and nutrition literacy, especially interactive and critical skills, and use stronger designs, e.g., in well-reported, large-sampled randomized 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 program, 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.

List of abbreviations

BMI: Body mass index; DDS: Dietary diversity score; EPHPP: Effective Public Health Practice Project; FNLIT: Food and nutrition literacy; HEI: Healthy Eating Index; PRISMA-P: Preferred Reporting Items for Systematic Review and Meta-Analysis Statement-Protocol Extension; RCT: Randomized Clinical Trial; SAKG: Stephanie Alexander Kitchen Garden; WHO: World Health Organization

Acknowledgments

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.

Authors' contributions

AD and NO conceived and designed the study. AD and ES developed the search strategy. AD and MS performed the search and selection of articles. AD and MK performed the analyses for the articles. NO and ES contributed to the discussion and conclusions of the study. AD is a major contributor in the writing of the manuscript, which NO and ES revised. All authors read and approved the final paper.

Financial support

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).

Availability of data and materials

All data generated or analysed during this study are included in this published article and its Supplementary Information files.

Declarations

Ethics approval and consent to participate

The current manuscript involves a systematic review. Our research did not involve human participants, human material, or human data in any direct way. Subsequently, a statement on ethics approval is not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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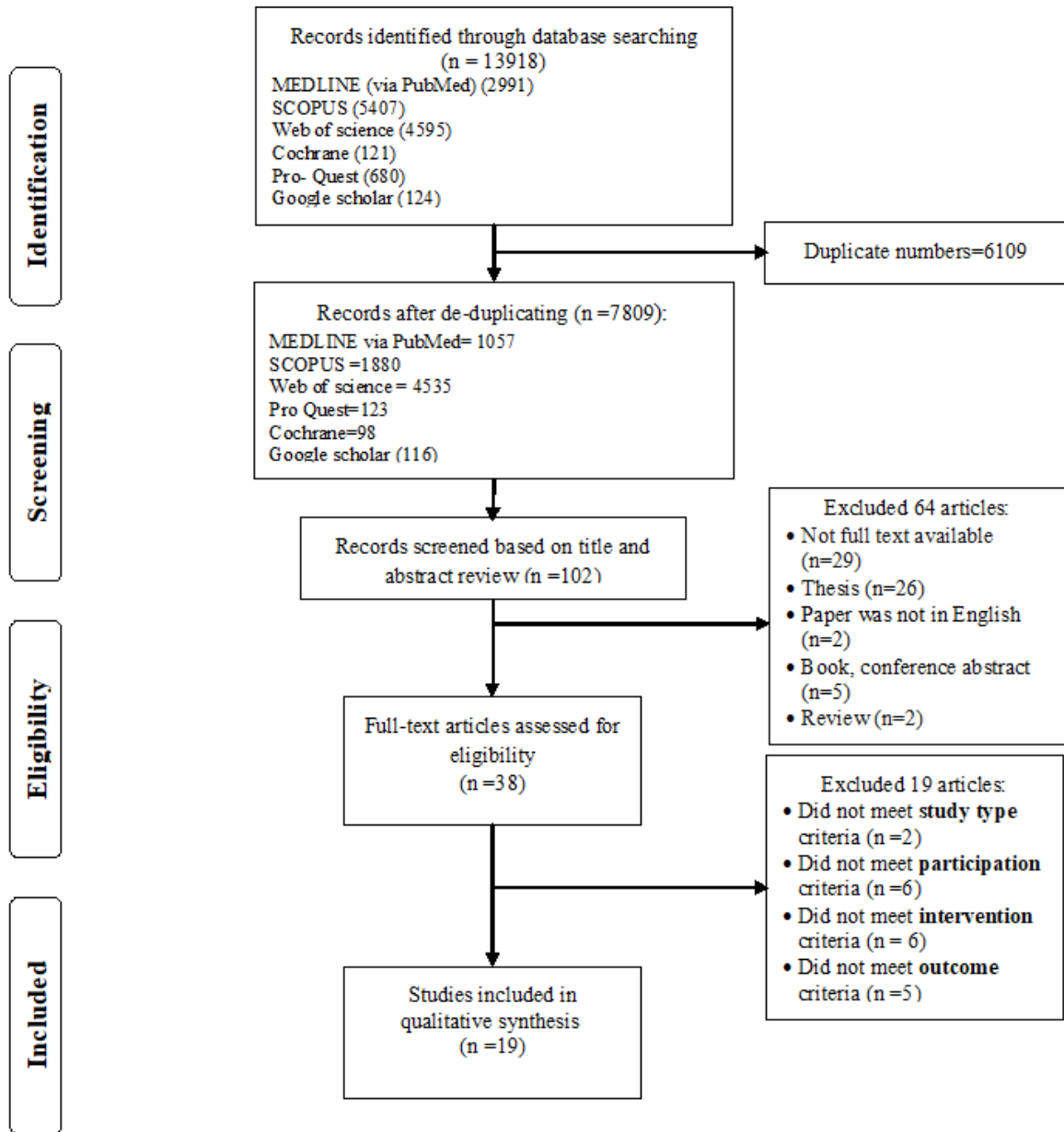


Fig 1: PRISMA diagram

	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and drop-outs	Global rating
Barnick et al., 2014 [1]	M	W	W	W	W	?	W
Beckman et al., 2007 [2]	S	M	W	M	W	M	W
Block et al., 2012 [3]	S	S	M	M	W	M	M
Cunningham-Sabo et al., 2014, [4]	M	W	M	M	S	M	M
Gavaravarapu et al., 2016 [5]	S	W	M	M	M	S	M
Gold et al., 2017[6]	M	S	S	M	W	S	M
Hawthorne et al., 2006 [7]	M	W	W	M	S	S	W
KATZ, et al., 2011 [8]	W	M	W	M	S	W	W
McAleese & Rankin, 2007 [9]	S	M	S	M	W	?	M
Miller A, et al., 2018 [10]	W	M	M	S	W	S	W
Morgan et al., 2010 [11]	M	M	W	M	S	S	M
Perez-Rodrigo & Aranceta,1997 [12]	W	M	M	M	W	M	W
PHABC, 2017[13]	W	W	M	M	W	M	W
Revell et al., 2004 [14]	S	M	S	S	W	W	W
Scherr RE et al., 2017 [15]	S	S	S	W	M	S	M
Thonney & Bisogni, 2006 [16]	M	W	S	M	W	W	W
Townsend et al., 2006 [17]	S	S	S	M	W	S	M
Treu et al., 2017 [18]	M	M	W	M	S	S	M
Wolf et al., 2018 [19]	S	W	M	M	M	W	W

Fig 2. Quality assessment (using the EPHPP) of reviewed studies (N= 19)

■ W: Weak ■ M: Moderate ■ S: Strong

Table 2: Key characteristics of reviewed studies (N=19)

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
Non-Randomized Controlled trials	Gardening-based interventions							
	McAleese & Rankin, 2007, Southeast Idaho ⁽⁴⁷⁾	children aged 12 years, n=99 Gender: NS	Garden based nutrition education, quasi-experimental pre-post design	3 treatment groups: 1 x 12 wk nutrition education, 1 x 12 wk nutrition education + garden-based activities, 1 x control.	Immediate ly 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)) (& vegetables 0.8 (SD 0.8) to 1.0 (SD 1.4)) than other 2 groups [skill/functional]. Nutrition education + garden-based activities group significantly increased their fruit and vegetable servings, V.A, C intake, and fiber intake [skill/functional]. Secondary: -
	Recipes skill building/Cooking-based interventions							
	Miller A, et al., 2016, Maine, Nebraska, South Dakota,	children aged 9-12 years, n = 35, Gender: NS	iCook 4-H intervention, 2-year control-	6-session curriculum taught through 3 months, focusing on families cooking, eating, and playing together.	Immediate ly after	No	SCT	Main: significant, positive differences, including 11% increase in cooking skill confidence (from 75% to 86%), desire to cook more

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
	Tennessee, and West Virginia (25)	and their primary meal preparers, n = 35	treatment intervention study					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 ⁽⁵¹⁾	children aged 8-12 yrs, n=150, Gender: NS	Nutrition Education of schoolchildren living in a low-income area in Spain/pre-post test	2 hr sessions x 5 weeks, included cooking, education, changes to school lunches & parental involvement + Food & nutrition incorporated into the curriculum. implementation duration was 2 yrs	Immediate ly after	No	NS	Main: Increased nutrition, food hygiene & food preparation knowledge, increased cooking skills & preparing dishes at home. increased intake of fruit, salad, fish & dairy [skill/functional] Secondary: -

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
	Revill et al, 2004, North east England (48)	10 schools (5 intervention & 5 control group), Student aged 11-12 yrs. n=167 Gender: NS	Food Club/pre-post test	After-school food club. 20-week x 2hr program aimed to teach cooking skills using inexpensive, healthful ingredients and essential equipment. The education content of food clubs included twenty sessions which as extra-curricular to be taught in schools by teachers. The education program 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	Immediate ly after	No	NS	Main: some limited positive changes to food intake, gains in confidence & skills in cooking & more involved cooking at home [skill/functional]. Secondary: -

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
				schools were asked to provide a suitable teaching room for the after-school cooking clubs. Part of the program was taking food home for the family to have for dinner.1 x control.				
Food labeling interventions								
	Gavaravarapu et al, 2016, Hyderabad, India ⁽⁴³⁾	School children. Aged 12–15 years. Females: NS. (n = 175)	Read-B4-U-Eat, Intervention group, and comparison group using pre-post intervention questionnaires	READ-B4-U-EAT multi-component school module to improve food label information and informed food choices. 4 sessions of 45 min. Delivered using videos, handouts, and presentations, by teachers. Use of nutrition labels evaluated with five questions (self-reported) and	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±3.07) [skill/functional] Secondary: -

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
					knowledge of nutrition label assessed using one question			
	Hawthorne et al., 2006, Houston ⁽⁵²⁾	Young adolescents. Aged 11–14 years. n = 35, 16 girls and 19 boys	How to read and use a nutrition facts label education program. Single cohort using pre-post tests	Program including calculating %DV with understanding serving sizes and defining DV.	Immediate ly 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 ⁽⁴⁶⁾ & 2014 ⁽⁵⁴⁾ , Missouri.	second, third, and fourth grade primary school students, n=1180 (628 intervention and 552	Nutrition Detectives™ program/case-control study	Nutrition Detectives program 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	Immediate ly after	Yes	NS	Main: Students' nutrition knowledge improved significantly compared to baseline [knowledge]. A significant gain of 15.0 percentage points for the 90-minute program and 16.2 percentage points for the 45-minute lesson in scores of food label literacy (ability to

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
		control group), aged 7-9 years old, 577 male and 604 females		and what nutritious foods to choose + mini-lesson 4 was an interactive activity + the final mini-lesson including the healthy choice of fresh produce and summarizing key points and takeaway messages. This program was evaluated for a 90-minute and 45-minute lesson with a presentation and hands-on activity.				distinguish between more and less healthful foods) of 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 ⁽⁵⁰⁾	School-age children in grade 3. Mean age 8.7 years. 52% female. (n =	Nutrition in Detectives and ABC for Fitness programs, Quasi-	The standard intervention (SI), including the Nutrition Detectives program (in 3rd grade) + ABC for Fitness program (in K-5 grades), provided daily physical	Immediate ly 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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
		1487), alongside their family. 17 primary schools (intervention) & 9 primary schools (control)	experimental 3 group design. Schools randomized on the district. Pre-posttests.	activity in classrooms and a program 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-posttests).				(without difference between the two intervention groups) Secondary: without significant improvement in BMI Z score and physical fitness
Food tasting interventions								
	Gold et al., 2017, North Dakota ⁽⁴⁵⁾	Third grade students, n= 747 (51.8% girls) from 26	Go Wild With Fruits and Veggies! (GWWFV),	The GWWFV curriculum was a 7-week school-based intervention comprised of a 7-lesson series including	Immediate ly 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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
		schools, control (12 schools, n=369), intervention (14 schools, n=378) pre/ post-test study	randomized control and intervention group with pre/ post-test study	classroom nutrition-based activities, taste testing, classroom movement activities, parent newsletters, and take-home challenges.				(skill/functional). Secondary: -
Multi-component interventions								
	Barnick et al., 2014, Cleveland, Ohio ⁽⁴⁹⁾	N= 86 student in 4th grade (treatment=43 , and control=43), Gender: NS	School Gardening Program, quantitative, quasi-experimental pre-post design	The school gardening program consisted of a single one-hour weekly session and was part of the ten-month curriculum. The one-hour session comprised a 20-minute lesson + 20-minute hands-on activity + a 20-minute nutrition piece that might include cooking, taste testing etc. Topics covered included	immediate	No	NS	Main: there was no statistically significant change in students' knowledge and attitude scores [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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
				photosynthesis, germination, soil sampling, and transplantation techniques.				days that the nutrition program was offered. Secondary: -
	Beckman et al, 2008, Minnesota ⁽²⁷⁾ /Lautenschlager ⁽⁵⁷⁾ & Smith, 2007, Minneapolis ⁽⁵⁷⁾	Inner-city youth (ages 8–13), n=40. Gender: NS	Youth Farm Market Project (YFMP), pre- and post-survey	During the ten-week garden project, participants were involved in activities with various aspects of the food system (gardening, harvesting, cooking, eating) and nutrition education as follow: Nutrition lessons facilitated by a nutrition educator with a new topic in each week (e.g., the food cycle, nutrients, stewardship), + an activity (e.g., role-playing) to foster participatory learning. Then,	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/days) in boys [functional skills]. Garden participants were more willing to eat nutritious food, try ethnic & unfamiliar food, expressed a greater appreciation for individuals & cultures, and were more likely to cook & garden.

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
				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.				Secondary: -
	Block et al., 2012, Melbourne ⁽²⁸⁾	Children in grades three	Stephanie Alexander	The teaching methods comprised enjoyable hands-	Immediately after	No	NS	Main: primary qualitative evaluation showed increasing child

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
		to six (aged 8-12 years), n=764 children (475 programs, 289 comparisons) with 562 parents (326 comparison) and 93 teachers. Gender: NS	Kitchen Garden (SAKG) Program, mixed methods, longitudinal, matched comparison trial	on food education through gardening, harvesting, preparing, and sharing fresh, seasonal, healthy, and delicious. The program 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.				willing to try new foods [skill/functional], confidence and skills in relation to cooking and gardening [skill/functional], improvement school social environment [skill/interactive], and increasing school community connections [skill/interactive]. Secondary: -
	Cunningham-Sabo et al., 2014, Santa Fe, (53)	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. 25x2-hour	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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
				cooking and/or 5x 1-hour fruit and vegetable tasting lessons				cooking experience (more than 2.5 times) [skill/functional]. Without a significant change in cooking attitude [skill/functional]. Secondary: -

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theor y	Outcomes [domain/dimension]
	Morgan et al., 2010, Australia ⁽⁴¹⁾	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: (4x45mins)/week education + garden (NE&G) classes, (3x1h)/weeks nutrition education (NE) lessons in the classroom) only and 1xcontrol 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 ⁽³²⁾	In Canadian schools without a control group,	Farm to school BC programs. Pre-posttest	Farm to School BC included three-component goals of farm to school programs: bringing healthy, local food	Immediately after	No	NS	Main: The evaluation found that farm to school movement has contributed toward realizing goals of food sovereignty through two	

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
		n=14,000 students enrolled in public schools in BC	intervention	into schools + hands-on experiential learning opportunities for students, and + fostering school and community connectedness. a 2-year project				main mechanisms, including advocacy for local and sustainable foods and mobilizing food literacy for increased public engagement with issues of social justice and equity in food systems. [skill/critical]. Secondary: -
	Wolf et al., 2018, New York State ⁽⁴⁰⁾	School children in grades 3–5 and 6–8. 50% female. (n = 1334)	Choose Health: Food, Fun, and Fitness (CHFFF), two cohort sub-samples, across age groups and settings evaluated	CHFFF includes a six-lesson curriculum for third to sixth-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	Immediate ly after	No	SCT	Main: Reading of nutrition Information increased significantly [skill/functional], more than a third of the third- to fifth-graders improved ≥ 1 point for each fruit & 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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
			using pre-post surveys (which featured nutrition label items)	hands-on, interactive nutrition education, 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).				their family to buy a new fruit & 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 ⁽²⁹⁾	Children aged 9-15yr olds n=128, Gender: NS	Cooking Up Fun (CUF), pre/post-test intervention	6 x 90 min sessions are designed to help young people acquire independent food skills to support healthy	Immediately after	No NS		Main: Skills were gained in knowledge [knowledge] & food preparation [skill/functional] Secondary: -.

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/N L validate tools	Theory	Outcomes [domain/dimension]
Randomized Controlled trials	Scherr RE et al., 2017, northern and central California ⁽⁴²⁾	Fourth-graders (aged 9–10 years) at 2 control schools (n = 179) and 2	Shaping Healthy Choices Program (SHCP), A clustered,	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.	Five overlapping immediately after the	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

study designs	Author/ Lead agency, Year, Country	Target group (age/gender/N)	Intervention (name & type)	Intervention description (components of intervention/ Intervention duration/ follow-up)	Timing of post-intervention evaluation	FL/NL	Theory	Outcomes [domain/dimension]
		intervention schools (n =230) and their parents and teachers. Gender: NS	randomized, controlled intervention	agriculture, + 4) foods available on the school campus, and + 5) school wellness committees and policies. The curriculum contained eight modules (15 classroom lessons + 19 take-home activities).				identification (1.18) [knowledge], and healthy food choices [skill/functional]. Secondary: a significant decrease in BMI percentiles. The percentage of overweight/obese students decreased from 55.6% to 37.8% from pre- to post-measure.
	Townsend et al., 2006, California ⁽⁴⁴⁾	children aged 9-12, n=5111, 2521 male (49.3%)	Youth Expanded Food and Nutrition Education Program (EFNEP), randomized, controlled field trial	Youth program 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

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
Moderate	Block et al., 2012 ⁽²⁸⁾	food preparation/cooking, gardening/harvesting, food tasting	teachers	garden specialist, kitchen specialist	in school	in curriculum	-	√	√	-	Preparing skills (cooking, safety), self-efficacy & confidence, trying ethnic & unfamiliar food	communicating & interacting	-
	Cunningham-Sabo et al., 2014 ⁽⁵³⁾	food preparation/cooking, food tasting	teachers	food educators	in school	in curriculum	-	√	-	-	planning & managing, self-efficacy & confidence, trying ethnic & unfamiliar food	-	-
	Gavaravara	food label literacy	teachers	Investigator	-	in	-	√	-	-	reading and	-	-

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	
	pu et al., 2016 ⁽⁴³⁾	(reading food labels and informed food choices)		rs		curriculum						using nutrition facts labels		
	Gold et al., 2017 ⁽⁴⁵⁾	food tasting	teachers	school food service professionals	-	in school curriculum	-	√	-	-		planning & managing,	-	-
	McAleese & Rankin, 2007 ⁽⁴⁷⁾	gardening/harvesting,	teachers	NS	-	in curriculum	-	√	-	-		planning & managing,	-	-
	Morgan et al., 2010 ⁽⁴¹⁾	gardening/harvesting, food tasting	teachers	NS	-	in curriculum	√	√	-	-		trying ethnic & unfamiliar food	-	-
	Scherr RE et al., 2017 ⁽⁴²⁾	recipes skill building, food preparation/cooking, gardening/harvesting	teachers	nutrition educator	-	in school curriculum	√	√	-	-		food selection	-	-

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
Quality	Townsend et al., 2006 ⁽⁴⁴⁾	food preparation/cooking, food tasting	teachers	NS	after school	in curriculum	√	√	-	-	Preparing skills (cooking, safety), planning & managing, food selection	-	-
	Treu et al., 2017 ⁽⁵⁰⁾	food label literacy (using food labels, grocery store tour)	teachers	NS	-	in curriculum	√	√	-	-	reading and using nutrition facts labels	-	-
	Barnick et al., 2014 ⁽⁴⁹⁾	food preparation/cooking, test tasting, gardening/harvesting	teachers	master gardener volunteers	in school	in curriculum	-	√	-	-	planning & managing, food selection	-	-
Weak	Beckman et	food	nutrition	NS	in school	extra-	√	√	-	-	Preparing	-	-

Quality	Study	Content/type of intervention	Facilitator	Supervisor	Cooking course - association setting	Curriculum	Dimensions affected by the intervention				Components affected by intervention		
							Knowledge	Functional	Interactive	Critical	Functional	Interactive	Critical
	al. I, 2008 ⁽²⁷⁾ Lautenschlager & Smith, 2007 ⁽⁵⁷⁾	preparation/cooking, supporting cultural practices & ethnic foods, gardening/harvesting	educator			curricular						skills (cooking, safety), planning & managing, trying ethnic & unfamiliar food	
	Katz, et al., 2011 ⁽⁴⁶⁾ Katz, et al., 2014 ⁽⁵⁴⁾	food label literacy (using food labels)	teachers	NS	-	in curriculum	√	√	-	-		recognition ability, reading, and using nutrition facts labels	-
	Miller A, et al., 2016 ⁽²⁵⁾	food preparation/cooking	teachers	NS	in school	in curriculum	-	√	√	-		Preparing skills (cooking, safety), planning & managing, communicating & interacting	-

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
													self-efficacy & confidence
	Hawthorne et al., 2006 ⁽⁵²⁾	food label literacy (calculating %DV with differing serving sizes)	registered dietitian	NS	-	extra-curricular	-	-	-	√	-	-	critically evaluating information
	Perez-Rodrigo & Aranceta, 1997 ⁽⁵¹⁾	recipes skill building, food preparation/cooking	teachers	NS	after school food club	in curriculum	-	√	-	-	-	-	Preparing skills (cooking, safety, planning & managing)
	Public Health Association of BC, 2017 ⁽³²⁾	gardening/harvesting, supporting cultural practices & ethnic foods	teachers	NS	-	in curriculum	-	-	-	√	-	-	ecological factors

Quality	Study	Content/type of intervention	Facilitator s	Supervisor	Cooking course - association setting	Curriculum	Dimensions affected by the intervention				Components affected by intervention		
							Knowledge	Functional	Interactive	Critical	Functional	Interactive	Critical
	Revill et al., 2004 ⁽⁴⁸⁾	recipes skill building, food preparation/cooking	teachers	NS	after school food clubs	extra-curricular	-	√	-	-	Preparing skills (cooking, safety), planning & managing, self-efficacy & confidence	-	-
	Thonney & Bisogni, 2006 ⁽²⁹⁾	food label literacy (reading food labels), food preparation/cooking	adult	NS	in school	in curriculum	√	√	-	-	Preparing skills (cooking, safety)	-	-
	Wolf et al., 2018 ⁽⁴⁰⁾	food preparation/cooking, recipes skill building, food label literacy	community health educators	NS	after school	in curriculum	-	√	-	-	planning & managing, food selection, reading	-	-

Quality	Study	Content/type of intervention	Facilitator	Supervisor	Cooking course - association setting	Curriculum	Dimensions affected by the intervention				Components affected by intervention		
							Knowledge	Functional	Interactive	Critical	Functional	Interactive	Critical
		(reading food labels)											and using nutrition facts labels, trying ethnic & unfamiliar food