



Review Article

Characteristics of successful primary school-based experiential nutrition programmes: a systematic literature review

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Abstract

Objective: Diet and nutrition in childhood has been associated with the risk of chronic disease later in life. The aim of this review was to identify key characteristics of successful experiential nutrition interventions aimed to change nutrition-related cognitive and behavioural outcomes in primary schoolchildren.

Design: A systematic literature review was undertaken using search terms ('food security', 'school', 'nutrition' and 'program') applied to five scientific databases (CINAHL, Scopus, Web of Science, Medline and Academic Search complete), with outcomes defined as nutrition-related knowledge, attitudes and/or dietary behaviours.

Participants: Primary school-aged children exposed to interventions conducted, at least partially, on school grounds.

Results: A total of 3800 articles were identified from the initial search and manual searching, of which sixty-seven articles were eligible for inclusion. Forty-two articles met the criteria of being successful, defined as achieving significant differences in outcomes of interest, accompanied by a demonstrated reach. Interventions included school gardens (*n* 9), food provision (*n* 5), taste testing (*n* 8), cooking classes (*n* 10) and multicomponent programmes (*n* 10). Nutrition education (when combined with taste testing), cooking-related activities and gardening interventions increased children's willingness to taste unfamiliar foods including new fruits and vegetables, improved their cooking and food preparation skills and increased nutritional knowledge.

Conclusions: This review provides evidence that nutrition education programmes in primary schoolchildren that are experiential in nature are most likely to be successful if they include multiple strategies, have parental involvement and focus specifically on vegetable intake.

Keywords
Primary school
Nutrition intervention
Experiential
Dietary behaviour
Knowledge
Experiential learning
Successful

Diet and nutrition in early childhood has been associated with the risk of chronic disease later in life⁽¹⁾. Therefore, it is important that healthy dietary behaviours are established in young children as these are likely to track through adolescence into adulthood⁽²⁾. In the past decade, primary school-aged children have been identified as having poor quality diets which are typically high in fat and sugar, whilst being inadequate in wholegrains, fruit and vegetables (FV)⁽³⁾. Poor quality diets can be attributed to many factors including lack of access to healthy options, individual taste preferences and lack of food literacy by both parents and

children⁽⁴⁾. This emphasises a need for programmes to target these modifiable factors.

The Ottawa Charter recommends that in order to be successful, health promotion interventions require supportive environments. This socioecological approach to improving health-related behaviours highlights the inter-relatedness of people, health and the communities in which they live⁽⁵⁾. Settings-based approaches that focus on creating supportive environments have been shown to be effective in influencing health-related behaviour change. Schools provide a logical setting in which to promote healthy eating behaviours as

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they have been shown to be particularly influential on children's eating patterns^(6–8). A recent review of twenty-seven school-based interventions reported moderate, but significant, effects on fruit intake; however, there is less evidence for beneficial effects on increasing vegetable intake⁽⁴⁾. It has been identified that most health behaviours and eating habits are established before the age of 15 years⁽⁹⁾; therefore, it is important that public health interventions target children in their earlier years to maximise their chances of developing lifelong positive health outcomes.

Experiential learning is defined as 'learning from life experience', rather than using didactic or theoretically based teaching methods that assess outcomes based on cognitive skills and academic knowledge⁽¹⁰⁾. A systematic literature review was conducted to investigate the evidence to date on experiential nutrition interventions aimed at primary school-aged children and to identify the key characteristics of successful programmes that influenced nutrition-related cognitive and behavioural outcomes (nutrition-related knowledge, preferences and attitudes; self-efficacy; and dietary intake) in this age group.

Methods

The study protocol was registered with PROSPERO (CRD42017072822)⁽¹¹⁾, and the findings were reported according to the Preferred Reporting Items for Systematic Reviews and Meta Analyses guidelines⁽¹²⁾.

Search strategy

The bibliographic databases that were searched included CINAHL, Scopus, Web of Science, Medline and Academic Search. The search was performed up to 30 June 2020. Search terms included: 'Food insecurity' OR 'Food security' OR 'Health knowledge' OR 'Health literacy' OR 'Health education' OR 'Health attitudes' OR 'Health behavior' OR 'Health practices' OR 'Food knowledge' OR Attitudes OR practices OR knowledge AND School* AND Nutrition* OR Food OR Healthy eating AND Program OR Project OR initiative. Search terms were adapted according to individual database requirements. In addition, citations and reference list searches were also conducted. An example of the search strategy is shown in Supplementary Table 1. Although food security was listed in the original PROSPERO protocol registration, lack of quantifiable and comparable measures of food security meant that this outcome was not included in the final review.

Eligibility criteria

Citations were collated into EndNote version X9⁽¹³⁾, and duplicates removed. Abstracts were reviewed by researchers (T.C. and N.D.) against inclusion criteria to determine eligibility of studies. The full-text articles of all potentially relevant citations were accessed and reviewed.

Discrepancies were resolved by consensus or adjudication by other members of the research team (K.C. and K.W.). Criteria for inclusion were experiential-based nutrition interventions conducted in primary school settings, including children aged 5–12 years, and reporting in English language.

Studies were excluded if: (1) the programme intervention was paired with a physical activity component (only outcomes related to nutrition interventions were targeted); (2) not predominantly experiential in nature, meaning that effects may have been attributable to other non-experiential aspects of the intervention; (3) outcomes reported not relevant to the research question; (4) did not report baseline and post-intervention measures; (5) theoretical/educational nutrition intervention (except in the case of being accompanied and supported by an experiential component); (6) not, at least partially, conducted in the grounds of a primary school setting and (7) intervention was designed for medical conditions, such as diabetes or obesity. Eligible study designs included randomised controlled trials (RCT), cluster RCT, quasi-experimental design and cohort studies.

Intervention types

Interventions were limited to experiential programmes in primary school settings that targeted beneficial changes in nutrition knowledge, preferences, attitudes, self-efficacy and dietary intake. Interventions included: School gardens; food provision; taste testing; cooking lessons; multi-component or other, relevant and interventions.

Outcomes

Health-related outcomes targeted in this review included dietary intake, nutrition-related knowledge, preferences or attitudes and self-efficacy. Measures for dietary intake were those reported in grams or servings per day from self or parental reports obtained through dietary recall, food diaries and/or FFQ. Measures of knowledge included response-scale questionnaires, tests on food-related knowledge or recognition of healthy food items. Measures for attitudes, preferences and self-efficacy were response scale questionnaires.

Interventions were deemed to be successful if they reported significant changes in one or more of the outcomes of interest and demonstrated reach (sample size of at least 100 and some degree of generalisability). Studies that were classified as being successful were scrutinised for key characteristics of the intervention that contributed to their success, and this information is presented in order to inform recommendations for future programmes. This data extraction was performed independently by two researchers (T.C. and K.C.) who then reached consensus.

Data extraction

Data collection methods followed the Cochrane review methodology⁽¹⁴⁾. Data were tabulated in a summary of findings (Table 1), according to the type of experiential activity.

Table 1. Summary of findings: studies on experiential nutrition interventions in primary schools

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95 % CI/effect size	GRADE rating ⁽¹⁵⁾
School gardens							
Randomised controlled trials							
Davis <i>et al.</i> , 2016 ⁽⁴¹⁾ ; California, USA; National Institute of Health grant	Grade 3–5, <i>n</i> 304	12 weeks	LA Sprouts programme – 90 min/week of gardening, NE and cooking	Y	Increased identification of vegetables Nutrition and gardening knowledge	<i>P</i> = 0.001 <i>P</i> = 0.003 <i>P</i> = 0.003	High
Hutchinson <i>et al.</i> , 2015 ⁽⁴⁹⁾ ; York, UK; National Institute for Health Research Public Health Research	Grade 3–4, <i>n</i> 777	18 months	RHS led school gardening intervention	Y Teacher-led gardening intervention	More likely to garden at home Teacher-led group was more likely than the RHS-led group to report that they ‘ate lots fruit’. The RHS-led group was associated with a greater increase in the number of vegetables recognised	NS <i>P</i> = 0.031	High
Quasi-experimental design							
Duncan <i>et al.</i> , 2015 ⁽⁴²⁾ ; Coventry, UK; Tanita healthy weight trust	Grade 2–3, <i>n</i> 77	12 weeks	School gardening programme 2 × 30 min garden-based classes (including tasting) per week and supporting curricula education	Y	Improvements in intentions & attitudes in relation to FV behaviour	<i>P</i> < 0.001 <i>P</i> < 0.01	Low
Kararo <i>et al.</i> , 2016 ⁽⁴³⁾ ; Indiana, US; State Department of Health	Grade 3, <i>n</i> 222	6–10 weeks	1 h/week school garden lessons, including preparing and tasting FV	n	Higher healthy food choice self-efficacy and higher family post-programme fruit and vegetable consumption	<i>P</i> < 0.05 <i>P</i> < 0.05	Low
Lineberger and Zajicek, 2000 ⁽⁴⁴⁾ ; Texas, US; Interdisciplinary research initiative programme	Grade 3 and 5, <i>n</i> 111	Not reported	Garden Activity Guide – 34 activities including outdoor garden or indoor grow laboratory	n	Increase in student’s vegetable preference and snack preference	<i>P</i> = 0.03 <i>P</i> = 0.009	Low
Leuven <i>et al.</i> , 2018 ⁽⁴⁵⁾ ; The Netherlands; Financial support from intervention primary schools	Grade 4–6, <i>n</i> 215	1 academic year	17 × 1 h lessons (1 classroom, 15 gardening and 1 harvesting and cooking)	Y	Increases in student vegetable knowledge (ability to recognise) Self-reported preferences for vegetables (remained high at 1-year follow-up)	<i>P</i> < 0.001 NS	Low
McAleese and Rankin, 2007 ⁽⁴⁶⁾ ; Idaho, USA; funding not reported	Grade 6, <i>n</i> 95	12 weeks	(1) 12-week classroom NE (2) 12-week classroom NE accompanied with garden experience.	Y	(2) Fruit servings increased 1.13/d (2) Vegetable servings increased 1.44/d (2) Combined FV servings increased from 1.93–4.5 servings/d. (2) Increased vitamin C and fibre intakes	<i>P</i> < 0.001 <i>P</i> < 0.001 <i>P</i> = 0.016 <i>P</i> = 0.001	Low



Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95 % CI/effect size	GRADE rating ⁽¹⁵⁾
Parmer <i>et al.</i> , 2009 ⁽⁴⁷⁾ ; Alabama, USA; funding not reported	Grade 2, <i>n</i> 115 students	28 weeks	(1) NE and Gardening, 1 h per fortnight NE with 1 h of gardening per fortnight (2) NE, received 1 h NE per fortnight	Y	(1) and (2) Increases in food group knowledge, FV identification & willingness to try FV. (2) More likely to choose and consume vegetable in a lunchroom setting.	NS $P < 0.001$ $P = 0.005$ $P < 0.01$ $t = 3.19$	Low
Ratcliffe <i>et al.</i> , 2011 ⁽⁴⁸⁾ ; Massachusetts, USA; Tufts Institute of the Environment Tufts College, tufts centre for children and the delores liebman fellowship	Grade 6, <i>n</i> 320 students	13 weeks	Garden sessions. 1 h × week and usual health science curricula education	Y Received same health science education.	Increased number of vegetables correctly identified. Increased willingness to taste vegetables Increased preference for vegetables Higher variety of vegetables tasted.	$P = 0.002$ NS $P = 0.029$ $P < 0.001$	Low
Food provision							
Randomised controlled trials							
He <i>et al.</i> , 2009 ⁽⁵¹⁾ ; Ontario, Canada; Ontario's Action Plan for Healthy Eating and Active Living, the Ontario Ministry of Health Promotion	Grade 5–8, <i>n</i> 1277	21 weeks	(1) FFVS 3 FV snacks per week and enhanced NE (2) FFVS 3 FV snacks per week and usual grade level nutrition curriculum.	Y No FFVS and usual grade level nutrition curriculum	(1) and (2) appeared to have slightly higher FV preference scores than the control group. Post-intervention (1) and (2) increased total fruit and vegetable intake (0.6 and 0.5 serving/d, respectively). (1) Students consumed more fruit and vegetables at school than students in the Control group (0.49 serving/d)	NS NS $P < 0.05$	High
Murphy <i>et al.</i> , 2011 ⁽⁵³⁾ ; Wales, UK; Welsh assembly government	Grade 5 and 6, <i>n</i> 4350	Intervention duration not reported. 4-month and 12-month follow-up.	Free daily breakfast programme. 5 × week.	Y	Increased positive attitudes towards eating breakfast Increased consumption of healthy food items at breakfast No difference in the healthy/unhealthy food items consumed during the rest of the day.	+0.74, 95 % CI 0.05, 1.43 $P < 0.01$ +0.23, 95 % CI 0.09, 0.37	High
Tak <i>et al.</i> , 2008 ⁽⁵²⁾ ; Amsterdam, The Netherlands; Dutch Ministry of Health, Welfare and Sport and Holland Produce Promotion in Zoetermeer	Grade 4, <i>n</i> 771	Intervention duration not reported. Follow-up at 1 year and 2 years.	Provision of FV twice a week during a fruit break and extra NE	Y	Significant increase in knowledge of the recommendations of fruit intake for boys. Significant increase in fruit intake. No effect for vegetable intake	$P < 0.05$ $P < 0.05$	High

Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
<p>Quasi-Experimental Sharma <i>et al.</i>, 2016⁽⁶⁰⁾; Texas, USA; Texas Department of Agriculture and Feeding Texas</p>	Grade 1, <i>n</i> 717	16 weeks	BB intervention, involving distribution of 50–60 servings of fresh food (donated from local food banks) sent home to families. Weekly, healthy recipe tastings featuring food from take-home kits and health education lessons in schools (including parents).	Y Received health education lessons with no BB.	<p>Increased in consumption of fruits and vegetables. Reduction in the amount of added sugars consumed Increase in fibre intakes (at mid-point but not end point)</p>	<p><i>P</i> = 0.046 <i>P</i> = 0.049 <i>P</i> = 0.014 <i>P</i> = 0.034</p>	Low
<p>Cohort Study Kastorini <i>et al.</i>, 2016⁽⁶⁴⁾; Athens, Greece; DIATROFI programme funded by Stavros Niarchos Foundation</p>	Grade 1–12, <i>n</i> 3941	Median duration 7 months	Provision of free daily meal and promotion of healthy nutrition for students and their families	n	<p>Increase for girls by 0.8% for adoption of Mediterranean diet pattern. Higher consumption of all food groups in students with lower food insecurity. Increases for consumption of Milk/yoghurt by 17%, vegetables by 17%, fruits by 18% and whole-grain products by 88%.</p>	<p><i>P</i> < 0.05 <i>P</i> < 0.05</p>	Low
<p>Cooking lessons Randomised controlled trials Cunningham-Sabo and Lahse, 2013⁽⁶⁹⁾; Colorado, USA; National Research Initiative Grant from the USDA National Institute of Food and Agriculture</p>	Grade 4, <i>n</i> 257 students	10 weeks	CWK programme – 3 × 2 h cooking lessons, 3 × 1 h FV tasting sessions and 1 × 1 h NE class	Y	<p>CWK intervention significantly improved student's vegetable preference. Fruit preference increased. Improvement in attitudes towards cooking and self-efficacy for CWK treatment group.</p>	<p><i>P</i> = 0.001 NS <i>P</i> = 0.029 <i>P</i> < 0.001</p>	High
<p>Quasi-Experimental Bisset <i>et al.</i>, 2008⁽⁶³⁾; Montreal, USA; Doctorate research bursary</p>	Grade 5 and 6, <i>n</i> 388	Students exposed to programme for 6 years	Little Cooks programme – 8 workshops involving food preparation and tasting	Y	<p>Increased knowledge of nutritional value of food and cooking. Increased knowledge of nutrition content, cooking procedures and food transformation. No change in knowledge of food guide, local food produce and international cuisine</p>	<p><i>P</i> < 0.001 <i>P</i> < 0.05</p>	Low



Table 1. *Continued*

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95 % CI/effect size	GRADE rating ⁽¹⁵⁾
Bai <i>et al.</i> , 2018 ⁽⁷²⁾ ; South Korea; Not reported	Grade 2, <i>n</i> 71	4 weeks	Weekly 40-min session including classroom lecture and hands-on cooking activities with two vegetables introduced in each session	Y	Significant improvement in vegetable consumption, intention, attitude, preference and self-efficacy compared with control.	$P \leq 0.01$ for self-efficacy and $P \leq 0.001$ for others	Low
Caraher <i>et al.</i> , 2013 ⁽⁶⁸⁾ ; London, UK; Worshipful Company of Cooks and supported by Academy of Culinary Arts	Grade 4 and 5, <i>n</i> 169	1 year	'Cooks adopt a School' Program, involving 3x cooking sessions throughout one school year hosted by a professional chef.	Y	Increases in vegetable consumption. Increase was in students cooking confidence	$P = 0.002$ $P = 0.000$	Low
Chen <i>et al.</i> , 2014 ⁽⁶⁵⁾ ; California, USA; USDA National Institute of Food and Agriculture. Agriculture and Food Research Initiative seed grant project.	Grade K-2, <i>n</i> 1204	3 months	A multicultural, multi-component intervention involving classroom food demonstrations (1x month) and tasting and an at-home cooking component with take home food kits.	Y	Students reported significantly higher preferences for all seven vegetables featured in food demonstrations and cooking. Student's frequency of consuming 3 featured vegetables also increased between pre- and post-intervention. Increased students' involvement in food preparation at home.	$P < 0.001$ for five vegetables, $P < 0.05$ for two vegetables. $P = 0.008$ (jicama) $P = 0.017$ (bell pepper) and $P = 0.001$ (asparagus) $P = 0.008$ ($P = 0.03$) ($P < 0.05$) NS	Low
Cunningham-Sabo and Lohse, 2014 ⁽⁷¹⁾ ; Santa Fe, USA; not reported	Grade 4, <i>n</i> 961	Not reported	(1) CWK-CT: Cooking with Kids curriculum including cooking and taste lessons and (2) CWK-T: CWK curriculum with no cooking, only taste lessons.	Y	In the CWK-CT group, the improvements in FV preference were significantly greater in males than females. Vegetable preference improved for both CWK-CT and CWK-T groups compared with control. Cooking self-efficacy was improved in students who participated in the CWK-CT intervention.		Low
Jarpe-Ratner <i>et al.</i> , 2016 ⁽⁶⁶⁾ ; Chicago, USA; ConAgra Foods	Grade 3–8, <i>n</i> 271	10 weeks	2 h x week cooking and NE course led by a trained chef-instructor	N	Nutrition knowledge of students increased. Participants increased their intake of fruit & vegetables. Increases in students cooking self-efficacy No reduction in amount of chips and soda consumed.	$P < 0.05$ $P < 0.001$ $P < 0.005$ $P < 0.001$	Low

Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
Liquori <i>et al.</i> , 1998 ⁽⁶⁷⁾ ; New York, USA; Part federal and private funding by Cooperative Agreement, Central Harlem Community of New York City.	Grade K-6, n 590	1 academic year	(1) CS + FEL: <i>CookShop</i> programme plus food and environment lessons. (2) CS: n = <i>CookShop</i> only. (3) FEL: food and environment lessons only	Y	Students who participated in the CS or CS + FEL programme reported higher mean food preference scores. Both CS and FEL had a positive effect on food knowledge. The CS intervention appeared to have a larger effect on food knowledge than the FEL intervention for children in grades 4–6. The CS also increased self-efficacy in cooking in older children.	Effect: 17.77 $P < 0.001$ effect: 7.69 $P < 0.05$ effect: 0.94	Low
Quinn, Horacek and Castle, 2003 ⁽⁷⁰⁾ ; New York State, USA; not reported	Grade 5, n 126	1 academic year	<i>CookShop</i> cooking lessons.	Y	Intervention increased identification and tasting of fruit and vegetables. Intervention group consumed more fibre, folic acid and fruit, milk and decreased intake of added foods.	($P < 0.05$) ($P < 0.05$)	Low
Zahr and Sibeko, 2017 ⁽⁶⁴⁾ ; Vancouver, CA; CAPSTONE project for the University of Massachusetts MPH in Nutrition programme and did not receive any funding of financial incentives.	Grade 4–5, n 100	Intervention duration not reported Follow-up 3 weeks	Project CHEF project involving cooking and tasting foods. 2.5 h × 4–5 sessions	Y	Increased familiarity and preference for healthy foods and self-reported cooking skills. 19% increased trying new foods, 13% increase in willingness to try new foods. 73% of parents saw increases in their child's cooking skills, 43.4% of children asked to make a recipe at home, 45.1% asked to buy specific ingredients	$P = 0.009$ broccoli $P = 0.000$ swiss chard $P = 0.038$ carrots $P = 0.001$ quinoa	Low
Taste testing Randomised controlled trials Gold <i>et al.</i> , 2017 ⁽⁵⁹⁾ ; North Dakota, USA; funding not reported	Grade: 3, n 662	7 weeks	7 × interactive lessons involved in the GWWFV programme. (1) GWWFV + TT or (2) GWWFV + No TT Both intervention groups also participated in federal FFVSP	Y Did not receive GWWFV or taste testing but did receive FFVSP.	Both groups with access to the FFVSP consumed more fruits and vegetables. GWWFV + TT group consumed more fruits and vegetables compared with GWWFV and no TT. GWWFV + TT group also had a greater reduction in the consumption of potato chips and French fries.	$P < 0.01$ $P < 0.0001$ $P < 0.05$ $P < 0.05$	High



Table 1. *Continued*

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95 % CI/effect size	GRADE rating ⁽¹⁵⁾
LaChausse, 2017 ⁽⁶¹⁾ ; California, USA; US Department of Agriculture SNAP-ED programme, through the California Department of Public Health	Grade 4–6, <i>n</i> 275	3 months	Harvest of the Month (HOM) programme, involving tasting produce, presentations, newsletters, recipes.	Y Participated in non-nutrition-related class (e.g. arts and craft)	Increased FV preference. No effects on FV consumption or other nutritional related behaviours, knowledge or efficacy.	<i>P</i> = 0.04	High
Morrill <i>et al.</i> , 2016 ⁽⁶⁰⁾ ; Utah, USA; Food Dudes programme was supported by grants from the US Department of Agriculture	Grade 1–5, <i>n</i> 2292	4.5 months 6-month follow-up	Food Dudes is a multi-component nutrition intervention based on role-modelling, repetitive tastings and rewards for FV consumption. (1) Students received the Food Dudes programme and were rewarded tangible prizes from teachers for consuming all FV provided for tasting. (2) Students received the Food Dudes programme but were verbally praised by teachers for consuming all FV provided in tasting.	Y	<i>Food Dudes</i> schools consumed more FV than control schools after phase I (serving Food Dudes targeted foods), with larger differences in prize schools than praise schools. After phase II (serving naturalistic cafeteria food), Food Dudes schools consumed 46 % more fruit and vegetables than control schools, with no difference between prize and praise schools. At 6-month follow-up, only prize schools consumed more fruit and vegetables than control schools.	92 % difference (prize) 50 % difference (praise) NS NS 0.12 cups, 42.9 % difference	High
Quasi-Experimental Battjes-Fries <i>et al.</i> , 2014 ⁽⁵⁵⁾ ; Wageningen, The Netherlands; Ministry of Economic Affairs of the Netherlands	Grade 3–6, <i>n</i> 1183	One academic year 4-week and 6-month follow-up	10–12 nutrition lessons from the Taste Lessons programme. Lessons incorporated cooking, tasting, experiment and excursion to a farm	Y	At first and second follow-up, the intervention groups showed a significantly higher increase in knowledge of unfamiliar foods, food identification and healthy eating. An increase was found in the number of foods known and tasted, intention to taste and healthy eating behaviours.	<i>P</i> < 0.05 <i>P</i> < 0.05	Low
Day <i>et al.</i> , 2008 ⁽⁵⁶⁾ ; Vancouver, CA; Action Schools! BC – Healthy Eating programme was funded by British Columbia Ministries of Health and Education, in partnership with Legacies Now Society.	Grade: 4–5, <i>n</i> 444	12 weeks	Action Schools! – 2 weekly healthy eating activities (45 min duration) + 1 monthly tasting activity	Y	Fruit and vegetables tasted increased by 5 %. No change in attitude to eating, willingness to try, variety, neophobia or knowledge of FV in disease prevention.	<i>P</i> < 0.05	Low

Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
Lakkakula <i>et al.</i> , 2010 ⁽⁵⁸⁾ ; Louisiana, USA; funding not reported	Grade 4 and 5, <i>n</i> 360	10 weeks	Wellness Partnership for Kids programme. A cafeteria-based tasting programme paired with school wellness curriculum. Children were provided 4 vegetables with their school lunch 1 d/week	n	Students who reported 'not liking' the vegetables after the first tasting increased their liking for three out of the four vegetables by the 10th tasting (improvements were not seen until the 8th tasting).	<i>P</i> = 0.05	Low
Lakkakula <i>et al.</i> , 2011 ⁽⁵⁷⁾ ; Louisiana, USA; funding not reported	Grade 1, 3 and 5, <i>n</i> 379	8 weeks Follow-up tastings were conducted at 4 and 10 months	Building Preferences for FV program. Students were offered a taste of 4 fruits 2 × week for weeks 1–4 and 4 vegetables 2 × week for weeks 5–8.	n	Students who indicated they 'did not like' after first tasting improved their liking for all items after the programme. On average, it required two tastes of fruit and five tastes of vegetable to observe a change in liking score. All improvements in liking were maintained at the two subsequent follow-ups.	<i>P</i> = 0.00 (8 items) <i>P</i> = 0.01 (2 items)	Low
Perry <i>et al.</i> , 1998 ⁽⁶²⁾ ; Minnesota, USA; Grant provided by National Cancer Institute	Grade 4–5, <i>n</i> 424	8 weeks 1-month follow-up	5-a-d Power Plus intervention – 16 × 45-min classroom sessions (2 × week) including snack preparation and taste testing. The intervention also included food service changes, parental education/involvement and industry support.	n	There was a significant increase in fruit consumption (0.62 serving/d difference between treatment and control) and combined FV consumption. Increases in lunchtime vegetable consumption in girls, daily fruit consumption and the proportion of total daily energy content attributable to FV.	<i>P</i> = 0.00 <i>P</i> = 0.00	Low
Multi-component interventions Randomised controlled trials Lakshman <i>et al.</i> , 2010 ⁽⁷⁵⁾ ; Cambridgeshire, England; Health Enterprise East, NHS innovations hub for east England assisted in producing the card game and corresponding curriculum.	Grade 5 and 6, <i>n</i> 2519	9 weeks	Students participated in the card Game 'Top Grub' with nutritional information and traffic light quality rating for various foods were accompanied by specialised education curriculum to compliment card game.	Y	Mean nutrition knowledge score was higher in intervention group compared with control. Children in the intervention schools indicated that they 'are currently eating a healthy diet' (39.6%) or 'would try to eat a healthy diet' (35.7%) more often than control schools.	95% CI 0.05, 2.16; <i>P</i> = 0.042 <i>P</i> < 0.001	High



Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
Sahota <i>et al.</i> , 2019 ⁽⁸²⁾ ; North England; Nestlé UK Healthy Kids Programme	Grade 3–6; <i>n</i> 358	17 months	The PhunkyFoods Programme is composed of intervention functions that impact on all three of the essential conditions for behaviour change, capability, opportunity and motivation.	Y	Significantly higher healthy balanced diet knowledge scores compared with control pupils in Year 4. At 18 months, the mean percentage of vegetables liked was higher in intervention group. Similarly, percentage of fruits liked was also higher	Mean difference 5.1 (95% CI 0.1–10.1, <i>P</i> = 0.05). (intervention 53.9% <i>v.</i> 43.0% control). (intervention 76.9% <i>v.</i> 67.2% control).	High
Quasi-Experimental Bissell <i>et al.</i> , 2018 ⁽⁷⁷⁾ ; USA	Grades 2 and 3 and then 3 and 4; <i>n</i> 102	2 years	A health intervention programme with visual presentation on topics relating to food advertising, nutrition, and fast-food options. Discussions held in class and each child given a folder with the presentation information provided as a handout, along with related games and additional activities to complete at home with their parents or on their own.	n	Significant positive increase in nutritional knowledge, attitudes towards healthy eating and exercise, food preferences and eating behaviour.	<i>P</i> < 0.001 for all outcomes	Very low
Jayne 2019 ⁽⁷⁸⁾ ; New Jersey, USA; RobertWood Johnson Foundation	Grade 3, <i>n</i> 194	1 h	Incorporating edutainment (Jump with Jill) into both a NE campaign and its evaluation; learning through play.	n	All aggregate responses for nutrition knowledge, attitudes and intention became significantly more positive following intervention	<i>P</i> = 0.05	Very low
Jung <i>et al.</i> , 2019 ⁽⁷⁹⁾ ; New York, USA; not reported	K to Grade 6 K-2nd graders (<i>n</i>) = 646 3rd–5th Graders – 826	1 year	The Healthy Highway© Program: an interactive, imaginative, content-based programme that teaches and reinforces essential health-related topics to K-5 students on healthy foods and basic nutrition with a road safety analogue. Includes cafeteria activities.	Y	Statistically significant more students improved their healthy eating literacy by including 'healthy (green light) and unhealthy (red light)' foods among their daily food choices.	<i>P</i> < 0.05	Very low

School-based experiential nutrition programmes

Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
Kim <i>et al.</i> , 2020 ⁽⁸⁰⁾ ; Seoul, South Korea; Joint Research Project and Rural Development Administration, Republic of Korea.	Grade 3, <i>n</i> 95 Grade 5, <i>n</i> 107	12 weeks	Mediator model including gardening, nutritional education and cooking activities utilising harvested foods from garden.	n	Significant increase in dietary self-efficacy, outcome expectancies, gardening knowledge, nutrition knowledge, vegetable preference, and vegetable consumption. Significant decrease in food neophobia	$P < 0.001$ $P < 0.05$	Very low
Poelman <i>et al.</i> , 2019 ⁽⁸¹⁾ ; Sydney, Australia; Hort innovations, Sydney, Australia	8–12 year olds, <i>n</i> 299	Five 1-h teacher led interventions	Vegetable Education Resource to Increase Children's Acceptance and Liking (VERTICAL), an experiential learning programme on vegetables, combining elements from sensory education and scientific insights into children's development of vegetable acceptance, such as exposure and role modelling.	Y	Increased knowledge about: vegetables and the senses; ability to verbalise sensations; vegetable acceptance; and willingness to try vegetables. No effect on food neophobia	$P = 0.002$ $P < 0.001$ $P = 0.007$ $P = 0.05$	Very low
Yoder <i>et al.</i> , 2014 ⁽⁷⁶⁾ ; Wisconsin, USA; Wisconsin's Department of Agriculture, Trade and Consumer Protection	Grade 3–5, <i>n</i> 1117	1 academic year	Farm-to-school programme including Harvest of the Month, school garden, tasting and classroom lessons.	n	Higher willingness to try FV. Knowledge of nutrition and agriculture. No effect on overall dietary patterns. Small increase in FV consumption from baseline among those with lower intakes.	$(P < 0.001)$ $(P < 0.001)$ NS	Very low
Evans <i>et al.</i> , 2012 ⁽⁷³⁾ ; Texas, USA; SHK was funded by Michael and Susan Dell Foundation	Grade 6–7, <i>n</i> 246	5 months	The SHK intervention involving six components: (1). In-class lessons; (2). After-school gardening programme; (3). Farm-to-school (local food provided in cafeteria); (4). Farmers' visits to school; (5). Taste testing; (6). Field trips to farms. Student exposure varied between and within schools. Exposure was determined by student reported questionnaires.	Y	At post-test students who were exposed to two or more components of the intervention reported increases in preference for FV, FV per day, self-efficacy, nutrition knowledge and a lower preference for unhealthy food. Interventions which saw the greatest improvements were farmers' visits, taste testing and cafeteria components.	NS, SE 0.12 $P = 0.0134$, SE 0.38 $P = 0.0091$, SE 0.74 $P = 0.0095$, SE 0.22 $P = 0.0089$, SE 0.40	Very low

Table 1. Continued

Author/year; country; funding	Sample	Intervention duration	Intervention	Control group	Relevant outcomes	Statistical significance/ 95% CI/effect size	GRADE rating ⁽¹⁵⁾
Prelip et al., 2012 ⁽⁷⁴⁾ ; California, USA; The California Dairy Council provided in-class materials and 5-a-d-powerplay education curricula	Grades 3–5, n 399	One-academic year	(1) Intervention + Network Los Angeles Unified Schools District programme, included schools' visits from chefs and farmers, theatrical performances, physical activity, art and HOM introducing new fruits and vegetables including taste testing. Accompanied with teacher training (1.5 h) with NE for students and parents. (2) Intervention Same as Intervention+ without parent NE programme.	Y Received NE based upon curriculum requirements of respective schools.	The Intervention+ produced improvements in consumption of vegetables, nutrition knowledge, student attitudes and beliefs towards consumption of vegetables and teacher influence on students' attitudes towards FV	NS P < 0.05 P < 0.01 P < 0.05	Very low

RHS, Royal Horticulture Society; FV, fruit and vegetable; NE, nutrition education; FFVS, FV snack programme; BB, Brighter Bites; CWK, Cooking with Kids; GWWFV, Go Wild with Fruits and Vegetables; TT, taste testing; FFVSP, Fresh Fruit and Vegetable Snack Program; SHK, Sprouting Healthy Kids; LA, Los Angeles.

Assessment of methodological quality

The GRADE criteria were used to assess quality of evidence⁽¹⁵⁾. Only RCT and cluster-RCT study designs could be assigned a *high*-quality rating, while quasi-experimental and cohort studies were assigned a *low* or *very low* rating. Discrepancies in quality allocation were resolved by consensus between members of the research team (T.C., K.C. and K.W.). The strength of evidence of studies was evaluated using the National Health and Medical Research Council's Levels of Evidence Manual.

Results

Study selection

The database search identified 3908 articles, with an additional six studies being included through manual searching of citations and grey literature. After refinement by title, 1361 articles were further investigated by reviewing their abstracts, thereafter, leaving 211 relevant articles for which full texts were extracted. Sixty-seven articles were identified to be relevant regarding experiential nutrition interventions and reported on the outcomes of interest. Of those, forty-two were determined as being successful and were reviewed in-depth (Fig. 1). Of the successful interventions, eleven were cluster-randomised trials (National Health and Medical Research Council's level II), thirty quasi-experimental design trials, including pre-post studies (level III-2) and one cohort study (level III-2), as shown in Table 1. Twenty-five studies that were considered to be unsuccessful, with reasons for this classification, are summarised in Supplementary Table 2^(16–40).

Experiential interventions and characteristics

Studies were dated from 1998 to 2020 and were conducted in Australia, UK, USA, Netherlands, Canada, South Korea and Greece. Study populations varied from 77 to 2519. Successful interventions included school gardens (n 9)^(41–49), food provision (n 5)^(50–54), taste testing (n 8)^(55–62), cooking lessons (n 10)^(63–72) and other multiple component interventions which included additional activities (n 10)^(73–82) such as farmer visits, Harvest of the Month Program or a nutrition education card game. Cognitive-based outcomes included food and nutrition-related knowledge, preferences, attitudes and self-efficacy. Behavioural outcomes included student or parent-reported dietary intakes of FV, wholegrains, dairy products, total fibre, added sugars, total fat and vitamin C. Of the school gardening programmes, nine of twenty identified studies were determined as successful, with the interventions typically lasting for 10–15 weeks^(41–48). Gardening interventions were the most intensive in relation to time and experiences, provided that they were often accompanied with harvesting, cooking and tasting of the produce grown^(41,42,45–48), in addition to tailored

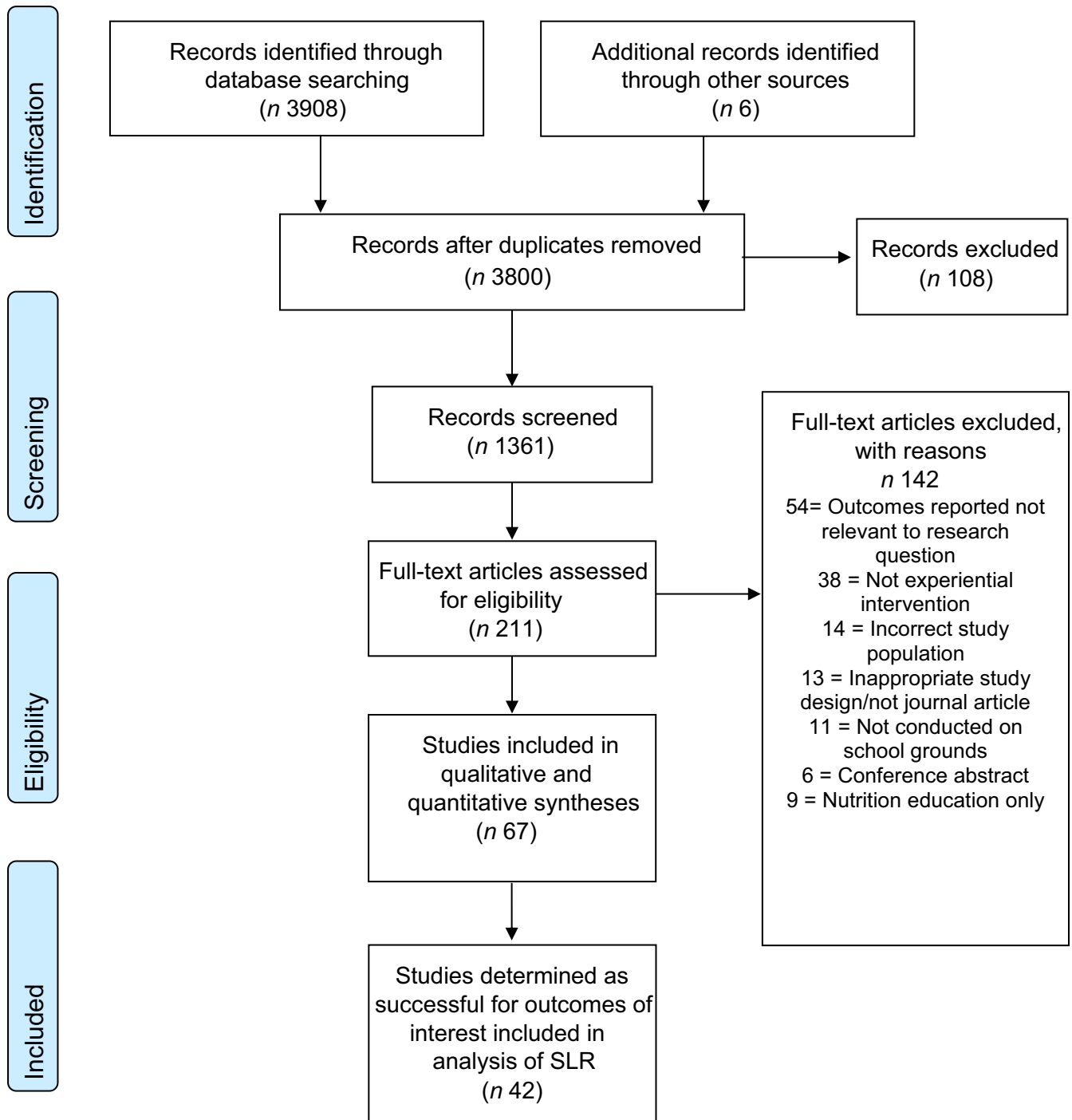


Fig. 1 (colour online) Preferred Reporting Items for Systematic Reviews and Meta Analyses flow diagram for systematic literature reviews

classroom nutrition education. The two highest quality studies (RCT) for which the evidence was strongest were a 12-week Little Sprouts programme ($n\ 304$)⁽⁴¹⁾ and an 18-month Royal Horticulture Society-led programme ($n\ 777$)⁽⁴²⁾. LA Sprouts is a 12-week gardening, nutrition and cooking intervention comprising 90 min/week that improved knowledge of nutrition and likelihood to garden at home, while the UK Royal Horticulture Society-led

programme was successful at increasing knowledge of vegetables in the groups randomised to receive instruction from external professionals rather than those led by teachers. The remaining seven studies were of low quality and mostly demonstrated improvements in preferences for FV and willingness to try new ones, with only three studies measuring actual consumption of these foods^(43,46,47).



All eleven of the gardening studies that were deemed as being unsuccessful, because of not achieving significant changes in the outcomes of interest (n 8) or having small sample sizes or lacking generalisability (n 3), were quasi-experimental and rated as either low (n 4) or very low (n 7) quality (see online supplementary material, Supplemental Table 2). Characteristics of these studies are informative and presented briefly here. A pilot project⁽¹⁶⁾ implemented in an inner city neighbourhood of Johannesburg, South Africa that is home to a large community of migrants did not improve students' dietary diversity or nutritional status over a 1-year period, as high year-round yield of produce was not attained. Two key learnings from the project were: (1) a need to change school culture by incorporating the garden as a catalyst for whole of school development; a fundamental concept of the WHO health promoting school model that has shown to be modestly successful⁽⁸³⁾; and (2) long-term engagement with the garden to ensure sustainability, with a recommended minimum of 3 years in order to impart skills, mentor across multiple growing seasons and have time to adequately integrate a garden into the culture of the school.

The Australian *Stephanie Alexander Kitchen Garden* Program consists of a minimum of a 45-min garden class and a 1.5-h kitchen class every week as an ongoing part of the school curriculum. Garden and kitchen classes are supervised by specialist staff with prior qualifications and experience in horticulture and hospitality, respectively, who are assisted by the classroom teacher. Surprisingly, in a non-randomised comparison of six schools receiving the programme and six control schools, neither child well-being (assessed through self-reported, health-related quality-of-life questionnaires) nor school performance differed between intervention and control schools. However, recruitment bias was evident in that five of the six control schools that agreed to participate had started their own edible gardens by commencement of the study. Thus, many of the children in the control schools also participated in gardening (and some cooking) activities, although for substantially fewer hours and in a less structured way than in the intervention schools.

A pilot of the LA Sprouts programme examined its influence on dietary intake, obesity risk and nutrition-related behavioral and psychosocial parameters in predominately Latino elementary students in Los Angeles⁽⁴⁰⁾. A weekly 45-min interactive gardening lesson was taught by a bilingual Latina-certified master gardener. The exploratory nature of the non-randomised controlled intervention was limited by the small number of participants, mostly of Latino origin, and low generalisability of the study findings. Significant results were found only for subgroups, not all participants. Despite efforts to emphasise a parental component, classes offered to parents of LA Sprouts participants were poorly attended. A later suitably powered, larger RCT study did report the programme to be effective⁽⁴¹⁾.

Two studies, both from Canada, investigated the effectiveness of introducing the EarthBox[®] water efficient, container gardening system into primary schools^(18,20) in combination with a vegetable and fruit snack programme. These container gardens can be used to grow vegetables, herbs and berries in the classroom setting. An 18-month study conducted in a rural First Nations elementary school found that although preference scores for vegetables improved 7 months following inception of the intervention, these had decreased to near baseline levels by 18 months⁽²⁰⁾. Children did not increase their home consumption of any produce they were exposed to at school, but instead the results indicated that foods most liked and disliked by children were also those most often and least often consumed by children at home, respectively. Similarly, there was a decline in vegetable preference in another 2-year programme⁽¹⁸⁾.

A lack of an intervention effect on vegetable preference or consumption patterns identified in many of the unsuccessful studies raises a question regarding the necessary dose of a school intervention, and the type of school intervention required to yield enduring change. These studies suggest that school interventions to improve children's diet quality through gardening also need to focus on influencing the home and community food environments, and increasing vegetable preferences more than fruit preferences as the latter is more difficult to shift in young children.

Of the thirteen studies investigating food provision programmes, defined as food or meals provided to children on school grounds for consumption either at school or at home, five were deemed successful (three high quality and two low quality). These were interventions that included a 16-week take-home food distribution co-op⁽⁵⁰⁾, a 21-week free FV snack programme⁽⁵¹⁾, a 12-month school breakfast programme⁽⁵³⁾, a 12-month free meal provision during the school day⁽⁵⁴⁾ and a 2-year free provision of fruit or ready-to-eat vegetables (cherry tomatoes and baby carrots) twice a week during a classroom fruit break⁽⁵²⁾. Food provision interventions were also frequently paired with relevant and comprehensive classroom nutrition education^(50-52,54). The *Brighter Bites* programme was particularly successful in achieving increased intakes of FV consumption by sending home fresh food to families⁽⁵⁰⁾, along with recipes, and involvement of parents in health education sessions. Programmes that provided snacks or meals on school grounds influenced change in dietary behaviours whilst at school⁽⁵¹⁻⁵⁴⁾, but their effect on overall diet quality is unknown. Of the three unsuccessful studies of food provision, a high-quality RCT from New Zealand found that after providing free fruit daily for one term, fruit intakes fell below baseline levels at 6 weeks of follow-up⁽²⁹⁾, indicating lack of sustained changes in dietary behaviours over time. In another RCT of moderate quality conducted in New Zealand, a free daily school breakfast programme decreased short-term hunger but



did not impact on children's overall school performance or attendance.⁽²⁸⁾

Of eleven studies reporting on taste testing interventions, eight were found to be successful (three high and five low quality), with frequency varying between weekly^(55,57–60,62) and monthly^(56,61). Five of these interventions also included a classroom nutrition education component^(55,56,59,61,62). Of the studies that measured food consumption as an outcome,^(59–62) three reported significant improvements associated with exposure to foods through tasting. The Food Dudes programme⁽⁶⁰⁾ provided prizes as incentives and incorporated targeted foods in the school cafeteria which improved student food choices. Studies found that repeated tastings were required to impact on liking for foods, especially for vegetables. A large study from the Netherlands (*n* 877) that included five tasting sessions failed to change willingness to taste unfamiliar vegetables and consumption of target foods⁽³¹⁾.

Ten^(63–72) of the eleven studies on cooking lesson interventions resulted in successful outcomes for self-efficacy and confidence in cooking skills. Cooking programme duration varied between three lessons⁽⁶⁸⁾, four lessons^(65,72), five lessons^(67,70), eight lessons⁽⁶³⁾ and ten lessons^(64,66,69,71), with three also including classroom nutrition education^(67,69–72). Notably, the four studies that measured food consumption^(65,66,68,70) reported improvements in dietary intake following participation in cooking classes. A single study deemed not to be successful was very low quality, conducted in only twenty-three students and provided only post-test data⁽³⁷⁾.

Ten^(73–82) of the eleven multicomponent activities were successful. The Australian Vegetable Education Resource to Increase Children's Acceptance and Liking (VERTICAL) programme combined elements such as exposure to vegetables as well as role modelling. In only five 1-h sessions, children's willingness to try new vegetables significantly increased⁽⁸¹⁾. Specialised education curricula designed to be accompanied with fun activities such as the 'Top Grub', card game⁽⁷⁵⁾. Over 9 weeks, children from intervention schools in this RCT had higher mean nutrition knowledge scores and were more likely to be currently eating a healthy diet compared with those children in control schools. The edutainment factor was also shown to be effective in a single 1-h programme (Jump with Jill programme) that incorporated an active, participatory game, which applied learning through play approach. Themed or novelty approaches have been found to be effective in primary schoolchildren. The Healthy Highway® Program is an interactive, imaginative, content-based programme that teaches and reinforces essential health-related topics to *K*-5 students on healthy foods and basic nutrition with a road safety analogue. In a study that extended this theme to the school cafeteria, and coded food choices as 'healthy (green light) or unhealthy (red light)', healthy choices improved⁽⁷⁹⁾. The UK PhunkyFoods Programme allowed schools to choose which elements of the programme they wanted to deliver as part of the school

curriculum, and this flexibility was perceived by teachers to be a strong programme attribute⁽⁸²⁾. Activities could be offered within the classroom or as a club, e.g. breakfast, after-school or lunch club, and resources included a wide selection of online, interactive cross-curricular healthy eating lesson plans and a resource box comprising food models, food mats, food cards, DVD and books to facilitate teaching staff in programme delivery.

In summary, key components of experiential strategies that are useful to increase children's vegetable and fruit intake, as well as help children to develop healthy eating habits include: improving the availability of FV at school, at home, and in the community; repeated taste testing opportunities for children; family involvement in activities that promote healthy eating at home; explaining to parents the importance of role modelling good nutrition and engaging children in hands-on activities with their peers such as growing and harvesting vegetables and fruit, and cooking.

Discussion

This systematic literature review qualitatively investigated the effects of experiential nutrition programmes on primary school-aged children in relation to cognitive and behavioural outcomes. It further identified key characteristics of successful programmes that achieved significant changes in the outcomes of interest and also provided a robust evaluation thereof. Such information is useful to guide future public health interventions in this setting. Characteristics of successful experiential nutrition interventions included: (1) frequent exposure that include multiple experiences, accompanied by relevant and comprehensive classroom nutrition education; (2) incorporation of parental involvement and take-home activities; (3) presentation in a context that was relevant and appropriate; (4) multicomponent interventions that are conducted on school grounds and (3) involvement of external personnel, such as expert educators, teacher training and volunteers. Involvement of food service providers to increase exposure, availability and accessibility of healthy food options was also beneficial, whilst adequate provision of funding and resources for implementation of the programmes is paramount. Successful interventions guided by a behavioural change theory tended to be the most impactful in terms of creating changes in both the school environment and children's behaviours.

It has been established that experiential learning accompanied with cross-curricula interventions is most beneficial and effective at producing knowledge and behaviour change in young children⁽⁸⁴⁾. In relation to the behavioural changes investigated in this review, garden-based learning strategies appeared to be the most influential strategies that related to dietary outcomes, particularly increased vegetable consumption^(42–48), which has proven difficult to achieve with other interventions^(4,52). Gardening, unlike



other experiential nutrition learning styles, has been intensively investigated in recent years⁽⁸⁵⁾. Food gardens have gained recognition as not only do they teach children about growing their own foods, but evidence also suggests that when children are involved in the process of growing fruits and vegetables, they are more likely to taste and consume them^(39,86). Potential reasons for the success of the garden-based programmes may include: (1) increased accessibility to healthful foods; (2) increased exposure of children to the practice of growing foods, as these interventions are typically more time intense than others and (3) the broad range of experiences offered including planting, gardening and harvesting through to cooking and tasting opportunities. Garden-based interventions have also been shown to increase children's willingness to try new foods and their ability to cook and prepare foods⁽⁸⁷⁾. The studies also significantly improved the ability of children to identify different FV, as well as other nutritional-related knowledge^(41–49). Our findings are supportive of the recommendations of the Community Preventive Services Task Force, Centers for Disease Control and Prevention⁽⁸⁸⁾, that indicate that food garden interventions, in combination with nutrition education, are effective in increasing vegetable intake in youth.

Interestingly, of the cognitive-based outcomes investigated in this review, cooking-based activities tended to have the most significant changes on student self-efficacy through food preparation skills^(64,66,68,69) as well as improvements in their food knowledge and preferences^(63,65–67,69–71). Cooking programmes offer children a unique hands-on experience that can provide lifelong skills⁽⁸⁹⁾. These benefits are coherent with similar research on culinary interventions in other settings^(90,91).

Food provision programmes have been associated with increasing the consumption of healthy foods and generating positive attitudes towards eating breakfast⁽⁹²⁾. The studies included in this review found significant improvements in dietary intakes of healthy foods⁽⁵³⁾ including FV^(50,51,54), wholegrains^(50,54), fibre⁽⁵⁰⁾ and dairy foods⁽⁵⁴⁾. All nutrition interventions that included tasting of FV increased overall short-term FV intakes, in addition to food knowledge and preferences. However, as with food provision interventions, results were difficult to demonstrate over the longer term because most studies did not include follow-up post-intervention. Studies which incorporated tasting activities impacted food knowledge through increasing students' ability to correctly identify certain FV. Interestingly, successful studies identified that increased exposure may lead to more significant results, as reported by one study where it took eight to ten encounters before scholars reported that they 'liked' the particular food item⁽⁵⁸⁾. Food-related attitudes, choice and intake in children are largely driven by taste preferences. A review by Barends *et al.*⁽⁹³⁾ reported that repeated exposure to vegetables in the first 3 years of life increased acceptance of the target vegetable, whereas exposure to variety was found to be particularly effective in increasing acceptance of a new vegetable.

Studies included in the current review support this strategy in older children attending primary school.

Nutrition interventions aimed at improving healthy behaviours need to focus on changing the environment and societal norms⁽⁹⁴⁾. When developing nutrition programmes within primary school settings, interventions need to target the multiple facets of the environment. This requires consideration in providing as many experiences as possible in relation to skills development of growing, cooking and tasting foods. Through increasing exposure and accessibility to healthy foods, the more likely it will be to meaningfully impact health knowledge and behaviour. Some successful interventions, particularly food provision and tasting programmes, achieved this through incorporating a cafeteria component and involved food service providers^(50,60–62,67,73,74) which assisted in increasing the exposure, availability and accessibility of healthier options.

Another frequently employed strategy used within experiential interventions was the inclusion of parental involvement and education. Parental involvement in school-based programmes can strengthen the home food environment and reiterate the healthy eating messages and habits being demonstrated at school. Involvement of parents, carers and family members has been identified as an important strategy in changing food-related behaviours in primary school-aged children⁽⁹⁵⁾, but there is limited information on how best to engage parents⁽⁹⁶⁾. Studies in the current review which incorporated parental involvement included activities such as take-home produce and recipes to cook and share^(42,43,45,50,61,62,64–66), additional homework activities or challenges⁽⁵⁹⁾, parent education sessions^(50,62,67,70,74) or parental volunteering in programme supervision^(53,63,67).

A common implementation strategy used by many of the studies included in this review was the use of external educators^(41,49,53,54,59,61,63–65,67–71,73) (including nutritionists/dietitians, chefs, horticulturalists and university researchers/students) or in-depth teacher training^(43,44,48,55,56,67,70,74) to assist in the effective delivery of the programmes. It has previously been demonstrated that intervention success is dependent upon a number of factors, with high levels of teacher self-efficacy and prior knowledge related to the intervention being among the most important⁽⁹⁷⁾. While the use of external educators and experts is important for ensuring information accuracy and student engagement, this may not be feasible due to funding requirements. Similarly, longer-term interventions with a high degree of implementation are more effective at achieving knowledge and behaviour change of schoolchildren, but upscaling of programmes may not be practical⁽⁹⁸⁾.

This review did not include programmes that were totally conducted off school grounds, such as farm visits^(99,100) because it was the aim of the review to identify successful programmes that could be run by all primary schools, regardless of proximity to food production sites,



or urban/rural location. In the USA, farm visits are a primary mode of experiential school-based nutrition learning provided through the federally funded USDA Farm to School grant programme⁽¹⁰¹⁾. There is high uptake of this programme⁽¹⁰²⁾, with participation rates of 42% in some school districts and extensive evaluation thereof^(76,103–107). The definition of USDA Farm to School programmes includes garden education, local procurement for school foods and experiential learning activities in agriculture, food, health or nutrition. Our search criteria did identify some programmes that included Harvest of the Month activities and farm visits, but only if they were included as a component of a larger programme, some of which was held on school grounds^(108–114). Likewise, the review did not include programmes conducted out of school hours, many of which have been evaluated as being effective for behaviour change^(115,116).

The US nationwide Coordinated Approach to Child Health (CATCH) programme⁽¹¹⁷⁾, first developed in the late 1980s and funded by the National Heart Lung and Blood Institute, was not included in the current review because it is paired with a physical activity component, and thus did not meet the eligibility criteria. CATCH has been proven to prevent childhood obesity and is supported by 25 years of operation, with 120 academic papers indicating as much as 11% decrease in overweight and obesity^(118–122). CATCH creates behaviour change by enabling children to identify healthy foods and by increasing the amount of moderate to vigorous physical activity children engage in each day. Today, CATCH serves children in 10 000 schools and communities across the USA, from pre-K to Grade 8, as well as in after-school settings.

The main limitation that needs to be considered in the interpretation of the findings of this review is the generally low quality of the cited studies. The studies varied extensively in quality; with only eleven of the forty-two cited studies analysed in the review receiving a high-quality GRADE rating, all of which were RCT. School-based programmes are often very challenging to randomise, and it is often not ethically appropriate to do so⁽¹²³⁾.

The short study duration of many included programmes is an additional limitation. Battjes-Fries⁽¹²⁴⁾ suggests that interventions should last at least 1 year in order to result in meaningful behaviour change. The food provision programmes and food tasting studies all had large sample sizes; however, most of the gardening and cooking studies had smaller sample sizes due to the intensive nature of the interventions. The interventions also lacked continued follow-up to evaluate longer-term results.

Another limitation is the variety of different instruments used to measure outcomes, making comparison between the cited studies difficult. Food provision intervention groups were commonly measured using the validated eighteen-item food security scale⁽¹²⁵⁾, while dietary behaviour change was generally assessed using 24-h-recalls or

FFQ. Food tasting programmes largely used non-validated research instruments, which were most often designed by those running the intervention, possibly resulting in misclassification or other biases. A lack of studies from low- and middle-income countries limits generalisability to these settings. Lastly, identification of key characteristics of the interventions deemed to be successful was subjective in nature; therefore, observer bias cannot be ruled out.

Despite these limitations, this review highlights the benefits of experiential interventions and provides direction for future programmes. Vegetable intake was found to be the most difficult of dietary behaviours to change but, collectively, the cited articles suggested that experiential hands-on activities such as gardening, cooking sessions and nutrition education combined with increased exposure to tasting vegetables were the most effective strategies.

A number of key recommendations have resulted from the findings of this review:

- Use behavioural change theory to guide interventions, as these are most impactful in terms of creating changes in both the environment and children's behaviours;
- Link experiential learning opportunities to specific curriculum topics and integrate with classroom-based learning, rather being provided in isolation;
- Include a focus on influencing the home and community food environment as well as providing exposure to experiential learning opportunities during school hours;
- Incorporate family involvement and take-home activities to encourage healthy eating at home and provide role modelling of good nutrition practices;
- Involve food service providers at schools to increase exposure, availability and accessibility of healthy food options;
- When developing a school garden programme, ensure long-term commitment of at least 3 years, to allow sufficient time to impart skills, mentor across multiple growing seasons and to adequately integrate the garden into the culture of the school;
- Ensure adequate resources are available for maintenance of food gardens, including weeding, watering and harvesting, particularly during school holidays;
- Provide repeated opportunities to taste foods to encourage acceptability by children, especially for vegetables;
- Where possible, include cooking-based activities as these are the most effective interventions that impact student self-efficacy, as well as improve their food knowledge and preferences;
- Engage specialist staff, trained in horticulture and cooking to deliver interventions rather than expect classroom teachers to add gardening or food preparation to their skillset.

Conclusion

This systematic literature review has identified that experiential nutrition programmes are able to improve primary schoolchildren's nutrition knowledge, attitudes, self-efficacy



and dietary behaviours. Experiential interventions which included multiple experiences and exposures were able to show increases in children's willingness to taste unfamiliar foods, their cooking and food preparation skills, as well as increased preference, knowledge and consumption of healthier foods. Vegetable intake appeared to be the most difficult behaviour to change but was most successfully addressed with food gardening approaches. Key characteristics of successful interventions were identified as parental involvement and take-home activities, sessions taught by external experts, as well as incorporation of food service providers to increase exposure, availability and accessibility of healthy foods within the school environment. Longer-term interventions are required to investigate sustainable behaviour change in improving dietary intakes in primary schoolchildren. Feasibility of larger scale programme dissemination and teacher training is also a worthwhile investigation for future research.

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Supplementary material

For supplementary material accompanying this paper visit <https://doi.org/10.1017/S1368980020004024>

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