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The impact of school-based cooking classes on vegetable intake, cooking skills and food literacy of children aged 4–12 years: A systematic review of the evidence 2001–2021

Karen L. Vaughan [a,*], Janet E. Cade [a], Marion M. Hetherington [a], James Webster [a], Charlotte E. L. Evans [a]

[a] *University of Leeds, United Kingdom*

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ABSTRACT

Background: Many children consume a poor quality diet with only a third of children aged 6–9 years eating vegetables daily. A high quality diet is important for good health in childhood; however, the prevalence of children living with obesity has doubled from 10% to 23% during primary school in the UK. Cooking lessons have the potential to improve diet quality and reduce obesity prevalence in childhood, both of which are associated with improved cardiometabolic outcomes in adulthood. The aim of this systematic review is to investigate the impact of school-based cooking classes on cooking skills, food literacy and vegetable intake of children aged 4–12 years.

Methods: We conducted a systematic review of OVID Medline, OVID Embase, EBSCO CINHAL and EBSCO ERIC for comparative studies that evaluated outcomes of children receiving cooking classes compared to a control group. Interventions included contained food preparation or a cooking activities and took place on school premises. Risk of bias was assessed using ROB2 and Robins-I. Outcomes were pooled in a meta-analysis using a random-effects model using standardised mean differences or reviewed using narrative synthesis. Certainty of evidence was assessed using GRADE.

Results: We included 21 studies, (6 randomised). Meta-analysis showed a small positive effect on cooking self-efficacy of 0.39 units (95% CI 0.05 to 0.54), and a small positive effect on vegetable intake of 0.25 units (95% CI 0.05 to 0.45). Programmes with more than 6 h of cooking showed the greatest effects.

Conclusions: Children's cooking programmes result in small improvements in cooking efficacy and vegetable intake, particularly those with more than 6 h of classes. It is recommended that future interventions use consistent measurement for children's food literacy and cooking confidence.

1. Introduction

The World Health Organization (WHO) Regional Office for Europe Data Dashboard shows that obesity continues to rise (World Health Organization, 2022b). Overall findings from the fifth round of the WHO Childhood Obesity Surveillance Initiative (COSI) report showed that 29% of children aged 7–9 years were living with overweight (including obesity) from the data collection 2018–2020 (World Health Organization, 2022a). National data from the National Child Measurement Programme shows that the prevalence of children living with obesity more than doubles from 10% of children at the start of primary school to around 23% at the end of primary school in the UK (NHS digital, 2022). There is an urgent need for interventions that reverse this trend. Body weight change is associated with an imbalance between energy content of food consumed and energy expended by the body (Hall et al., 2012). Excess energy intake from foods and drinks which are high in sugars contributes to unhealthy weight gain, overweight and obesity (World Health Organization, 2020b). People living with obesity and overweight have higher risk of cardiovascular disease (Dimbleby, 2021; Umer et al., 2017).

The World Health Organization reports that daily vegetable consumption for children aged 6–9 years is only a third (35%) across 27 countries, and 11% never ate vegetables or did so less than once a week (World Health Organization, 2022a). Fruit and vegetable consumption

* Corresponding author.
E-mail address: mc17kv@leeds.ac.uk (K.L. Vaughan).

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has been highlighted as important for obesity prevention (World Health Organization, 2002; 2020b) and therefore policies and interventions that promote increasing intake in children to improve diet quality are highly relevant for public health.

Policy analysis undertaken by Smith et al., in 2022 has shown that all eleven of the countries included in their study had a dedicated food curriculum in primary schools to address food literacy. These were either practical (for example Home Economics) or health oriented (for example Health and Physical Education) (Smith, Wells, & Hawkes, 2022). A framework used to evaluate 'Food Preparation Skills' contribution to food literacy within the curriculum revealed that Iceland, Norway, Slovenia and Scotland scored highest at 70%–100%, compared to Ireland and England which scored below 20%. The policy analysis found that whilst countries often have a mandatory food curriculum, 'there is no consensus in primary food education' about what this constitutes and if it includes cooking lessons (Smith et al., 2022).

Previous reviews have shown a link between broad, multi-component nutrition education programmes in primary schools and improved dietary intake for children (Charlton et al., 2020; Hersch, Perdue, Ambroz, & Boucher, 2014; Lavelle, 2023). Interventions that last a year or longer are more likely to have a positive impact on anthropometric outcomes in children (Chaudhary, Sudzina, & Mikkelsen, 2020; World Health Organization, 2002, 2020a). Hasan and colleagues provided an analytic framework to conceptualise the potential link between culinary interventions (cooking classes), intermediate outcomes (behavioural, cardiometabolic, anthropometric, quality of life, dietary intake) and final outcomes (mortality and morbidity) for both adults and children (Hasan et al., 2019).

It is hoped that interventions that involve participatory cooking classes in primary schools will increase cooking skills, cooking confidence, and improve vegetable intake. However, it is not clear from the existing evidence if cooking interventions that take place in primary schools improve cooking confidence, food literacy and dietary habits of children since reviews in this research area indicate high risk of bias in studies included (Charlton et al., 2020; Chaudhary et al., 2020; Hasan et al., 2019; Hersch et al., 2014) and few studies use an adequate sample size (Lavelle, 2023). Our search from January 2001 to December 2021 is in response to this issue, and updates a prior review by Hersch et al. from 2014 using a similar search strategy (Hersch et al., 2014). It was hoped that recent Consort guidelines for RCTs would lead to higher quality studies.

To update the evidence base, we performed a systematic review and meta-analysis of the available literature on participatory cooking classes based in primary schools to investigate the impact on cooking confidence, food literacy and dietary intake. The studies included were randomised controlled trials (RCT), cluster RCTs or quasi-experimental design such as non-randomised trials.

2. Method

The reporting of this systematic review complies with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021) and follows a prospectively registered protocol (Vaughan et al., 2021).

2.1. Data sources and search strategy

A search was conducted in OVID Medline, OVID Embase, EBSCO CINHAL and EBSCO ERIC using two search concepts: 1) 'cooking' or 'food preparation' or 'food literacy' or 'food technology' mapped to subject headings and key word search; 2) 'primary school' or 'elementary school' mapped to subject headings and key word search. There were no English language limits on the searches. The full search strategy is shown in Appendix 1. Table 1 shows the Participant, intervention, comparator, outcome and study design (PICOS) criteria for inclusion of studies for the review. For interventions, we described the practical elements that must be a component (practical food preparation, cooking activity or both). For outcomes, we included a wide number of outcomes that could potentially be of interest, including cooking skills, cooking self-efficacy, food literacy and others. The search strategy undertaken in January 2022 identified 1195 citations. Two additional studies were identified from existing literature reviews (Bennett, Mockler, Cunningham, Glennon-Slattery, & Johnston Molloy, 2021; Charlton, Comerford, Deavin, & Walton, 2020).

Table 1
Participants, intervention, comparator, outcome and study design (PICOS) criteria for inclusion of studies for review.

PICOS criterion	Inclusion criteria
Participants	School children aged 4–12 years old
Interventions	Practical classes in school setting that included children involved in food preparation (e.g. mashing, peeling, grating, mashing, measuring, weighing, mixing) or cooking activity (cooking on a hob or in the oven) or both food preparation and cooking activity.
Comparisons	Control group or multi-arm trial
Outcomes	Cooking skills/cooking self-efficacy/cooking competency, Food literacy, Dietary habits/fruit and vegetable intake/food preferences
Study Design	RCT, cluster RCT and quasi experimental design

2.2. Study selection

Studies were included if the domain being studied was nutrition education with a specific focus on cooking skills and food literacy. The participant population was school children aged 4–12 years. The search strategy undertaken in January 2022 identified 1195 citations.

The intervention exposure had three inclusion criteria: 1) includes food preparation (e.g. washing, peeling, grating, mashing, measuring, weighing, mixing) or cooking activity (cooking on a hob or in the oven) or both food preparation and cooking; 2) takes place at least partially on the school premises; 3) takes place during the school day or as an after school activity. Intervention exclusion criterion were: 1) tasting fruit and vegetables only but no food preparation or cooking activity; 2) cooking or food preparation classes taking place totally off the school premises. Studies were not restricted if they had multiple components in additional to cooking and food preparation activities, nor where they restricted on length of study or hours of intervention. Study designs included randomised controlled trials (RCTs), cluster randomised controlled trials (cluster RCTs), and quasi-experimental (non-randomised trials).

Primary outcomes were: 1) cooking skills/cooking self-efficacy/cooking competency; 2) food literacy; 3) dietary habits/fruit intake/vegetable intake/food preferences. Secondary outcomes also included were childhood obesity/BMI/BMI z-score/weight change but are not the focus of this paper.

We did not include editorials, systematic reviews, letters or conference abstracts. Studies were screened by two independent reviewers using the screenatron feature in the software SR Accelerator (Bond University, 2022). The level of agreement between review authors ranged from 0.406 to 0.705 (Cohen's Kappa) for initial title and abstract screening and from 0.342 to 0.583 (Cohen's Kappa) for full text screening. All discrepancies were considered by a third reviewer and resolved using the disputatron feature from SR Accelerator. Discussion between reviewers revealed that disagreements were most often due to the intervention criteria, specifically whether it took place in a school and if children were directly involved in the food preparation or cooking activities. An agreed list of reject codes was used to label each study at the full text review stage.

2.3. Data extraction and risk of bias assessment

We pilot tested data extraction using an Excel spreadsheet. The following information was extracted for a summary sheet: author/year/country; title of article, study design, sample size, duration of intervention, cooking hours, cooking components, other components, type of outcome. Columns for broad outcome categories were: cooking skills/cooking self-efficacy/cooking competency; food literacy; dietary habits/vegetable intake/food preferences; and BMI z-score. Additional sheets were used to collect data on mean scores, standard deviations, change scores for intervention and control groups, grouping studies together by outcome type. Cochrane Risk of Bias 2 tool in Excel was used to assess the risk of bias in RCTs (University of Bristol, 2021) and Robins-I tool for non-randomised trials (Sterne et al., 2016). Data extraction and quality assessment was completed by KV and checked by JW.

Dietary intake outcome was more complex to extract, having many potential components. We narrowed our focus for synthesis by looking specifically at intake of vegetables across studies as increasing vegetable intake was an aim of many of the programmes.

2.4. Outcome measures

We evaluated three types of behavioural outcomes: cooking confidence, food literacy and vegetable intake. For cooking confidence, we looked at outcomes described in studies as either cooking self-efficacy, self-efficacy to cook and/or cooking attitudes. Food literacy was assessed where studies measured the impact of an intervention on knowledge of food and healthy lifestyles included knowledge of healthy diet. Units for the analysis of vegetable intake were 'veg servings per day', 'vegetable consumption', vegetable intake score' or 'number of days vegetables eaten at supper' and therefore random-effects meta-analysis was used to address the variation in outcome scales used by different studies (Borenstien, 2021)

2.5. Data synthesis and analysis

For outcomes where there was three or more similar studies to allow for a meta-analysis, we used a random-effects model in RevMan 5.4 to pool the mean differences across studies (Borenstien, 2021; The Cochrane Collaboration, 2020). Where there were too few studies reporting a similar outcome with sufficient details, we presented the results using a narrative description.

3. Results

3.1. Study characteristics

A total of 21 studies met the inclusion criteria shown in Fig. 1.

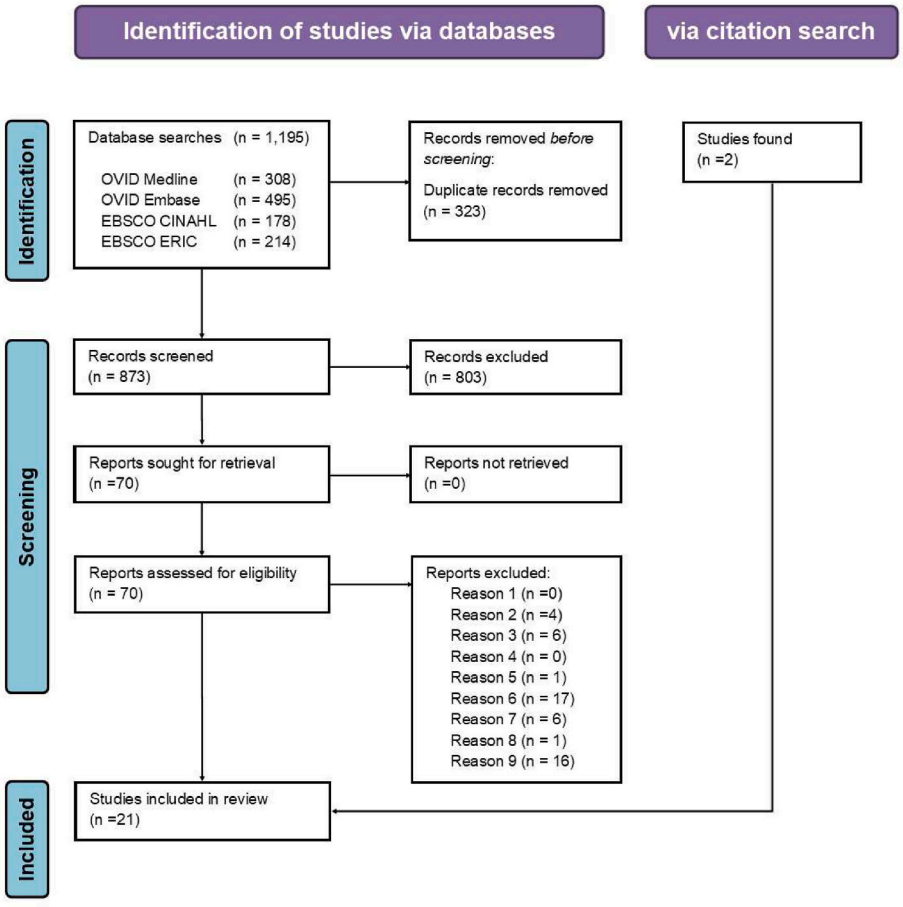

Fig. 1. Flow chart depicting the process of study selection.

3.2. Description of the interventions

Interventions ranged in duration from 1 week to 104 weeks (2 years), with cooking activity range from 1 h to 115 h. Of the 21 studies included, 6 were randomised controlled trials and 15 were non-randomised controlled trials. The location of interventions included Australia, Canada, Japan, Netherlands, Spain, UK and USA. The total number of participants in all studies was 12,542 and for individual studies this ranged from 100 (Zahr & Sibeko, 2017a) to 3135 (Davis et al., 2021).

The Cooking with Kids programme was a 10-week programme delivered in the spring and included three, 2-h cooking lessons. Recipes used in the cooking lessons were Chinese-American fried rice with vegetables; east Indian lentils with carrot and raisin pilaf; and potatoes persillade with cabbage (Cunningham-Sabo & Lohse, 2013). The EgizuSUK Project was a 3-week intervention with 1 h of cooking. In the first workshop participants were asked to choose a recipe, thinking about how difficult it might be; the second workshop involved shopping for ingredients; and in the third workshop children used the recipe to cook a meal (Maiz, Urkia-Susin, Urdaneta, & Allirot, 2021). The Texas Sprouts programme was a larger study and involved 11 h of cooking. There were 18 lessons that were 60 min in length and each one included either a garden taste lesson or a cooking lesson (Davis et al., 2021). In the 'Taste Lessons' study in Netherlands, a 5-week intervention, there were three trial arms: taste lessons vegetable menu group (which included 1 h of cooking), taste lessons group and a control group (Battjes-Fries et al., 2016). Table 2 provides further detailed information on all of the included studies' characteristics.

3.3. Effect on cooking self-efficacy

Eight studies investigated outcomes related to cooking skills, cooking attitudes and cooking self-efficacy. Some measured 'attitudes towards cooking'(Landry et al., 2019; Maiz et al., 2021; Yoshii, Akamatsu, Ishihara, & Izumi, 2021) and other studies described outcomes as either 'cooking self-efficacy' or 'self-efficacy to cook (Cunningham-Sabo & Lohse, 2013; Landry et al., 2019; Maiz et al., 2021). One study measured a variety of specific outcomes (cut vegetables and fruit, measure ingredients, use a knife) but without a pooled estimate for cooking self-efficacy (Zahr & Sibeko, 2017a). Six studies were included in a random effects meta-analysis using standardised mean differences to investigate the overall effect on cooking self-efficacy. The authors used random effects meta-analysis (rather than fixed effects) to account for the different measurement tools used in the studies (Deeks, 2023). The results showed a small positive effect on cooking self-efficacy of 0.39 units (95% CI 0.05 to 0.54) favouring the intervention. Heterogeneity for the analysis was very high; $I^2 = 88\%$, ($P < 0.001$). The forest plot showing effects for cooking self-efficacy is shown in Fig. 2.

3.4. Effect on food literacy

Three studies were included in the analysis on food literacy outcomes, however the concept was interpreted differently for each intervention. The Hovland study from North Carolina, USA measured food-based science knowledge (Hovland et al., 2013). For the Parmer study in Alabama, USA we took a pooled average of 4 scores; MyPyramid food groups; nutrient-food association, nutrient-job association; and food and vegetable identification (Parmer, Salisbury-Glennon, Shannon, & Struempler, 2009). The Sahota study in England, UK used Healthy Lifestyle Knowledge scores (Sahota, Christian, Day, & Cocks, 2019). Whilst all these studies showed a positive raw mean difference between the control arms favouring the intervention, it was not appropriate to undertake a meta-analysis due to the differences in intervention components and measurement of the outcomes relating to food literacy. Table 3 shows the intervention components for the three studies, outcome measurement and raw scores for impact.

3.5. Effect on vegetable intake

Sixteen studies included some data on dietary habits with outcomes ranging from fruit intake (servings), vegetable intake (servings), vegetable intake score, fruit intake score, vegetable servings per day, fruit servings per day, pooled average for eating vegetables, 24-h fruit and vegetable intake and number of days per week vegetables eaten at supper. We extracted the data on the vegetable intake outcomes only for analysis. The authors used random effects meta-analysis (rather than fixed effects) to account for the different measurement tools used in the studies (Deeks, 2023). We included seven studies for a meta-analysis to investigate the effect of cooking interventions on vegetable intake. The random effects meta-analysis calculating standardised mean difference showed a small effect on vegetable intake of 0.25 units (95% CI 0.05 to 0.45). Heterogeneity was high; $I^2 = 87\%$, ($P < 0.001$). The forest plot showing effects on vegetable intake is shown in Fig. 3.

3.6. Summary of evidence

The overall summary of evidence table completed using GRADEpro software shows that the certainty of evidence was very low for cooking self-efficacy and vegetable intake outcomes (Schunemann, Brozek, Guyatt, & Oxcman, 2013). For the outcome cooking self-efficacy, the certainty of evidence is very low due to different measures for cooking self-efficacy and the confidence interval overlapping the line of no effect. For the outcome vegetable intake, the certainty of evidence is very low due to different measures of vegetable intake and there is only one RCT study that assessed this outcome. Of the six other non-randomised studies that measured the outcome vegetable intake, 5 of these were assessed as having serious risk of bias. Table 4 shows the certainty of assessment judgments across risk of bias, inconsistency, indirectness, imprecision with effect sizes for randomised trials and non-randomised trials (observational studies).

3.7. Risk of Bias

Six RCTs were assessed using the Cochrane Risk of Bias 2 for clusters tool (University of Bristol, 2021). Two of the studies, Waves intervention and Texas Sprouts intervention, showed low risk of bias (Adab et al., 2018; Davis et al., 2021). Four of the studies showed some concerns. For example, the Cooking with Kids study did state that four schools were randomly assigned to an intervention (2 schools) or a comparison group (2 schools) but there was no description of how this was done and there was no flow diagram. A high risk of bias on reported results was identified for the Landry study as a previous paper on the same study measured outcomes in a different way, signalling that the methodology for measuring the outcome changed after the data was collected and it is not explained (Davis, Spaniol, & Somerset, 2015; Landry et al., 2019). For the Sahota and Maiz studies, some concerns related to the reported result as there was no protocol document available and so not possible to check if the data analysed was in accordance with a pre-specified plan (Maiz et al., 2021; Sahota et al., 2019). The RCT studies are shown in Fig. 4.

Fifteen studies were assessed using the Robins-I tool for non-randomised intervention studies (Sterne et al., 2016). Of these studies, 7 were assessed as having moderate risk of bias, 7 with serious risk of bias and one study with critical risk of bias. Serious risk of bias was most often due to confounding factors not being addressed. Where studies identified confounding factors such as socioeconomic differences across schools and sought to ensure these were balanced across the trial arms, the study was assessed as having low risk of bias. Two studies were assessed as having serious and critical risk of bias due to missing data. For example, the Bisset study did not describe what data was missing and how this was addressed (Bisset, Potvin, Daniel, & Paquette, 2008) and the Caraher study only reported data from one of the trial arms (Caraher, Seeley, Wu, & Lloyd, 2013).

Table 2
Study characteristics.

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
1	**Adab P**, Pallan MJ, Cade J, Ekelund U, Barrett T, Daley A et al. **2014** *England, UK*	Preventing childhood obesity, phase II feasibility study focusing on South Asians: BEACHeS	quasi-experimental	574	269	305	6.48	To increase healthy cooking skills and confidence and influence dietary behaviour	52	na	6 inervention components including a 5-week courses on healthy cooking	Physical activities in and out of school. Course run by premier league football	BMI z-score, childhood obesity, body image questionnaires, Diet (CADET)
2	**Adab P**, Pallan MJ, Lancashire ER, Hemming K, Frew E, Barrett T et al. **2018** *England, UK*	Effectiveness of a childhood obesity prevention programme delivered through schools, targeting 6 and 7 year olds: cluster randomised controlled trial (WAVES study)	cluster RCT	1392	660	732	6.3	Aim 2: improve children's dietary intake	52	3	1) 3 x Cooking skills workshops	2) Villa Vitality - 6 weeks	BMI z-score, childhood obesity, Diet (CADET)
3	**Alexander AG**, Grant WL, Pedrino KJ, Lyons PE. **2014** *California, USA*	A Prospective Multifactorial Intervention on Subpopulations of Predominately Hispanic Children at High Risk for Obesity	quasi-experimental	561	272	289	na	To measure the responses to these interventions as a function of the degree of body habitus, as indicated by BMI subgroups.	26	26	2 x 30-min cooking classes per week	physical activities, health camps, chef in the classroom, parent groups.	BMI
4	**Battjes-Fries M**C, Haveman-Nies A, van Dongen EJ et al. **2008** *Netherlands*	Effectiveness of Taste Lessons with and without additional experiential learning activities on children's willingness to taste vegetables	quasi-experimental	1010	702	308	10.3	To assess the effectiveness of Taste Lessons with and without additional learning activities on children's willingness to taste unfamiliar vegetables.	na	1	1 cooking lesson (additional activity)	5 Taste Lessons and 4 additional activities: veg quiz, excursion, homework, cooking lesson.	Willingness to taste vegetables, Vegetable consumption, food neophobia (Child Food Neophobia Scale)
5	**Bisset S**L, Potvin L, Daniel M, Paquette M **2008** *Montreal, Canada*	Assessing the Impact of the Primary School-based Nutrition Intervention Petits cuistots – parents en réseaux	quasi-experimental	388	209	179	4.5	To evaluate Petits Cuistots programme on 1) knowledge, attitude, capacity and experience of nutrition and cookery. 2) parental involvement.	52	12	8 x Nutritional Workshops delivered for 1.5 h.		*Knowledge of nutrition*, Attitude to food, *Experience of Food preparation*, **cooking skills/ competence (capacity)**.
6	**Caraher M**, Seeley A, Wu M, Lloyd S **2013** *England, UK*	When chefs adopt a school?: an evaluation of a cooking intervention in English primary schools.	quasi-experimental	169	86	83	6	To measure the impact of chefs in schools on food preparation skills, food consumption and cooking confidence.	6	na	Two sessions with a chef	none	Cooking confidence, vegetable consumption, food confidence
7	**Chen Q**, Goto K, Wolff C, Bianco-Simeral S, Gruneisen K, Gray K **2014** *California, USA*	Cooking up diversity. Impact of a multicomponent, multicultural, experiential intervention on food and cooking behaviors	quasi-experimental	1204	604	600	6	To evaluate the impact of a pilot intervention promoting ethnic produce through classroom food demonstrations,	16	na	Monthly demonstrations of cooking recipes with tasting sessions followed by home cooking activity.	Family component - food kits to take home and cook recipes at home.	Food preferences, vegetable consumption, cooking at home survey

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Table 2 (*continued*)

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
		among elementary-school students from low-income ethnically diverse families						tastings and home cooking activities.					
8	**Cunningham-Sabo** L, Lohuse, B, **2013**, *Colorado, USA*	Cooking with Kids Positively Affects fourth Graders' Vegetable Preferences and Attitudes and Self-Efficacy for Food and Cooking	RCT	257	137	120	na	To evalute the impact of the Cooking with Kids (CWK) food education programme.	10	12	6 x 2-h cooking lessons delivered by a food educator	3 tasting lessons with multi-sensory exploration of citrus, pears and salad greens.	Vegetable preference, cooking attitudes, cooking self-efficacy.
9	**Davis JN**, Ventura EE, Cook LT **2011** *Los Angeles, USA*	LA Sprouts: A Gardening, Nutrition, and Cooking Intervention for Latino Youth Improves Diet and Reduces Obesity	quasi-experimental	104	34	70	9.8	To evaluate 12-week LA Sprouts on dietary intake and obesity risk.	12	9	12 × 45 min cooking/nutrition instruction.	12 × 90 min sessions which included 2 elements: 1) gardening instruction 2) nutrition/ cooking instruction (both for 45 min)	BMI, body fat %, Dietary intake
10	**Davis JN**, Asigbee FM, Landry MJ **2021** *Texas, USA*	School-based gardening, cooking and nutrition intervention increased vegetable intake but did not reduce BMI: Texas sprouts - a cluster randomized controlled trial	cluster RCT	3135	1412	1723	9.22	To evalute 1-year Texas Sprouts on dietary intake, obesity outcomes and blood pressure on school children.	39	11	11 x 1-h cooking lessons	Gardening lessons, teaching garden, lessons in nutrition and 9 parent lessons.	BMI, waist circumference and body fat %, *blood pressure* and dietary intake.
11	**Ensaff H**, Crawford R, Barker ME, Russell JM **2017** *England, UK*	Preparing and sharing food: a quantitative analysis of a primary school-based food intervention	quasi-experimental	325	154	171	na	Impact of school-based Jamie Oliver Kitchen Garden Project.	39	28	90-min cooking sessions, fortnightly delivered over an academic year.	none	Cooking knowledge/ experience, food awareness, food enjoyment, food neophobia and food fusiness.
12	**Gibbs L**, Johnson B, Block K et al. **2013** *Australia*	Expanding Children's Food Experiences: The Impact of a School-Based Kitchen Garden Program	quasi-experimental	764	475	289	na	To evalute the Stephanie Alexander Kitchen Garden Programme.	104	115	90 min cooking classes, weekly for 2 years.		Willingness to try new foods, food literacy.
13	**Hovland JA**, Carraway-Stage VG, Cela A **2013** *North Carolina, USA*	Food-Based Science Curriculum Increases 4th Graders Multidisciplinary Science Knowledge	quasi-experimental	641	380	261	na	To evaluate the FoodMASTER initiative on food-related science knowledge.	39	29	24 x 45-min Foodscience lessons lessons during the academic year.	teachers received training before the intervention started.	Food Literacy (science knowledge about food)
14	**Jaenke R**L, Collins CE, Morgan PJ **2012** *Australia*	The Impact of a School Garden and Cooking Program on Boys' and Girls' Fruit and	quasi-experimental	127	70	57	na	To examine gender differences in the impacct of a school garden and nutrition curriculum on FV	10	na	Garden programme involved 45-min for 4 x times a week, over 10	Nutrition education component, parent newsletters,	Food preverences (F&V), F&V intake.

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Table 2 (*continued*)

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
		Vegetable Preferences, Taste Rating, and Intake						intake, willingness to taste and taste ratings.			weeks (cooking and gardening).	homework with cooking activities.	
15	**Landry MJ**, Markowitz AK, **2019** *Texas, USA*	Cooking and Gardening Behaviors and Improvements in Dietary Intake in Hispanic/Latino Youth	RCT	290	160	130	9.2	To assess the changes in cooking and gardening behaviours with changes in dietary intake and obesity of LA Sprouts.	12	9	12 × 45 min cooking/nutrition instruction.	12 × 90 min sessions which included 2 elements: 1) gardening instruction 2) nutrition/ cooking instruction (both for 45 min)	BMI z-scores, 41-item Block Kids Food Screener (food intake), self-efficacy to cook fruits and vegetables, Motivation for health behaving.
16	**Maiz E**, Urkia-Susin I, Urdaneta E, **2021** *Spain*	Child Involvement in Choosing a Recipe, Purchasing Ingredients, and Cooking at School Increases Willingness to Try New Foods and Reduces Food Neophobia	quasi-experimental	202	103	99	na	To investigate effect of involving children in cooking on their lunch food choice at school.	3	1	3 x workshops (last one including cooking a recipe)	There were two groups: Nutrition Education (NE) and Hands-on (HO). HO had the cooking-related activities.	BMI, Veg preferences, KidMed mediterranean diet, Spanish Child Food Neophobis Scale, Cooking Self-efficacy.
17	**Parmer SM**, Salisbury-Glennon J, Shannon D **2009** *Alabama, USA*	School Gardens: An Experiential Learning Approach for a Nutrition Education Program to Increase Fruit and Vegetable Knowledge, Preference, and Consumption among Second-grade Students	quasi-experimental	115	76	39	na	To examine effects of school garden on children's F&V knowledge, preference and consumption.	28	14	For the NE and G group - later stages involved cooking. NE + G included 1 h gardening every two weeks.	Nutrition only group; nutrition education and gardening; control group.	Nutrition Knowledge, F&V preferences, F&V consumption at lunchtime.
18	**Sahota P**, Christian M, Day R, Cocks K. **2019** *England, UK*	The feasibility and acceptability of a primary school-based programme targeting diet and physical activity: the PhunkyFoods Programme	cluster RCT	311	168	143	7.25	Feasibility study to evaluate the PhunkyFoods programme and impact on nutrition knowledge, physical activity knowledge and behaviours.	26	na	Complex menu of components including D&T lesson plans, which involve food preparation skills.	Complex menue of components about health eating and healthy living for delivery in schools.	Healty Lifestyle Knowledge (HLKQ), Diet and Lifestyle behaviour (SNAP), Body Shape Perception Scale (BSPS), BMI.
19	**Wolfe WS**, Dollahite J **2021** *New York, USA*	Evaluation of the Choose Health: Food, Fun, and Fitness 3rd- to 6th-Grade Curriculum: Changes in Obesity-Related Behaviors	quasi-experimental	561	561	561	na	Evalute CHFFF intervention - which aims to decrease childhood obesity and chronic disease risk.	6	6	Each lesson includes 2 recipes and at least one tasted in class.		a 22-item diet survey including: Veg intake, Fruit intake, fast food intake, fast food intent to consume.
20	**Yoshii E**, Akamatsu R **2021** *Tokyo, Japan*	Impact of a school-based cooking programme on home cooking participation in Japan	quasi-experimental	312	170	142	na	To evaluate the impact of school-based cooking programmes on cooking activities at home.	3	2.25	3 x 45-min lessons: 1 lesson peeling an apple, 1 lesson cooking a recipe, 1 lesson peeling an apple (review)	cooking homework and parent newsletters.	Children's cooking attitudes, self-efficacy and participation in cooking at home.

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Table 2 (*continued*)

	Author, Year, Country	Title of Article	Study Design	Sample size analysed	Intervention	control	Mean age	Study Objectives	Duration (weeks)	cooking hours	Cooking Intervention Components	Other Intervention Components	Outcome description
21	**Zahr R**, Sibeko L **2017** *Massachusetts, USA*	Influence of a School-Based Cooking Course on Students' Food Preferences, Cooking Skills, and Confidence	quasi-experimental	100	68	32	na	To evaluate influence of Project CHEF (Cook Healthy Edible Food) on students food preferences, cooking skills and confidence.	1	15	3 h day of preparing food and cooking recipes for a week.	There was some elements of food literacy instruction within the practical sessions.	Liking new foods, preferences for new foods, cooking skills and cooking confidence.

The main risk of bias in non-randomised studies is due to confounding and measurement of outcome domains. The bias relating to confounding could have been addressed through the randomisation process. However, it is interesting to note that all studies had moderate or critical risk of bias in the measurement of outcomes, which is due to the signalling questions in the Robins-I tool, judging this as at least moderate if the trial is not blinded to assessors. In contrast, whilst the Rob-2 tool for RCTs asks a similar question about whether the assessors are aware that the trial is taking place, the algorithm result can still obtain a low risk of bias judgment for this domain even when not blinded. The studies assessed using the Robins-I risk of bias tool are shown in Table 5.

4. Discussion

The findings support the importance that cooking plays for improving and food literacy and diet quality. Results indicated that cooking programmes increased vegetable intake, cooking confidence and food literacy, although increases were only small. Diet quality is important for children's health as vegetable intakes are generally low, and this is thought to be an intermediate outcome leading to improved health (Hasan et al., 2019; Nekitsing & Hetherington, 2022; Upton, Upton, & Taylor, 2012; World Health Organization, 2002). This is the first meta-analysis on this topic. The evidence presented here is important to improve the promotion of school-based food education which specifically includes the teaching of food preparation skills and cooking lessons for children (Dimbleby, 2021; World Health Organization, 2020a).

However, there are concerns about the research design and quality of studies in this field. A recent critical review which also looked at cooking interventions (but with wider inclusion and different outcome criteria assessing psychosocial and wellbeing outcomes) expressed concerns about the quality of studies, with only two of 38 studies having a positive quality assessment rating (Lavelle, 2023).

The main challenge with comparing the effects of studies was the variety of measures for outcomes and lack of comparable data. Heterogeneity was high for cooking self-efficacy, likely reflecting the different contexts such as length of intervention and the style of questions in different measuring tools for this outcome. For example, the Cunningham-Sabo Cooking with Kids survey included 8 items on cooking self-efficacy from Lohse et al. (Cunningham-Sabo & Lohse, 2013; Lohse, Cunningham-Sabo, Walters, & Stacey, 2011) and scored this ranging from 8 to 40. The Mais study also used an 8-item scale on cooking self-efficacy but with score ranges from 6 to 3 (Maiz et al., 2021). In contrast, the study from Japan by Yoshii et al. used a cooking self-efficacy scoring system of 1–4 (Yoshii et al., 2021). The LA Sprouts study by Landry et al. used a 14-item item scale which included attitudes, self-efficacy and motivation to cook questions and a total cooking behaviours score (Landry et al., 2019). Despite variation across studies, the authors propose that a meta-analysis is still informative and have followed Cochrane guidance by providing 'prediction intervals from the random-effects meta-analysis as a way of presenting the extent of between-study variation'(Deeks et al., 2023). Standardised mean differences were used, which is a common approach for combining outcomes from studies with different scales to standardize the outcomes (Borenstien et al., 2021).

The individual effects sizes and summary effects for outcomes are small. One likely reason could be the dosage (number of cooking hours) across interventions. There was a huge variation in the cooking programmes. For example, the 6 studies where we examined cooking confidence showed a bigger impact with the dose of the intervention. The two studies with the smallest dose of cooking hours (1 h and 2.25 h) these showed the smallest raw mean differences between the intervention and control arms (−0.031 and 0.13) (Maiz et al., 2021; Yoshii et al., 2021). The studies with the largest dose of cooking hours (15 h and 28 h) showed larger raw mean differences between the intervention and

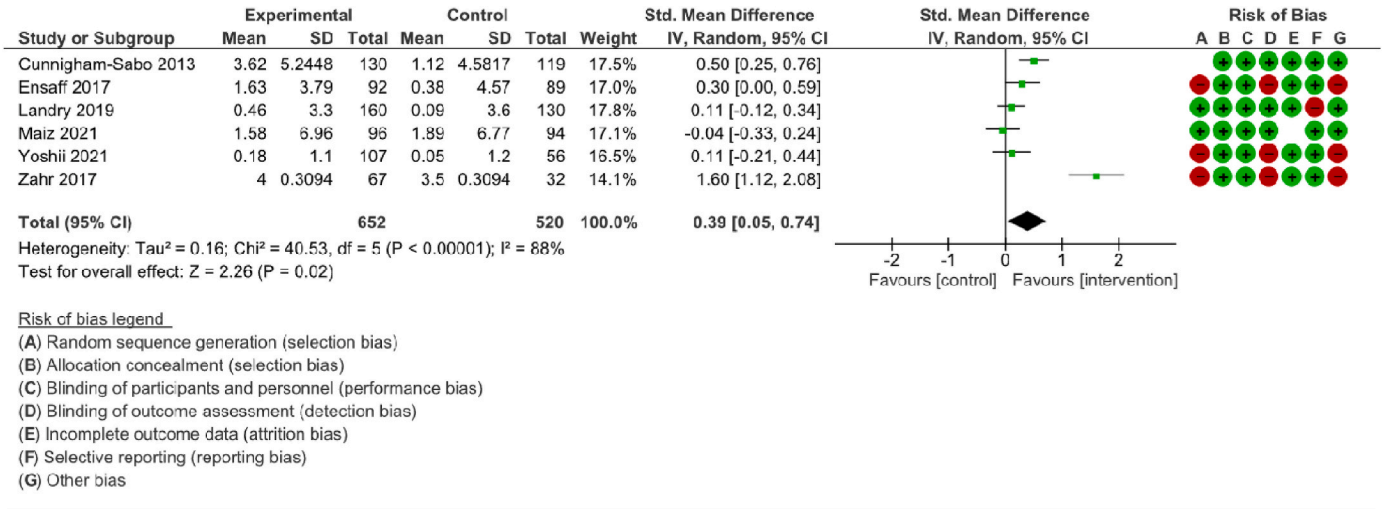

Fig. 2. Forest Plot showing effect on cooking self-efficacy in children aged 4–12 years.

Table 3
Food Literacy impact for three studies in North Carolina, Alabama and England.

Study	Intervention components related to food and cooking	Food Literacy measurement	Raw mean difference between intervention and control arms
Hovland JA, Carraway-Stage VG, Cela A 2013 North Carolina, USA	24 x 45-min food science lessons during the academic year.	Food based science knowledge 13-question multiple choice exam.	1.21 favouring intervention (no 95% CI reported)
Parmer SM, Salisbury-Glennon J, Shannon D 2009 Alabama, USA	14-h programme. For the Nutrition Education and Gardening group - later stages involved cooking.	Nutrition knowledge survey 16-items (food groups, nutrient knowledge, fruit and vegetable identification)	1.37 favouring intervention (no 95% CI reported)
Sahota P, Christian M, Day R, Cocks K. 2019 England, UK	18-month healthy lifestyles programme including lesson plans, which involved food preparation skills.	Healthy Lifestyle Knowledge Scores (including nutrition knowledge and food)	0.8 favouring intervention (95% CI -4.3, 2.7)

control arms (0.5 and 1.3) (Ensaff, Crawford, Russell, & Barker, 2017; Zahr & Sibeko, 2017b). The exception to this is the Cunningham-Sabo study, which had just 6 h of cooking dosage but with the largest non-standardised mean difference between the intervention and control arms of 2.5 (Cunningham-Sabo & Lohse, 2013).

There are other reasons why interventions might vary in impact which are related to theoretical underpinnings of the programme designs. Behaviour change techniques (BCTs) have been commonly advocated in healthy lifestyle interventions so that the mechanisms for effective components are understood and built into the design (Marques et al., 2023; Michie et al., 2011). Hollywood and colleagues recommend that BCT CALO-RE taxonomy to inform the design and delivery of cooking interventions (Hollywood et al., 2018). It has also been proposed that there is a need for best practice reporting guidance so standardize processes of applying behaviour change theory and detail reported in publications (Chakraborty et al., 2022; Lavelle, 2023). However, the process of coding interventions is a highly skilled task requiring familiarity with BCT labels and complex interpretative judgements (Wood et al., 2015). It is possible see from the study intervention descriptions that most cooking lessons in schools are likely to include BCT's such as 'instruction on how to perform the behaviour' [BCT label 4.1] 'demonstration of the behaviour' [BCT label 6.1] and 'behaviour practice/rehearsal' [BCT label 8.1] when teaching children how to prepare food and cook recipes. However, it is less clear from descriptions whether other BCTs such as 'identification of self as a role model' [BCT label 13.1], 'framing/re-framing' [BCT label 13.2] and 'verbal persuasion about capability' [BCT label 15.1] are part of interventions (Michie et al., 2013). None of the studies examined provided clarity on the BCTs used within the intervention components and so it is not possible to evaluate whether some studies had a higher impact on outcomes because of theoretical underpinnings of programme design.

4.1. Practical implications

Schools participating in cooking interventions may have additional practical challenges such as lack of equipment, safety issues with managing hot items in the classrooms, particularly for this age group where resources are limited for this curriculum (Day, Sahota, & Christian, 2019; Frerichs et al., 2015; World Health Organization, 2020a). There may also be some reluctance to teach practical food skills to younger children, although it has been shown that children can learn age appropriate food preparation skills starting in primary and infant schools (Dean, O'Kane, et al., 2021). It is therefore not surprising that schools in many countries have been found to prioritise food knowledge curriculum over practical food skills learning (Smith et al., 2022).

To develop a higher certainty of evidence findings, there is a need for more high quality randomised controlled trials evaluating cooking interventions in schools. Future trials could consider using the Tool for Food Literacy Assessment in Children (TFLAC) by Amin et al. which contains numerical values for food systems knowledge, cooking skills, cooking knowledge, nutrition knowledge and self-efficacy (Amin, Lehnerd, Cash, Economos, & Sacheck, 2019). This tool was developed by a panel of food and nutrition experts in three phases for content validity and has been adapted for use in the UK (Vaughan et al., 2022). For measuring cooking competence, future trials could consider using the tools developed by Dean et al., in 2021; CooC11 and CooC7 are two measures of cooking competence developed and reviewed by an expert panel, based on new recommendations about children's developmental skills and are relevant for this specific age group (Dean et al., 2021a; Dean et al., 2021b). We propose that these measurement tools stand up well to scrutiny using the Risk of Bias 2 assessment questions on outcome domain (University of Bristol, 2021) and have been used with

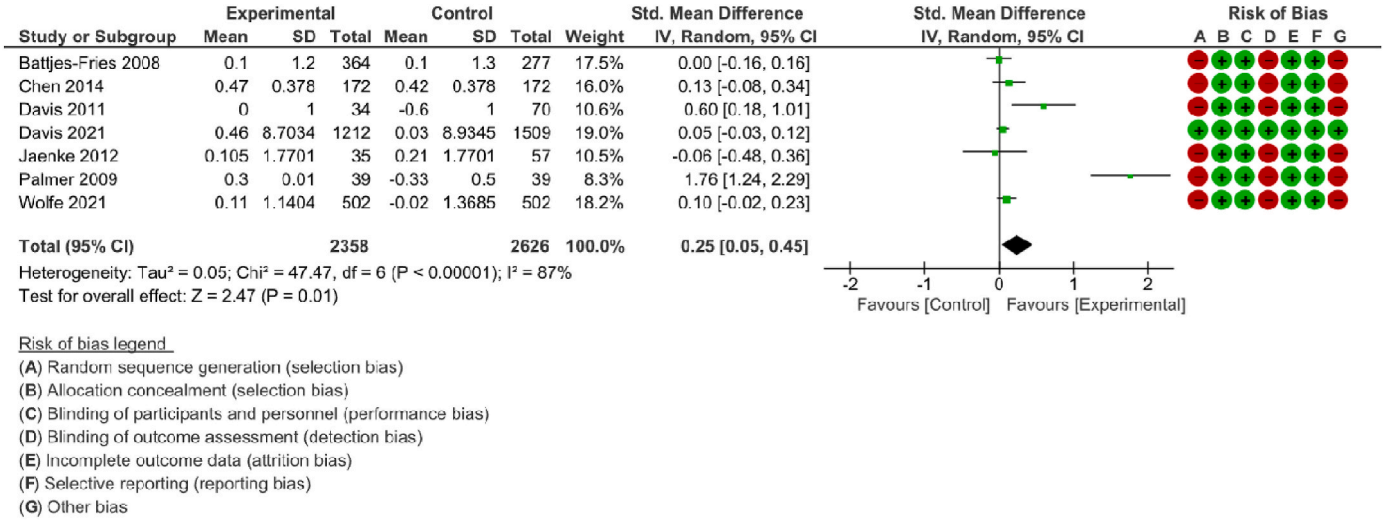

Fig. 3. Forest Plot showing effect on vegetable intake in children aged 4–12 years.

Table 4
Summary of evidence table completed using GRADEpro Software.

Certainty assessment							№ of patients		Effect	Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	cooking classes for children	comparison	Absolute (95% CI)	
Cooking Self-efficacy										
3	randomised trials	not serious	very serious[a]	not serious	serious[b]	none	386	343	– SMD **0.19 SD higher** (−0.12 lower to 0.51 higher)	⨁◯◯◯ Very low
3	observational studies	serious[c]	very serious[a]	not serious	serious[b]	none	266	177	– SMD **0.65 SD higher** (−0.11 lower to 1.41 higher)	⨁◯◯◯ Very low
Vegetable intake										
1	randomised trials	not serious	very serious[d]	not serious	serious[e]	none	1212	1509	– MD **0.43 higher** (−0.24 lower to 1.1 higher)	⨁◯◯◯ Very low
6	observational studies	very serious[f]	very serious[d]	not serious	not serious	none	1146	1117	– SMD **0.34 SD higher** (0.05 higher to 0.64 higher)	⨁◯◯◯ Very low

CI: confidence interval; **MD:** mean difference; **SMD:** standardised mean difference.
Explanations.
[a] The heterogeneity is high due to different measures for cooking self-efficacy.
[b] Confidence interval overlapped line of no effect.
[c] Two of the studies had moderate risk of bias and 1 study had serious risk of bias.
[d] The heterogeneity is high due to different measures for vegetable intake.
[e] There is only 1 RCT study that assessed vegetable intake. The other 6 studies were non-randomised controlled trials.
[f] Of the 6 non-randomised studies measuring the outcome vegetable intake, 5 of these were assessed as having serious risk of bias.

children of this age group in cooking interventions (Amin et al., 2019; Dean et al., 2022; Dean et al., 2021a; Vaughan et al., 2022). The Cook-ED model and matrix could also provide further guidance for researchers for designing cooking interventions (Asher et al., 2020, 2022).

4.2. Limitations and strengths

The strength of the review is that 21 studies were selected using SR accelerator software with two independent reviewers and a third reviewer to resolve disputes. These studies were then examined for risk of bias, summary effects for vegetable intake and cooking confidence outcomes and the GRADE approach was used to evaluate the certainty of evidence for these outcomes.

The limitations of the review are a low number of high quality cluster randomised controlled trial studies, serious inconsistency in the type of interventions, and serious concerns about imprecision of the effects. Therefore, the overall certainty of evidence is low, as shown in Table 4. Further high-quality studies evaluating cooking interventions in schools are needed to increase the certainty of evidence. Future reviews might also include the search term 'culinary' and branch terms since this is

Fig. 4. Risk of Bias assessments for cluster RCTs.

Table 5
Risk of bias in non-randomised controlled trial studies.

Study	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall Bias
Adab 2014	Low	Low	Low	Moderate	Low	Moderate	Low	Moderate
Alexander 2014	Serious	Low	Low	Moderate	NI	Moderate	Low	Serious
Battjes-Fries, 2008	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Bisset, 2008	Low	Low	Moderate	Low	Serious	Moderate	Moderate	Serious
Caraher, 2013	Serious	Low	Low	Low	Critical	Critical	Critical	Critical
Chen, 2014	Moderate	Low	Low	Low	Low	Moderate	Low	Moderate
Davis, 2011	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Ensaff, 2017	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Gibbs, 2013	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Hovland, 2013	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Jaenke, 2012	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Palmer, 2009	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Wolfe, 2021	Low	Low	Low	Low	Low	Moderate	Low	Moderate
Yoshii, 2021	Serious	Low	Low	Low	Low	Moderate	Low	Serious
Zahr, 2017	Low	Low	Low	Low	Low	Moderate	Low	Moderate

now increasingly used for cooking interventions. There is a need for funding prioritisation for this research area.

5. Conclusions

Whilst a small number of trials showed small pooled effects for increased vegetable intake and increased cooking confidence, more high quality randomised evaluations are needed to increase the certainty of evidence. Future trials should consider detailing behaviour change techniques of interventions so that more can be understood about what works and in what circumstances for complex multi-component interventions (Lavelle, 2023; Skivington et al., 2021). Consistent use of outcome tools for vegetable intake, Food Literacy and cooking competence will improve the consistency and precision of meta-analysis and therefore the certainty of evidence.

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Availability of data and materials

The datasets analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

N/A.

Consent for publication

N/A.

Ethical statement

The Systematic Review of Cooking Interventions in Primary Schools 2001–2021 did not involve human participants, human material, or human data and therefore did not require ethical approval.

CRediT authorship contribution statement

Karen L. Vaughan: Writing – review & editing, Writing – original draft, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Janet E. Cade:** Writing – review & editing, Validation, Supervision. **Marion M. Hetherington:** Writing – review & editing, Supervision. **James Webster:** Writing – review & editing, Validation, Data curation. **Charlotte E.L. Evans:** Writing – review & editing, Validation, Supervision, Formal analysis.

Declaration of competing interest

The authors of the manuscript for Systematic Review of Cooking Interventions in Primary Schools 2001–2021 declare that they have no competing interests.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107238.

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