Lead Article

Theoretical and practical approaches for dietary behavior change in urban socioeconomically disadvantaged adolescents: a systematic review

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Context: *There is limited evidence on strategies used to promote dietary behavior changes in socioeconomically disadvantaged urban adolescents and on their effectiveness.* ***Objective:*** *A synthesis of nutrition interventions used in this group of adolescents is provided in this systematic review.* ***Data Sources:*** *Five electronic databases (PubMed, Web of Science, CINAHL, PsycINFO, and ERIC) were searched until November 2020 to identify relevant studies.* ***Data Extraction:*** *Forty-six manuscripts (n = 38 intervention studies) met the inclusion criteria. Quality was assessed with the Effective Public Health Practice Project Quality Assessment Tool. A qualitative synthesis summarizing data on study characteristics was conducted.* ***Data Analysis:*** *Studies were classified by intervention type as those focusing on hedonic determinants of dietary intake (n = 1), environmental changes to promote a specific dietary intake (n = 3), cognitive determinants (n = 29), and multicomponent strategies (n = 13). The social cognitive theory was the most applied theoretical framework, either alone or combined with other frameworks. Most of the intervention studies targeted multiple dietary outcomes, and success was not always reported for each.* ***Conclusions:*** *Despite the heterogeneity of the studies and lack of combination of dietary outcomes into dietary scores or patterns to evaluate changes on the individuals' whole diets, long-term, theory-driven interventions targeting a single dietary factor seem promising in obtaining sustainable dietary behavior changes.*

Systematic Review Registration: *PROSPERO registration no. CRD42020188219.*

INTRODUCTION

Adolescence is a period of rapid growth and physical, psychological, and emotional development changes.[1] Adolescent health is determined by early childhood factors together with specific biological and social changes that occur during this time and are shaped by social determinants of health.[2] Furthermore, future health-related-behaviors are established during this life phase, which can lead to the onset of certain chronic

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diseases during adulthood and also can impact the health and development of the next generation and potential offspring.[2] Therefore, addressing adolescents' unhealthy behaviors will contribute not only to their future health but to the health of the next generations.[2]

As with other health behaviors, eating patterns established during adolescence track into adulthood.[3,4] According to the World Health Organization, a healthy diet includes the intake of fruit, vegetables, legumes, nuts, and whole grains, coupled with limited free sugars, saturated and trans- ats, and salt consumption.[5] Having a healthy diet is crucial to maintain a healthy lifestyle and to prevent chronic diseases such as obesity, cardiovascular diseases, or cancer, among others.[5,6] According to the latest report of the Health Behaviour in School-Aged Children survey conducted among European and Canadian adolescents, most adolescents do not meet the current nutritional recommendations.[7] Although intakes of fruit and vegetables have increased and consumption of sweets and soft drinks has declined since 2014, nearly two-thirds of the adolescents do not eat enough fruits and vegetables and 1 in 4 and 1 in 6 eats sweets and sugary drinks, respectively, daily.[7] In addition, the report highlighted that social inequalities are still present in eating behaviors. Adolescents from socioeconomically disadvantaged backgrounds had unhealthier eating habits, because they were less likely to eat fruit and vegetables daily and more likely to consume soft drinks than were their more affluent peers.[7] Similarly, in their the systematic review, Desbouys et al[8] concluded that higher parental socioeconomic status was associated with healthier dietary patterns and higher dietary scores, including intake of greater amounts of fruits, vegetables and dairy products intake and lower intake of sugar-sweetened beverages and energy-dense foods among adolescents. For that reason, prevention efforts should be made to promote the acquisition of healthy dietary habits during adolescence, especially among those from disadvantaged backgrounds.

Nutrition interventions may have the potential to change dietary behavior in adolescents. However, changing dietary behavior represents a considerable challenge because the determinants of consumption are multiple, whether general, environmental, or individual, and interact to form a complex system.[9] In addition, the success of an intervention not only depends on the determinants of intake targeted but on multiple factors that may explain why many interventions do not result in significant changes in dietary behaviors whereas others do. In their review of how to design effective nutrition interventions for adolescents, Hoelscher et al[10] identified some relevant factors that seemed to determine the success of nutrition interventions, such as using a theoretical framework; having a behavioral focus instead of a knowledge-based focus, including both individual and environmental components; delivering an appropriate dose in terms of duration and intensity; and applying strategies adequate to the developmental stage of the adolescents. Likewise, in a more recent review of multistrategy nutrition education programs for adolescents attending secondary schools in developed countries,[11] authors concluded that programs that used a theoretical model to guide the intervention were effective in significantly changing dietary intake. Other factors identified in the review that had impact on the success of the school-based interventions included facilitation of the program by school staff and teachers, parental involvement, and changes to the school food environment.[11] However, little is known about the strategies used to change dietary behavior in socioeconomically disadvantaged adolescents and the effectiveness of nutrition interventions in this population group. Therefore, our systematic review question was "What sort of behavior change techniques and theoretical frameworks are applied among socioeconomically disadvantaged urban adolescents to change determinants of diet and, consequently, improve their dietary behaviors?" Our aim for this review was to provide a synthesis and critical review of the strategies and theoretical frameworks used in dietary interventions carried out with socioeconomically disadvantaged adolescents living in urban areas. The results of this review will inform the development of intervention studies that seek to change dietary behaviors by promoting healthier dietary habits in this population group.

METHODS

This systematic review was compliant with current recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses to report evidence in a specific topic area.[12] The systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO; registration no. CRD42020188219). A search protocol was created that can be accessed on request to the authors.

Our ultimate purpose for this review is to inform the development of an intervention program to promote vegetable intake in adolescent boys and girls, aged 13–15 years, living in socioeconomically disadvantaged, urban areas in a high-income country. For that reason, to retrieve as many relevant studies as possible, adolescence was defined as the period between 12 and 18 years, based on the stages of the school system: preschool (<6 years), primary school (6–12 years), and secondary school (12–18 years). Samples of adolescents were considered socioeconomically disadvantaged when they were described as such by the study

researchers or the study was conducted in a setting described as socioeconomically disadvantaged,[13] or >50% of the study participants were classified as socioeconomically disadvantaged on the basis of the socioeconomic level indicator applied in the studies.

Search strategy

Five electronic bibliographic databases—PubMed, Web of Science, CINAHL, Eric, and PsycINFO—were searched from inception until November 2020 to identify relevant studies. Key search terms were combined within the following 4 categories: lifestyle interventions (eg, lifestyle, diet, exercise), health promotion, population of interest (eg, adolescents, youth), and behavior change strategies (eg, behavioral theory). To retrieve as many studies as possible, no specific keywords were used for socioeconomic status. As an example, the search carried out in PubMed is provided as supplementary information (see Appendix S1 in the Supporting Information online). Manual searches of reference lists of previously published reviews and of the included articles were carried out to identify additional studies.

Inclusion and exclusion criteria

To be eligible, studies had to meet the following criteria: (1) included a sample comprising socioeconomically disadvantaged individuals (or with largest percentage of disadvantaged individuals or comparing disadvantaged vs nondisadvantaged adolescents) aged between 12 and 18 years (or with a mean age between 12 and 18 years); (2) reported on dietary and/or lifestyle, including diet, interventions with the aim to change dietary behavior regardless of their effectiveness; (3) conducted in urban settings of high-income countries;[14] (4) were primary prevention trials (intervention studies) for healthy individuals, including randomized controlled trials, quasi-experimental trials, and pretest-posttest studies; (5) reported quantitative findings on intervention dietary components; (6) were written in English, French, Spanish, Portuguese, or Catalan; and (7) were published in peer-reviewed journals. Table 1 summarizes the inclusion criteria.

Study selection, data extraction, and data synthesis

Two review authors (S.B.S. and A.M.) independently screened 10% of the titles and abstracts against the study selection criteria. The remaining 90% of the records were screened by 1 reviewer (S.B.S.), who excluded irrelevant records. Again, the same 2 reviewers independently reviewed 10% of full-text papers that either met the eligibility criteria or had insufficient information in the abstract to determine eligibility. One reviewer (S.B.S.) reviewed the full text of the remaining papers and determined the final pool of articles included in the review. The 2 researchers discussed any discrepancies that arose during the screening of titles and abstracts and during the review of the full texts, and reached an agreement. There was no need to involve a third reviewer.

Two independent reviewers (S.B.S. and E.G.) performed data extraction using an Excel spreadsheet to collect key data from each study, including first author and year of publication; study design; project name (if any); aim; intervention setting; study population characteristics (namely, sample size at baseline, age at baseline, sex, race or ethnicity, setting, and country); theoretical basis; intervention description; duration of exposure, follow-up, and frequency; dietary outcome measure and measurement tools; and main findings on the intervention dietary components. Unclear or missing data about the intervention and/or the study population were sought by checking former related references.

Given that the aim of this review was exploratory and high heterogeneity was found among study methodologies and outcome measures, no attempts were made to quantitatively combine the studies, such as through meta-analysis. Therefore, a qualitative synthesis summarizing data on study characteristics and on the results of the included studies was conducted.

Study quality assessment

The quality and risk of bias of each included study were assessed using the Effective Public Health Practice Project Quality Assessment Tool.[15] Studies were individually rated on a variety of components, including selection bias, study design, confounders, blinding, data collection methods, withdrawals and dropouts, intervention integrity, and analysis. Individual components were rated as strong (score, 1), moderate (score, 2), or weak (score, 3). For each study, a final score was obtained that considered all the ratings of the individual components. Studies were classified as strong (no weak ratings), moderate (1 weak rating), or weak (≥2 weak ratings). Those studies rated as weak were not removed, but the risk of bias of their evidence was highlighted. Two reviewers (S.B.S. and E.G.) independently evaluated the studies. Reviewers compared study component ratings and agreed on a final decision to determine the final study quality.

RESULTS

Study selection

The study selection process is shown in Figure 1. After removal of duplicates, 4711 articles were screened. An

Table 1 **PICO and other criteria for inclusion of studies**

Criterion	Included
Study design	Primary prevention trials (intervention studies)
Type of publication	Articles published in peer-reviewed journals
Language	English, Spanish, French, Portuguese, Catalan
Geographic region	Urban settings in high-income countries
Population (P)	Socioeconomically disadvantaged adolescents aged 12–18 y from the general population
Intervention/exposure (I)	Dietary and/or lifestyle, including at least a dietary component, interventions aiming to change dietary behavior
Comparison/control (C)	No intervention
Outcome (O)	Dietary intake measurement

additional 4502 articles were excluded upon review of titles and abstracts. Of the remaining 209 full-text articles reviewed, 163 were eliminated as a result of the eligibility criteria. The review included a total of 46 articles that met the eligibility criteria. Among these 46 articles, a total of 38 interventions were identified.

Details of the studies are summarized in Table 2[16–19] for interventions that focused on hedonic determinants of dietary intake (n = 1) and on environmental changes to promote specific dietary intake (n = 3). Table 3[20–48] summarizes studies that included interventions focused on cognitive determinants (n = 29), and Table 4[49–61] summarizes studies in which researchers used interventions that combined approaches (n = 13).

Given the huge heterogeneity in dietary behaviors investigated, intervention methodological aspects, dietary assessment methodologies applied, reported units of measurement, and statistical analyses performed in the studies, among other factors, no attempts were made to synthesize the findings in terms of those dietary behaviors most significantly influenced by the interventions.

Interventions aimed to change hedonic factors

One 2-phase, controlled intervention study[16] conducted over 2 weeks among high school teenagers in the United States (9th through 12th grades) aimed to improve or change the taste of vegetables by adding spices and herbs to common vegetable recipes served in the school canteen. After weighing plates' waste, researchers concluded that total vegetable consumption significantly increased when spices and herbs were added to typical recipes. They observed higher amounts of vegetable intake when a student-led advocacy component aiming to promote vegetable intake was incorporated.

Interventions based on changing the environment

Changing the environment to encourage dietary behavior change was the approach applied in 3 intervention studies,[17–19] although the study by Hovdenak et al[19] was the follow-up of another study.[17] Bere et al[17] provided Norwegian children attending primary schools with either free or paid fruit and vegetables once a day for a whole academic year. At follow-up, and regardless of parental educational level, children who received free fruit and vegetables had significantly higher intake of these 2 food items than those children who had to pay a fee to take part in the program and those not receiving the program at all. Children in the free program whose parents had low educational level reported lower intakes of unhealthy foods such as soda, candy and chips, as compared with those children from low parental education level who were not part of the program. After 15 years, Hodvenak et al[19] concluded that the tracking coefficients for daily fruit intake were low considering the total sample and adjusting for intervention type, particularly among those with parents from lower education. On the other hand, Davis et al[18] also provided free fresh fruit and vegetable snacks to US high school teenagers (9th–12th grades) for 3 school semesters. Despite the lack of baseline measurement, a significantly higher percentage of teenagers in the intervention reported eating fruit and fruit juices at least twice a day at follow-up as compared with their peers in the control school, though no differences were observed for vegetable intake.

Interventions based on changing or using cognitive factors

In 29 articles, including 23 different interventions, authors used information, education, or other cognitive techniques to promote dietary behavior changes in adolescents from disadvantaged backgrounds. Thirteen studies followed a pretest-posttest design,[20,25,26,28–32,35,39,41,44] 10 were randomized controlled trials,[22,24,27,36–38,40,42,45–47] 1 study had a nonequivalent control group design,[33] and 5 studies did not provide details on the study design applied.[21,23,34,43,48] Seven studies did not have a control group.[21,25,29,34,39,44,47] Most of the interventions were carried out in school settings, including high schools,[21,23,26,27,29–32,34–39,42,44,45] middle schools,[24,25,40,41,43,48] and vocational schools.[46] Among the 3 studies that targeted the community,[20,22,47] 2 also included households.[22,47] One study targeted youth service agencies.[28] Four interventions were conducted in Australia,[29,36–38,44,45] 1 in England,[42] and 1 in the Netherlands.[46] The remaining interventions were conducted in the United States.[20–26,28,30–35,39–41,43,47,48] Sample sizes ranged between 16 and 2279

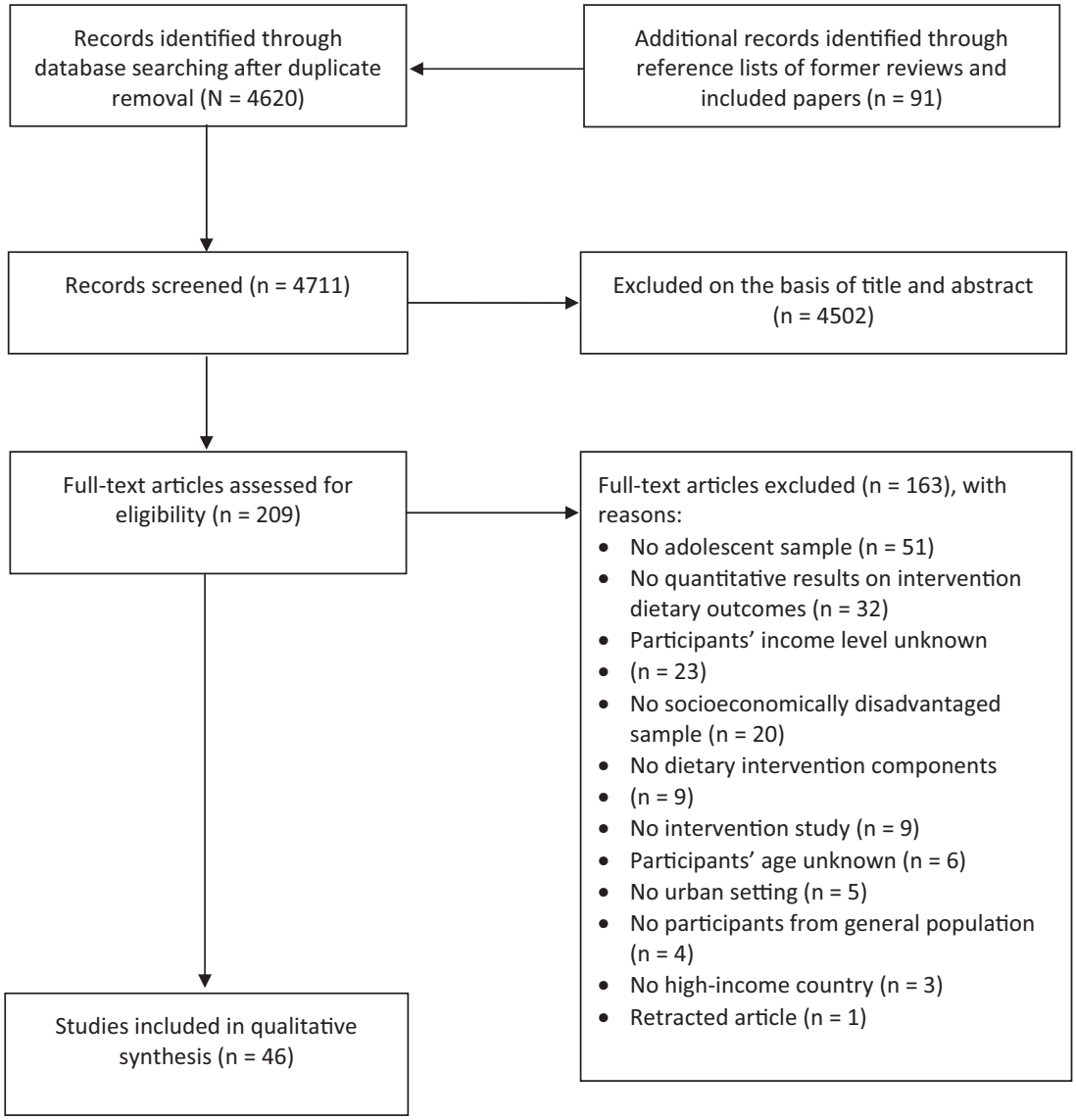

Figure 1 **Flow chart of the study selection process**.

participants, with most studies including between 100 and 1000 participants. Only 4 studies had samples sizes of >1000 participants,[24,34,35,44] whereas 5 studies involved <100 participants.[21,26,39,47,48]

A wide range and combination of theoretical frameworks were applied to develop the intervention programs. The social cognitive theory (SCT) was the most commonly adopted framework, either alone[27,33,36,37,40,41,43,44] or in combination with other frameworks such as the self-determination theory,[24,38,39,45] the family systems theory,[47] and Freire's empowerment education approach.[29] One study applied the transtheoretical theory,[28] and 2 intervention studies combined the transtheoretical theory with health promotion models[30–32] or with the theory of planned behaviour.[42] An extended theory of planned behaviour,[25] the message interpretation process model,[20] the intervention theory of Sidani and Branden,[26] and the self-regulation theory[46] were among the other frameworks adopted. No details on the framework applied or on whether a framework was used were provided in 4 studies.[21,23,34,35]

The interventions applied a range of techniques to promote dietary behavior change among disadvantaged adolescents. Providing nutrition information and/or education[20,23–40,43–45,47,48] was the approach most commonly used, followed by development of nutrition-related skills[20,21,30–33,35,39,48]; application of goal-setting techniques[22,24,25,28,43,46,47]; use of role-modeling[30–32,38,44,45]; provision of tailored information,[28,42,47] a demonstration,[21,34,35] or a gardening experience[41]; use of social support[36]; and invoking of self-monitoring,[36] motivation,[48] and behavioral skills.[48] Most of the intervention studies (n = 15) did not apply a unique

Table 2 **Main characteristics of included studies on hedonic determinants of dietary intake (n = 1) and on environmental changes to promote a specific dietary intake (n = 3)**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
Interventions on hedonic determinants of dietary intake										
D'Adamo et al, 2021 (United States)[16]	To determine whether addition of spices and herbs to the NSLP vegetables would increase intake	2-phase, controlled intervention	Participation in the NSLP free-and-reduced-price meals (100%)	High school	Sample size: N = 4570 plates Age group: 9th–12th graders Sex: boys (43%); girls (57%) Race/ethnicity: Black (76%), Hispanic (10%), ≥2 races (10%), White (4%), Asian (<1%)	Not stated	Intervention: typical vegetables recipes (usual condition) and vegetable recipes with spices and herbs (intervention condition) were served and for 2 wk, the remains on the plate were collected and weighed for each condition. A student-led advocacy component was included to promote vegetable intake among peers. Control: Same as intervention but without student-led advocacy	Duration: Two 2-wk periods (8 wk) Follow-up: n/a Exposure: once daily (lunch time)	Intake of vegetables (g/d) Weighed plate waste	Total intake of vegetables with spices and herbs was 15.4% higher than with typical recipes, without student-led advocacy, and 27.2% higher than typical recipes with the student-led advocacy component.
Interventions on environmental changes to promote a specific dietary intake										
Bere et al, 2005 (Norway)[17]	To investigate the effect of the Norwegian School Fruit Programme on the intake of fruit and vegetables and on the consumption of unhealthy snacks (ie, soda, candy and potato chips).	No info	Household income and parental education: High (41.7%) vs. low (58.3%)	Primary schools	Sample size: 795 Age: 11–12 y (estimated mean age: 12.3 y, 7th graders) Sex: Boys (49.9%), girls (50.1%) Race/ethnicity: No info	Not stated	Intervention: Daily fruit and vegetable provision (1 piece) either free or paid. Control: No fruit and vegetable provision	Duration: ∼9 mo (1 school y) Follow-up: baseline (1 mo pre-intervention) and after 8 mo (end of school year) Exposure: once every school day	Total portions per day of fruit and vegetables; Intake of soda, candy, and potato chips (times/wk). 24-h fruit and vegetable recall, and a food frequency questionnaire	At follow-up, pupils attending the free-fruit schools had significantly greater intake of fruit and vegetables than pupils at the paid-fruit and no-fruit schools ($P < 0.001$; mean intakes were 1.1, 0.4, and 0.2 portions, respectively). Subscribers at the paid-fruit schools had significantly more intake than the nonsubscribers at the same schools. No interactions were found between parents' educational level, household income, and fruit and vegetable intake. Significant differences among the 3 groups (free, paid, and no fruit) were found for pupils with parents with low educational

(continued)

Table 2 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
										levels for intake of soda, candy, and chips. The free-fruit group reported a significantly lower intake of soda, candy, and chips than did the no-fruit group.
Davis et al, 2009 (United States)[18]	To investigate if those exposed to the Fresh Fruit and Vegetable Program reported eating more fruit and vegetables	Quasi-experimental design (cross-sectional postintervention survey)	Eligibility for free or reduced-price meals (57%)	High school	Sample size: N = 2892 Age groups: 9th (30.9%), 10th (21.8%), 11th (24.6%), and 12th (22.7%) graders Sex: boys (44.9%); girls (55.1%) Race/ethnicity: Black (35.2%), Hispanic (31.1%), Asian/other (10.0%), and White (23.7%)	Not stated	Intervention: daily provision of free fresh fruit and vegetable snacks. Students could eat as many items as they wanted as long as the supply lasted. Control: no intervention	Duration: 3 school semesters Follow-up: after 1 y (no baseline measurement) Exposure: daily for 3 semesters	Frequency of intake of fruit, vegetables, potatoes, french fries, and 100% fruit juice, and frequency of intake of fruit and vegetable in the classroom The Youth Risk Behavior Surveillance System questionnaire	Significantly more intervention-school students reported eating fruit and 100% fruit juice ≥2 times per day than did control-school students (39.3% vs 27.3%). No significant differences were observed for vegetable intake.
Hovdenak et al, 2019 (Norway)[19]	To investigate the potential tracking of fruit, vegetable, and snacks consumption from childhood to adulthood	Longitudinal cohort design	Parental education: high (45.8%) vs. low (54.2%)	Elementary schools	Sample size: N = 1950 Mean age: 11.8 y Sex: boys (50.5%); girls (49.5%) Race/ethnicity: information not provided	Not stated	Intervention: daily free provision at school of 1 piece of fruit or a vegetable Control: no intervention	Duration: ∼9 mo (1 school year) Follow-up: baseline (beginning of school year), end of 1 y intervention, and 1, 3, 7, and 14 y postintervention Exposure: once every school day	Fruit and vegetable (portions/d and times/wk) and unhealthy snack (eg, soda, candy, and potato chips), intake times/wk. 24-h fruit and vegetable recall, and a food frequency questionnaire	Participants whose parents had lower education level had a lower tracking coefficient for daily fruit intake (0.19) than did participants whose parents had a higher level of education (0.26). Tracking coefficients for fruit were low for both groups.

Abbreviations: n/a, not applicable; NSLP, National School Lunch Program.

[a]Percentage of those study participants classified as socioeconomically disadvantaged according to the socioeconomic level indicator applied in the study.

[b]Results refer to the whole participating population unless otherwise stated.

Table 3 **Main characteristics of included studies of cognitive factors (n = 29)**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
Austin et al, 2020 (United States)[20]	To test a family-centered, media literacy–oriented intervention to reduce marketing influences, enhance nutrition knowledge, improve the selection of foods in the home environment, and improve fruit and vegetable consumption	Pretest-posttest study with control groups	Participation in the assistance programs for free or reduced-price school meals and SNAP (80.4%)	Community	Sample size: N = 189 child-parent dyads Age: 9–14 y (mean age: 11.0 y) Sex: information not provided Race/ethnicity: White (70.5%), Hispanic or Latino (11.1%), American Indian/ Alaskan Native (7.3%), Black (6.3%), Asian (1.9%), other (2.9%)	MIP model	Intervention: media literacy and nutrition skills intervention Control: not stated	Duration: 6 wk Follow-up: baseline and after 6 wk Exposure: 6 sessions (1 session/wk, 2 h/ session)	Number of fruits and vegetables eaten the previous day National Collaborative on Childhood Obesity Research Measures Registry questionnaire	Youth in the intervention group showed significant improvements in fruit and vegetable consumption compared with the control group.
Bishop et al, 2018 (United States)[21]	To examine if receiving the intervention improved participants' self-reported nutrition and physical activity habits	Not stated	Participation in the free or reduced-price lunch program (80%)	High school	Sample size: N = 16 Age: 16–18 y: 16 y, 18.8%; 17 y, 50.0%; and 18 y, 31.3% Sex: boys (38%); girls (62%) Race/ethnicity: Hispanic	Not stated	Intervention: 2 after-school events, including a healthy meal cooking demonstration and recipe provision and an activity where students blended a smoothie by pedaling an exercise bike Control: n/a	Duration: 2 d Follow-up: baseline and immediately postintervention Exposure: 2 sessions during school hours	Servings of fruits and vegetables per day Questionnaire	No improvement in the average (mean ± SD) of daily consumption of servings of fruit (2.44 ± 1.21 vs 3.06 ± 1.34) and of vegetables (1.81 ± 1.47 vs 2.31 ± 1.35; $P = 0.09$) were observed.
Black et al, 2010 (United States)[22]	To evaluate a home or community-based health promotion and obesity prevention program on changes in body mass index status, body composition, physical activity, and diet	Randomized controlled trial	Family income (families living below the federal poverty limit) (56%)	Household and community sites	Sample size: N = 235 Age: 11–16 y (mean age 13.3 y) Sex: boys (50.6%); girls (49.4%) Race/ethnicity: non-Hispanic Black (97%)	SCT	Intervention: One-to-one sessions that applied principles of mentorship (role modeling and support), participatory learning, and goal setting techniques. Other activities were a dietary and physical activity challenge, a video promoting healthy eating and physical activity, healthy snack preparation, tasting and recipe sharing, and recommendations for physical activity. Control: no intervention	Duration: not stated Follow-up: baseline, after 11 mo and 24 mo Exposure: 12 sessions	Total energy intake, dietary fat intake, and servings of fruit, vegetables, snacks/desserts, milk, nondiet soda, and fried foods per day Youth Adolescent Food Frequency Questionnaire	No significant changes in total energy intake, and intake of dietary fat, vegetables, nondiet soda, and fried foods for the intervention group and between the intervention and control groups. Significant effect in reducing consumption of snacks and desserts at both postintervention ($\beta = -2.21$; SE = 0.66; $P = 0.001$) and delayed follow-up ($\beta = -0.69$; SE = 0.31; $P = 0.026$) and in reducing consumption of fruit (including juice) at postintervention ($\beta = -0.41$; SE = 0.18; $P = 0.021$)
Casazza and Ciccazzo, 2007 (United States)[23]	To determine which health education delivery method would elicit a greater behavior change in terms of dietary habits and physical activity	Not stated	Eligibility for the free lunch program (62.3%)	High schools	Sample size: N = 311 Age: 13–18 y (mean age: 15.8 y) Sex: boys (34.2%); girls (65.8%) Race/ethnicity: non-Hispanic Black (51.6%), Hispanic (24.0%), White (14.5%), Indian (1.5%), Asian (0.4%), mixed race or ethnicity (7.6%)	Not stated	1. Intervention: 2 groups: computer-based education 2. traditional education via lectures and pamphlets Control: no intervention	Duration: ∼10 wk Follow-up: baseline and after 11 wk Exposure: 5 sessions (45 min each)	Fat, saturated fat, and fiber intake (g/d) Servings/d of fruit and vegetable intake Dairy intake Goals for Health Questionnaire food frequency questionnaire 2 nonconsecutive 24-h dietary recalls	Computer-based intervention group had a decrease in self-reported dietary fat intake (mean ± SEM) from baseline to postintervention (84.3 ± 90.1 g/d vs 50.8 ± 39.3; $P < 0.001$). No significant changes in saturated fat, dairy consumption, fiber, or fruits/vegetables intake in any of the groups

(continued)

Table 3 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
Contento et al, 2007 (United States)[25]	To examine the impact of an innovative, inquiry-based, science education curriculum designed to foster healthful eating, physical activity, and a healthy weight by enhancing agency and competence	Pretest-posttest study	Schools located in underserved and low-income neighborhoods	Middle schools	Sample size: N = 278 Age: 11–13 y (mean age: 12 y; 7th graders) Sex: information not provided Race/ethnicity: Black (25%), Hispanic (70%), and other race or ethnicity (5%)	Extended theory of planned behavior	Intervention: Analysis of personal food and activity data, health-related knowledge, goal setting, and goals achievement. Development of motivation and skills to achieve targeted obesity-reducing behaviors related to diet and physical activity (Choice, Control and Change curriculum). Control: n/a	Duration: 7–8 wk Follow-up: baseline and postintervention Exposure: 24-lessons curriculum (30–35 sessions)	Frequency of consumption and portion sizes of fruits and vegetables (times/d); candy and salty and sweet packaged snack food (d/wk and times/d); drinking water (times/d); and sweetened carbonated and noncarbonated beverages during the past week (d/wk and times/d); frequency of eating at fast-food restaurants (d/wk), usual portion sizes, and eating fast-food meals (d/wk) EatWalk survey	Postintervention, students significantly increased their frequencies of fruit intake (1.60 vs 1.85 times/d; $P = 0.03$) and decreased the frequency of sweetened beverages (4.50 vs 4.19 d/wk; $P = 0.038$), packaged snacks (28% decrease in weekly consumption; ($P < 0.001$), eating at a fast-food restaurant (14% reduction; $P = 0.003$), and drank smaller portions of carbonated drinks (23% reduction; $P < 0.001$) and sweetened noncarbonated drinks (40% reduction, $P < 0.001$). No changes in vegetables and water intake
Contento et al, 2010 (United States)[24]	To evaluate the impact of a science and nutrition education middle-school curriculum on behaviors related to obesity risk reduction or energy balance–related behaviors and on potential mediators of behavior change	Pre-and post cluster randomized intervention, control	Participation in the free or reduced-price lunch program (78%)	Middle schools	Sample size: N = 1136 Age: 11–13 y (mean age: 12 y; 7th graders) Sex: boys (51%); girls (49%) Race/ethnicity: Black (25%), Hispanic (70%), and other race or ethnicity (5%)	SCT and self-determination theory	Intervention: Choice, Control & Change curriculum, which includes analysis of personal food and activity data, health-related knowledge, goal setting, and goal achievement Development of motivation and skills to achieve targeted obesity-reducing behaviors related to diet and physical activity (Choice, Control & Change curriculum). Control: standard science curriculum of equal intensity and duration, receiving Choice, Control, & Change curriculum the next term as a delayed intervention	Duration: 8–10 wk Follow-up: baseline and postintervention Exposure: 24-session curriculum (45 min/session)	Frequency and portion sizes of fruits and vegetables during meals and snacks; water at meals, snacks, and in between; processed, packaged snacks; sweetened beverages at meals, snacks, and in between; and when eating at fast-food restaurants EatWalk Survey, a modified version of the Block food frequency instrument for children	Students in intervention schools compared with the delayed intervention controls (mean ± SD) reported significantly less consumption of sweetened drinks: during meals (intervention: 2.85 ± 2.1 times/wk; control: 3.79 ± 2.2 times/wk; $P < 0.001$); in snacks and between meals (intervention: 3.17 ± 2.4 times/wk; control: 3.99 ± 2.4 times/wk; $P = 0.001$); and packaged snacks (intervention: 2.98 ± 2.0 times/wk; control: 3.60 ± 2.0 times/wk; $P = 0.005$). No increases in the intakes of water, fruits, and vegetables
Covelli, 2008 (United States)[26]	To evaluate the efficacy of an intervention program that aimed to (1) increase knowledge of health promotion; (2) increase daily exercise; (3) increase intake of fruits and vegetables; and (4)	Quasi-experimental and repeated measures design	Eligibility for free or reduced-price meals (>90%)	High school	Sample size: N = 48 Age: 14–17 y (mean age 15 y) Sex: boys (66.7%); girls (33.3%) Race/ethnicity: Black	Intervention theory of Sidani and Branden	Intervention: program focused on behavioral components of health knowledge, health promotion concepts, nutrition, and exercise, and integrated biological sciences,	Duration: 9 wk Follow-up: weeks 1 and 9 Exposure: 2 weekly sessions (1.5 h/session)	Daily intake and types of fruits and vegetables and of food high in salt. 2-d dietary history recall and nutrition questionnaire	There was a significant positive difference in the daily intake of fruits and vegetables (mean ± SD) between the intervention and the control groups

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Table 3 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	maintain normal blood pressure levels						writing and grammar skills, and mathematical concepts that were part of the school's curriculum. Control: no intervention; Regular Life Management class			(4.9 ± 1.2 vs 2.5 ± 0.1; $P = 0.0001$).
Dewar et al, 2013 (Australia)[27]	To evaluate the 24-mo impact of a school-based obesity prevention program	Cluster randomized controlled trial	Schools located in low-income communities	Secondary schools	Sample size: N = 357 Mean age: 13.2 y (8th graders) Sex: girls (100%) Nationality, geographic region, or race/ethnicity: Australian (85.4%), European (10.1%), Asian (1.1%), other race or ethnicity (3.1%)	SCT	Intervention: intervention components included enhanced school sport sessions, lunchtime physical activity sessions, nutrition workshops, interactive educational seminars, pedometers for self-monitoring, student handbooks, parent newsletters, and text messages to reinforce and encourage targeted health behaviors. Control: no intervention	Duration: 12 mo Follow-up: baseline and after 12 mo (pos-intervention) and 24 mo (follow-up) Exposure: three 90-min nutrition workshops; three 30-min seminars; 40 90-min sport sessions; 30 30-min lunch sport sessions; 10 wk of information from PA and nutrition handbooks; 4 parent newsletters; text messaging 1–2 times per week	Energy intake Australian Child and Adolescent Eating Survey	The intervention and control groups decreased their energy intake (median 33.8 kcal/kg/d vs 33.6 kcal/kg/d, respectively). There were no group-by-time effects for any of the health behaviors (no intervention effect).
DiNoia et al, 2008 (United States)[28]	To examine the efficacy of an intervention for increasing fruit and vegetable consumption	Pretest-posttest quasi-experimental design	Low-income communities with ≥20% of families with incomes below the federal poverty level (87%)	Youth services agencies	Sample size: N = 507 Age: 11–14 y (mean age: 12.4 y) Sex: boys (39%); girls (61%) Race/ethnicity: Black (85%) and Hispanic (15%)	Transtheoretical model	Intervention: computer intervention adapted to the users' state of change, including consciousness raising, dramatic relief, and environmental reevaluation processes (precontemplation state); self-reevaluation and self-liberation strategies (contemplation/preparation state); and reinforcement management, helping relationships, counterconditioning, and stimulus control processes (action/maintenance state) Control: no intervention, only the regular program	Duration: 4 wk Follow-up: baseline and 2 wk postintervention Exposure: four 30-min weekly sessions	Fruit and vegetable intake Questionnaire	Youths in the intervention group had greater fruit and vegetable consumption than did control particpantss (mean servings [SD], 3.25 [1.50] vs 2.46 [1.39]).
Foley et al, 2017 (Australia)[29]	To assess changes in energy balance-related behaviors and intentions of those acting as peer leaders to deliver the SALSA program to younger students	Pre- and posttest design	School socioeconomic level assessed with the School's Index of Community Socio-Educational Advantage (60%)	Secondary schools	Sample size: N = 415 Age: 15–16 y (10th graders) Sex: boys (36%); girls (64%) Race/ethnicity: information not provided	SCT and Freire's empowerment education approach	Intervention: training to deliver the SALSA educational program designed to improve food, beverage, physical activity, and recreational screen-time behaviors Control: n/a	Duration: 25 d Follow-up: baseline and 2 wk postintervention Exposure: 1-d training workshop and delivery of 4 sessions (70 min/session) to younger students	Fruit, vegetable, and sugar sweetened beverage daily intake, and breakfast-eating frequency Short food frequency questionnaire	There were significant increases in the proportion of peer leaders who reported eating ≥2 servings of fruit/d fruit, from 54% to 63% ($P < 0.01$); eating ≥5 servings of vegetables/d increased from 8% to 12% ($P < 0.01$); and drinking <1 cup/d of sugar sweetened

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Table 3 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
										beverages increased from 56% to 62% ($P < 0.01$). Changes in eating breakfast daily depended on sex ($P < 0.004$): boys increased breakfast frequency (13%); girls decreased (−0.4%). Dietary outcomes were not moderated by school socioeconomic status.
Frenn et al, 2003 (United States)[30]	To improve low-fat diet and moderate and vigorous physical activity	Quasi-experimental design	Schools defined as low- to middle-income (no information provided on indicator used) Eligibility for free or reduced-price meals (45.2%)	Middle schools	Sample size: N = 126 Age: 12–15 y (7th graders: 73.2%; 8th graders: 26.8%) Sex: boys (45.2%); girls (54.8%) Race/ethnicity: Black (47.5%), White (38.5%), Hispanic (3.3%), Asian (7.4%), and Native American (3.3%)	Transtheoretical model and health promotion model	Intervention: internet and video sessions focusing on raising awareness of current eating and exercise for those in precontemplation and contemplation stages of change. Those in preparation, action and maintenance stages of change acted as peer models and led healthy snack and exercise laboratory sessions. Control: no intervention	Duration: 1 school year (∼10 mo) Follow-up: baseline and postintervention Exposure: 4 sessions plus a healthy snack session and a gym class (6 sessions, 50 min/session). Gym class in 1 school only	Intake of high- and low-fat foods Food Habits Questionnaire	No differences in percentage of fat were observed between the intervention and the control groups. Percentage of fat in food was reduced significantly among Black, White, and Black/Native American girls in the intervention group postintervention, compared with the control ($P = 0.018$).
Frenn et al, 2003 (United States)[31]	To examine the effectiveness of an intervention in reducing percentage fat in diet and increasing physical activity	Quasi-experimental design	Family income based on census per capita income by race for zip code	Middle school	Sample size: N = 182 Age: 12–17 y (mean age: 13.8 y; 6th, 7th, and 8th graders) Sex: boys (47%); girls (52%) Race/ethnicity: Black (50%), White (20%), Hispanic (14%), and other races (15%)	Transtheoretical model and health promotion model	Intervention: 2 groups: (1) precontemplation stages of change: consciousness raising about diet and exercise and self-reevaluation strategies; (2) preparation, action, and maintenance stages of change: consciousness raising, social liberation, counterconditioning, stimulus control, helping relationships, reinforcement management, dramatic relief, environmental reevaluation, and training to act as peer models Control: no intervention; usual classroom education	Duration: not stated Follow-up: baseline and postintervention Exposure: 4 classroom sessions (45 min/session) and 4 small group sessions (only for those in preparation, action, and maintenance stages of change)	Frequency of consumption of high- and low-fat foods Food Habits Questionnaire	Posttest percentage fat in food was significantly lower for the intervention group compared with the control group ($P = 0.04$).
Frenn et al, 2005 (United States)[32]	To examine the effectiveness of an internet/video-delivered intervention to increase physical activity and reduce dietary fat	Quasi-experimental design	Eligibility for free or reduced-price meals (85.6%)	Middle school	Sample size: N = 132 Age: 12–14 y (7th graders) Sex: boys and girls Race/ethnicity: Hispanic, Black, White, Native American, Asian, and other races or ethnicities	Transtheoretical and Health Promotion models	Intervention: internet/video-delivered intervention on consciousness raising to reduce dietary fat, eating more vegetables and fruits, eating breakfast and lunch, and choosing snacks wisely; self-reevaluation strategies, and decisional balance aspects to improve access and reduce barriers to	Duration: 1 mo Follow-up: baseline and postintervention Exposure: 8 sessions (40 min/session)	Frequency of consumption of high- and low-fat foods Food Habits Questionnaire	Those who completed more than half the sessions decreased the percentage of dietary fat from 30.7% to 29.9 % ($P = 0.01$), whereas those in the control had 31.5% dietary fat intake on pretest and 31.6% on posttest. Those participating in less than half of the

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Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
							healthy foods and physical activity; and to emphasize benefits of healthy foods and physical activity Control: no intervention; usual classroom education			diet sessions were not significantly different than students in the control group classes ($P = 0.08$).
Harley et al, 2018 (United States)[33]	To examine the effectiveness of a classroom-based, experiential culinary and nutrition literacy program designed to influence healthy eating	Nonequivalent control group design	Participation in free or reduced-price school meal program (84.3%)	Kindergarten through-out8th-grade schools	Sample size: N = 195 Age: 11–13 y (6th and 7th graders) Sex: boys (47.2%); girls (52.8%) Race/ethnicity: Black (34.7%), Hispanic (33.4%), White (25.1%), other races or ethnicities (8.0%)	SCT	Intervention: 4 iterative classroom demonstration projects, including hands-on culinary and nutrition literacy curriculum Control: no intervention; usual school curriculum	Duration: 6 wk Follow-up: baseline and after ∼7 wk Exposure: 6 weekly sessions (2 h/session)	Times per day of fruit, vegetables, and whole-grain consumption Youth Risk Behavior Surveillance System Questionnaire and the Power of 3: Get Healthy with Whole Grains Foods program adult survey	There were significant increases in times per day of fruit and vegetable consumption (1.2 times/d; $P = 0.02$) and vegetable only consumption (0.9 times/d; $P = 0.02$) in the intervention group compared with the control group. There were no significant differences in whole-grain consumption between the groups.
Heo et al, 2016 (United States)[34]	To evaluate the effects of a program on nutrition, mental health, and physical activity knowledge and health behavior	Not stated	Participation in free or reduced-price school meal program (>50%)	Public high schools	Sample size: N = 2255 Age: 13–20 y Sex: boys (55.5%); girls (44.5%) Race/ethnicity: Hispanic, non-Hispanic Black, Asian/Pacific Islander, non-Hispanic White	Not stated	Intervention: school wellness programming using classroom teaching to promote changes in nutrition, mental health, and physical activity behaviors, and demonstration events out of the classroom. Control: n/a	Duration: 1 school year Follow-up: baseline (beginning school year) and after 8 mo (end of school year) Exposure: 10 lessons/wk (30 min–1.30 h/session) and 10.5 h exposure to events over 18 wk, 36 h of optional after-school activities over 36 wk	Intake of fruits, vegetables, sugar-sweetened beverages, and high energy density foods, and breakfast consumption Youth Risk Behavioral Surveillance Questionnaire	Boys significantly increased in mean ± SD fruit and vegetable intake by 0.06 ± 0.03 ($P = 0.03$). Girls increased breakfast consumption (OR, 1.27, 95%CI, 1.01–1.58; $P = 0.04$), and decreased sugar-sweetened beverages and energy dense food intake by 0.05 ± 0.02 ($P = 0.03$).
Heo et al, 2018 (United States)[35]	To test whether the HealthCorps program would improve weight status and to identify knowledge and health behavior domains that would be increased with the program	2 parallel-arm quasi-experimental, pretest-posttest comparison design	Eligibility for free or reduced-price school meal program (>50%)	High schools	Sample size: N = 832 Mean age: 15.4 y Sex: boys (57.2%); girls (42.8%) Race/ethnicity: Hispanic (41.5%)	Not stated	Intervention: classroom lessons to build mental resilience, healthy eating habits, and physical fitness, weekly after-school clubs on nutrition, physical fitness, and/or mental resilience, and activities outside the classroom such as lunchroom food samplings, cooking programs, Youth Lead Action Research, and community-wide festivals Control: no intervention	Duration: 1 school year or 1 semester Follow-up: baseline (beginning school year) and after 4 mo (end of semester) or 8 mo (end school year) Exposure: 10 classroom lessons weekly or bi-weekly. Total exposure: ≤45 h over a maximum of 36 wk	Fruit, vegetable, high-energy-density food, water, juice, and sugar-sweetened beverage intake, and breakfast consumption Youth Risk Behavioral Surveillance Questionnaire	There was a significant increase in mean ± SD fruit and vegetable intake by boys (0.38 ± 0.18) and girls (0.63 ± 0.20) in the intervention group. No significant results were observed for high-energy-density food, water and juice, sugar-sweetened beverage, and breakfast intake by either boys or girls in the intervention group as compared with those in the comparison arm.
Lubans et al, 2009 (Australia)[36]	To evaluate the impact of a multicomponent, extracurricular, school sport intervention that included pedometers for self-monitoring along	Randomized control trial	Schools located in urban areas with low-to-moderate socioeconomic status (n/a)	Secondary schools	Sample size: N = 124 Mean age: 14.1 y Sex: boys (42.7%); girls (57.3%) Nationality: 94.4% born in Australia	SCT	Intervention: multicomponent, extracurricular, 10-wk school sport program with information sessions and nutrition messaging,	Duration: 6 mo Follow-up: baseline and after 6 mo Exposure: 10 sessions (1 session/wk), monthly parent	Intake of fruit, vegetables, daily soft drinks, water, and energy-dense and/or low-nutrient snacks. Frequency of intake of energy-dense and/or	The number of boys in the intervention group who reported eating ≥3 snacks each day decreased (from 47%

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Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	with social support from parents and e-mail feedback						including pedometers and diaries for self-monitoring of physical activity and diet, and social support from parents and through e-mails Control: 10-wk school sport program only	newsletter, tracking steps for 6 mo	low-nutrient snacks between meals NSW SPANS 2004	to 21%; $P = 0.04$). The number of girls in the intervention group who reported eating ≥ 2 servings/d of fruit increased (from 46% to 76%; $P = 0.03$). No statistically significant differences between the intervention and control groups for any of the dietary outcomes at baseline or at follow-up
Lubans et al, 2012 (Australia)[37]	To evaluate the effects of an intervention to prevent unhealthy weight gain	Cluster randomized controlled trial	Schools located in low-income communities according to the SEIFA IRSD. Schools classified within an IRSD decile ≤ 5 (lowest 50 %) were considered eligible (n/a)	Secondary schools	Sample size: N = 357 Age: 12–14 y (mean age 13.2 y; 8th graders) Sex: girls (100%) Nationality, geographic region, or race/ethnicity: Australian (85.4%), European (10.1%), Asian (1.1%), other race or ethnicity (3.1%)	SCT	Intervention: intervention components including enhanced school sport sessions, lunchtime physical activity sessions, nutrition workshops, interactive educational seminars, pedometers for self-monitoring, student handbooks, parent newsletters, and text messages to reinforce and encourage targeted health behaviors Control: no intervention	Duration: 12 mo Follow-up: baseline and after 12 mo Exposure: 60–80-min sport sessions (4-wk units), 3 interactive seminars, pedometers, nutrition handbooks, 3 nutrition workshops, weekly (2 terms) or bi-weekly (1 term) messages, 4 parent newsletters	Energy intake Australian Child and Adolescent Eating Survey	No group by time effects for energy intake were observed.
Lubans et al, 2016 (Australia)[38]	To report the sustained impact of the ATLAS obesity prevention program on primary and secondary outcomes, which were assessed 10-mo after program completion	Cluster randomized controlled trial	Schools located in low-income communities according to the SEIFA IRSD Schools classified within an IRSD decile ≤ 5 (lowest 50 %) were considered eligible (n/a)	Secondary schools	Sample size: N = 361 Age: 12–14 y (mean age 12.7 y) Sex: boys only Nationality, geographic region, or race/ethnicity: Australian (77.2%), European (14.8%), African (1.9%), Asian (1.9%), Middle Eastern (0.6%), other races or ethnicities (3.6%)	SCT and self-determination theory	Intervention: teacher professional development, provision of fitness equipment to schools, face-to-face physical activity sessions, lunchtime student mentoring sessions, researcher-led seminars, a smartphone application and website, and parental strategies for reducing screen-time Control: no intervention; regularly scheduled school sports and physical education lessons	Duration: 20 wk Follow-up: baseline and after 8 mo and 18 mo Exposure: 1 h researcher-led seminars, 30 h enhanced school sport sessions, 2 h lunchtime physical activity-mentoring sessions, pedometers for 17 wk, 4 parental newsletters, and a smartphone application for 15 wk	Frequency of intake of fruit-based drinks and soft drinks or nonalcoholic cordials NSW SPANS	There was a significant decrease in sugar-sweetened beverage consumption within the intervention group from baseline to immediately postintervention (mean 3.9 vs 3.1 250 mL glasses/d; $P < 0.001$). No significant change was from baseline to 18 mo and between groups were observed.
Luesse et al, 2019 (United States)[39]	To assess the initial efficacy of the curriculum and to provide an in-depth understanding of the potential behavioral outcomes and psychosocial mediators	Single-arm pretest–posttest	After-school program sites located in low-income neighborhoods (n/a)	After-school classrooms	Sample size: N = 32 Mean age :12.1 y Sex: boys (50%); girls (50%) Race/ethnicity: Black (56.3%), Hispanic (34.4%), White (3.1%), mixed race or ethnicity (6.3%)	SCT and self-determination theory	Intervention: health education curriculum designed to help youth become critical of the corporate food supply and familiar and confident in selecting and preparing whole or minimally processed food, including marketing strategies and preparation and eating of dishes with these foods Control: n/a	Duration: 10 wk Follow-up: baseline and after 12 wk Exposure: 10 weekly 2-h sessions	Frequency of intake of whole or minimally processed foods (fruit and vegetable intake) and highly processed foods FHC Questionnaire	There was a large, positive, significant increase in mean ± SD frequency of fruit and vvegetable servings per week intake (1.70 ± 0.63 vs 2.15 ± 0.60; $P < 0.01$) compared with baseline. No significant differences in consumption of highly processed foods

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Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
Muzaffar et al, 2014 (United States)[40]	To improve knowledge, outcome expectations, self-efficacy, and self-reported food intake and skills and to compare passive vs active online learning	Randomized controlled trial	Participation in free or reduced-price school meal program (62%)	Middle schools	Sample size: N = 214 Age group: 6th, 7th, and 8th graders Sex: boys and girls Race/ethnicity: information not provided	SCT	Intervention: online educational intervention with interactive features such as videos (observational learning), narrated text (social persuasion), and knowledge and skill-based games (outcome expectancies, self-efficacy) Control: passive online educational intervention with noninteractive texts	Duration: 2 wk Follow-up: baseline and after 2 wk Exposure: 5 session (30–40 min/session)	Intake of fruit, vegetables, and fat The Rapid Eating Assessment Plan	Both intervention and control groups improved significantly in terms of fat and fruit and vegetable intake after the intervention.
Ratcliffe et al, 2011 (United States)[41]	To evaluate the impact of participating in a school garden program on the ability to identify, willingness to try, preference for, and overall consumption of vegetables	Quasi-experimental, pre- and post panel design	Eligibility for free or reduced-price meals (64%)	Middle schools	Sample size: N = 320 Age: 11–13 y (6th graders) Sex: information not provided Race/ethnicity: Latino (30%), Asian American (29%), Black (22%), Filipino American (9%), Pacific Islander (3%), and White non-Hispanic or other race or ethnicity (7%)	SCT	Intervention: garden-based learning sessions that were integrated into regularly scheduled science class Control: health and science learning objectives without a gardening program	Duration: 13 wk Follow-up: baseline (beginning school year) and after 10 mo (end of school year) Exposure: 13 sessions (1 h session/wk)	Types and frequency of vegetable intake Garden Vegetables Frequency Questionnaire and Taste Test	Compared with the control group, students in the garden group significantly increased the average number of vegetable varieties they consumed more than once a month (1.1 ± 4.1 vs -0.9 ± 4.6; $P = 0.001$), both for the vegetables they grew (0.5 ± 0.2 vs -0.3 ± 0.2; $P = 0.005$) and those they did not (0.5 ± 0.2 vs -0.6 ± 0.3; $P = 0.001$). Children in the garden group ate a significantly greater variety of vegetables at school than those in the control group (0.5 ± 2.1 vs -0.3 ± 1.7; $P = 0.01$). No significant difference between the 2 groups was observed for vegetable intake at home.
Rees et al, 2010 (England, UK)[42]	To evaluate the effectiveness of a computer-generated, tailored intervention at increasing brown bread, whole-grain cereal, fruit and vegetable intakes	Clustered randomized controlled trial	Schools located in low-income areas (n/a)	Secondary schools	Sample size: N = 823 Age: 12–16 y Sex: girls only Race/ethnicity: White (53.4 %), Asian (18.7%), Black (15.8%), mixed race (10.0%), other ethnicity (2.1%)	Theory of planned behavior and the transtheoretical model	Intervention: computer-generated leaflet tailored to the participants' responses to a baseline diet and psychological questionnaire Control: generic leaflet based on national guidelines	Duration: not stated Follow-up: baseline and after 3 mo Exposure: 1 session	Intake of brown bread, whole-grain cereal, fruit and vegetables Three 24-h dietary recalls	The intervention group significantly increased brown bread intake from (0.39 to 0.51 servings/d; $P < 0.05$) with a smaller but significant increase in the control group also (from 0.28 to 0.35 servings/d; $P < 0.05$). No significant effects of the intervention for other foods
Shilts et al, 2009 (United States)[43]	To determine the effectiveness of the guided goal-setting strategy on changing adolescents' dietary and physical	Not stated	Participation in free or reduced-price school meal program (65%)	Middle school	Sample size: N = 94 Mean age: 14.0 y (8th graders) Sex: boys (55%); girls (45%)	SCT	Intervention: goal-setting guided intervention including lessons and a workbook with handouts and supplemental nutrition and	Duration: 5 wk Follow-up: baseline and after 6 wk Exposure: 10 h (5 lessons, 2 sessions/wk, 1 h/session)	Frequency of specific dietary behaviors, including breakfast consumption Youth Risk Behavior Survey	No significant differences were found between groups using the full sample. A subsample with treatment

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Table 3 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	activity self-efficacy and behaviors				Race/ethnicity: Asian (34%), Hispanic (25%), non-Hispanic White (21%), non-Hispanic Black (13%), Asian Indian (3%), other race or ethnicity (4%)		fitness information Control: lessons and a workbook adapted to the control group condition; no goal setting guided intervention			participants who made a goal effort and control participants who did not spontaneously set goals, greater gains in dietary behavior (5.46 ± 2.50 vs −1.16 ± 3.22; $P = 0.02$) were made by treatment participants.
Shrewsbury et al, 2020 (Australia)[44]	To examine the effect of the SALSA program on frequency of eating breakfast, fruit and vegetable intake, sugar-sweetened beverage intake, participation in moderate to vigorous physical activity, recreational screen time, and intentions to change these behaviors over the next month	Pre- and posttest design	School socioeconomic level assessed with the ICSEA score: high (42.1%) vs low (57.9%)	High schools	Sample size: N = 2056 Age: 13–14 y (8th graders) Sex: boys (45.9%); girls (54.1%) Race/ethnicity: information not provided	SCT and empowerment educational approach (to be added to text)	Intervention: peer-led, school-based educational program including lessons on healthy eating and physical activity Control: n/a	Duration: 10–13 wk Follow-up: baseline and after 96 d (median number of days) Exposure: 4 sessions (70 min/session)	Fruit, vegetable, and sugar-sweetened beverage daily intake, and breakfast eating frequency Energy Balance Related Behavior Questionnaire, based on NSW SPANS	There were significant increases in eating ≥2 fruit servings/d ($P < 0.05$) and in drinking <1 cup/d of sugar-sweetened beverages ($P < 0.001$) among students from low-socioeconomic-status schools.
Smith et al, 2014 (Australia)[45]	To evaluate the effects of the multicomponent, school-based, obesity prevention intervention incorporating smartphone technology	Cluster randomized controlled trial	Schools located in low-income communities according to the SEIFA of relative socioeconomic disadvantage. Schools located in areas with a SEIFA value of ≤5 (lowest 50%) were considered eligible (93.1%)	Secondary schools	Sample size: N = 361 Age: 12–14 y (mean age 12.7 y) Sex: boys only Nationality, geographic region, or race/ethnicity: Australian (77.2%), European (14.8%), Asian (1.7%), Middle Eastern (0.6%), other race or ethnicity (3.6%)	SCT and self-determination theory	Intervention: a multicomponent intervention targeting participants' motivation for physical activity during scheduled school sports, including teacher professional development, provision of fitness, face-to-face physical activity sessions, lunchtime student mentoring sessions, researcher-led seminars, a smartphone application and website, and parental strategies for reducing screen time. Control: no intervention; regularly scheduled school sports and physical education lessons	Duration: 20 wk Follow-up: baseline and after 8 mo Exposure: 2 6-h workshops, 1 fitness instructor session, three 20-min seminars, 20 90-min sport sessions, six 20-min lunch sport sessions, 17-wk access to pedometers, 4 parental newsletters, and 15-wk access to smartphone application	Frequency of intake of fruit-based drinks and soft drinks or nonalcoholic cordials NSW SPANS	Boys in intervention group reported significantly less consumption of sugar-sweetened beverages than boys in the control group at follow-up (mean: −0.6 ± 0.26 glass/d; $P = 0.01$).
Spook et al, 2016 (the Netherlands)[46]	To identify the effectiveness of Balance It on changes in dietary intake and physical activity and their determinants	Pre- and post-cluster randomized trial	Education level (vocational schools) (n/a)	Secondary vocational schools	Sample size: N = 231 Age: 15–21 y (mean age 17.3 y) Sex: boys (37.2%); girls (62.8%) Nationality: Dutch background (73.2%), non-Dutch background (26.8%)	Self-regulation theory	Intervention: interactive multimedia game where players set their own graded tasks Control: no intervention	Duration: 4–6 wk Follow-up: baseline and after 4 wk Exposure: daily for 4 continuing weeks or weekly for 6 continuing weeks	Intake of fruit, vegetables, snacks, and soft drinks Food frequency questionnaire	No significant differences between the intervention group and control group in terms of dietary intake. Active users' (ie, actual intervention users) significantly decreased snack consumption compared with the control group (mean change: active users, −0.20; control group: −0.08; $\beta = -0.36$; $P = 0.01$).
Wilson et al, 2002 (United States)[48]	To compare the effects of 3 intervention programs based on different theoretical frameworks on increasing fruit and vegetable intake and physical activity	Not stated	Annual family income (sample mean <$30000/y)	Middle schools	Sample size: N = 53 Age: 11–15 y Sex: boys (58.5%); girls (41.5%) Race/ethnicity: Black	SCT	Intervention: (1) SCT + MI group: education, behavioral skills training with feedback and reinforcement plus self-presentation	Duration: 12 wk Follow-up: baseline and after 12 wk Exposure: 12 1-h sessions plus cooking class once per week.	Intake of fruit and vegetables (servings/d). 3-day dietary record	Both the SCT + MI (2.6 ± 1.4 vs 5.7 ± 2.2; $P < 0.05$) and the SCT-only (2.5 ± 1.2 vs 4.8 ± 2.4; $P < 0.05$) groups had greater

(continued)

Table 3 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
							videotapes to portray successful coping strategies to change dietary and physical activity behaviors (2) SCT-only group: education, behavioral skills training with feedback and reinforcement Control: education on general health-related issues (education-only group)			increases in fruit and vegetable intake from before to after intervention treatment. No significant differences were observed in the education-only group (2.3 ± 1.0 vs 3.3 ± 2.1; $P > 0.05$).
Wilson et al, 2014 (United States)[47]	To examine the effects of a web-based tailored parenting intervention on increasing fruit and vegetable intake	1-group pretest-posttest design	Household yearly income (<$25 000/year; 59.6%)	Household and community sites	Sample size: N = 47 parent-adolescent dyads Mean age: 13.3 y Sex: boys (40.4%); girls (59.6%) Race/ethnicity: Black	SCT, self-determination theory, and family systems theory	Intervention: web-based intervention including feedback, information, goal setting, and action plan Control: n/a	Duration: not stated Follow-up: baseline and after 1 wk Exposure: 1 session (45–60 min)	Intake of fruit and vegetables (servings/d). Fruit and vegetable screening tool	Daily fruit intake (mean ± SD) pre- vs posttest: 1.71 ± 0.93 vs 2.27 ± 0.92; $P < 0.05$) and combined daily fruit and vegetable intake (pre- vs posttest: 3.34 ± 1.46 vs $4.07 \pm +1.47$; $P < 0.05$) significantly increased from pretest to 1-wk follow-up. No significant differences were observed in adolescents' daily vegetable intake between pretest and 1-wk follow-up (1.63 ± 0.80 vs 1.80 ± 0.81; $P < 0.05$)

Abbreviations: ATLAS, Active Teen Leaders Avoiding Screen-time; FHC, Food, Health & Choice; ICSEA, Index of Community Socio-Educational Advantage; IRSD, Index of Relative Socioeconomic Disadvantage; MI, motivational intervention; MIP, message interpretation process; n/a, not available; NSW, New South Wales; OR, odds ratio; PA, Physcial Activity; SALSA, Students As LifeStyle Activists; SCT, social cognitive theory; SD, standard deviation; SE, standard error; SEIFA, Socio-Economic Indexes for Areas; SNAP, Supplemental Nutrition Assistance Program; SPANS, Schools Physical Activity and Nutrition Survey.

[a]Percentage of those study participants classified as socioeconomically disadvantaged according to the socioeconomic level indicator applied in the study.

[b]Results refer to the whole participating population unless otherwise stated.

Table 4 **Main characteristics of included studies of multicomponent strategies (n = 13)**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
Birnbaum et al, 2002 (United States)[49]	To increase fruit and vegetable intake and decrease the fat intake of low-income young adolescents, to reduce their risk of cancer	Group-randomized trial	Participation in the free or reduced-price lunch program (n/a)	Middle and junior high schools	Sample size: N = 3503 Age group: 7th graders Sex: boys (50.6%); girls (49.4%) Race/ethnicity: White (68.7%), Black (10.4%), Asians or Pacific Islander (6.9%), multiracial (5.6%), other racial/ethnic groups (8.5%)	Social cognitive theory	Intervention: multi-component, school-based intervention program including school environment components, classroom curricula components, and peer-leaders component 3 exposure groups: 1. School environment interventions only 2. Classroom curriculum plus school environment interventions 3. Peer leaders plus classroom curriculum plus school environment interventions (highest exposure) 4. Control: no intervention (least exposure)	Duration: 2 y Follow-up: baseline (beginning school year) and after 9 mo (end of school year) Exposure: 10 curriculum sessions	Daily servings of fruit and vegetable intake, modified version of the Behavioral Risk Factor Surveillance System measure Usual food choices, modified version of an existing scale	Peer leaders reported nearly a full-serving significant increase in daily fruit and vegetable consumption and nearly a half-serving increase in daily fruit consumption. No significant changes in daily fruit and vegetable servings from baseline to end of 7th grade were seen in students exposed to the curriculum plus school environment intervention and to the school environment intervention only. There was no change in daily fruit and vegetable servings from baseline to end of 7th grade among students in control schools.
Bogart et al, 2014 (United States)[50]	To increase uptake of cafeteria food, increase fruit and vegetable servings, decrease school-store snack sales and increase water consumption among students	Randomized controlled trial	Participation in the NSLP free and reduced-price meals (54%)	Middle schools	Sample size: N = 3211 Age group: 7th graders Sex: Information not provided Race/ethnicity: Latino (74.7%), Black (14.2%), White (5.7%), Asian/Pacific Islander (5.5%)	Social-cognitive theory, socio-ecological model, and diffusion of innovation theory	Intervention: combination of school-wide environmental changes, multimedia, encouragement to eat cafeteria food (because of school policies to provide healthier food), and student advocacy Control: no intervention	Duration: 5 wk Follow-up: baseline and after 42 mo (3.5 y) Exposure: 25 sessions (peer leaders)	Number of fruits and vegetables served, students served lunch, snacks sold per attending student, and water consumption frequency School records on cafeteria, school-store data, and a survey	Intervention schools had increases of 15.3% more fruit served ($P = 0.01$), 10.4% more lunches served ($P < 0.001$), and 11.9% fewer snacks sold ($P < 0.001$) relative to the control schools. No significant changes in vegetables served were observed. Intervention-school students reported greater tap water consumption ($P = 0.04$) compared with control-school students.
D'Adamo et al, 2016 (United States)[51]	To determine whether an experiential nutrition education intervention focusing on spices and herbs improved diet quality	Nonrandomized 2-arm controlled trial	Participation in free or reduced-price school meal program (75%)	Public high schools	Sample size: N = 110 Age group: 9th–12th graders (mean age: intervention group, 16.2 y; control group, 17.1 y)	Not stated	Intervention: standard nutrition education plus adjuvant Spice MyPlate curriculum, including education sessions, a tour of a	Duration: 6 wk Follow-up: at baseline and after 3, 6, and 10 wk Exposure: 6 sessions (1 h/session)	Intake of vegetables (cups), fruits (cups), dairy (cups), whole grains (ounces), and protein foods (ounces)	There were significant improvements ($P < 0.05$) in the Spice MyPlate group compared with

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Table 4 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	and healthy eating attitudes more than standard nutrition education alone				Sex: boys (33.6%); girls (66.4%) Race/ethnicity: Black (80.6%), White (7.8%), Hispanic (1.9%), Asian or Pacific Islander (1.9%), Native American (1.9%), other race or ethnicity (5.8%)		local grocery store, and cooking sessions Control: standard nutrition education in US Department of Agriculture MyPlate guidelines		3-day food records	the control in consumptions of whole-grain (31.2 g/wk) and protein foods (13.2 ounces/wk) intake.
Dubuy et al, 2014 (Belgium)[52]	To explore the effectiveness of a school program combined with the use of professional football (soccer) players for promoting positive dietary habits and physical activity	Controlled pretest-posttest design	Proportion of socially vulnerable pupils in schools according to official indicators (n/a)	Professional football (soccer) clubs and schools	Sample size: N = 605 Age: 10–14 y Sex: boys (68.4%); girls (31.6%) Nationality: Belgian, Turkish, Moroccan, Bulgarian, Dutch, Albanian, Czech	Elaboration likelihood model	Intervention: 3 components: (1) a start clinic (healthy diet and physical activity encouragement involving football (soccer) players); (2) a school program (school and classroom activities connected on healthy eating and physical activity); (3) and an end clinic. Control: no intervention, only regular school curriculum	Duration: 4–5 mo Follow-up: baseline and after 4 mo Exposure: 2 clinics and a 4-mo school program	Frequency of intake of fruits, vegetables, water, soft drinks, and sweet and savory snacks; and breakfast intake Food frequency questionnaire	No intervention effects were found among boys for consumption of breakfast, fruit, soft drinks, or sweet and savory snacks. Girls were excluded from analyses because of very low participation.
Evans et al, 2012 (United States)[53]	To measure the effects of different levels of exposure to a multiple-component intervention on fruit and vegetable intake and on related psychosocial factors	Unequal treatment–control posttest only design	Eligibility for free or reduced-price meals (70%)	Middle schools	Sample size: N = 246 Age group: 6th graders (55%) and 7th graders (45%) Sex: boys (26%); girls (74%) Race/ethnicity: Hispanic (59%), White (19%), Black (16%)	Social cognitive theory	Intervention: 6 components were included: (1) in-class lessons; (2) after-school gardening program; (3) farm-to-school cafeteria component; (4) farmers' visits to schools; (5) taste testing; (6) field trips to farms. Schools had varying levels of exposure to 6 components of the intervention. Control: no intervention	Duration: 5 mo Follow-up: baseline and after 5 mo (postintervention) Exposure: 4 school lessons, 1–2 farmer visits, 3 tasting sessions, and 1 field trip to farms; locally grown vegetable provision once per week	Frequency of fruit and vegetable intake Food frequency questionnaire	Students who were exposed to $\geq$2 intervention components scored significantly higher ($P = 0.01$) on fruit and vegetable intake than did students who were exposed to $<$2 intervention components. Exposure to individual components did not significantly increase fruit and vegetable intake.
Haerens et al, 2007 (Belgium)[54]	To evaluate the effects of a healthy-food intervention combining changes in the school environment with nutrition education through interactive computer-tailored feedback	Clustered randomized controlled trial	Parents' occupation (67.5%)	Middle schools	Sample size: N = 2840 Age: 11–15 y (mean age 13.1 y; 7th and 8th graders) Sex: boys (63.4%); girls (36.6%) Race/ethnicity: information not provided	Transtheoretical model and theory of planned behavior	Intervention: healthy-eating promotion intervention combining changes in the school environment with nutrition education through interactive, computer-tailored feedback. 2 groups: (1) intervention plus parental support, and (2) intervention alone Control: no intervention	Duration: 9 mo (1 school y) Follow-up: baseline (beginning school y) and after 10 mo (end of school year) Exposure: weekly availability of fruit for sale, free or low-priced water availability, number of computer sessions unclear	Fat, fruit, water, and soft drinks intake Food frequency questionnaires and self-administered questionnaire (fat intake only)	For girls, fat intake and percentage of energy from fat decreased significantly more in the intervention group with parental support than in the intervention alone group ($P < 0.05$) and the control group ($P < 0.001$). For boys, there were no significant decreases in fat intake or

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Table 4 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
										percentage of energy from fat. No intervention effects were found in boys or in girls for fruit, soft drinks, and water consumption.
Haerens et al, 2006 (Belgium)[55]	To evaluate the 2-y effects of an intervention targeting physical activity and healthy eating.	Randomized controlled trial	Parents' occupation (67.4%)	Middle schools	Sample size: N = 2840 Age: 11–15 y (mean age 13.1 y; 7th and 8th graders) Sex: boys (63.4%); girls (36.6%) Race/ethnicity: information not provided	Transtheoretical model and theory of planned behavior	Intervention: healthy-eating promotion intervention combining changes in the school environment with nutrition education through interactive, computer-tailored feedback. 2 groups: (1) intervention plus parental support, and (2) intervention alone Control: no intervention	Duration: 2 school y Follow-up: baseline (beginning first school y) and after 10 mo (end of first school year) and 20 mo (end of second school year) Exposure: weekly availability of fruit for sale (low price or free), free or low-priced water availability, computer-tailored intervention once per year for 1 h each for physical activity and healthy eating	Fat, fruit, water, and soft drinks intake Food frequency questionnaires and self-administered questionnaire (fat intake only).	For girls, there were significant positive intervention effects on fat intake ($P < 0.05$) and percentage of energy from fat ($P < 0.001$) after 2 y. No significant intervention effects on other eating behaviors and on boys were found. Parental involvement did not increase intervention effects.
Lautenschlager and Smith, 2007 (United States)[56]	To evaluate whether a garden project could change eating or gardening behavior	Pretest-posttest	Youth living in low-income areas (n/a)	Youth Farm and Market Project sites	Sample size: N = 96 Age: 8–15 y Sex: Boys (43.8%) and girls (56.3%) Race/ethnicity: Black (35.4%), White (33.3%), Hispanic/other Hispanic (16.7%), Hmong (12.5%), American Indian (1%), other (1%)	Theory of planned behavior	Intervention: gardening program, nutrition curriculum fostering participatory learning, and cooking curriculum. Control: n/a	Duration: 10 wk Follow-up: baseline and postintervention Exposure: 3 sessions/wk	Fruit and vegetable intake (servings/d). Survey questions and a 24-h recall	Boys significantly increased intake of fruit mean ± SD (2.01 ± 1.73 vs 3.05 ± 3.05; $P = 0.03$) and vegetables (2.05 ± 1.34 vs 3.43 ± 2.52; $P = 0.01$). No significant changes were observed for girls after the program.
Lewis et al, 2018 (United States)[57]	To increase fruit and vegetable intake, reduce junk food consumption, and increase physical activity	Not stated	No information provided (sample described as low income)	Middle schools	Sample size: N = 30 Age: 11–14 y (5th, 6th, and 7th graders) Sex: boys and girls Race/ethnicity: Black (77%), Hispanic/Latino (10%), Asian (3%), biracial (10%)	Community-based participatory research model	Intervention: evidence-based program (Botvin's Life Skills Training), including engagement in health education, meals and snacks, trips to grocery stores and local farms, and physical activities conducted at school, after school, and during the summer Control: n/a	Duration: ∼2 y, 9 mo Follow-up: Baseline and postintervention Exposure: 8-wk health education program, after-school club 5 d/wk, summer day camp (3–6 wk)	Frequency of intake of fruits, vegetables, and junk food Survey	No significant differences in junk food intake and in fruit and vegetable intake between baseline and follow-up
Millar et al, 2011 (Australia)[58]	To evaluate the effectiveness and economic efficiency of a multifocused, multisite, community-based intervention to reduce adolescent	Longitudinal cohort follow-up design	Samples in areas of relative disadvantage below the state's average on an index of relative socioeconomic disadvantage (n/a)	Secondary schools	Sample size: N = 3040 Age: 12–18 y (mean age, 14.6 y) Sex: boys (53.5%); girls (46.5%) Race/ethnicity: information not provided	Analysis Grid for Elements Linked to Obesity framework	Intervention: the program focused on capacity building of families, schools, and communities to promote healthy eating and physical activity.	Duration: 3 y Follow-up: baseline and after 1–3 y (when students left school) Exposure: not stated	Intake of fruit and vegetables, breakfast consumption, home lunches, and soft drinks, nonalcoholic cordials, or snack foods from takeaway	There were no improvements from baseline to follow-up in breakfast consumption, home lunches, fruit or

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Table 4 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	overweight and obesity by building community capacity to promote healthy eating and physical activity						Control: no intervention		shops or milk bar after school Knowledge, attitudes, and behaviors survey	vegetable intake, limiting sugar-sweetened soft drinks, fruit drinks or cordials or snack foods between groups.
Shin et al, 2015 (United States)[59]	To improve youth food-related psychosocial factors (namely, behavioral intentions, self-efficacy, knowledge, and outcome expectancies) and food purchasing and preparation patterns, and decrease youth's body mass index for age	Clustered randomized trial	Recreation centers located in low-income neighborhoods (n/a)	Recreation centers, corner stores, and/or carry-out restaurants	Sample size: N = 152 Age: 10–14 y (mean age, 13 y) Sex: boys (41.4%); girls (58.6%) Race/ethnicity: no information provided	Social cognitive theory	Intervention: nutrition promotion and education using point-of-purchase materials such as posters and flyers in stores and interactive sessions such as taste testing and cooking demonstrations to increase availability and selection of healthful foods Control: no intervention	Duration: 8 mo Follow-up: baseline and after 2 y Exposure: not stated	Healthful beverage, healthful snack, unhealthful beverage, unhealthful snack, and fast-food purchases. Healthful food preparation Youth Impact Questionnaire	No significant impact of the intervention on healthful purchasing and preparation scores by treatment group. Unhealthful snack purchasing score significantly increased ($P = 0.01$) as total exposure score increased in the intervention group.
Siega-Riz et al, 2011 (United States)[60]	To examine the effects of an intervention on self-reported dietary intakes of energy, macronutrients, and grams consumed of selected food groups.	Cluster-randomized study	Eligibility for free or reduced-price meals (>50%)	Public middle schools	Sample size: N = 3908 Age: 10–11 y (mean age, 11.3 y; 6th graders) Sex: boys (47%); girls (53%) Race/ethnicity: Hispanic (56%), Black (16.5%), White (20%), other race or ethnicity (8%)	Socio ecological model only mentioned in discussion	Intervention: multiple components including nutrition, physical education, behavior change, and social marketing–based communications, including changes to the school environment, messages about healthy eating, cafeteria-based educational events, taste tests to introduce new food items, and nutrition education provided in the classroom and through parent newsletters Control: no intervention	Duration: 5 semesters (3 y) Follow-up: baseline and after 3 y Exposure: 1–3 taste tests per semester, 1 cafeteria learning laboratory per semester, 10 weekly nutrition education sessions per semester, and parental newsletters	Intake (in grams) of fruit, vegetables, grains, legumes, sweets, sweetened beverages, higher-fat milk, lower-fat milk, water, energy, macronutrients, and fiber Block Kids Questionnaire semiquantified food frequency questionnaire	Average daily fruit consumption was 10% higher at the end of the study in the intervention schools than in the control schools (138 g, or ~2 servings, vs 122 g, respectively; $P = 0.002$). Reported water intake was ~2 fl. Oz. more in the intervention schools than in the control (483 g vs 429 g, respectively; $P = 0.01$). There were no significant differences between intervention and control groups for mean intakes of energy, macronutrients, fiber, grains, vegetables, legumes, sweets, sweetened beverages, and higher- or lower-fat milk consumption.
Trude et al, 2018 (United States)[61]	To evaluate the impact of a multilevel intervention on purchasing behavior of healthier and unhealthier food items and on the consumption of high-	Group-randomized controlled trial	Recreation centers located in low-income neighborhoods with > 20% of residents living below the poverty line. Household participation in food	Recreation centers, corner stores, and carry-out restaurants	Sample size: N = 509 Age: 9–12 y (66.6%), 13–15 y (33.4%) Sex: boys (44.6%); girls (55.4%) Race/ethnicity: Black (96.9%)	Social cognitive theory	Intervention: increased access to low-sugar foods and beverages at wholesalers and small food stores, and purchase and consumption	Duration: 6 mo Follow-up: baseline and after 6–12 mo Exposure: 14 weekly sessions (1 h/session) for adolescents and text messages for	Intake of fruit (including 100% fruit juice), vegetables, and sugar (sugar-sweetened beverages and sweets intake) and purchasing healthier	Intervention youth increased healthier foods and beverages purchases by 1.4 more items per week than comparison youth

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Table 4 **Continued**

Reference (country)	Aim	Study design	Socioeconomic level indicator (%)[a]	Intervention setting	Population characteristics	Theoretical basis	Intervention description	Duration of exposure, follow-up, frequency	Dietary outcome(s) (measures, tools)	Main findings on dietary components[b]
	sugar, high-fat snacks and beverages		assistance programs: SNAP (70.8%) or WIC (22.4%)				encouragement through youth-led nutrition education in recreation centers, in-store promotions, text messaging, and a social media program directed at caregivers Control: no intervention	caregivers 3–5 times a week over 6 mo	and less healthy food or beverage varieties in the previous 7 d Block Kids Food Frequency Questionnaire and Child Impact Questionnaire for purchasing behavior	($\beta = 1.4$; 95%CI, 0.1–2.8). After the intervention, there was a 3.5% decrease in kcal from sweets for older intervention-group youth, compared with the control group ($\beta = -3.5$; 95%CI, −7.76, − 0.05). No impact on sugar-sweetened beverages consumption

Abbreviations: NSLP, National School Lunch Program; SNAP, Supplemental Nutrition Assistance Program; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.
[a]Percentage of those study participants classified as socioeconomically disadvantaged according to the socioeconomic level indicator applied in the study.
[b]Results refer to the whole participating population unless otherwise stated.

approach but combined some of those listed in the preceding sentence.[20,21,24,25,28,30–36,38,39,43–45,47,48] In 6 articles, authors reported effective intervention outcomes by improving the targeted dietary behaviors,[20,26,28,40,45,48] whereas in 4 articles, no changes after the intervention were observed.[21,27,36,37] The remaining studies reported some level of success given that multiple dietary outcomes were measured and success was not necessarily observed for all the targeted outcomes. Sex-specific intervention effects with varying levels of success in changing dietary behaviors between boys and girls were reported in 3 articles.[29,30,34] Another 3 studies observed that the success of the intervention was conditioned by either the level of exposure to the intervention components[32,46] or the level of motivation of the participants,[43] with greater exposure to intervention components or participants' motivation resulting in more successful interventions.

Multicomponent interventions

A total of 13 studies, including 12 interventions, were classified as multicomponent interventions because they applied a combination of strategies to change dietary behavior among disadvantaged adolescents. Five were randomized controlled trials,[49,54,55,59–61] 2 were controlled trials in which no randomization was carried out,[50,51] 3 followed a pretest-posttest study design,[52,56,58] and 1 study only included a posttest evaluation.[53] One article did not provide any information on the study design.[57] All but 2 studies[56,57] included a control group. Nine intervention studies were carried out in schools and 1 included both schools and professional football (called soccer in the United States) clubs.[52] Two intervention studies[59,61] targeted recreation centers, corner stores, and carryout restaurants, and 1 intervention was implemented through a voluntary, multicultural gardening enterprise.[56] Nine intervention studies were conducted in the United States,[49–51,53,56,57,59–61] 2 in Belgium,[52,54,55] and 1 in Australia.[58] Sample sizes ranged between 30[57] and 3908 participants.[60] Five intervention studies included >1000 participants.[49,50,54,55,58,60] The sample sizes of another 5 interventions ranged between 100 and 1000 participants,[51–53,59,61] and 2 intervention studies included <100 participants.[56,57]

The SCT was the theoretical framework most used: 5 intervention studies applied it either alone[22,48,49,53,59,61] or in combination with the socio-ecological model and the diffusion of innovation theory.[50] One intervention study applied the theory of planned behavior,[56] and another combined that theoretical framework with the transtheoretical model.[54,55] The elaboration likelihood model,[52] the Analysis Grid

for Elements Linked to Obesity framework,[58] and the community-based participatory research model[57] were used in 1 intervention study each. One study did not provide information on the use of a theoretical framework,[51] and another study only mentioned the socioecological model in the discussion section; however, it was not clear if the authors applied the framework in any of the aspects of the intervention study.[60]

Most of the intervention studies combined an educational component with changes in the school or the community food environment, gardening programs, tasting sessions, and/or cooking demonstrations. Two studies included the role of the peer leader, involving college students in 1 of the studies[61] and adolescents in the other,[49] in delivering the intervention components to their peers. As a result, peer leaders significantly increased their fruit and vegetable intakes at follow-up.[49] Three studies[52,57,58] were not successful in changing the dietary components evaluated. The remaining intervention studies only reported relative effectiveness, because they were effective for changing a few dietary components but not for all those initially targeted. Three studies reported sex-specific differences in the effectiveness of the intervention; that is, they observed changes in some dietary behaviors in 1 sex, but not in the other.[54–56] Three intervention studies reported better outcomes when participants were exposed to several intervention components as opposed to those adolescents only exposed to 1 single component[49,54] or to <2 intervention components.[53]

Study quality assessment

The results of the evaluation of the studies' methodological quality are shown in Table S1 in the Supporting Information online. Among the 46 articles included in the present review, 10 were classified as strong,[24,27,29,38,44,49,53–55,60] 18 as moderate,[17,19,20,22,25,28,31–33,43,45,46,48,50–52,59,61] and 18 as weak.[16,18,21,23,25,26,30,34–36,39–42,47,56–58] The low-quality rating of the studies was mainly due to nonrepresentativeness of their samples; to a lesser extent, a low-quality rating was due to no control of confounders or to lack of information about confounding factors, and lack of information regarding the methodology, such as evidence of use of validated questionnaires and degrees of blinding.

DISCUSSION

To our knowledge, this is the first review to explore which strategies and theoretical frameworks are commonly used to change eating behaviors of socioeconomically disadvantaged adolescents and to examine if these approaches had an impact on eating behavior. Four main intervention types were identified. Interventions based on changing or using cognitive factors were used most commonly, followed by interventions applying multicomponent strategies. A wide range of theoretical frameworks was applied, but the SCT was commonly applied either alone or in combination with other frameworks. Although a few intervention studies were successful in changing adolescents' eating behaviors, the majority of the studies only reported changes in some behaviors but not for all those targeted as part of the intervention.

Individuals have a genetic predisposition to like sweet and salty foods, whereas bitter or sour foods tend to be rejected.[62] This is 1 explanation for why humans prefer some foods over others. For that reason, some intervention studies aiming to increase the intake of certain foods, such as vegetables, modify the foods' taste or flavor by adding other ingredients to make them more appealing to young people. The main determinant for liking vegetables among pre-adolescent children aged 10–12 years is taste,[63,64] and it is likely that disliking the taste of vegetables continues during adolescence. Likewise, Appleton et al[65] showed how the addition of salt, condiments, or flavored dips were useful to increase the intake of certain vegetables in young children. Although changing vegetable taste slightly seems to represent a promising avenue to promote vegetable intake in youths, it cannot be assumed that this strategy would also work among disadvantaged teenagers, because only 1 study intervened on taste.[16] The authors used a relatively large sample size, but the measurement period was limited to 2 weeks and there was no follow-up on how this approach could have influenced the overall intake of vegetables in this population group.

In 2 intervention studies,[17,19] researchers aimed to modify the environment to change dietary behavior among disadvantaged adolescents. These interventions, which are generally known as choice architecture interventions, are based on making subtle alterations in the food-choice environment to modify eating behavior and food choices in the desired direction.[66] More specifically, choice architectural nudge interventions aim to encourage the individuals to make healthier food choices without restricting or eliminating choices of less-healthy options.[67] Although these interventions constitute a promising approach to achieve dietary behavioral change in the short term, their long-term effects can still be questioned, particularly for some foods such as vegetables. Another aspect to consider is that the provision of fruits and vegetables tends to be limited in time. Longer exposure to the program may be needed to allow adolescents to adopt this new dietary behavior and translate it into a habit. Furthermore,

choice architectural nudge interventions may need to be accompanied by other measures to promote sustained dietary behavior change in disadvantaged adolescents. Nørnberg et al[66] did not report conclusive results in their review on the effects of nudge interventions on adolescents' vegetable intake. They concluded that distributing free vegetables did not significantly affect vegetable intake. Only those interventions that increased the variety of vegetables were effective in increasing intake levels in adolescents.[66] Overall, the success of choice architectural nudge interventions alone in promoting eating behavior, albeit promising, is still limited and needs more research.

The majority of the intervention studies included in this review applied 1 or several cognitive factors to change eating behavior of disadvantaged adolescents. Although most of the studies combined ≥2 of these techniques, no pattern between the approaches applied and the effectiveness of the interventions was identified. Both successful and unsuccessful interventions included a nutrition education component either alone or combined with other components. Appleton et al[65] suggested that intervention studies that include an education component may be beneficial among adolescents because, unlike younger children, their cognitive functions, such as attention, memory, and reasoning, are increased. On the other hand, because knowledge accumulates over time and experience, it may be difficult to deduce which education sources were responsible for dietary behavior change.[65]

Teaching nutrition-related skills (eg, how to cook) may have some potential in changing intake and preference for certain foods as it provides an opportunity to taste new fruits and vegetables.[67] This approach also teaches life skills, such as food preparation skills and self-efficacy.[67] Nevertheless, the long-term effect of cooking programs on changing children's eating behavior has not been evaluated.[67]

The use of goal setting to change behavior in the field of nutrition is relatively recent, compared with other strategies.[68] Although goal setting is more effective to promote dietary behavior change among people with health conditions,[69] it could also be a useful strategy for adolescents, because it enhances self-efficacy and self-monitoring.[70]

Another common strategy was the use of role modeling, mainly by involving adolescents' peers. It is known that people around adolescents, including parents, teachers, peers, and social media influencers, have an influence on what adolescents eat. During adolescence, attachments increasingly shift from parents toward peers. For that reason, parents' influence at this stage decreases and peers' influence increases.[71] In this regard, DeCosta et al[67] concluded in their review that role modeling influenced adolescents' food preferences, intake matching, and amount of consumed foods, and that role modeling was likely to increase adolescents' intake of those foods that are accepted by the group. Nevertheless, the main issue with role modeling is that it can have an effect in both directions—that is, promoting intake of healthy foods but also of unhealthy foods. As highlighted in previous reviews,[67] the effect of role modeling depends on whether the modeled food is considered healthy, and on whether the target food is modeled as positive or negative. In addition, not only the peers' but also the parental influence on food intake depends more on their own behavior than on their message about the target food.

Effective interventions using cognitive factors tended to have shorter follow-up periods (ie, 2–12 weeks) than unsuccessful ones (6–24 months). This suggests that targeting specific cognitive factors to promote changes in eating behaviors could be effective in the short term, but that these changes may not be sustained in the medium and long terms. Similarly, do Amaral e Melo et al[72] noted that for 3 of the 4 studies included in their review, the significant findings initially observed postintervention disappeared at 6-months' follow-up. On the other hand, intervention studies tended to use multiple outcome measures and they did not report success for all the measures evaluated. This phenomenon could not only be explained by the length of follow-up and the type of strategy implemented but by other factors, such as the number of outcome measures targeted or the intervention dose adolescents were exposed to. However, studies rarely provided information on adolescents' adherence with the intervention and on the number of intervention components they were truly exposed to. On the other hand, it is important to note that only 5 studies in this group were rated as strong in terms of quality, as opposed to 16 studies that were rated as weak. This emphasizes the need for more high-quality studies to draw more reliable conclusions.

Overall, all the intervention studies combining several strategies to change dietary behavior applied a nutrition education component. Although educating study participants about nutrition seems to be a crucial aspect of eating-behavior change interventions, it should be accompanied by other strategies to achieve long-term dietary behavior changes. Results from a meta-analysis on the effect of nutrition education programs and garden programs in school-aged children showed that nutrition education programs alone had marginal or nonsignificant effect on vegetable intake, or even resulted in marginally decreased fruit intake.[73] DeCosta et al[67] concluded in their review that including hands-on approaches such as gardening and cooking programs could encourage greater and more sustainable dietary behavior changes compared with nutrition education

only. Although most of the multicomponent interventions included in this review combined nutrition education with changes in the environment, other approaches such as cooking sessions, tasting sessions, and farms visits were also applied. However, given that different combinations of approaches were used among studies and the varying degrees of success reported by the studies, it is difficult to determine what combination worked best or which component was most successful among disadvantaged adolescents. In addition, that significant results were not observed in most studies for all the targeted dietary outcomes or for all groups (eg, boys vs girls) could also be a consequence of other practical aspects, such as length of follow-up or the exposure to the intervention, rather than the specific strategies applied as part of the intervention.

As already observed among those intervention studies focusing on cognitive factors, follow-up periods were relatively short for the successful interventions (ie, 9–10 months), as opposed to 1–3 years in 2 of the 3 nonsuccessful interventions. It is reasonable to think that long follow-up periods could dilute the intervention effects to some extent and could explain why some interventions were more successful than others. Likewise, Appleton et al[65] concluded that, overall, studies reported reductions in effect size because follow-up periods were extended. Other factors, such as exposure to the intervention, may have also played a role in the effectiveness of the interventions. Unfortunately, exposure to intervention components, when reported, was reported very differently among studies, which made it impossible to make comparisons of exposure across studies. Overall, as noted, studies did not provide information on the participants' exposure to the intervention. Measuring the level of exposure to the intervention components is crucial to determine the intervention's effectiveness. Nevertheless, that some interventions were successful for some dietary aspects gives some promising ideas of the sort of activities that could work for disadvantaged adolescents. However, the interventions may still need to be redesigned to allow for more sustained behavior changes. Another aspect to consider when implementing multicomponent interventions is their cost-effectiveness, because they can be time consuming and costly.[65]

In general, most of the intervention studies collected multiple measures, because intervention outcomes and success were not observed for all the measures. Likewise, Appleton et al[65] also noted in their review that studies reported varying degrees of benefit when multiple measures were collected in the studies. Dietary behavior change is a complex process determined by social, emotional, and cognitive factors.[72] Therefore, targeting several behaviors simultaneously may be too challenging and burdensome for individuals. In this regard, do Amaral e Melo et al[72] concluded in their review that targeting a single behavior resulted in better intervention outcomes. However, it should be considered that socioeconomically disadvantaged adolescents were targeted in only 1 of the 11 studies include in the do Amaral e Melo et al[72] review. Behavior change may be even more difficult among disadvantaged youths because this group may often lack a supportive environment to accomplish these changes. Therefore, in this population group, targeting single dietary behaviors could be a more effective approach to promote behavioral changes. In addition, given the complexity inherent to changing behavior, achievements may need to be deemed on an individual basis, and even small achievements should be considered important, because they can be meaningful for the individual and can encourage additional changes. Small but sustainable behavior changes look more promising than greater short-term changes, which may be difficult to maintain over time. On the other hand, the measurement tools applied to measure the intervention outcomes could be somewhat responsible for the varying degrees of success observed in the interventions. A wide range of questionnaires was used in the studies in this review, including but not limited to food frequency questionnaires and 24-hour dietary recalls, to collect dietary data. These methods are subject to socially desirable answers and to measurement error. Providing data on the accuracy and reliability of the questionnaire is needed. There was a lack of information on the validity and reproducibility of the tools applied to measure dietary intervention outcomes in the studies included in this review. Less than half of the studies used tools that had previously been tested for validity and reliability. It should be noted that a tool that was valid and reliable in a specific population may not be equally valid and reliable in another, different population.

In only a few studies did authors not apply a theoretical framework as part of the intervention study. Nutrition education interventions that follow an existing theory and are behaviorally focused are more effective in achieving behavior change.[74] The SCT was the most predominant theoretical framework applied in the intervention studies included in this review, followed by the theory of planned behavior and the transtheoretical model. Similarly, the SCT was the theoretical basis most commonly followed by the studies included in the review by do Amaral e Melo et al.[72] Intervention studies often use theories in combination, because they consider different constructs; therefore, different determinants of health behaviors can be targeted.[72] Using a specific theoretical framework or a combination of theories did not seem to determine the success of the

interventions included in this review. However, for most of the studies, when and how the constructs of the theoretical frameworks were applied to the intervention were unclear. As observed by Thomson and Ravia,[75] the majority of the studies only described the theoretical basis very briefly, and only a few provided a detailed explanation of how the constructs were applied; of rationale, activities, and materials development; and of delivery approaches and/or measurements. This lack of information hinders our ability to evaluate how the use of a particular theory or combination of theories was more effective than another. However, as already noted by Hamel and Robbins,[76] other factors beyond the theoretical framework applied, such as the targeted behaviors, intervention content, mode of delivery, intervention dose and intensity, or the setting, may be equally or more important for achieving the expected outcome.

Existing evidence shows that the impact of behavior change interventions depends on sex, age, ethnicity, and other population-specific factors, including socioeconomic level.[77,78] In fact, previous literature suggests that socioeconomically advantaged children and adolescents tend to profit more from health-related interventions than those belonging to more disadvantaged backgrounds. In particular, healthy eating interventions not targeting low-income adult participants tend to result in larger effects than those targeting low-income populations, suggesting that they are less effective in these populations.[79] Differences in the effectiveness of interventions between socioeconomically favored and socioeconomically disadvantaged populations can be due to several factors. Among these, people from socioeconomically disadvantaged backgrounds may have worse or less-healthy starting levels of behavior coupled with a lack of behavior change support within their physical and social environments. [80] In addition, the difficulties in recruiting participants to and the higher attrition rates frequently observed in community-based programs promoting healthy eating in socioeconomically disadvantaged groups[80] can further explain these differences. Likewise, low retention and attendance rates also seem to be related to the lack of beneficial effects of intervention programs aiming to reduce weight among socioeconomically disadvantaged adolescents.[78] For that reason, dietary behavior change interventions need to be tailored to the targeted population group to increase their effectiveness. In their review of strategies of obesity prevention and treatment programs among adolescents from disadvantaged backgrounds, Kornet-van der Aa et al[78] recommended the use of experiential activities as opposed to didactic lessons, delivery of no- or low-cost interventions to schools and students, involvement of adolescents in the development and delivery of the interventions, and involvement of parents in the intervention as promising strategies to achieve successful behavior change in this population group.

Studies' comparability and data synthesis were hindered by the highly heterogeneous nature of the studies included in this review. For that reason, findings were only summarized narratively. Combining studies' dietary outcomes into existing dietary scores (eg, Healthy Eating Index) or data-driven dietary patterns was a potential way to consider dietary intake patterns rather than individual foods, because varying the intake of certain foods unavoidably affects the whole diet of the individuals beyond those food items initially targeted by the intervention program. However, neither of these approaches was considered in this review, which can be seen as a study limitation. It should also be acknowledged that most of the studies were conducted in the United States and included adolescents from different ethnic backgrounds. This may limit the relevance and applicability of the findings to other countries and ethnic groups with different sociocultural values and socioeconomic circumstances. This issue was mitigated by limiting the search to studies carried out in high-income countries only. However, even among high-income countries, each country has particular cultural and contextual scenarios.

Finally, an effort was made to include all the literature relevant to the research question, but other qualifying studies may have been involuntarily omitted from the review. Because the search strategy only included published articles, studies that are part of the grey literature, such as conference proceedings, were not considered in this review. Another limitation of the present review is that only 10% of the titles, abstracts and full texts were independently screened by 2 reviewers. However, 2 reviewers independently assessed the quality and extracted data for all the studies.

Strengths of the current review include the focus on a vulnerable population group (ie, socioeconomically disadvantaged adolescents), which has not been the focus of other reviews. That a systematic approach was applied can also be seen as a strength. The strategy was not limited to only studies that were published in English; studies published in 5 languages were considered.

CONCLUSION

In this review, we summarized data from 46 studies (n = 38 intervention studies) focusing on dietary behavior change interventions targeting socioeconomically disadvantaged adolescents. Overall, cognitive factors were those most targeted and SCT was the theory most frequently applied by the studies to achieve behavior change in this population group. A variety of successful

intervention strategies were identified to achieve positive dietary behavior changes; however, follow-up periods tended to be short and those interventions with longer follow-up did not always observe sustained benefits. In addition, multiple dietary outcomes were often targeted, and interventions did not have a significant impact on all of them. The heterogeneity of the studies, together with the fact that dietary outcomes from the interventions were not combined into dietary scores or patterns to evaluate the overall effect of the intervention program on the participants' diets, hindered the ability to determine which intervention type could be more effective. However, long-term, theory-driven interventions that target behavior change of a single dietary factor could potentially be more successful in obtaining long-term benefits. Researchers conducting intervention studies may also need to consider how habits are formed and/or how behavioral norm changes occur to achieve more sustained dietary behavior changes. Therefore, there is a need for intervention studies examining the long-term benefits and sustainability of nutrition programs to reliably inform policies tailored to disadvantaged adolescents.

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Declaration of interest. The authors have no relevant interests to declare.

Supporting Information

Appendix S1 **Search strategy and search terms used in PubMed.**

Table S1 **Study quality assessment using the Effective Public Health Practice Project Quality Assessment Tool.**

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