Lead Article

Factors that contribute to effective nutrition education interventions in children: a systematic review

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Context: *Establishing healthy dietary practices at an early age is crucial, as dietary behaviors in childhood track to adulthood.* ***Objective:*** *The purpose of this systematic review was to identify factors associated with successful nutrition education interventions conducted in children and published between 2009 and 2016.* ***Data Sources:*** *Using the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) guidelines, relevant studies were identified through the PubMed, Web of Science, ScienceDirect, and ERIC (Educational Resources Information Center) databases.* ***Study Selection:*** *Studies published in English between 2009 and 2016 that included a nutrition education intervention among children aged 2 to 19 years were included. Review articles, abstracts, qualitative or cross-sectional studies, and studies targeting children with special nutritional needs were excluded.* ***Data Extraction:*** *Four authors screened and determined the quality of the studies using the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) system and extracted the data from the articles.* ***Data Analysis:*** *Forty-one studies were included: 7 targeted preschool children, 26 targeted elementary school children, and 8 targeted secondary school children. A total of 46% met their primary objectives of nutrition education intervention, while the rest either partially achieved or did not achieve their stated objectives.* ***Results:*** *Successful interventions targeting school children engaged parents by means of face-to-face sessions, identified specific behaviors to be modified, and assured fidelity by training teachers or recruiting trained experts to deliver the intervention. In addition, they allowed adequate dosage, with an intervention duration of at least 6 months, and used age-appropriate activities.* ***Conclusions:*** *Interventions with a multicomponent approach that were age appropriate and of adequate duration ($\geq$ 6 months), that engaged parents, and that ensured fidelity and proper alignment between the stated objectives, the intervention, and the desired outcomes were more likely to succeed.*

INTRODUCTION

Development and growth during childhood, which sets the trajectory for lifelong health, is heavily influenced by nutritional intake.[1] A balanced and nutrient-dense diet provides children with essential nutrients for optimal growth and development, while diets with imbalanced or inadequate nutrients may lead to insufficient

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nutrient intake or overweight, which affects health and performance in childhood as well as in adulthood.[1] More importantly, children's dietary practices and behaviors may track to adulthood, potentially influencing health status during adulthood.[2,3] Therefore, it is important to establish healthy dietary practices and behaviors at an early age, which in turn may lead to optimal growth and development and healthier dietary choices later in life.[3]

Contento[4] defined nutrition education as "any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food- and nutrition-related behaviors conducive to health and well-being." Nutrition education is a critical component in the development of healthy eating practices and behaviors,[5] as it enhances the knowledge and skills children need to make healthful dietary choices.[6–8] For example, a nutrition education intervention study by Dunton et al[6] among primary school children showed significant improvement in children's knowledge and intake of fruit and vegetables as well as decreased consumption of soda and high-energy foods post intervention. Similarly, a properly designed nutrition education program has the potential to enhance motivation and preference for eating healthful food and to facilitate the implementation of appropriate dietary practices.[8,9] In addition, healthy dietary practices are associated with improved academic performance.[10,11] For example, after attending the nutrition education intervention EatFit, which aimed to increase the frequency and quality of morning meals, the consumption of iron-rich food, and the level of physical activity, school-aged children showed significantly improved academic performance, specifically in mathematics and English.[10]

Despite convincing evidence that nutrition education has the potential to influence children's dietary choices, improve health, and enhance academic performance, the specific characteristics of effective nutrition education programs for children are not clearly defined.[12–14] Effectiveness of nutrition education for children is further complicated by the wide variance in age, physical growth, and cognitive development during childhood, which ranges from preschool age to high school age. For example, the approaches needed to capture the cognitive capability and attention span of preschool children are different from those needed for elementary or high school children.[15–18] Active parental participation might be key for effective nutrition education for one age group, but not the other.[19,20] It is therefore critical to identify the aspects of nutrition education that are essential for each age group and to differentiate those that are essential for all categories. The purpose of this systematic review is to identify the characteristics associated with successful nutrition education interventions in children, as evidenced by the achievement of stated objectives in 3 different age groups: preschool children, elementary school children, and secondary school students. This review followed the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) guidelines.[21]

METHODS

Age categorization of children

Building on the work of a prior systematic review on factors that contribute to successful intervention in nutrition education for adults,[22] this review aims to identify factors associated with successful nutrition education interventions among children. To account for the wide range in the age (2–19 years) and cognitive development of children, the review and the subsequent analysis were based on developmental stages categorized into preschool, elementary, and secondary school children in order to identify key strategies associated with successful interventions in the context of each age category.

Research team

The research team consisted of 6 members. The lead investigator and 5 graduate students conducted the search, screened the articles for quality and relevance on basis of the established criteria, and extracted information on a spreadsheet. Authors independently analyzed the findings and identified the factors that characterized successful interventions. Afterward, results were discussed and a consensus was reached.

Literature search strategy

This review followed the recommendations and criteria established in the PRISMA statement (see Appendix S1 in the Supporting Information online).[21] Articles published between 2009 and 2016 were obtained from electronic searches of 4 databases, namely PubMed, Web of Science, Science Direct, and ERIC (Education Resources Information Center) from 2009 to 2016. Keywords entered in varying combinations included "nutrition education," "nutrition education intervention," "children," and "dietary behavior."

Inclusion and exclusion criteria

Research articles were evaluated using the PICOS (Population, Intervention, Comparators, Outcome, and Study design) model (Table 1).[21] The following

Table 1 **PICOS criteria for inclusion and exclusion of studies**[a]

Category	Inclusion	Exclusion
Participants	Children aged 2–19 y, alone or accompanied by parents and/or teachers and/or those who prepared meals	Children aged < 2 y; children with special nutritional needs; parents or caregivers only; teachers only; those who prepared meals only
Intervention	Face-to-face nutrition education interventions	Online nutrition education interventions
Comparator	With or without control group; nutrition education intervention only, physical activity intervention only; similar intervention	None
Outcomes	Nutrition-related outcomes such as anthropometric measurements (eg, body mass index, waist circumference, etc); biochemical measurements (eg, glycemia, lipid profile, etc); dietary intakes, knowledge, preferences, attitudes, behaviors, self-efficacy; cultural nutrition awareness factor; dietary diversity score; physical activity (time, attitudes, behaviors); or food and beverage availability at schools	No nutrition-related outcomes; outcomes measured only in children with pre-existing medical conditions
Study design	Randomized controlled trials, pre-post design quasi-experimental studies English language Published from 2009 to December 2016	Meta-analyses and systematic reviews; reviews; qualitative studies; cross-sectional studies; abstracts; gray literature; book chapters

[a]Elaborated according to the description of PICOS criteria as provided by Liberati et al (2009).[21]

inclusion criteria were applied: (1) studies were published between 2009 and 2016, (2) publications were available in English, and (3) articles described nutrition education interventions conducted among children aged 2 to 19 years. The following were excluded: (1) review articles, abstracts, or qualitative or cross-sectional studies, (2) studies targeting populations with special nutritional needs (eg, hospitalized children), (3) nutrition education interventions targeting caregivers or parents exclusively, and (4) publications based on the same data set used in an already-included study, in which case only the most recently published study was included. After the initial abstract screening, articles selected were divided between 4 trained research team members who evaluated whether articles met the inclusion criteria and determined the quality of each study. The lead investigator systematically trained the research team about the methods of systematic review, step by step.

A total of 351 original studies published between 2009 and 2016 on nutrition education interventions in children without preexisting medical conditions were evaluated. Of the 351 studies evaluated, 303 (86%) did not meet the inclusion criteria (Figure 1[21]). For the purposes of this systematic review, 48 studies qualified for inclusion.

Assessment of study quality and risk of bias

To minimize bias, reviewing authors were trained to assess quality on the basis of PRISMA recommendations,[21] and 2 authors independently assessed each included article. After the initial assessment, the reviewing authors exchanged the articles without sharing the results of assessment. In addition, all authors discussed each article as a group and either confirmed or added to the findings of the 2 reviewing authors. The group made the final decision on whether to include or exclude each article, and a quality score for each study was assigned by the 2 reviewing authors.

Determination of the quality of the studies was guided by the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) system of rating the quality of evidence.[23] A thorough assessment of the study's description, design, measurements, data analysis, interpretation of results, and power and outcomes formed the basis for quality assessment. Each factor scored 0 points if the article lacked a complete description of the factor analyzed or 1 point if the article provided a complete description of such factor. The quality score was calculated by summing all the component scores. Studies were rated and categorized as having low risk of bias (5–6 points), moderate risk of bias (3–4 points), or high risk of bias (1–2 points). Once the 2 reviewing authors established the scores, the 4 research members and the leader of the research team discussed any discrepancies until consensus was reached. Of the 48 studies that met the inclusion criteria, 7 articles categorized as having a high risk of bias were excluded from this review (Figure 1[21]).

Approach to analysis

Reviewing authors independently extracted data from 41 published articles and transferred them to a spreadsheet for analysis. Table 2,[3,8,24–47] Table 3,[48–55] and

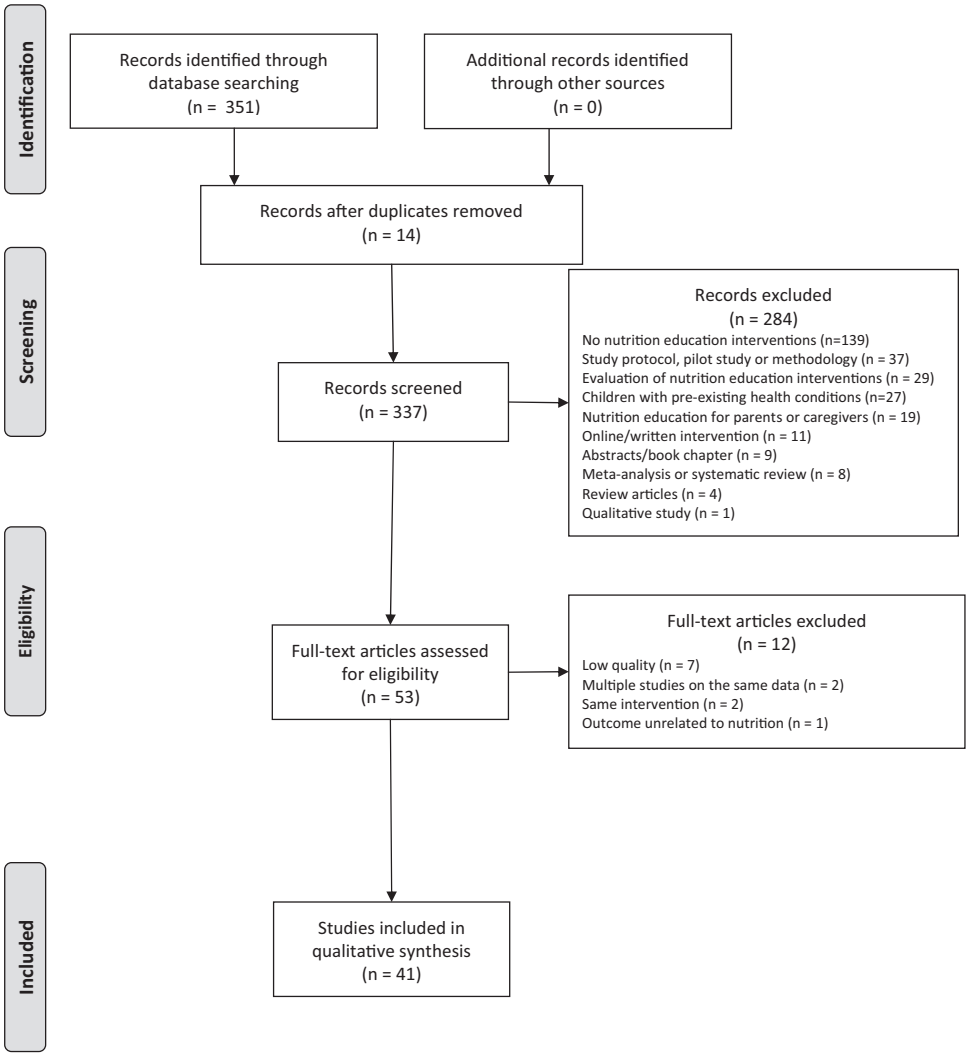

Figure 1 **Flow diagram of the literature search process.**

Table 4[56–62] summarize key information from the analyzed studies. The primary analytic goal was to determine the overall effectiveness of nutrition education interventions in modifying dietary and physical activity behaviors in children and adolescents aged 2 to 19 years. To determine whether an intervention was successful, the outcome of the study was compared with the stated purpose or objectives of the study. Once a study was classified as achieving its intended purpose on the basis of the results, the following contributing factors were analyzed: (1) study design; (2) type of intervention and activities implemented; (3) duration and dosage of the intervention; (4) number of objectives in the study; (5) fidelity in implementing the intervention; and (6) use of theory in directing the study. These factors were identified through systematic review of the 41 published nutrition education interventions. The duration of intervention was categorized as short if the study had a cumulative duration of less than 5 months. The duration was considered long if a study lasted for a total of 5 months or more. This classification of duration was deemed appropriate on the basis of the descriptions used by the authors of the original studies. It is noteworthy that the included studies rarely reported the dosage and frequency of the intervention. Therefore, it was reasonable to report the total amount of time spent in intervention in months. Fidelity as a factor in this systematic review was assessed on the basis of (1) the authors' declaration in the limitation section and (2) the description of who conducted the intervention and how the intervention was implemented.

A semiquantitative approach was used to summarize the findings from nutrition education interventions. Results from nutrition education interventions were dichotomized on the basis of whether they reported a statistically significant ($P < 0.05$) improvement in dietary intakes, physical activity, or other related risk factors for obesity and diet-related chronic

Table 2 **Nutrition education interventions at the elementary school level**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Battjes-Fries et al. (2015)[24]	1183 children in grades 5–8	To assess the effect of the Dutch school-based education program Taste Lessons on children's behavioral determinants toward tasting unfamiliar foods and eating a variety of healthy foods	Quasi-experimental	One school year (2011–2012). Teachers implemented lessons in a flexible way	No theory	Partially achieved	Moderate	There were no significant differences between IG and CG in expected positive taste or willingness to taste unfamiliar foods at either follow-up measurement. At the first follow-up, participants in IG showed a significantly higher positive change in knowledge than those in CG ($P < 0.01$). This remained significant at the second follow-up ($P < 0.05$) Children in grades 5 and 6 from IG showed a significant change in number of foods tasted and a significantly higher positive change in subjective norm of their parents at the first follow-up ($P < 0.05$)
Cunningham-Sabo & Lohse (2013)[25]	237 children in 4th grade	To assess the effect of CWK on students' FV preferences, cooking attitude, and cooking self-efficacy in a mostly non-Hispanic white sample that assured no previous CWK exposure	RCT	10 wk total, with a 1-h introductory lesson, three 2-h cooking classes, and three 1-h FV tasting sessions (10 h total)	No theory	Achieved	Moderate	Fruit preferences significantly increased in IG from baseline to follow-up ($P = 0.012$). Within IG, fruit preferences were greater in those with preintervention cooking experience at both baseline and follow-up ($P < 0.05$) Vegetable preferences were significantly higher in IG than in CG at follow-up ($P = 0.001$) The IG showed significantly greater improvement in cooking attitudes than the CG ($P = 0.02$)
Francis et al. (2010)[26]	579 children in 6th grade	To evaluate the effectiveness of a short-term, school-based, multicomponent education intervention on improving the knowledge, attitudes, and behavior of primary school children toward better dietary and activity habits	RCT	1 mo (frequency not mentioned)	Bloom's mastery learning model	Partially achieved	Moderate	There was a significant change in the proportion of students in IG reporting fruit consumption levels of $\geq$2 servings a day ($P < 0.01$). The proportion of students in IG reporting vegetable consumption within the past 24 h significantly increased from baseline to postintervention assessment ($P < 0.01$). Students in IG showed significant changes in their knowledge scores vs those in CG ($P < 0.01$). There was a significant decline in reported fried food intake in IG from baseline to post intervention ($P < 0.01$). The proportion of students reporting regular PA at least 3 times per week significantly increased in IG ($P < 0.01$)

(continued)

Table 2 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Gallotta et al. (2016)[27]	230 children aged 8–11 y	To assess the effect of a 5-mo PE and NE intervention on body composition, PA level, time spent on sedentary activities, and eating habits of primary school children	Cluster RCT	5 mo total. NE administrated once per month. Fruit or vegetable provided once per week. 1-h PA session administered twice per week	No theory	Partially achieved	Low	Weekly PA level significantly increased after the intervention in the 2 IGs ($P < 0.0001$). Sedentary time significantly decreased in children in all groups, from 565.7 to 492.1 min/wk ($P < 0.0001$). There was a significant increase in consumption (times per week) of vegetables (3.97 vs 4.29, $P < 0.05$) and fruits (4.30 vs 4.85, $P < 0.05$) post intervention. Consumption of bread significantly decreased post intervention in children with normal fat (4.72 times/wk vs 4.08 times/wk, $P < 0.05$), while the consumption of snacks significantly decreased post intervention in both children with normal fat (3.20 times/wk vs 1.94 times/wk) and in obese children (3.07 times/wk vs 2.24 times/wk)
Gibbs et al. (2013)[28]	764 children in grades 3–6	To evaluate the achievement of the SAKG Program in increasing children's appreciation of diverse, healthy foods	Pre-post	2.5 y total, with 45–60 min of gardening class and 90 min of kitchen class administered every week	SEM and principles of effective health promotion	Achieved	Moderate	At follow-up, after adjusting for baseline and grade, children showed a significant increase in willingness to try new foods if they had never tried it (OR = 1.95; 95%CI, 1.06–3.58; $P = 0.03$), if they had cooked it (OR = 2.37; 95%CI, 1.45–3.90; $P = 0.001$), and if they had grown it (OR = 2.25; 95%CI, 1.47–3.47; $P < 0.001$)
Herbert et al. (2013)[29]	104 children aged 7–11 y	To evaluate the effectiveness of the Energize program for changing dietary and PA habits compared with a CG of children not participating in the program	Quasi-experimental	1-h weekly session for 12 wk	SCT, TRA, and HBM	Partially achieved	Low	There was a significant difference between groups in the post-test score for consumption of french fries and chips after controlling for the pre-test score ($P = 0.044$). The Energize group consumed significantly less french fries and chips compared with the CG. A marginally significant ($P < 0.10$) increase in vegetable consumption was detected for the Energize group as compared with the CG over time ($P = 0.068$). PA habits were not significantly different between the Energize and CG groups at post-test follow-up ($P > 0.05$)

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Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Katz et al. (2011)[30]	1180 children aged 7–9 y, grades 2–4	To enhance the ability of both students and their parents to distinguish more healthful from less healthful options among a wide variety of food choices	RCT	Five 20-min lessons	SEM	Partially achieved	Low	Nutrition knowledge in both students and the parents of students in IG improved significantly (18.1% ± 26.9%; $P < 0.01$; and 7.9% ± 19.9%; $P < 0.01$) compared with baseline. No statistically significant improvements observed in dietary patterns from baseline between the IG and CG of both students and parents in terms of calories, protein, total fat, carbohydrates, iron, saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, sodium, or folate intake
Keihner et al. (2011)[31]	1154 children aged 8–12 y	To encourage children to eat the recommended amount of FVs and get at least 60 min of PA daily in order to promote healthful growth, development, and academic achievement	RCT	One 50-min lesson per week for 8 wk	Resiliency Theory and SCT	Achieved	Low	Children in IG were significantly more likely than those in CG to improve their knowledge about the total number of daily servings of FVs ($P < 0.05$) and the number of daily servings of vegetables needed for good health ($P < 0.001$), as well as the vitamin C obtained from eating FVs ($P < 0.05$). In both 4th and 5th grades, children in IG showed improvements in FV asking and shopping self-efficacy ($P = 0.04$) and in FV eating self-efficacy ($P < 0.001$). They were significantly more likely than CG children to improve their knowledge about the number of minutes of PA needed daily for good health ($P < 0.001$) and the health benefits of PA ($P < 0.01$)

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Table 2 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Kipping et al. (2014)[32]	2242 children aged 9–10 y	To investigate the effectiveness of a school-based intervention to increase PA, reduce sedentary behavior, and increase FV consumption in children	Cluster RCT	16 lessons over a period of 6–7 mo. Teachers implemented lessons in a flexible way	SCT	Not achieved	Moderate	None of the 3 primary outcomes (time spent per day in MVPA, time spent in sedentary behavior, and servings of FVs) differed between children in schools allocated to IG and those allocated to CG. The intervention was effective for 3 of 9 secondary outcomes after multiple testing was taken into account: self-reported time spent in screen viewing on weekends (−21 min/d [95%CI, −37 to −4; $P = 0.01$]), self-reported servings of snacks (−0.22/d [95%CI, −038 to −0.05; $P = 0.01$]), and servings of high-energy drinks (−0.26/d [95%CI, −0.43 to −0.10; $P = 0.002$]) were all reduced
Kristjansdottir et al. (2010)[33]	265 children aged 7–9 y	To increase FV intake in the IG by at least 20%	Pre-post	2 y (frequency not mentioned)	No theory	Achieved	Moderate	At follow-up, intakes of raw vegetables ($P < 0.001$), cooked vegetables ($P < 0.05$), and total vegetables ($P < 0.001$) and total intake of FVs ($P < 0.05$) and fish ($P < 0.001$) were higher in IG compared with CG, and intake of candy was lower ($P < 0.05$). Percentage of energy from MUFAs ($P = 0.029$) and the intakes of fiber ($P = 0.013$), potassium ($P = 0.005$), magnesium ($P = 0.012$), copper ($P = 0.035$), and β-carotene increased significantly in IG compared with CG, and increase in vitamin C intake was of borderline significance ($P = 0.056$)
Mittman et al. (2016)[34]	1376 children and adolescents aged 7–14 y	To investigate the effects of the Cancer Society of Lower Saxony's school-based NE program "5-a-Day for kids," designed to increase children's FV consumption	Pre-post	135 min for 1 time	No theory	Not achieved	Low	No steady increase could be observed for intake of FVs throughout the day, neither at follow-up 1 nor at follow-up 2. In contrast, intakes of vegetables and fruit juice, as well as total intake of fruit/vegetables/juice, showed a significant decline between baseline and follow-up 1 and between baseline and follow-up 2. Only fruit consumption rose temporarily between baseline and follow-up 2, though not significantly

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Table 2 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Morgan et al. (2010)[35]	127 children aged 11–12 y	To measure the effects of a garden-based NE program on FV knowledge, willingness to taste, food preferences, and perceived quality of school life in upper primary school children vs in a control group	Quasi-experimental	Three 1-h NE sessions over 10 wk and one 45-min session 4 times per week	SCT	Partially achieved	Moderate	Students in NE&G and NE groups were significantly more willing to taste vegetables and rated the tastes more highly than did students in CG ($P < 0.001$). There was a significant difference ($P = 0.02$) in FV knowledge between NE&G group and CG, but only among those students who started with lower FV knowledge. For willingness to taste, there was a significant between-group difference for 4 vegetables: capsicum ($P = 0.04$), broccoli ($P = 0.01$), tomatoes ($P < 0.001$), and peas ($P = 0.02$), with NE&G students being significantly more willing to taste these than students in NE group or CG
Moss et al. (2013)[36]	65 children in 3rd grade	To introduce the CATCH nutrition curriculum and Farm to School program to assess nutrition knowledge of 3rd-grade students, and increase their FV consumption behavior	Quasi-experimental	Two 30-min NE lessons and a 2-h farm tour over a 4-wk period	SEM	Partially achieved	Moderate	Significant differences in knowledge of fiber were found ($P < 0.001$). Differences in knowledge of vitamins and minerals, reported vegetable consumption behavior at school, and farm exposure were also significant ($P < 0.05$). No significant relationships were found between self-reported FV consumption and participation in the farm tour
Muros et al. (2015)[37]	134 children aged 10–11 y	To investigate the effects of 4 experimental conditions and 1 CG on health-related parameters, such as the lipid, physiological, and anthropometric profiles of children	Pre-post	6-mo intervention, with 60-min sessions of PA twice a week, 2 1-h NE classes for children, and 6 2-h NE classes for parents	No theory	Achieved	Low	Students in groups receiving PA reduced their fat percentage ($P \leq 0.05$) and increased their muscle mass post intervention ($P \leq 0.05$). The lipid profile improved in all IGs post intervention. The proportion of macronutrients and dietary cholesterol improved ($P \leq 0.001$) in groups receiving NE. The post-test comparison showed significantly lower fat percentage, sum of skinfolds, waist circumference, and PA in NE group relative to CG

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Table 2 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Parmer et al. (2009)[38]	115 children in 2nd grade	To examine the effects of a school garden on children's FV knowledge, preference, and consumption	Pre-post	28 wk, with a biweekly 1-h sessions of NE and biweekly 1-h sessions of gardening	No theory	Achieved	Low	Participants in NE&G and NE groups exhibited significantly greater improvements in nutrition knowledge and taste ratings than those in CG ($P \leq 0.001$). Moreover, NE&G group was more likely to choose and consume vegetables in a lunchroom setting post assessment than either the NE group or the CG ($P \leq 0.01$)
Prelip et al. (2012)[8]	399 children aged 9–11 y	To assess the impact of a multicomponent NE program on student knowledge, attitudes, and behaviors related to consumption of FVs	Quasi-experimental	One school year. Teachers had freedom to develop their own lesson plans but were required to complete at least 10 h over a 3-mo period	SCT and TPB	Partially achieved	Moderate	The intervention with 4 components (program, nutrition curriculum, teacher training, and parent workshop) resulted in a positive change in knowledge ($P < 0.05$) and in attitudes and beliefs toward vegetables ($P < 0.01$). There were significant effects of teacher influence on students' FVs attitudes in both the intervention with 4 components and the intervention with 2 components (program and teacher's training) ($P < 0.05$). However, there was no significant increase in students' FV consumption
Rosário et al. (2012)[39]	464 children in grades 1–4	To assess the impact of a 6-mo nutrition program, delivered and taught by classroom teachers with in-service nutrition training, on prevention of overweight and obesity among children in grades 1–4	RCT	Twelve 3-h NE sessions over a 6-mo period	HPM and SCT	Partially achieved	Moderate	In IG, the increase in BMI *z* score was significantly lower than that in CG ($P = 0.009$); fewer proportion of children became overweight in IG vs CG (5.6% vs 18.4%; $P = 0.037$). Significantly fewer children in IG (5.6%) than in CG (18.4%) became overweight after the intervention. After controlling for confounders, the predicted odds of overweight incidence were 75% lower for IG (OR = 0.25; 95%CI, 0.07–0.92; $P < 0.05$)

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Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Rosi et al. (2016)[40]	8165 children in grades 3–5	To improve nutritional knowledge of children participating to the Giocampus Program	Pre-post	Three 3-h NE classes over 2 academic years	No theory	Achieved	Moderate	Children's nutritional knowledge significantly increased ($P < 0.001$) in all school grades. The integrated "learning through playing" approach, which included educational figures, tools, and games, was successful in improving children's nutritional knowledge
Safdie et al. (2013)[41]	830 children in grades 4–5	To evaluate the effectiveness of an ecologically based program aimed at promoting healthy eating and PA in selected Mexico City schools to optimize to overall energy balance in childhood as a strategy for obesity prevention	RCT	18-mo intervention (frequency not mentioned)	No theory	Partially achieved	Low	In intervention schools, availability of healthy foods increased with a concomitant decrease in availability of unhealthy foods ($P < 0.05$). Food intake showed the same trend, but the difference was not statistically significant. In intervention schools, children did not engage in more MVPA during PE class or recess but increased their number of steps taken
Saraf et al. (2015)[42]	2384 children in grades 6–7	To assess the effectiveness of a multicomponent school-based intervention in improving knowledge and behavioral practices related to diet, PA, and tobacco use in middle school children of rural Ballabgarh, North India	RCT	45-min NE sessions and a 20-min flip-chart demonstration over a 9-mo period. Frequency not mentioned	No theory	Achieved	Low	Knowledge about PA, diet, and tobacco improved significantly ($P < 0.05$) in IG vs CG. Proportion of students attending PT classes for $\geq$5 d/wk increased significantly (17.8%; $P < 0.01$) in IG vs CG. Proportion of students consuming fruits increased (10%; $P < 0.01$) in IG vs CG. Pre-post decrease in prevalence of current smoking was significantly greater (7.7%; $P < 0.01$) in IG vs CG

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Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Sevinç et al. (2011)[43]	6771 children and adolescents aged 7–13 y	To (1) determine the effect of applying both PA and healthy nutrition programs vs a healthy nutrition program only for preventing obesity in primary school students in Denizli, Turkey; (2) to determine the relationship of this effect with possible variables; and (3) to construct an obesity-control program aimed at the students	RCT	8-mo intervention. 3-h PE sessions per week plus NE program for students, parents, and teachers. Frequency and duration of NE session not mentioned	No theory	Achieved	Low	Increase in BMI between the 2 measurements was 0.51 $\pm$ 0.98 in the CG, which was significantly ($P = 0.000$) higher than that in both the intervention 1 (0.37 $\pm$ 1.08) and the intervention 2 (0.35 $\pm$ 1.13) groups. However, there was no significant difference between the intervention groups When each group was compared, there was a significantly lower BMI increase in males (0.25 $\pm$ 0.90) vs females (0.48 $\pm$ 1.21) in IG 1 ($P = 0.000$)
Shah et al. (2010)[44]	3128 children and adolescents aged 8–18 y	To assess the impact of a controlled educative intervention on health- and nutrition-related knowledge and behavior of urban Asian Indian children and adolescents	Pre-post	Weekly 60-min lesson over a 6-mo period	No theory	Achieved	Low	After the intervention, knowledge and behavior scores improved in all children except 15- to 18-year-olds from private schools ($P < 0.001$). A significantly higher improvement in knowledge and behavior was observed in younger children (aged 8–11 y) vs those aged 12–18 y, in females vs males, and in government schools vs private schools ($P < 0.05$ for all)
Steyn et al. (2015)[45]	998 children in grades 4–6	To promote healthy eating habits and regular PA in learners, parents, and educators and to promote the development of a school environment that would foster a healthy lifestyle via an HK intervention	RCT	3-y intervention. Frequency not mentioned	No theory	Not achieved	Moderate	The intervention effect was not significant in consumption of food items (fried potato chips, fried food, pies, potato crisps, take-away foods, processed meat, table sugar, chocolate, sweets, cakes/biscuits, squashes/cordials) at follow-up 1 or at follow-up 2. Moreover, in intervention schools, there was a >10% increase in children who consumed potato crisps, processed meat, sweets, and carbonated beverages between 2009 and 2011. The mean DDS for intervention schools increased from 4.56 in 2009 to 5.03 in 2010 to 4.91 in 2011. There were no significant intervention effects at either of the 2 time points (2009, 2011) for DDS, fat intake score, and sugar intake score

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Table 2 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
Toruner et al. (2015)[46]	1105 children in grades 3–7	To evaluate the effectiveness of a school-based healthy life program on healthy life habits (eating breakfast and exercising), knowledge, BMI, and blood pressure	RCT	Four 40-min sessions over a 6-mo period	No theory	Partially achieved	Moderate	Neither before nor after the program was there any statistically significant difference found within or between the IG and the CG with respect to daily meals, eating breakfast, and time spent in front of a television or personal computer ($P>0.05$). The percentage of children who reported daily exercise duration as $\geq$1 h increased from 58.8% to 67.8% ($P=0.006$) Post-test knowledge scores of IG children significantly increased from 21.98 to 24.27 ($P=0.001$). No statistically significant ($P>0.05$) difference was observed in the initial or the final BMI or in the blood pressure of IG children
Wall et al. (2012)[47]	2231 children in 4th grade	To assess impact of a classroom-based, standardized intervention to address limited vegetable consumption	Pre-post	3–5 wk	No theory	Achieved	Moderate	Students in IG improved in vegetable-related attitude, self-efficacy, preference, and knowledge scores ($P<0.001$)
Zhou et al. (2013)[3]	1023 children in grades 5–8	To assess the effectiveness of a school-based nutrition and food-safety education program among primary school and junior high school students in China. The assessment focused on change in scores for nutrition and food safety knowledge, attitude, and practices (KAP) at pre-post intervention and at 9-mo follow-up	Pre-post	50-min sessions. Neither total duration of intervention nor frequency of sessions was mentioned	No theory	Partially achieved	Moderate	Nutrition knowledge scores of students in IG increased significantly, from a mean of 9.03 points before the intervention to 14.70 points immediately after the intervention ($P<0.01$). The long-term knowledge score in IG was 12.35, which was lower than the score immediately after the intervention ($P<0.01$) but higher than the baseline score ($P<0.01$) and higher than the baseline and long-term scores in CG ($P<0.01$) There was a statistically significant difference between scores immediately after interventions and long-term scores in terms of having unhealthy food preferences and picky eating habits ($P<0.05$) Food safety scores of the IG post intervention were higher ($P<0.01$) than those of the CG both preintervention and at 9-mo follow-up

Abbreviations: BMI, body mass index; CATCH, Coordinated Approach to Child Health; CG, control group; CWK, Cooking with Kids; DDS, dietary diversity score; HBM, Health Belief Model; HK, Healthy Kick; HPM, Health Promotion Model; IG, intervention group; FV, fruit and vegetable; MUFAs, monounsaturated fatty acids; MVPA, moderate to vigorous physical activity; NE, nutrition education; NE&G, nutrition education and gardening; OR, odds ratio; PA, physical activity; PE, physical education; PT, physical training; RCT, randomized control trial; SAKG, Stephanie Alexander Kitchen Garden; SCT, Social Cognitive Theory; SEM, Socio-Ecological Model; TPB, Theory of Planned Behavior; TRA, Theory of Reasoned Action.

Table 3 **Nutrition education interventions at the secondary school level**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/construct	Achievement of objectives	Risk of bias	Major findings
Campos Pastor et al. (2012)[48]	263 children and adolescents aged 12–16 y	To assess the repercussion of an NE program on anthropometric variables, eating habits, and metabolic syndrome components in adolescents	Pre-post	45-min session every 2 wk for a school year	No theory	Achieved	Moderate	At end of school year, the percentage of male and female adolescents with overweight or obesity in IG was significantly lower (overweight from 31.5% to 21.3% in males and 21.7% to 14% in females ($P < 0.001$); obesity from 7.9% to 5.5% in males and 4.7% to 3.9% in females ($P < 0.001$). Percentage of students with biochemical data suggestive of metabolic syndrome was significantly lower (32.2% vs 19.7%, $P < 0.001$)
Dehdari et al. (2014)[49]	100 girls aged 13 y	To examine the effect of an NE intervention based on Pender's HPM in improving the frequency and nutrient content of breakfast among female Iranian students	Quasi-experimental	Weekly 60-min session for 4 wk	Pender's HPM	Achieved	Moderate	IG reported a significant increase ($P < 0.05$) in perceived benefit, self-efficacy, positive activity-related effect, interpersonal influences, situational influences, commitment to a plan of action, and weekly frequency of breakfast consumption compared with CG. There were significant reductions ($P < 0.05$) in immediate competing demands and preferences, perceived barriers, and negative activity-related effect constructs in IG compared with CG
Maatoug et al. (2015)[50]	4003 children and adolescents aged 11–16 y	To evaluate the effectiveness of Schools in Health, a school-based PA and nutritional behavior intervention, in reducing rates of overweight and obesity among school children in Sousse, Tunisia	Quasi-experimental	On the majority of the days, school children leaders motivated their peers to adopt healthy eating behaviors One PA session and 1 session to promote a healthy diet; frequency of sessions was not mentioned Duration of each session was not mentioned Total duration of intervention was 3 y	No theory	Partially achieved	Low	There was no significant change in the BMI of IG, while the percentage of obese school children in CG increased significantly, from 4.5% to 6.9% ($P < 0.001$). Percentage of children who consumed recommended amounts of FVs increased significantly, from 30% to 33.2% in IG ($P = 0.03$), while it decreased significantly in CG, from 40.2% to 35.0% ($P = 0.001$) In the IG, there was a significant decrease in school children who completed the recommended amount of PA, dropping from 29.1% to 25.5% ($P = 0.01$)

(continued)

Table 3 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/construct	Achievement of objectives	Risk of bias	Major findings
Murimi et al. (2015)[51]	233 children and adolescents aged 11–19 y	To examine the effects of a school-based point-of-testing counseling and NE intervention on age- and gender-specific BMI percentile, blood lipid profile, and blood pressure among students in grades 6–12 in a rural community and to examine changes in students' nutrition knowledge over a 3-y period	Longitudinal	Each student received a weekly 1-h counseling session for 12 wk Total duration of intervention: 3 y	No theory	Partially achieved	Moderate	High-density lipoprotein levels significantly increased between the 2nd and 4th visits ($P < 0.05$). Participants who attended the intervention at least 4 times showed stabilized or improved blood values and anthropometric measurements. Significant increases in nutrition knowledge were documented for students in grades 7 and 8 but not for those in other grades ($P < 0.01$)
Rani et al. (2013)[52]	181 adolescents in grades 8–9	To assess the knowledge and practices of high school students with respect to healthy diets before and after an NE program	Pre-post	Weekly 1-h session for 10 wk	HBM	Partially achieved	Moderate	Following the NE program, satisfactory dietary knowledge significantly improved from 37% to 67% ($P < 0.001$). Similarly, students showing a positive attitude toward healthy diet increased from 18% to 40% ($P < 0.001$) Proportion of students choosing soft drinks declined from 20% to 10% ($P < 0.01$), and consumption of fast food items through fast food restaurants declined significantly
Singhal et al. (2010)[53]	510 adolescents aged 15–17 y	To assess the effectiveness of a school-based low-cost nutrition and lifestyle education intervention on behavior modification and risk profile of Asian Indian adolescents in a metropolitan city in North India	RCT	Weekly 30-min NE session for 10 wk 30-min PA session 5 times per week for 8 wk Weekly 1-h individual counseling session Monthly 7-min counseling session for parents and monthly 1-h training session for volunteer students from the 11th grade Total duration of intervention: 9 mo	No theory	Achieved	Low	Significant increase seen in proportion of IG having knowledge of the following: simple and complex carbohydrates ($P = 0.003$), concept of empty calories ($P < 0.001$), sources and adverse effects of *trans* fats ($P < 0.001$), high-fat milk products ($P = 0.002$), refined cereals ($P = 0.003$), importance of fiber in the diet ($P = 0.02$), and causes and types of diabetes ($P < 0.001$). Significantly lower proportion of IG consumed aerated drinks ($P < 0.001$) and energy-dense unhealthy foods such as burgers, pizzas, and french fries at follow-up ($P = 0.03$). Significant decrease in mean waist circumference ($P = 0.02$), sagittal abdominal diameter ($P < 0.001$), waist-to-hip ratio ($P = 0.02$), and fasting blood glucose ($P = 0.05$) in IG compared with CG

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Table 3 **Continued**

Reference	Study sample	Objective of intervention	Study design	Length and frequency of intervention	Behavioral theory/construct	Achievement of objectives	Risk of bias	Major findings
Somsri et al. (2016)[54]	131 adolescents aged 16 y	To examine and compare the effectiveness of a CCBNEd program and an HCBNEd program on the promotion of FV consumption	Quasi-experimental	Weekly 50-min NE session for 4 wk	SCT	Achieved	Low	FV-related knowledge scores increased significantly ($P < 0.001$) in all 3 groups post test Attitude toward FV consumption improved significantly, from 70 to 82 points in CCBNEd and from 72 to 74 points in HCBNEd ($P < 0.01$). Post test, an increase in eating FVs was observed in CCBNEd. Amounts of FVs consumed increased significantly ($P < 0.001$) in CCBNEd, 3-fold (from 40 g to 120 g) for fruit and 2-fold (from 65 g to 123 g) for vegetables, compared with baseline values
Viggiano et al. (2014)[55]	3110 children and adolescents aged 9–19 y	To confirm the effectiveness of Kaledo (a board game) in improving nutrition knowledge and in promoting long-term healthy dietary behavior in a large cohort study	Cluster RCT	Weekly 30-min session for 20 wk	No theory	Achieved	Moderate	At first postintervention assessment (6 mo), IG had significantly higher scores than CG (14.4 vs 10.9, $P < 0.001$) on AFHC In addition, there was a significant difference between IG and CG in mean values of nutritional knowledge adjusted for score at baseline (6.5 vs 4.6, $P < 0.001$). At the same assessment, for the section "healthy and unhealthy diet and food," there was a significant difference between IG and the CG in mean values adjusted for score at baseline (11.2 vs 10.4, $P < 0.001$). There was a significantly higher moderator effect difference between IG and CG in high schools (11.8 vs 10.4, $P = 0.023$) compared with middle schools (10.7 vs 10.9, $P = 0.571$)

Abbreviations: AFHC, Adolescent Food Habit Checklist; BMI, body mass index; CCBNEd, Cosmetic Content-Based Nutrition Education; CG, control group; FV, fruit and vegetable; HCBNEd, Health Content-Based Nutrition Education; HBM, Health Belief Model; HPM, Health Promotion Model; IG, intervention group; NE, nutrition education; PA, physical activity; RCT, randomized controlled trial; SCT, Social Cognitive Theory.

Table 4 **Nutrition education interventions at the preschool level**

References	Study sample	Objective of nutrition education	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
De Bock et al. (2012)[56]	377 children aged 3–6 y	To assess the effects of a preschool-based nutritional intervention on both behavioral outcomes, such as children's FV and water consumption, and anthropometric measures	Cluster randomized	15 sessions, 2 h each, over a 6-mo period	Pandura's social learning theory and Zajonc's exposure effect	Partially achieved	Moderate	Significant change from baseline in FV intake ($P < 0.05$ and $P < 0.01$): mean increase from baseline of 0.17 point on the 6-point ordinal scale ($P < 0.05$) for fruit consumption frequency and 0.22 point ($P < 0.01$) for vegetable consumption frequency. Intervention had no significant effect on daily water intake, consumption of high-energy drinks, BMI, waist-to-height ratio, or total body fat
Gao et al. (2016)[57]	1819 preschool children aged 4–6 y	To examine the effect of NE on children's breakfast patterns	RCT	Monthly lecture and activities for 8 mo (2 semesters in a kindergarten)	Cognitive Behavioral Change Theory	Achieved	Moderate	At end of intervention, significant difference between IG and CG in frequency of eating breakfast ($P = 0.02$) At end of study, children in IG chose more nutrient-dense foods for breakfast compared with children in CG, who chose more energy-dense foods according to the nutrition label on the food ($P < 0.001$) Quantity of food consumed at breakfast increased significantly in IG but decreased in CG ($P < 0.001$)
Hoffman et al. (2011)[58]	297 children in kindergarten and 1st grade	To examine the effects of a multicomponent, theory-based, 2.5-y intervention on children's FV consumption, FV preferences, FV knowledge, and BMI	Randomized, multiyear intervention	Daily or most of the days during the school year	SCT and SLT	Partially achieved	Moderate	In year 1, children in IG consumed 22 more grams (1.5 tbsp) of fruit and 7 more grams (1.5 tsp) of vegetable per lunch ($P < 0.0001$ and $P < 0.005$, respectively) compared with children in CG In year 2, IG consumed 15 more grams (1 tbsp) of fruit and 3 more grams (0.5 tsp) of vegetables per lunch ($P < 0.0005$ and $P < 0.05$, respectively) compared with children in CG In year 3 and follow-up, IG did not consume more fruit than CG ($P < 0.05$) In year 3, IG consumed 3 more grams of vegetables than CG ($P < 0.05$) Children in IG scored about 0.5 to 0.66 of a point higher for knowledge than children in CG at each point of data collection. Experimental minus control knowledge score at year 1: 0.49; at year

(continued)

Table 4 **Continued**

References	Study sample	Objective of nutrition education	Study design	Length and frequency of intervention	Behavioral theory/ construct	Achievement of objectives	Risk of bias	Major findings
								2: 0.51; at year 3: 0.67; and at follow-up: 0.49 ($P < 0.05$)
Hu et al. (2010)[59]	1819 children aged 4–6 y	To evaluate the impact of NE in kindergartens and to promote healthy dietary habits in children	RCT	Once monthly for 8 mo	No theory	Partially achieved	Low	Post intervention, significant differences between IG and CG for unhealthy snacks (31.7% vs 41.8%), monotonous diet (16.8% vs 18.7%), adult assistance during meals (9.5% vs 12.5%), playing during dinner (17.5% vs 25.2%), and watching television during dinner (19.3% vs 17.8%) ($P < 0.05$) Healthy lifestyle behavior, such as eating breakfast (91.0% at baseline to 92.3% after the intervention) and taking part in outdoor activities (62.5% at baseline to 63.0% after the intervention), improved markedly in IG ($P < 0.05$). Mean scores for nutritional knowledge among IG parents rose significantly from pre test (10.5 points) to post test (11.9 points) ($P < 0.0001$)
Lerner-Geva et al. (2015)[60]	204 children aged 4–6 y	To assess the effectiveness of an intervention program to improve kindergarten children's eating and leisure habits in Israel	Cluster RCT with 3 groups: full intervention (NE plus PA), intervention (only NE), and CG	One lesson per week for 10 wk	No theory	Partially achieved	Moderate	Significant association between level of nutritional knowledge and age ($P < 0.01$). In the initial analysis adjusted for baseline measures, significant reduction in daily energy intake was seen in entire IG with entire intervention (NE and PA), from 5239 kJ at baseline to 4709 kJ at follow-up ($P = 0.03$). Group with intervention (only NE) significantly increased nutritional knowledge ($P = 0.03$). No changes in BMI, time spent watching television or playing computer games, exercise, and sleep observed after the intervention
Peñalvo et al. (2013)[61]	2062 children aged 3–5 y	To evaluate the efficacy of the Program SI! in improving indicators of the acquisition of healthy behaviors in children aged 3–5 y	Cluster RCT	During 1 academic year: 20 h of instruction per program component (diet, PA, and human body) and 10 h of instruction for managing emotions	SCT and trans-theoretical models in health promotion	Partially achieved	Low	After 1 school year, the intervention increased children's knowledge, attitudes, and habits scores, both overall (3.45; 95%CI, 1.84–5.05) and component specific (diet: 0.93; 95%CI, 0.12–1.75; PA: 1.93; 95%CI, 1.17–2.69; human body: 0.65; 95%CI: 0.07–1.24) score. However, no effect on the school environment or on overall scores for parents or teachers was found

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Table 4 **Continued**

References	Study sample	Objective of nutrition education	Study design	Length and frequency of intervention	Behavioral theory/construct	Achievement of objectives	Risk of bias	Major findings
Witt & Dunn (2012)[62]	263 preschool children aged 4–5 y	To determine whether CMH, an interactive nutrition and PA program for preschool children, increases FV consumption	Intervention study with IG and CG	Weekly sessions of 15–30 min for 6 wk	No theory	Achieved	Moderate	Children who received CMH significantly increased their consumption of fruit snacks by approximately 20.8% ($P < 0.001$) and their consumption of vegetable snacks by approximately 33.1% ($P < 0.01$) between baseline assessment and the assessment conducted 3 mo after completion of CMH program

Abbreviations: BMI, body mass index; CG, control group; CMH, Color Me Healthy; FV, fruit and vegetable; IG, intervention group; NE, nutrition education; PA, physical activity; RCT, randomized controlled trial; SCT, Social Cognitive Theory; SLT, Social Learning Theory; tbsp, tablespoon; tsp, teaspoon.

diseases. This approach was used to allow for the diverse range of reported statistics, outcomes, and measurement units.[63]

RESULTS

A total of 41 studies describing nutrition education interventions focused on children and published between 2009 and 2016 were assessed for their effectiveness on the basis of reported evidence that the interventions met their stated primary research objectives. A majority of the studies (73%; n = 30) were conducted outside the United States, while slightly more than one-fourth of the studies (27%; n = 11) were conducted within the United States. Most of the studies (63%; n = 26) targeted elementary school children (Table 2), while 8 (20%) targeted secondary school children (Table 3) and 7 (17%) targeted preschool children (Table 4).

A total of 19 studies (46%) met their primary research objectives, as evidenced by their reported results, while another 19 studies (46%) partially met their stated objectives and 3 studies (7%) did not meet their stated objectives. Seventeen of the 41 studies were informed by theory but were not theory driven. There was no convincing difference between the studies that used theory as compared with those that did not use theory.

Successful nutrition education interventions in elementary schools

Successful interventions targeting elementary school children engaged parents by means of face-to-face sessions, identified specific behaviors to be modified, and assured fidelity by training teachers or recruiting trained experts to deliver the intervention. In addition, they allowed adequate dosage, with an intervention duration of at least 6 months, and used age-appropriate activities.

Parental engagement. Although engaging parents in the interventions was a common factor in both successful and unsuccessful interventions, half of the successful interventions engaged parents on a face-to-face basis instead of simply sending information to parents.[28,33,37,42–44] For example, Muros et al[37] conducted 6 nutrition classes for parents in addition to the activities provided for children in the 3 groups that received nutrition education (nutrition education, nutrition education plus physical activity, and nutrition education plus physical activity plus provision of 2 L of extra virgin olive oil per week so that parents could substitute olive oil for the usual oil consumed). After the intervention, the children's cholesterol intake was

significantly decreased in all 3 groups ($P = 0.000$, $P = 0.001$, and $P = 0.000$, respectively), bringing the cholesterol values closer to the stated recommendations of less than 300 mg/d. In contrast, studies that engaged parents remotely by providing websites, assigning homework, or sending written materials such as newsletters did not report achieving their objectives.[24,27,32,35] For example, the study by Morgan et al[35] provided 3 series of newsletters that focused on the health benefits of eating fruits and vegetables and included strategies for increasing fruit and vegetable intake at home. This intervention did not succeed in increasing either vegetable or fruit consumption ($P = 0.22$ and $P = 0.23$, respectively). Similarly, 8 (57%) of the studies that targeted elementary school students but did not engage parents at all were not successful in achieving their objectives.[3,29,34,36,39,41,45,46] For example, Moss et al[36] conducted an intervention that aimed to increase knowledge and consumption of fruit and vegetables among 3rd-grade students. They reported improved knowledge of fiber ($P < 0.001$) and vitamins and minerals ($P < 0.05$), but they did not find a significant change in consumption of fruit and vegetables.

Specific and measurable behavioral outcomes. Similarly, identification of a specific desired behavioral outcome was critical in achieving stated objectives.[25,28,31,33,37,38,40,43,44,47] For example, Kristjansdottir et al[33] aimed to increase fruit and vegetable intake in the intervention group by at least 20%. Participants in this study increased their intake of fruits and vegetables by 54%. Other common behavioral outcomes identified were to improve fruit and vegetable preferences[25,28,38]; to increase knowledge about nutrition[38,42,44] and physical activity[31,42,44]; and to improve health-related parameters such as physiological and/or anthropometric measurements.[42,43] In contrast, interventions designed with broad goals that were not specific to a behavior were not successful in achieving their objectives.[24,27,29,30,35,39,41,45,46] For instance, the intervention by Steyn et al[45] aimed to promote physical activity and healthy eating habits among the participants. Although dietary diversity increased, physical activity and fruit and vegetable consumption did not. The intervention was not specific to the desired behavioral outcomes of increased physical activity and improved eating habits.

Fidelity of interventions. The importance of implementing the interventions as intended by using a standardized protocol to ensure fidelity was critical among successful interventions targeting elementary school children. Successful interventions either trained existing teachers or engaged nutrition experts in the implementation of the intervention.[26,28,33,37,38,40,42–44,47] For example, in the study by Cunningham-Sabo and Lohse,[25] food educators received for 30 hours of training to teach cooking and tasting lessons for the intervention. This study significantly increased the preferences of fruits and vegetables ($P = 0.012$ and $P = 0.001$, respectively) and improved attitudes toward cooking ($P=0.02$). Conversely, interventions that lacked proper training for the implementers compromised fidelity and were unsuccessful.[8,24,35,34,39,41] For instance, although the study by Battjes-Fries et al[24] provided an introductory workshop as well as manuals and materials for the teachers, a standardized protocol for implementation to ensure fidelity was lacking. Teachers were given options to implement the intervention over 2 weeks, 1 week, or even a semester. As a result of the lack of a standardized implementation plan, only one-third of the intervention was implemented, leaving the other two-thirds of the intervention uncompleted and, therefore, unsuccessful.

Adequate duration of intervention (at least 6 months). In addition to fidelity, an adequate nutrition education dosage or intervention period of 6 months or more was predictive of success for most of the successful interventions (67%; $n = 8$).[28,33,37,38,40,42–44] For example, the intervention carried out by Parmer et al[38] focused on increasing fruit and vegetable knowledge, preferences, and consumption among 2nd-grade children for a duration of 7 months. The results showed significant improvement in nutrition knowledge ($P < 0.01$) and taste ratings ($P < 0.001$) in the intervention group compared with the control group. In contrast, the 8 studies (57%) that spent less than 6 months on the intervention did not meet or only partially met their stated objectives.[3,27,29,30,34–36,46] For example, a 1-time (135 min) intervention study by Mittman et al[34] among 7- to 14-year-old children and their parents did not achieve its stated objective of increasing fruit and vegetable intake in any of the assessment periods. Instead, fruit and vegetable intake showed a significant decline between baseline and the 2 follow-up assessments.

Age-appropriate activities. Finally, successful interventions targeting elementary school children used age-appropriate activities.[25,26,28,31,37,38,40,42,44,47] Age-appropriate activities at the elementary school level included cooking and/or tasting sessions[25,28,47]; a learning-through-playing approach based on age or grade[40,44,47]; gardening sessions[28,38]; training classes in physical activity[37,42]; the use of posters, masks, and songs[31,44]; and the use of vocabulary and mathematics questions based on nutrition-related issues.[26,31] In particular, the intervention carried out by Keihner et al[31] designed different activities based on grade level.

For example, 4th-grade students were asked to search for a nutrition-related word and write a composition about its qualities and health benefits, while the 5th-grade students completed a word scramble and prepared a group oral report about food qualities and health benefits. This study significantly increased students' knowledge of fruits and vegetables ($P < 0.05$) and self-efficacy toward eating fruits and vegetables ($P < 0.001$), while interventions that implemented a single intervention within a wide age range without discriminating according to age were not successful in achieving their objectives.[3,8,24,27,29,30,34,39,46] For example, Herbert et al[29] evaluated the effectiveness of their intervention in changing behavior and physical activity habits among children aged 7 to 11 years. This intervention, which included a 15-minute lecture on different nutrition topics, a 10-minute physical activity warm-up, and a 35-minutes aerobic exercise and fitness game, provided the same activities for all age groups. Although the intervention group showed a significant reduction in the consumption of french fries and chips, there was no significant increase in either the consumption of vegetables or physical activity in comparison with the control group.

Successful nutrition education interventions in secondary schools

The successful nutrition education interventions that targeted secondary school children added policy and environmental changes to the intervention, used age-appropriate activities that included technology, identified specific behaviors, aligned activities with their stated objectives, offered the intervention frequently (such as weekly or biweekly), engaged parents on a face-to-face basis, and trained implementers to ensure fidelity.

Environmental and policy changes. Change of environment was a factor in 3 of the 8 successful interventions in this category.[48,50,53] It was effective in increasing healthy food choices, changing attitudes, or reducing weight as measured by body mass index (BMI). For example, an intervention by Campos Pastor et al[48] provided a daily balanced breakfast composed of a dairy product, fruits, cereals, nuts, and a sandwich with protein content; a prescribed well-balanced diet; and lessons on dietary and lifestyle recommendations for students, family members, and teachers. After the intervention, the authors observed decreases in the prevalence of overweight and obesity ($P < 0.001$) and the prevalence of metabolic syndrome ($P < 0.001$). Similarly, a study by Singhal et al[53] that introduced environmental and policy-level change in the school cafeterias replaced soft drinks and high-calorie foods with healthful Indian foods. At the 6-month follow-up assessment, a significant reduction was found in the proportion of children who consumed soft drinks (from 26.3% to 11.2%; $P < 0.001$) and energy-dense unhealthy foods (from 16.1% to 7.2%; $P = 0.03$). Likewise, Maatoug et al[50] encouraged the snack stores in schools to replace sugary snacks with healthful snacks and encouraged students to include fruit, vegetables, or dairy products in their meals by offering incentives. After the intervention, students in the intervention group significantly increased their intake of fruit and vegetables ($P = 0.04$).

Age-appropriate activities. Similar to the interventions conducted among elementary school children, interventions that used age-appropriate activities among secondary school children were more likely to achieve their objectives. Age-appropriate activities in secondary school included role play, peer-led discussions, student health fairs, sports games, the use of cosmetic content–based nutrition education, and the use of technology, such as surfing the internet or using a multimedia CD.[49,50,54,55] For example, the intervention developed by Dehdari et al[49] focused on frequency and nutrient intake during breakfast, using the theory of Pender's Health Promotion Model. Students were divided into small groups to surf the internet, design posters, or create role play about aspects of breakfast consumption. Other activities included strategies to overcome the perceived barriers to eating a healthy breakfast. The results of the intervention showed significant increases in perceived benefit, perceived self-efficacy, positive activity-related affect, interpersonal influences, situational influences, commitment to a plan of action, and weekly frequency of breakfast consumption in the intervention group compared with the control group ($P < 0.05$). In addition, the use of age-appropriate topics relevant to secondary school children was effective in changing behavior. For instance, Somsri et al[54] compared the effectiveness of a cosmetic content–based nutrition education with that of a health content–based nutrition education in promoting fruit and vegetable consumption. After the intervention, knowledge scores, attitude scores, and the amount and variety of fruits and vegetables consumed in the cosmetic content–based nutrition education group significantly increased compared with baseline ($P < 0.001$).

Aligning objectives with activities. Alignment of intervention activities with the stated objectives and the desired outcome was critical for the success of interventions among secondary school children.[48,49,53–55] For example, the intervention developed by Viggiano et al[55] assessed

the effectiveness of the game Kaledo in improving nutrition knowledge and in promoting long-term healthy dietary behavior in adolescents. The intervention focused on the use of Kaledo, a board game that represents a journey through daily meals of the Mediterranean diet. After 6 months of the intervention, the results showed a significant improvement in the children's nutrition knowledge, physical activity, food habits, and BMI *z* score in the intervention group compared with the control group ($P < 0.001$).

Adequate duration of intervention (at least 6 months). Adequate dosage and frequency of exposure were important factors among successful secondary school interventions. Six of the 8 successful interventions provided weekly or biweekly sessions that lasted between 30 and 60 minutes.[48,49,52–55] For instance, Campos Pastor et al[48] designed a 45-minute program that was implemented biweekly for 1 academic year. Significant decreases in the percentage of students who were overweight ($P < 0.001$) and who improved their glucose and triglyceride levels ($P < 0.001$) were observed in the intervention group.

Parental engagement. Similar to findings in effective elementary school interventions, 4 of the 8 successful interventions involved face-to-face interaction with parents.[48–50,53] For instance, the study by Singhal et al[53] engaged parents by providing a day-long health camp led by a trained nutritionist. At the 6-month follow-up assessment, significantly more students from the intervention group brought lunch from home that included fruit ($P < 0.001$) as compared with the control group.

Fidelity of interventions. As noted with the elementary school interventions, accurate implementation of interventions is critical to ensure fidelity. Among the secondary school interventions, all 8 interventions were implemented by trained nutritionists, researchers, or teachers and reported using a standardized format.[48–55]

Successful nutrition education interventions in preschools

Successful nutrition interventions in preschoolers targeted specific behaviors, aligned activities with the stated objectives and expected behaviors, engaged parents on a face-to-face basis, and provided hands-on activities. Similar to successful interventions in the other age groups, effective preschool interventions included age-appropriate activities, ensured fidelity by providing training to teachers, and offered short but frequent sessions to accommodate the short concentration span of preschoolers.

Specific and measurable behavioral outcomes. Targeting specific behaviors to modify was one of the characteristics commonly observed among the successful interventions.[56–58,62] For example, Hoffman et al[58] planned a 2.5-year intervention that included knowledge, preference, and consumption of fruits and vegetables. More specifically, their results showed a significant increase in fruit and vegetable intake, ie, 1.5 tablespoons of fruit ($P < 0.0001$) and 1.5 teaspoons of vegetables during lunch ($P = 0.005$) for the duration of the project.

Aligning objectives with activities. Successful interventions strongly aligned their objectives with the activities implemented.[57,58,60,61] For instance, Gao et al[57] examined the effect of nutritional education on children's breakfast patterns. The intervention included teaching parents the benefits of breakfast for children and the methods of breakfast preparation. The lessons were accompanied by visual aids such as pictures and food models of breakfast items and an illustrated book for children. Parents received brochures with example of breakfast meals. This intervention resulted in a significant increase in both the frequency of breakfast intake ($P = 0.02$) and the selection of more nutrient-dense breakfast meals ($P < 0.001$) in the intervention group compared with the control group. In contrast, 2 interventions that partially met their objectives did not align their stated objectives with the activities.[56,59] For example, De Bock et al[56] conducted an intervention aimed to improve fruit, vegetable, and water consumption and to decrease anthropometric measurements such as BMI, waist circumference, waist-to-height ratio, and total body fat. The intervention activities were focused on fruits and vegetables as snacks and the importance of drinking water. Although the intervention significantly increased the intake of fruits and vegetables ($P < 0.05$ and $P < 0.01$, respectively), there was no significant change in daily water consumption, BMI, waist-to-height ratio, or total body fat.

Parental engagement. As observed among successful interventions in elementary and secondary schools, 5 of 7 studies that targeted preschoolers in this review included parental engagement on face-to-face basis, with hands-on activities in addition to lectures.[56,57,59–61] For example, De Bock et al[56] created hands-on activities in which parents and children interacted in activities such as preparing fruit and vegetable snacks. These strategies significantly increased the intake of fruits ($P < 0.05$) and vegetables ($P < 0.01$).

Fidelity of interventions. To ensure fidelity, all successful nutrition education interventions provided training to

teachers[58,60–62] or health professionals[56,57,59] to implement the interventions. For instance, Lerner-Geva et al[60] provided training for teachers. By the end of the intervention, children showed significantly increased nutritional knowledge ($P = 0.03$).

Age-appropriate activities. Although age-appropriate interventions were important in all age groups, they were critical in the preschooler age group.[56–60,62] Age-appropriate activities in preschool included learning through a story book[57,59]; using role models through play acting, posters, or videos[56,58]; exploring with the senses[62]; and playing games or coloring sheets with peers.[60] For instance, the intervention conducted by Witt and Dunn[62] consisted of hands-on, 30-minute weekly lessons. It included the use of music, exploration of the senses, colors, and imaginary trips to promote the consumption of fruits and vegetables. The intervention was delivered in short but frequent sessions to accommodate the short concentration span of preschoolers. As a result, there was a significant increase between baseline and the 3-month follow-up in the consumption of fruit snacks (by approximately 20.8%; $P < 0.001$) and vegetables snacks (by approximately 33.1%; $P < 0.01$). In contrast, a study by Peñalvo et al[61] designed to promote healthy behaviors in preschool children included activities to teach correct management of emotions to develop protective behaviors against abuse of tobacco, alcohol, and drugs. At the end of the intervention, no significant improvement in this component was observed. In the current systematic review, the discussion of tobacco, alcohol, and drugs was not considered age-appropriate for preschool children.

DISCUSSION

The purpose of this systematic review was to identify factors characterizing studies published between 2009 and 2016 that were successful in achieving their stated objectives in nutrition interventions among children. In order to capture age-based strategies, studies were grouped and reviewed according to their targeted age groups: preschool, elementary, and secondary school children. Seven overarching factors emerged as critical to successful nutrition education among children: (1) a multicomponent (involving teachers and parents), multilevel (including the schools and the home) approach; (2) adequate duration of intervention and frequency of exposure; (3) parental engagement; (4) age-appropriate, hands-on experiences; (5) fidelity as ensured by training of the implementers and standardization of the protocol among all groups; (6) environmental change to impact knowledge (upstream outcome) and then behavior (midstream outcome); and (7) proper alignment between the stated objectives, the intervention, and the desired outcome, which is needed to affect weight or BMI (downstream outcome). The findings of the current systematic review are based on critical analysis of these factors. The use of behavior theories in the studies reviewed was not associated with success of interventions, perhaps because other factors mentioned above were more critical or because the majority of the studies that used theory were informed by theory but were not theory driven. However, a review by Murimi et al[22] that looked at factors associated with successful interventions among adults found that interventions were more likely to succeed if they were theory driven. Theory-driven studies use the specific theory constructs in the methodology, intervention, and assessment, while theory-informed studies might identify the theory that informs their studies but may not use all its constructs throughout the study.[4]

Multicomponent and multilevel interventions

Effective nutrition education is a complex undertaking that calls for a systematic and comprehensive assessment of the determinants of—as well as the barriers to—the desired outcome to inform the intervention.[64] This review found that nutrition education interventions with a comprehensive, multicomponent, and multilevel approach were more likely to achieve their stated objectives in all age groups. For example, a majority of the preschool interventions that were successful utilized both teachers and nutrition experts to implement the interventions in school settings and engaged the parents to extend the intervention to the home.[56–62] In addition to incorporating multiple components, they included several levels of intervention, such as knowledge, tasting sessions, and skills building.[56,60,61,62] These findings confirm the finding of a systematic review by Colquitt et al,[65] who concluded that multicomponent interventions in preschool children were associated with a reduction in overweight or obesity. Similarly, the current review found that nutritional interventions in elementary schools were more likely to meet their objectives when they were multifaceted, had a high frequency of exposure, were delivered by nutritionists or trained teachers, and engaged parents. This confirms the findings of a review by Van Cauwenberghe et al,[66] namely that multicomponent interventions that include improved availability of fruit and vegetables, a nutrition education curriculum delivered by teachers, and at least some parental involvement can improve intake of fruits and vegetables.

Duration and frequency of exposure

Health-related behavior change is a complex process that includes new behaviors to learn and undesired behaviors to reduce. This process often requires time to learn new skills, identify resources, practice the new behavior, and identify support to sustain the new behavior.[67] In addition to including multiple levels and multiple components, this current review found that reviewed interventions were more likely to meet their stated objectives when they were implemented for more than 6 months and offered frequent exposures, such as weekly or biweekly. This finding was in agreement with the results of a systematic review performed by Murimi et al[22] on nutrition education for adults, which found that interventions implemented for more than 5 months were more likely to meet their stated goals. Similarly, a systematic review by Ling et al[68] found that increasing the length of an intervention or including a long-term follow-up of at least 12 months might help to identify a delayed intervention effect.

Parental engagement

Although most school children spend most of their day time at school, significant health and dietary behaviors are acquired long before school age and are enforced daily either by parental modeling, feeding style, or availability of the desired food choices during breakfast or dinner.[69] It is therefore critical for interventions targeting children to incorporate both the school and the home environment to be effective in promoting a sustainable healthy lifestyle.[70] This systematic review found parental engagement in all 3 age groups to be critical for successful interventions aimed at modifying dietary behavior or weight loss. The majority (n = 21) of the studies did not engage parents, and other studies engaged parents by passive methods (n = 6) such as providing them with written information or directing them to a website.[24,27,31,32,35,62] Successful studies were more likely to engage parents actively, ie on a face-to-face basis, by offering them nutrition classes[33,37,49,59,60] or health fairs[42,50,53,61]; requiring them to accompany their children during cooking, tasting, or nutrition education sessions[43,48,56,57]; or allowing them to be part of the program's staff.[28,44] This was especially critical in the interventions that targeted preschool students.[56,57,59–61] These findings are congruent with the results of a meta-analysis performed by Ling et al,[68] who concluded that interventions providing skills training and behavioral change strategies aimed at parents were associated with improvement of children's BMI in preschool. Similarly, a systematic review by Loveman et al[71] demonstrated that, when interventions with multiple components (ie, diet, physical activity, and behavior) were delivered to the parents of elementary school children, children's body weight improved by significantly decreasing an average of 0.1 in BMI z score at the longest follow-up period (9–12 months) ($P = 0.04$). Similarly, Meiklejohn et al[72] found significant changes in anthropometric measures among adolescents when parents were engaged. More importantly, active parental engagement compensated for short intervention durations, as demonstrated by a review conducted by Neimeier et al,[19] who found that children and adolescents' actual BMI reductions were greater in interventions that engaged parents, even when controlling for the duration of interventions. In addition, the duration of interventions and parent participation both contributed independently to intervention success rates.[19]

Age-appropriate and experiential learning

The pool of interventions in the current review represented a wide age range, from preschool to high school age. The wide difference in age implies a wide difference in cognition, abstract thinking, and skills, among others.[15–18] It was therefore critical for this review to assess the design of the interventions on the basis of age appropriateness. The results of this assessment showed that interventions applying age-appropriate and/or experiential activities were more likely to be successful. For example, Hoffman et al[58] and Witt and Dunn[62] designed studies to increase the consumption of fruits and vegetables among preschoolers by implementing age-appropriate activities such as the use of role models (cartoons, teachers, coaches) and activity-based lessons that included tasting, imagining, and color associations with fruits and vegetables. Hoffman et al[58] significantly increased the consumption of fruits and vegetables, and Witt and Dunn[62] significantly increased the consumption of fruit and vegetable snacks. The findings of this systematic review concur with those of Dudley et al,[73] who concluded that experiential learning strategies were associated with the largest effects across studies that reported outcomes of reduced food consumption or energy intake, increased fruit and vegetable consumption or preference, and increased nutritional knowledge. Similarly, all elementary school interventions that met their stated objective applied interactive education and hands-on experiences in teaching physical activity and healthy eating behaviors.[25,26,28,31,33,37,38,40,42–44,47] Among secondary school children, age-appropriate activities that led to successful interventions included the use of topics important to adolescents. For example, the cosmetic content–based nutrition intervention by Somsri et al[54] (a nutrition education intervention that explained the benefits of fruit

and vegetable consumption for the skin, body shape, body weight, and other aspects of body image) was more effective in increasing fruit and vegetable consumption than the health-based intervention.

Fidelity of interventions

Fidelity in intervention ensures that all intervention activities are executed as planned in the methods. In this review, studies that had high fidelity were more likely to succeed in achieving their stated objectives, ie, approximately 82% (n = 31) of the interventions that met or partially met their objectives trained existing teachers or engaged nutrition and physical activity experts in the implementation of the interventions. These findings are in agreement with a review by Ross et al[74] and Ling et al,[68] who found that providing preschool teachers with a health promotion opportunity to enhance their health knowledge increased healthy behaviors, reduced stress, and increased the fidelity and quality of the intervention.

Environmental changes for upstream and midstream outcomes

The results of this review found that environmental changes were critical in achieving stated objectives among interventions that targeted secondary school students. For example, 3 of the 7 successful interventions[48,50,53] were effective in increasing positive attitudes toward increasing fruit and vegetable consumption and reducing either weight as measured by BMI or unhealthy food choices such as carbonated drinks, burgers, pizzas, and french fries. Environmental changes included providing a standardized breakfast for students during the duration of the intervention and prescribing a well-balanced diet. These resulted in a significant decrease in the prevalence of overweight and obesity ($P < 0.001$) and metabolic syndrome ($P<0.001$).[48] Similarly, a study by Singhal et al[53] that implemented an environmental and policy-level intervention by replacing sugar-added beverages with healthful Indian foods was successful in reducing the consumption of sugar-added beverages and increasing the consumption of healthful alternatives. Other systematic reviews have found environmental and/or policy interventions to be effective in changing behavior. For example, a systematic review by Silveira et al[75] showed that school environmental change to ensure an uninterrupted supply of fruits and vegetables in schools allowed children and adolescents to have access to these foods, thereby increasing the feasibility of incorporating fruits and vegetables in their diet. Similarly, a systematic review by Mercado et al[76] found studies that addressed the school or community environment were successful in decreasing the BMI of participants. Examples of environmental strategies included modification of food served in schools and creation of safe walking routes to schools. Another environmental strategy, the Delicious and Nutritious Garden intervention, included cooking and taste testing reported a significant increase in the number of fruits and vegetables ever eaten, in vegetable preferences, and in fruit and vegetable asking behavior at home.

Activities based on stated objectives and targeted expected outcomes

The importance of setting realistic objectives and planning activities aligned with the objectives and the desired behavior was critical in studies that were successful in achieving their objectives. Nutrition education interventions that succeeded had clear alignment between the stated objectives, the desired outcome, and the implemented activities. For example, in the study by Gao et al,[57] the objective of the program was to promote consumption of a healthy breakfast for children. To achieve their objectives, the authors addressed both the children, who had a role in consuming the breakfast, and the parents, who had a role in preparing the breakfast. The intervention included educating children about the benefits of eating breakfast and educating parents about the methods of breakfast preparation. This intervention resulted in a significant increase in the number of times children ate breakfast and the selection of more nutrient-dense breakfast choices in the intervention group. Another example is provided by Singhal et al,[53] whose study among adolescents focused on the benefits of physical activity and healthy foods such as fruits, vegetables, and dairy and the harmful effects of junk foods. The study promoted healthy lifestyles among the adolescents by engaging them in activities such as planning their own lunch, planning healthy diets daily by themselves, and listing healthy alternatives to high-calorie foods. The intervention significantly lowered the consumption of carbonated drinks and energy-dense foods and significantly increased fruit intake during lunch. Other systematic reviews found similar findings. For example, a review by Murimi et al[22] found that studies whose objectives, activities, and desired outcomes were aligned were more likely to be successful. Similarly, a systematic review by Silveira et al[75] concluded that interventions using structured activities aligned with specific objectives to provide knowledge about the benefits of maintaining a healthy diet were more likely to be successful.

This review has 2 limitations. First, only articles published in English were considered. Therefore, it is

possible that some recent and important findings published in languages other than English were left out. Second, this review was limited by a lack of adequate information in the methods and results of some articles. This hindered the ability to properly evaluate the contributions and effectiveness of specific components of nutrition education interventions, including the use of theory and the dosage of interventions (frequency and duration). Despite these limitations, the strength of the current review lies in its analysis of several factors that contributed to the success of various types of interventions. This is different from previous reviews that focused primarily on the analysis of a single type of intervention and the related outcome.

CONCLUSION

This review indicates that nutrition education interventions are more likely to be successful in achieving their objectives when experiential activities such as gaming, gardening, and cooking demonstrations are incorporated and when specific dietary behaviors are targeted for modification. In addition, interventions that engaged parents through face-to-face interaction and delivered extensive training for external experts and teachers to enhance fidelity were more likely to achieve their objectives. While all the successful interventions reported an increase in participants' knowledge, interventions were more likely to be successful in changing behavior when the duration of the intervention was more than 6 months.

Studies that delivered interventions within a period of less than 6 months, used intervals of more than 2 weeks between lessons, or delivered a single-dose educational intervention were less likely to be successful in achieving their objectives. Similarly, interventions that delivered passive education programs for parents, such as providing a web link or written material, did not benefit from that component of parental involvement. In addition, interventions were less likely to meet their stated objectives if they broadly promoted healthy eating in general without targeting a specific behavior or did not ensure fidelity but just provided tool kits without specific guidance on the usage of the material instead of training the teachers directly. While most interventions were successful in improving knowledge, attitudes, and behavioral measures, downstream variables such as BMI, waist circumference, and percent body fat, when used as outcome measures, did not show any meaningful improvement without the use of multiple components and long durations.

This systematic review demonstrates the importance of designing an age-appropriate intervention of adequate duration (at least 6 months) to change behavior in all age groups of school children. Researchers planning to implement interventions among preschool children are encouraged to design short but frequent sessions to accommodate the short attention span of preschoolers, to include hands-on activities, and to work with parents, preferably on a face-to-face basis. A combination of adequate dose (duration of at least 6 months) and trained implementers is critical for elementary school children, while the use of technology and age-appropriate topics is important for secondary school children. Although the use of theory did not determine the success of the interventions analyzed in this review, it is important to note that most of the interventions were only informed by a theory but were not designed and driven by theory. As indicated by a previous systematic review on nutrition education in adults, theory-driven interventions are more likely to be successful.[22]

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Supporting Information

The following Supporting Information is available through the online version of this article at the publisher's website.

Appendix S1 **PRISMA checklist**

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