

Professional Development for Elementary School Teachers in Nutrition Education: A Content Synthesis of 23 Initiatives

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Objective: Although the importance of healthy eating is well known, eating patterns among school-aged children and adolescents rarely meet dietary guidelines. Schools are an effective and efficient setting for nutrition education; however, there is a dearth of research focusing on the key role of the teacher. In this study, we identified the role of professional development (PD) for elementary school teachers in delivering nutrition education programs. **Methods:** We used the results of a systematic literature search and meta-analysis to synthesize PD content reported in successful elementary school nutrition education programs (ie, ones reporting positive and significant changes in elementary school students' nutritional outcomes). **Results:** Few studies provided evidence or methodologic descriptions of teacher PD. Of the 23 nutrition education programs assessed for descriptions of teacher PD, 14 provided print and electronic information or people resources, 12 detailed who delivered the teacher PD, and 11 described the PD duration. **Conclusions:** Our findings from this content synthesis suggest that whereas teachers can make improvements in nutritional outcomes, the teacher PD component is not only underreported but also understudied. Therefore, the role of teacher PD is not widely understood, particularly the extent to which teacher PD influences teacher pedagogical practices and student nutritional outcomes.

Key words: nutrition education; teacher professional development; teacher in-service training; elementary school; healthy eating outcomes.

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Healthy eating patterns among school-aged children are important for their growth and well-being, as well as for the maintenance of a healthy weight, and providing protection against chronic disease and premature mortality.^{1,2} Moreover, childhood eating patterns affect wellbeing during adulthood.³⁻⁵ The establishment and maintenance of healthy eating patterns is particularly important during childhood, not only due to tracking of these behaviors into adulthood,

but also due to the significant physical, mental, and cognitive development that occurs, resulting in the highest nutrient requirements at any time across the lifecycle.⁶

Although the importance of healthy eating is well known, eating patterns among school-aged children and youth rarely meet Australian dietary guidelines.⁷ In 2007, an Australian national survey showed that the nutritional intake of 9-13-year-old children revealed that consumption of sodium,

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sugar, and saturated fat was higher than recommended.⁸ When focusing on core food groups recognized by the Australian Dietary guidelines (eg, fruit and vegetables, dairy, meats, fish, grains and cereals), nutritional intake did not meet the recommended servings for vegetables, fruit, and dairy,⁸ and, in the period between 1995 and 2007, vegetable intake decreased.⁹ More recently, community-based samples of Australian children from New South Wales¹⁰ and South Australia¹¹ reported that less than 1 in 10 (7% and 9%, respectively) met the recommended daily intake of 5 servings of vegetables per day, with children frequently consuming a range of discretionary foods, otherwise known as energy-dense and nutrient poor food and beverages. This suggests that more servings of core food groups, particularly vegetables, and greater dietary diversity would be preferable. These nutritional trends are prevalent worldwide, with some evidence identifying deterioration in aspects of dietary quality for children across many world regions, including low- and middle-income countries.¹²

A multitude of factors affect the development of eating patterns of school-aged children.¹³ Environmental factors, such as family eating patterns and school provisions are also known to play an important role. Schools are a popular setting for health promotion and nutrition education, as they offer continuous, intensive contact with children, and therefore, also can reach families and community members.¹⁴ The positive effects of school-based food and nutrition education programs to improve children's knowledge,¹⁴⁻¹⁸ attitudes,¹⁷⁻¹⁹ preferences,^{17,20} behavior,^{15,16,18,19} and self-efficacy^{17,21} have been reported in international literature. Furthermore, other studies have correlated nutrition, health, and academic performance among school-aged children.²²⁻²⁶ As such, schools will continue to be an effective and efficient setting for nutrition education; however, there is a dearth of research focusing on the key role of the teacher and teaching practices that leads to such positive changes in children's healthy eating outcomes.

The World Health Organization's Information Series on School Health recommends a combination of various teaching methods for students to improve their knowledge, beliefs, and skills.²⁷ Two systematic reviews and meta-analyses of teaching approaches embedded in interventions to improve healthy eating patterns in elementary and secondary

school children, respectively,^{28,29} identified experiential learning approaches (gardening, food preparation and cooking); cross-curricular approaches (linking health education with another learning area) had the greatest effects on increased knowledge, reduced energy intake, and increased intake of fruits and vegetables, compared with other teaching approaches. Other strategies that support these classroom-based approaches are engaging parents through face-to-face nutrition education sessions and assuring fidelity by training teachers to support the delivery of the intervention.^{28,29} However, little attention has focused on whether these teaching approaches have a positive effect over the long term (beyond the intervention), and ultimately, the health of children as they progress to adulthood.

The sustainability of a school-based program with positive effects on healthy eating outcomes also depends on the extent to which the teachers implement the teaching approaches in the classroom and over an extended period. Research reports that elementary school teachers often display low levels of nutritional knowledge, self-efficacy, and skills to deliver nutrition education and use appropriate classroom resources effectively.^{29,30} These barriers to implementing nutrition education programs in elementary schools may be addressed with effective continuing professional development that emphasizes how nutrition education curricula can help students, teachers, and schools meet nutritional education goals through the implementation of quality pedagogies, teaching approaches, strategies, and resources.³¹ Research on the impact of the nature and quality of elementary school teacher professional development for teaching healthy eating largely has been absent from the literature, until Dunn et al's systematic review and content analysis of K-12 classroom teacher professional development in nutrition education programs.³² In this review, the authors found that little information was provided that described the role of teacher PD in the course of delivering nutrition education in K-12 classroom-based programs. The most common elements of PD described in the literature were the time spent in PD and follow-up with instructors during or after program implementation. There was a notable lack of description of teacher PD, despite those teachers in the reviewed studies highlighting a stronger need for PD activities to support the delivery of nutrition education programs. As such, this paper builds upon

Dunn et al's review,³² by extracting PD content that focused on elementary school nutrition programs taught by classroom teachers that were deemed successful nutrition education programs, as defined by positive changes in at least one of the elementary school students' healthy eating outcomes – namely nutritional knowledge, energy intake, fruit, vegetable and/or sugar consumption. From a health, education, and economic perspective, it is important to investigate the descriptions of teacher PD that led to positive changes in elementary school students' nutritional outcomes. As such, the specific aims of this paper are to synthesize descriptions of teacher PD characteristics and supports reported in successful nutritional education programs and to identify commonalities and links between these and improvements in elementary school students' nutritional outcomes.

Content Synthesis

This content synthesis followed an established framework for comprehensive literature evaluation.³³ The lead author (LP) determined eligible articles to be included in the content synthesis. Eligible articles were empirical studies reporting on elementary school nutrition programs taught by classroom teachers that were deemed successful nutrition education programs as defined by positive and significant changes in elementary school students' nutritional knowledge, energy intake, fruit, vegetable and/or sugar consumption. Two authors (LP, TW) reviewed the eligible articles to assess how teachers were trained as part of the intervention. Articles were assessed for the following elements: (1) mentions of teacher PD, (2) PD duration (eg, length of PD provided for teachers in terms of number of sessions and time), (3) frequency of teacher PD (eg, whether it was a once-off approach or regularly scheduled throughout the nutrition education program); (4) who delivered the PD to teachers (eg, external/internal to the school); and (5) materials provided to teachers (eg, to help implement the nutrition education program). Discussions were organized at the end of this process to reach consensus on disagreements.

RESULTS

The systematic review process yielded 34 studies for final inclusion in this systematic review and

meta-analysis. Of these 34 studies, 7 had a focus on energy intake, 5 had a focus on sugar consumption, 21 looked at fruit and vegetable consumption and 13 focused on nutritional knowledge. As the focus of this paper was to report on elementary school nutrition programs taught by classroom teachers that were deemed successful, 29 of the 34 studies were included in the content synthesis. Of the 29 included, 3 made statistically significant changes to energy intake, 2 for sugar consumption, and 12 for both fruit and vegetable consumption and nutritional knowledge. However, it should be noted that 6 of these studies significantly changed more than one healthy eating outcome,^{20,34-38} and therefore, there were a total of 23 individual studies included in this content synthesis.

Study descriptions, including location, study design, sample size (schools and students), nutrition education program duration, frequency and PD approaches are given in Appendix 1. Of the 23 nutrition education programs assessed for descriptions of teacher PD, 74% (N = 17) mentioned teacher PD. Eleven nutrition education programs provided information about PD duration, with 10 outlining frequency of PD. Twelve studies described the party or source delivering the PD for teachers. Several interventions provided information via print, electronic, or people resources (N = 14; 61%) that were delivered to teachers during the PD to enhance the implementation of the nutrition education program. These resources were given to teachers to enhance the delivery of the intervention and could have included student work material for the classroom. Two of the studies reported collection of process data,^{20,34} but only one of these studies²⁰ reported on teacher satisfaction levels with PD delivery, resources, and implementation of the nutrition education program. Overall, descriptions of PD elements were minimal in most interventions. Only one intervention included descriptions of all PD elements,³⁵ with only an additional 3 studies^{36,38,39} including a mention of all but one of the PD elements. It is notable to mention that these 4 studies^{34,36,38,39} were of the 6 studies that had a statistically significant impact on more than one healthy eating outcome for elementary school students.

The most reported PD feature were the resources provided to teachers to help support the delivery of the nutrition education program (N = 14;

61%). However, there was a diversity of resources used, depending on the nutrition education program. Resources ranged from technical support, people support (eg, university students, researchers, parents), curriculum and programming resources, school garden seeds and equipment, greater provision of water, fruits and vegetables provided to school, marketing material for schools, and a show presented by children's role models. Delivery of PD was the second most mentioned element of teacher PD, with researchers, special resource teachers, and department- or government-funded curriculum teachers delivering the teacher PD. The important information relating to the duration and frequency of the PD sessions was reported in less than half of the studies (N = 10-11), with 4 of these studies^{38,40-42} clearly outlining that the PD was a one-time session of only a couple of hours before the intervention. This shows that most studies reporting on duration and frequency utilised at least 2 PD sessions of various lengths before and/or during the implementation of the nutrition education program.

Although few studies provided evidence or descriptions of teacher PD, several offered suggestions for improving programs: (1) engaging elementary schools teachers in continuous or on-going PD; (2) collecting process evaluation data including teacher PD, fidelity to the program curriculum, curriculum delivery, use of program materials, and program attendance; and (3) designing a curriculum that aligns with educational standards, outcomes and frameworks such as the health promoting skills approach.

DISCUSSION

This content synthesis presents nutrition education literature published in peer-reviewed and scholarly journals focusing on information about teacher PD in elementary school-based nutrition education programs. Therefore, the aim was to describe teacher PD used in school-based interventions and identify which characteristics are common among studies that reported statistically significant, positive changes in healthy eating outcomes. Specifically, this review investigated the duration, frequency of training received, the characteristics of who delivered the PD, the resources used to support PD, teacher delivery of the nutrition education program, and teacher satisfaction. Despite many elementary school-based nutrition

education interventions using classroom teachers as partners or sole deliverers in implementing the intervention, the PD approach and strategies that are designed to enhance elementary school teachers' delivery is not comprehensively reported. The most reported PD characteristic was resources. As mentioned previously, resources ranged from technical support, people support (eg, university students, researchers, parents), curriculum and programming resources, school garden seeds and equipment, greater provision of water, fruit and vegetables provided to school, marketing material for schools, and a show presented by children's role models. Although it may be argued that these should not be considered as part of teacher PD and support delivery of nutrition education to students, due to low levels of elementary school teachers' nutritional knowledge, self-efficacy, and skills to deliver nutrition education effectively,^{29,30} these resources should be considered as part of a comprehensive PD program. In addition, further consideration should be given to spending time with teachers to ensure that they are capable, competent, and confident in accessing, using and evaluating these resources over an extended period of time to ensure that elementary school teachers are able to deliver nutrition education programs as intended to determine good practice and to improve the design and delivery of elementary school nutrition education programs.

Due to the low reporting of all the other PD features and characteristics, it is not possible to determine the extent of the influence that teacher PD had on students' healthy eating outcomes. This is an important finding, as it shows that future studies in this area should report extensive teacher PD descriptions to enable us to have a better understanding of the role of teachers in such interventions. It also will present opportunities for researchers or practitioners to design replicable or evidence-based interventions.

Another major shortfall cited in this review and content synthesis is that only 2 of the school-based interventions included teacher satisfaction measures or process evaluations, despite international recommendations for school-based nutrition programs to do so.⁴⁵ Teachers have a major influence over the adoption and implementation of nutrition education programs in schools; therefore, it is es-

sential to determine the impact of interventions on teacher-level outcomes. Whereas there is general agreement that no single approach to teacher PD is effective for all teachers all of the time,⁴⁶ maintaining face to-face contact and providing teachers with opportunities to discuss implementation progress is essential in achieving intervention and teacher satisfaction outcomes. In addition, teachers engage more with PD material when they perceive it to be practical and 'hands on', relevant, and applicable, and provide ideas and practices they can use in the classroom.⁴⁶ As recommended in the papers that presented these interventions, ongoing support through structured PD can ensure the design and content of the program are constantly evolving to meet the specific needs of the teachers and school community and ensure teacher satisfaction for sustainability goals; however, this needs to be assessed more rigorously for elementary school teachers and nutrition education programs.

The content synthesis has several strengths and limitations. The studies included here represent the most comprehensive published elementary school nutrition education literature with details of teacher PD to date. Despite this, information about teacher PD remains minimal, and studies include little about the PD program, teacher involvement in PD, frequency, duration, material covered, resources provided, and teacher satisfaction with the PD and program delivery. A major limitation of this study is that elements of teacher PD can be assessed only to the extent that they are reported in the original research. It could be possible that the teacher PD in these studies was inadequately reported, rather than inadequately conducted, and thus, the actual quality of the teacher PD may have been underestimated. This highlights the need for a consistent approach to teacher PD design, delivery, and reporting so we can evaluate the intervention and impact on student-level outcomes. Furthermore, it is difficult to determine evidence-based approaches to effective teacher PD from this literature as teacher PD for elementary school nutrition education interventions have not been linked to outcomes for teachers, and even though this review and content synthesis was linked to positive changes to student healthy eating outcomes, there was not enough detail provided to determine effective teacher PD components. Although this is a limitation for the present review, it presents a major limi-

tation for the broader body of elementary school nutrition education literature.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

The World Health Organization's Information Series on School Health recommends a combination of various teaching methods for students to improve their knowledge, beliefs, and skills. When focusing on nutrition education, there is research focusing on the key role of the elementary school teacher and the teaching practices that leads to positive changes in children's healthy eating outcomes. However, there is much less research focusing on the PD needed to provide elementary school teachers with the knowledge, skills, and values to implement these teaching practices over a sustainable period.

The findings of this content synthesis suggest that although elementary school teachers are capable of making improvements in students' nutritional outcomes, the teacher PD component that may or may not have influenced the teachers' teaching practices and improvements in students' nutritional outcomes, is not only underreported but is understudied. This presents a major issue for researchers, practitioners, and policymakers in terms of funding, designing, and implementing replicable or evidence-based nutritional programs with appropriate teacher PD.

Future studies in this area should report extensive teacher PD descriptions to enable policymakers, researchers, and practitioners to improve their understanding of the role of teachers in nutritional programs and interventions. Future studies also should examine teacher PD in successful nutrition education programs with high levels of teacher satisfaction and fidelity. Doing so likely will lead to robust discussions of successful nutritional education programs for elementary teachers and students that can reach and attain outcomes of an extended period.

Human Subjects Approval Statement

As a content analysis of the literature, the Institutional Review Board of the University of Sydney declared this research to have an exempt status.

Conflict of Interest Disclosure Statement

The authors report no conflict of interest.

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Appendix 1
Study Descriptions, Including Location, Study Design, Sample Size (School and Student),
Nutrition Education Program Duration, Frequency, and Professional Development Approaches

Author, date, program	Location	Study Design	Sample Size (school, students)	Nutrition education program duration and frequency	Professional development duration	Professional development frequency	Delivery of Professional development by external or internal party	Materials provided (print, electronic, people)	Measurement of teacher satisfaction
Energy intake									
Simons-Morton, 1991 ⁴⁷	US	Randomized controlled trial	Sample size NR, children in elementary school from K-4.	A total of 6 classroom education sessions (Go For Health Curriculum) were provided and cafeteria food was provided to school children, modified to be lower sodium and fat, modeled on the New School Lunch program.	NR	NR	Teachers and food service staff in the school were trained by Go For Health research staff	Training, consultation and technical support provided to schoolteachers and food service staff.	NR
Maniós, 2002 ⁴⁸	Crete, Greece	Experimental	4171 students in grade 1	Spanning 6 years, the intervention consisted of annual sessions (13-17 hours total) of nutrition education based on the health profile component of the American Health Foundation's Know Your Body school health promotion program.	NR	NR	Researchers conducted the training sessions for school staff. Dietitians closely monitored the implementation of the intervention.	Materials provided to school staff NR. Members of the research team periodically visited the intervention schools to provide support and assist in delivery of the intervention.	NR

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Appendix 1 (cont.)

Author, date, program	Location	Study Design	Sample Size (school, students)	Nutrition education program duration and frequency	Professional development duration	Professional development frequency	Delivery of Professional development by external or internal party	Materials provided (print, electronic, people)	Measurement of teacher satisfaction
Liquori, 1998⁴⁹	New York, NY, US	Quasi-experimental	590 students in grades K-6	5-month program consisting of a 13-day rotating cycle that repeated 6 times. Experiential activities included classroom cooking activities, taking 17 class trips to a local community garden and 10 lessons that help children make connections between food, health, and the environment.	After-school, 3-hour sessions provided.	2 sessions for instructors provided in total.	Cookshop instructors provided education sessions to classroom teachers, university students and parents.	First activities included reviewing the curriculum guide, discussing Cookshop activities, preparing and tasting Cookshop recipes. At a later date, follow up activities included discussing the experience of conducting cooking classes, experiential learning and teamwork in the classroom setting.	NR
Fruit and Vegetable consumption									
Struempfer, 2014³⁴	Alabama, US	Quasi-Experimental	2477 students in grade 3	For 17 weeks, students tasted a rotating selection of fruits and vegetables that were included in the School Lunch Program. They also took part in a Body Quest nutrition curriculum and iPad app education.	NR	NR	NR	NR	NR

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Appendix 1 (cont.)

Author, date, program	Location	Study Design	Sample Size (school, students)	Nutrition education program duration and frequency	Professional development duration	Professional development frequency	Delivery of Professional development by external or internal party	Materials provided (print, electronic, people)	Measurement of teacher satisfaction
Day, 2008⁵⁰	British Columbia, Canada	Controlled trial	444 children in grades 4-5	A 12-week intervention integrated classroom learning, environmental change strategies, and a family/community component to promote the consumption of fruits and vegetables.	1-1/2 hours of training provided	NR	NR	Schools were provided with a menu of classroom activities and implementation tools.	NR
Prelip, 2012⁴⁰	Los Angeles, CA, US	Quasi-experimental pretest/post-test design	399 low-income children in grades 3-5	Network Los-Angeles Unified School District nutrition program to increase nutrition knowledge, with interactive activities to increase positive attitudes towards fruits and vegetables	Teachers in the study condition completed 10 hours of nutrition education. In the first quarter, the 2 training workshops, the first was 1 hour conducted as professional development and the second was 90 minutes in duration.	In the 2 training workshops, the first was 1 hour conducted as professional development and the second was 90 minutes in duration.	Teacher training workshops were delivered by Network Los Angeles Unified School District, 5-A-Day PowerPlay! representatives and Dairy Council representative.	Teachers were taught how to integrate nutrition lessons into the curriculum and classroom including the Harvest of the Month program, and were provided with 5-A-Day PowerPlay! And Dairy Council materials.	NR
Gortmaker, 1999³⁹	Baltimore, MD, US	Quasi-experimental	2103 children in grades 4 and 5	2 year intervention taught in class by teachers, based on the EatWell and Keep Moving Program, aiming to increase consumption of	1 day of teacher training and 2 staff wellbeing meetings and if administering a Food and Activity	Annual training provided for the 1 day of teacher training and staff wellbeing meetings.	NR	Teachers provided with Eat Well and Keep Moving Program banners, cups for a "Get 3-at-School & 5-a-Day" competition and	NR

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				fruits and vegetables.	Survey, teachers completed a 1 hour training session beforehand. Interviewers who completed 24 hour dietary recalls from students completed a 3 day training session and 15 practice interviews before entering the field.			completed hands on practice of lessons for the classroom.	
Gatto, 2017⁵¹	Los Angeles, CA US	Randomized controlled trial	375 students in grades 4 and 5	12 week nutrition, gardening and cooking intervention with weekly 90 minute sessions	NR	NR, only reported as “several sessions”	NR, only reported as “train the trainer” sessions.	NR, only reported that schools were provided with educational resources and supplies	NR
Cooke, 2011⁵²	United Kingdom	Controlled trial	422 children aged between 4 and 6 years.	Intervention conducted for 3 weeks, with children receiving daily sessions spanning 12 sessions	NR	NR	NR	NR	NR
Auld, 1998⁵³	Colorado, US	Quasi-experimental	647 students in Grades 2-4.	16 weekly, experiential, behavior-change-oriented lessons, taught in alternate weeks	The teachers’ intervention consisted primarily of SKIT role modeling	Bi-weekly, plus teachers also participated in professional	Professional development was provided for participating teachers by	All lessons incorporated preparing or eating food, knowledge of	NR

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				by the classroom teacher and SRT (special resource teacher), and 6 parent taught lunchroom activities.	and support during the intervention (16 weeks). On alternate weeks (every second week), the SRT guided the classroom teacher on delivery of the lessons and provided materials and food, but was not present when the teacher conducted the lesson.	development, which provided more structured nutrition information, a rationale for nutrition education, and hands-on activities to further self-efficacy and skill building.	researchers and special resource teachers.	the Food Pyramid, and targeting a fruit or vegetable consumption behavior. Lessons supported other classroom disciplines (math, science, literacy, and social studies) because of teachers' greater willingness to accept such lessons when classroom time for nutrition alone could not be justified	NR
Amaro, 2006³⁶	Italy	Two-group design (treatment and control) with pre- and post-assessment	241 children aged 11–14 years	The intervention group participated ever week in one play session of Kalèdo, a board-game (15–30 min) for 24 weeks.	NR	NR	Instructions were provided for participating teachers by researchers. E.g., Teachers were instructed to select different partners each week Extra play sessions took place between children that were absent.	Kalèdo, the board game. Other PD resources NR.	NR

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Rosario, 2016 ³⁷	Portugal	Cluster, randomized control trial	464 children in grades 1-4	2 school terms where trained teachers conducted classroom activities to increase nutrition knowledge, then a dietary recall was conducted.	72 hour workshop and 12 sessions within a 6-month period, each session lasting 3 hours. Individual meetings with teachers were also held just prior to the intervention being conducted.	12 sessions in a 6-month period	Researchers conducted the training sessions.	NR	NR
Fahlman, 2008 ¹⁵	Michigan, US	Quasi-experimental	783 middle school students	Over the course of 1 months, students were taught about the contents and benefits of the food groups, eating based on the food groups, reading food labels, body image, and surviving fast food restaurants and the school cafeteria.	8 hours	Once	Training provided by Michigan Model Nutrition Curriculum instructors	The in-service was based on the middle school book "What's Food Got to Do With It?"	NR
McAleese, 2007 ³⁸	Idaho, US	Quasi-experimental	99 students in grade 6 aged 10-13 years	12 weeks during which students completed 3x24 hour recall workbooks, participated in a school garden project and cooked foods produced from the garden.	NR	NR	NR	NR	NR

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Horne, 2004⁵⁴	London, UK	Quasi-experimental	749 children aged 5-11 years.	For 5 months, students were provided with fruits and vegetables at lunchtime as snacks at school. Older students also watched a series of videos called "The Food Dudes".	NR	NR	NR	NR	NR
Nutritional knowledge									
Campbell, 2012⁵⁵	British Columbia, Canada	Cluster randomized control trial	873 students from K-7	21 peer to peer instructions were provided in a school year, where older students were paired with younger, to instruct them for 45 minutes to promote healthy eating, through the "Healthy Buddies" program.	1 day work-shop	Once	NR	NR	NR
Baranowski, 2000⁵¹	US	Randomized controlled intervention trial.	1732 children in grades 2-3	6 weeks, with 12 sessions of the "Gimme 5" program, lasting 45 to 55 minutes per session.	A one day, 6-hour work-shop provided as in-service training.	Annually	Trained teachers	NR	NR

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Lakshman, 2010 ²	Cambridgeshire, UK	Randomized control trial	2519 children aged 9–11 years	9 weeks during the summer term of a school year, where students played a card game “Top Grub” as often as possible including a minimum period of weekend play at home.	NR	NR	NR	NR	NR
Fahlman, 2008 ⁵	Michigan, US	Quasi-experimental	783 middle school students	Over the course of 1 month, students were taught about the contents and benefits of the food groups, eating based on the food groups, reading food labels, body image, and surviving fast food restaurants and the school cafeteria	8 hours	Once	Training provided by Michigan Model Nutrition Curriculum instructors	The in-service was based on the middle school book “What’s Food Got to Do With It?”	NR
Friel, 1999 ⁵⁶	Ireland	Quasi-experimental	821 schoolchildren aged 8–10 years	20 sessions over 10 weeks	NR	NR	Professional development was provided for participating teachers by researchers.	Program materials entitled “Hearty Heart and Friends” were developed around a group of extraterrestrial cartoon characters based on the American	NR

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								<p>Hearty Heart model. The resource materials consisted of lesson plans, activity worksheets for pupils, a home team pack to involve parents and the food diaries.</p>	
Prelip, 2012⁴⁰	Los Angeles, CA, US	Quasi-experimental pretest/post-test research design	399 low-income grade 3-5 students	At least 10 hours of nutrition education per quarter in 1 school year.	<p>The first teacher training workshop was a one-hour training session. The second workshop was an additional 90-minute training session that informed teachers how best to use the HOM (Harvest of the Month) program with students, how to do tasting and sampling, and how to integrate nutrition lessons into the classroom curriculum.</p>	<p>Teachers attended 2 workshops. Teachers of grades 3, 4, and 5 received training on how to implement HOM in the classroom and use the Dairy Council materials. Teachers of grades 4 and 5 also received training in the 5-A-Day PowerPlay! program.</p>	<p>Professional development for teachers was provided by external Network- LAUSD, 5-A-Day PowerPlay! and Dairy Council representatives.</p>	<p>Participating teachers committed to using 3 standardized nutrition education curricula: HOM program (introduce new F&V each month), the Dairy Council of California (focus on food groups) and 5-A-Day PowerPlay! (encourage 3-5 cups of F&V per day).</p>	NR

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Francis, 2010 ⁵⁷	Sangre Grande, north-east Trinidad	RCT	579 Grade 6 students	The intervention was conducted for one month, with one lesson each week.	NR	NR	Professional development was provided for participating teachers by researchers.	Teachers who volunteered underwent extensive training geared at standardization of measurement, and delivery and evaluation of the content of the various modules, but details of these NR.	On the issues of quality of course material, clarity of delivery of course material, course content, quality of activities, reported student impression of the course material and overall opinion of the study unit, teachers and principals in the intervention schools gave ratings of very good (or “5” which was the highest rating on a 5 point Likert scale.
Auld, 1998 ⁵³	Colorado, US	Quasi-experimental	647 students in Grades 2-4.	16 weekly, experiential, behavior change-oriented lessons, taught in alternate weeks by the classroom teacher and SRT (special resource teacher), and 6 parents taught lunchroom activities.	The teachers’ intervention consisted primarily of SRT role modeling and support during the intervention (16 weeks). On alternate weeks (every second week) the SRT guided the	Bi-weekly, plus teachers also participated in professional development, which provided more structured nutrition information, a rationale for nutrition	Professional development was provided for participating teachers by researchers and special resource teachers.	All lessons incorporated preparing or eating food, knowledge of the Food Pyramid, and targeting a fruit or vegetable consumption behavior. Lessons supported other classroom	NR

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Amaro, 2006 ³⁶	Italy	Two-group design (treatment and control) with pre- and post-assessment	241 children aged 11–14 years	The intervention group participated every week in one play session of Kalédo, a board-game (15–30 min) for 24 weeks.	classroom teacher on delivery of the lessons and provided materials and food, but was not present when the teacher conducted the lesson.	education, and hands-on activities to further self-efficacy and skill building.	Instructions were provided for participating teachers by researchers. E.g., Teachers were instructed to select different partners each week. Extra-play sessions took place between children that were absent.	Kalédo, the board game. Other PD resources NR.	NR
Morgan, 2010 ²⁰	Newcastle, Australia	Quasi-experimental	127 students in Grades 5 and 6 (11–12 years old).	The intervention was a 10-week program (3x1 hour NE lessons in the classroom) plus planting and tending of a school garden. The gardening intervention	NR	NR	Professional development was provided for teachers by researchers for the nutrition education (NE) component but details NR, other than a meeting with	The researchers identified previously used curricula identified in other studies and modified them for the Australian context and worked with	NR

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				involved the class spending approximately 45 min in the garden 4 times a week.			teachers to discuss cross-curriculum integration. A representative from the organization, Slow Foods Hunter (NSW), was involved in the study and attended preliminary meetings with teachers to provide advice regarding the nature of garden-based activities, maintenance of the garden and provision of some garden-related educational resources.	teachers to develop an integrated unit of work called "How do you grow?" Teachers also accessed lesson ideas from their personal teaching resources. The gardening component of the intervention included seeds, planting, and maintenance support.	
Anderson, 2005⁸⁸	Dundee, Scotland	RCT	128 students aged 8-11 years.	Intervention was 9 months in duration.	NR	Teacher information sessions (delivered in school assemblies, training sessions and classroom presentations). Suggests frequency but number not given.	NR	The intervention program provided increased provision of F&V in schools (tuck shops and school lunches), tasting opportunities, a range of point-of-purchase marketing (posters and quizzes), and	NR

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Liquori, 1998 ⁴⁹	New York, US	Quasi-experimental, pre/post intervention-comparison group design	590 Grades K-6 students	10 lessons across 10 weeks; lessons approximately 45 minutes in length.	Cookshop (CS) intervention instructors were organized into 20 teaching teams, each including a classroom teacher, one or 2 university students, and a parent. Professional development helped classroom teachers and	There were 2x3 hr after school professional development sessions. The first session took place 2 weeks prior to the intervention. Activities at this training included reviewing the curriculum	Teachers, university students and parents delivered the intervention curriculum. CS Program was developed in the Central Harlem community of New York City. The Community Food Resource Center (CFRC), a non-profit advocacy agency, functioned as the	The CS curriculum resources included: university students, parents, and cooking experiences of 60-90 minutes.	Process data was collected but NR.
								newsletters for children and parents. Curriculum materials at age 6-7 and 10-11 years (largely focusing on practical food preparation and tasting, promoted through hands-on activities, written work, videos, self-monitoring materials and story books) were also utilized.	

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				other instructors become comfortable with the CS intervention with 2 after-school training sessions.	guide, discussing CS activities, and preparing and tasting several CS recipes. The second session took place after the instructors had taught 3 CS lessons. At this training, the team members discussed their first-hand experiences with the joys and pitfalls of cooking, experiential learning, and teamwork in the classroom setting.		lead organization in a collaborative network that linked the schools with agency resources and community participants in the design and implementation of this nutrition intervention.		
Sugar consumption									
Van de Gaar, 2014⁵⁹	Rotterdam, Netherlands	Controlled trial	1288 children aged 6-12 years	1 school year.	NR	NR	The intervention was developed by the local government using health promotion tools – intervention mapping – in combination with social marketing. NR if the local government research team	Water campaign consists of lessons at school combined with integrated community activities that promote water consumption in various ways including PE lessons, provision of free water	NR

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Note.
NR = Not reported