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Author manuscript

*Am J Prev Med.* Author manuscript; available in PMC 2022 August 11.

Published in final edited form as:

*Am J Prev Med.* 2020 July ; 59(1): e15–e26. doi:10.1016/j.amepre.2020.01.011.

## Healthier Food and Beverage Interventions in Schools: Four Community Guide Systematic Reviews

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### Abstract

**Context:** Healthy eating during childhood is important for optimal growth and helps reduce risk of obesity, which has potentially serious health consequences. Changing the school food environment may offer one way to improve students' dietary intake. This manuscript reports four Community Guide systematic reviews examining the effectiveness of interventions in schools promoting healthy eating and weight.

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**Evidence acquisition:** School obesity prevention programs aiming to improve diet were identified from a 2013 Agency for Healthcare Research and Quality systematic review and an updated search (August 2012–January 4, 2017). In 2017–2018, Community Guide systematic review methods were used to assess effectiveness as determined by dietary behavior and weight changes.

**Evidence synthesis:** Interventions improving school meals or offering fruits and vegetables ( $n=27$  studies) are considered effective. Evidence is insufficient to determine effectiveness of interventions supporting healthier snack foods and beverages outside of school meal programs given inconsistent findings ( $n=13$  studies). Multicomponent interventions to increase availability of healthier foods and beverages are considered effective. These interventions must include one component from school meals or fruit and vegetable programs and interventions supporting healthier snack foods and beverages ( $n=12$  studies). There is insufficient evidence to determine effectiveness of interventions to increase water access because only two studies met inclusion criteria.

**Conclusions:** Two school-based dietary interventions have favorable effects for improving dietary habits, and modest effects for improving or maintaining weight. More evidence is needed regarding interventions with insufficient findings. These reviews may inform researchers and school administrators about healthy eating and obesity prevention interventions.

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## CONTEXT

Healthy eating during childhood is important for optimal growth; helps prevent high cholesterol and high blood pressure and reduces the risk of developing osteoporosis, iron deficiency, dental caries, and obesity.<sup>1,2</sup> As almost one in five school-aged children have obesity,<sup>3</sup> promoting healthier dietary habits during childhood is critical. Schools play an important role in preventing obesity because most children in the U.S. attend school nearly 7 hours a day during the school year and consume approximately half of their daily calories at school.<sup>4,5</sup> A healthy school nutrition environment may support healthier choices by increasing availability of nutritious foods and beverages, promoting messages about healthy eating, and providing opportunities to learn healthy habits.<sup>6–8</sup>

This Community Guide report includes four systematic reviews: Review 1 assessed school meals or fruits and vegetables served as snacks, Review 2 assessed offering healthier snack foods and beverages, Review 3 assessed interventions that combined components from Review 1 and Review 2, and Review 4 assessed increased access to water. These interventions align with the Centers for Disease Control and Prevention's (CDC's) Comprehensive Framework for Addressing the School Nutrition Environment and Services.<sup>4</sup> For each review, evidence was examined on the effectiveness on dietary habits and weight status, and the applicability of findings to various U.S. populations using Community Guide methods.

### Conceptual Approach and Analytic Framework

These four Community Guide reviews examined interventions that promoted healthy weight by providing healthier foods and beverages, limiting access to less healthy foods and beverages, or both. Healthier foods and beverages include fruits, vegetables, whole grains,

low-fat or fat-free dairy, lean meats, beans, eggs, nuts, and items that are low in saturated fats, salt, added sugars, and have no trans fats. Less healthy foods and beverages include those with more added sugars, fats, and sodium.<sup>1</sup>

Review 1 assessed meal or fruit and vegetable (FV) snack interventions that aim to increase the availability of healthier foods and beverages offered in schools. These include school meal policies that ensure school breakfasts or lunches meet specific nutrition requirements (e.g., School Breakfast Program, National School Lunch Program) or FV programs that provide fresh FV to students during lunch or snack.

Review 2 examined interventions supporting healthier snack foods and beverages sold or offered in schools. These interventions include changes to foods and beverages sold during the school day outside of school meal programs, or changes to rules or policies for celebrations. Food and beverage policies require foods and beverages sold during the school day, outside of school meal programs, to meet established nutritional standards or guidelines. These foods and beverages are often referred to as “competitive foods and beverages” because they are sold in competition with school meal programs, and include in-school fundraisers, à la carte foods, vending machines, school stores, and snack bars. This does not include FV programs, which are included in the first intervention category. Celebration rules or policies encourage serving healthy foods and beverages during classroom celebrations, parties, and special events or encourage rewards of nonfood items for academic achievement or good behavior.

Review 3 assessed multicomponent interventions to increase availability of healthier foods and beverages in schools, which must include one component from each of the interventions described in Review 1 (meal or FV snack interventions) and Review 2 (healthier snack foods and beverages sold or offered).

Review 4 evaluated interventions to increase water access in schools, which ensure students have access to safe, free drinking water in schools. These interventions include procedures to ensure water fountains are clean and maintained, availability of water fountains and hydration stations throughout the school and on school grounds, and policies allowing students to have water bottles in class.

Interventions also may include marketing strategies and healthy eating learning opportunities. Marketing strategies include the placement of healthier foods and beverages, pricing healthier foods and beverages at lower costs, setting up displays of FV, and offering taste tests. Healthy eating learning opportunities include nutrition education and strategies that give children knowledge and skills to help choose healthier foods and beverages.

The analytic framework (Figure 1) illustrates hypothesized pathways in which school dietary interventions lead to improved dietary and weight-related outcomes. School nutrition policies and programs may improve the school nutrition environment by increasing the availability of healthier food and beverages, and limiting the availability of less healthy food and beverages.<sup>10,11</sup> These interventions may lead to increased knowledge, skills, and self-efficacy. They may support improved dietary intake, leading to improved clinical and

weight-related outcomes. Interventions may lead to increased health-related quality of life, whereas potential harms include possible negative effects on body image.

## EVIDENCE ACQUISITION

Detailed systematic review methods used by The Community Guide are published elsewhere.<sup>12</sup> For this review, the team included subject matter experts in obesity and nutrition from various agencies and institutions along with systematic review experts from the Community Guide Branch at CDC. The team worked in collaboration with the independent, nonfederal, unpaid Community Preventive Services Task Force (CPSTF).

### Search for Evidence

The search for evidence consisted of two steps. The first step involved searching existing systematic reviews on effectiveness of school-based dietary interventions. An existing systematic review was identified: “Agency for Healthcare Research and Quality (AHRQ) Childhood Obesity Prevention Programs: Comparative Effectiveness Review and Meta-analysis.”<sup>13</sup> The second step was updating the search adopting AHRQ’s school nutrition–related search terms and databases. The AHRQ literature search ended in August 2012; this Community Guide update searched August 2012–January 4, 2017. The searches were conducted in CINAHL, [ClinicalTrials.gov](https://www.clinicaltrials.gov), Cochrane, Embase (Ovid), PsycINFO (Ovid), and PubMed, and included peer-reviewed journal articles, books, and the gray literature of theses and dissertations. Reference lists in retrieved articles were also reviewed. The search is available on the Community Guide website under Supporting Materials ([www.thecommunityguide.org/findings/obesity-meal-fruit-vegetable-snack-interventions-increase-healthier-foods-beverages-schools](http://www.thecommunityguide.org/findings/obesity-meal-fruit-vegetable-snack-interventions-increase-healthier-foods-beverages-schools)).

### Inclusion and Exclusion Criteria

Studies were included if schools were the primary setting, intervention programs or policies were aimed at obesity prevention or healthy weight promotion to the general student population, took place in kindergarten through high school, and reported a dietary or weight-related outcome estimated to be at least 6 months after the intervention program or policy began. In addition, studies had to be: comparison group, before–after, or post-only studies with a comparison; conducted in a very high Human Development Index country (for comparability to U.S. populations)<sup>14</sup>; and published in English.

Studies were excluded if they focused on: only participants who were overweight or had obesity, weight loss interventions, or diseases or chronic conditions.

### Data Abstraction and Quality Assessment

In 2017–2018, included studies from the AHRQ review and updated search were independently abstracted by two reviewers. The suitability of each study design was rated as greatest, moderate, or least, depending on the degree to which the design protected against threats to validity.<sup>12</sup> Abstraction was based on a Community Guide abstraction form that included information on study quality, participant demographics, and outcomes. Disagreements between reviewers were reconciled by consensus. Threats to validity were

used to characterize studies as having good (zero to one limitation), fair (two to four), or limited (five or more) quality of execution. These included internal and external threats to validity, such as poor description of the intervention, population, or sampling frame; poor measurement of exposure or outcome; poor reporting of analytic methods; loss to follow-up; or intervention and comparison groups not being comparable at baseline. Studies with limited quality of execution were excluded from the analyses.

### Outcomes of Interest

Dietary effectiveness was assessed by the most commonly reported measures that were relevant to the intervention. For school meal or FV interventions (Review 1), dietary effectiveness was assessed by FV intake for the total day. For healthier snack foods and beverages interventions (Review 2), dietary effectiveness was assessed by total day sugar-sweetened beverage (SSB) and low-nutrient food intake. For multicomponent healthier meal and snack interventions (Review 3) dietary effectiveness was assessed by total day FV, SSB, and low-nutrient food intake. Lastly, for water access interventions (Review 4) dietary effectiveness was assessed by water and SSB intake.

Effectiveness for weight-related outcomes were assessed using BMI z-score and overweight or obesity prevalence. A decrease in BMI z-score and overweight or obesity prevalence was considered favorable. Given national trends demonstrating modest increases in obesity prevalence among children,<sup>15</sup> the team considered studies without a control group that reported no change in weight-related outcomes as favorable as this demonstrated potential for a decreased rate of change in BMI z-score, overweight, or obesity prevalence.

This body of evidence includes objective and self-reported measures. Most height and weight data were objectively measured. Nearly all dietary outcomes were self-reported using various food and beverage intake instruments.

### Calculation of Effect Estimates for Qualifying Studies

Effect estimates were calculated when the adjusted change was not provided; otherwise, the adjusted values provided in the publication were used. The formula for calculating effect estimates was carried out using one of three methods, depending on study design and variability of the outcome. The preferred method included non-treated comparison (C) and intervention (I) study arm, the basic unit for the calculation, with measurements made before and after the intervention. For studies with multiple intervention arms meeting the inclusion criteria and a single non-treated comparison arm, effect estimates for the intervention arm were calculated using the same comparison arm. For studies with a comparison group, the team used the following formula:

$$(I_{\text{post}} - I_{\text{pre}}) - (C_{\text{post}} - C_{\text{pre}}),$$

where  $I_{\text{post}}$  is the post-test for the arm of participants receiving the intervention (or for studies with multiple measurement points, the time point closest to the conclusion of the intervention was used),  $I_{\text{pre}}$  is the pretest for the arm receiving the intervention,  $C_{\text{post}}$  is the post-test for the comparison arm, and  $C_{\text{pre}}$  is the pretest for the comparison arm.

To pool data from multiple studies reporting similar outcome measures, relative percentage change was calculated using the following formula:

$$([I_{\text{post}} - I_{\text{pre}}] / I_{\text{pre}} - [C_{\text{post}} - C_{\text{pre}}] / C_{\text{pre}}) \times 100.$$

When studies did not include a comparison arm that assessed dietary behaviors, the team assumed that in the absence of an intervention no change would have occurred. For studies without a comparison arm that assessed obesity or overweight status, the team assumed a modest increase may have occurred. The following formula was used:

$$I_{\text{post}} - I_{\text{pre}}.$$

When possible for each primary outcome measure, the median effect estimates from individual studies with the interquartile interval (IQI), the interval between the first and third quartiles, was reported.

## EVIDENCE SYNTHESIS

Figure 2 summarizes the search process. The updated Community Guide search identified 27,761 records. Subject matter experts and a review of reference lists identified 16 records. After removing duplicates, 26,893 references were screened. Two reviewers screened the full text of 1,101 potentially relevant articles, identifying 54 studies for the review. School meal or FV interventions (Review 1) included 27 studies<sup>16–43</sup> (one study was reported in two publications<sup>29,43</sup>), snack food and beverage interventions (Review 2) included 13 studies,<sup>44–56</sup> multicomponent healthier meal and snack interventions (Review 3) included 12 studies<sup>57–68</sup> (one study was reported in two publications<sup>59,63</sup> and two studies were reported in one publication<sup>66</sup>), and water access interventions (Review 4) included two studies.<sup>69,70</sup>

Appendix Figure 1 (available online) displays the quality assessment. The most common limitations were for sampling ( $n=23$ ) and exposure ( $n=18$ ). Study and intervention characteristics, population characteristics, and outcomes are described for each intervention. Information for the individual studies in each review is available on The Community Guide website under Supporting Materials (Review 1, Review 2, Review 3, Review 4).

### Review 1: School Meal or Fruit and Vegetable Interventions

School meal or FV interventions included 14 studies<sup>16,17,23–25,27,30,32,34–36,38–40</sup> from the U.S., with the remaining 13 conducted in Europe,<sup>18–21,26,31,41,42</sup> Australia,<sup>37</sup> Canada,<sup>28,29,43</sup> Taiwan,<sup>22</sup> and the United Kingdom.<sup>33</sup> Sixteen studies reported on population density; seven<sup>16,32,34,36,37,39,40</sup> reported a mixed setting, two<sup>28,29,43</sup> reported a rural setting, and seven<sup>23–25,27,35,38,41</sup> reported urban or suburban settings. Most studies were implemented only in the school setting. Fourteen studies<sup>18–20,27–30,32–36,41–43</sup> included FV programs and 14 studies<sup>16,17,21–26,31,35,37–40,42</sup> included school meal changes (Table 1).

Interventions took place in elementary, middle, and high schools. Most studies reported about half of their study population was female. Of the 14 studies that reported race and ethnicity, the median for the proportion identifying as white was 36.7%, black was 20.1%, Hispanic was 31.2%, and other was 9%.<sup>16,17,24,25,27–30,32,34,39–41,43</sup> Two studies took place in First Nations populations.<sup>28,29,43</sup> Ten studies were in low-SES populations.<sup>23–25,28,29,32–34,36,38,43</sup>

Eighteen study arms from 17 studies reported FV intake. Nine study arms from eight studies reported a median relative increase of 20% (IQR=4.3%, 38.5%) for FV intake for the total day (Table 2).<sup>18–20,26,31,34,41,42</sup> Six studies<sup>23,27,29,32,33,39,43</sup> reported FV intake for the total day that could not be plotted: One study<sup>29,43</sup> reported an increase in FV consumption, one study<sup>23</sup> reported no change in fruit consumption but an increase in vegetable consumption, one study<sup>27</sup> reported an increase in fruit consumption but no change in vegetable consumption, one study<sup>32</sup> reported no change in fruit consumption but did not assess vegetable consumption, one study<sup>39</sup> reported an increase in FV consumption among students with low access to FV, and one study<sup>32</sup> reported FV consumption increased in rural areas but not city or suburban areas. Information on the remaining three studies<sup>17,24,30</sup> that reported FV intake and other dietary behavior outcomes is in Appendix Table 2 (available online).

Eight studies reported BMI z-score, overweight prevalence, or obesity prevalence. Three studies reported BMI z-score with a median increase of 0.01 (range=0.14–0.03) (Table 2).<sup>16,26,36</sup> Six studies reported change in obesity or overweight and obesity prevalence combined following CDC,<sup>16,28,40</sup> International Obesity Task Force,<sup>21,31</sup> or Taiwanese definitions.<sup>22</sup> Obesity prevalence was reported in one study<sup>40</sup> with a decrease of 7.7 percentage points (Table 2). Five studies with a baseline median overweight and obesity prevalence combined of 32.9% reported a decrease of 9.6 percentage points (IQR= –10.7, –1.6) (Table 2).<sup>16,21,22,28,31</sup> With one exception,<sup>31</sup> all studies objectively measured height and weight. Six interventions focused on school meals whereas two interventions offered FV programs. Results were similar regardless if focus was a school meal or FV program.

## Review 2: Snack Food and Beverage Interventions

All 13 studies were conducted in the U.S., and in schools alone.<sup>44–56</sup> Twelve studies<sup>44–55</sup> reported on population density of the community where the intervention occurred; 11<sup>44,45,47–55</sup> reported a mixed setting (i.e., urban, suburban, and rural) and one reported an urban or suburban setting.<sup>46</sup> All of the snack food and beverage studies included a competitive foods and beverages component (Table 1).

Interventions took place in elementary, middle, and high schools. Most studies reported about half of their study population was female. Of the 12 studies that reported race and ethnicity, the median for the proportion identifying as white was 58.9%, black was 15.4%, Hispanic was 18.5%, and other was 9.5%.<sup>44–47,49–56</sup> Two studies<sup>44,46</sup> were in low-SES populations.

Intake of SSBs was reported by seven studies. Three studies reported a median increase of 0.03 SSB servings per day (range= –0.33–0.08) (Table 2).<sup>45,46,54</sup> Information on four studies



reporting SSBs could not be plotted owing to the use of various measures; other dietary behavior outcomes are in Table 2 or Appendix Table 2 (available online).<sup>48,50,53,55</sup>

Three studies reported overweight or obesity prevalence following the CDC definition<sup>47,49,52</sup>; one<sup>52</sup> objectively measured height and weight, and two<sup>47,49</sup> used parent-reported child height and weight data. One study reported a significant decreased probability of being overweight in states with strong laws for competitive food nutrition content, but no association with the probability of having obesity (Table 2).<sup>52</sup> One study examined the association between competitive food and beverage laws and overweight or obesity, by school level.<sup>49</sup> For the elementary level, strong laws were associated with reduced odds of obesity compared with states with no laws (OR=0.57 for both four or more strong laws and two to three strong laws) (Table 2). Lastly, one study reported students in states with strong school competitive food and beverage laws reported no change in odds of overweight and obesity combined compared to students living in states with no laws (Table 2).<sup>47</sup>

### Review 3: Multicomponent Healthier Meal and Snack Interventions

Included studies were conducted in the U.S.,<sup>58–60,63,65,66</sup> Canada,<sup>61,62,64</sup> and the United Kingdom.<sup>57,67,68</sup> Ten studies<sup>58–63,65–68</sup> were conducted in schools alone and two<sup>57,64</sup> were conducted schools plus the home setting. Nine studies reported information on population density; four<sup>59,61–63,66</sup> reported multiple settings, four<sup>57,58,65,66</sup> reported an urban or suburban setting, and one was rural.<sup>60</sup> Twelve studies<sup>57–68</sup> included school lunch changes, nine studies<sup>59–67</sup> included competitive foods and beverages, and two studies<sup>57,58</sup> included a FV program (Table 1).

The majority of interventions took place in elementary and middle schools, with one study<sup>62</sup> taking place in middle and high schools. Studies reported about half of their study population was female. Of the five studies that reported race and ethnicity, the median proportion identifying as white was 19%, black was 19%, Hispanic was 54%, and other was 10%.<sup>58,60,65,66</sup>

Five studies reported on the effectiveness outcome of FV intake and three on SSB intake. Four studies reported a median relative increase of 15% for FV intake for the total day (IQR=1.0%, 45.0%) (Table 2).<sup>57,59,61,63,64</sup> Two studies reported a decrease in SSBs (Table 2).<sup>59,61,63</sup> Additional information on dietary behaviors are reported in Appendix Table 2 (available online).

Six studies reported BMI z-score, overweight prevalence, or obesity prevalence. Two studies reported BMI z-score. One study<sup>65</sup> reported a BMI z-score decrease of 0.01 and one study<sup>58</sup> reported no change (Table 2). Six studies in five publications<sup>58,61,62,65,66</sup> reported overweight or obesity prevalence following CDC<sup>58,65,66</sup> or International Obesity Task Force<sup>61,62</sup> definitions. Four studies reported overweight and obesity prevalence combined.<sup>61,65,66</sup> In two large U.S. studies, the average odds of overweight and obesity prevalence combined were no longer increasing during the post-policy period, and there were population-level improvements in overweight and obesity trends (data not shown).<sup>66</sup> The remaining two studies reported no change in overweight and obesity prevalence (Table 2).<sup>61,65</sup> One study<sup>58</sup> reported obesity prevalence and found a 1.0 percentage point decrease, and another study<sup>62</sup>



reported a reduced odds of being overweight (OR=0.85, 95% CI=0.59, 1.20) or obese (OR=0.92, 95% CI=0.73, 1.16) (Table 2). With one exception,<sup>62</sup> all studies objectively measured height and weight.

#### Review 4: Water Interventions

Water intervention studies were conducted in the U.S.<sup>70</sup> and Europe.<sup>69</sup> Both were conducted in schools alone and in urban or suburban settings. In addition to increasing access to water, one study<sup>69</sup> included healthy eating learning opportunities (Table 1).

One study<sup>69</sup> took place in elementary schools, and the other in elementary, middle, and high schools.<sup>70</sup> Both studies reported about half of their study population was female.

One study<sup>69</sup> reported on the effectiveness outcomes of water and SSB intake with an increase of 1.1 glasses of water per day and no change in soft drink consumption. Both studies<sup>69,70</sup> reported small decreases in BMI z-score and overweight and obesity prevalence combined (Table 2).

## DISCUSSION

### Summary of Findings

Based on these findings, the CPSTF recommends two intervention approaches: school meal or FV interventions (Review 1) based on improvements in FV consumption and no increase in weight status among school-aged children, and multicomponent healthier meal and snack interventions (Review 3) based on evidence of maintaining weight status among school-aged children. The CPSTF considered evidence on snack foods and beverages interventions (Review 2) inconsistent. Lastly, there were too few studies for water access interventions (Review 4) to support a CPSTF recommendation.

A 2018 systematic review of school food environment policies reported results similar to these Community Guide reviews.<sup>71</sup> The authors reported school food environment policies (direct provision of healthful foods and beverages, competitive food and beverage standards, and school meal standards) can improve selected dietary behaviors. The conceptual approach for the Community Guide reviews and the review by Micha et al.<sup>71</sup> differed, which resulted in intervention categories being defined differently. These reviews can help inform decision makers regarding the best intervention to implement for their population.

### Applicability

Applicability was assessed for the two recommended interventions. Findings are applicable to male and female students in the U.S. and other high-income countries, urban and suburban populations, diverse races and ethnicities, and various income statuses. School meal or FV interventions are applicable to students in elementary, middle and high schools, and multicomponent healthier meal and snack interventions are applicable to students in elementary and middle schools (no studies included high school students only). Most interventions lasted at least 1 school year. Specifics are available in The Community Guide website under Applicability and Generalizability Issues ([www.thecommunityguide.org/sites/default/files/assets/Obesity-School-Interventions.pdf](http://www.thecommunityguide.org/sites/default/files/assets/Obesity-School-Interventions.pdf)).

## Evidence Gaps

Additional research is needed to fill existing gaps in the evidence base. Evidence gaps are cross-cutting and intervention-specific.

Fidelity of implementation was rarely reported within the included studies. Process evaluations could provide information on the extent the schools' implement these interventions (e.g., fidelity and intensity) and what training is provided for staff. Some research suggests interventions might be effective when both state and local policies are enacted.<sup>54,72</sup> More evidence is needed to understand what level (i.e., national, state, or local) of policy implementation is needed in order to be effective. Studies should also consider population density. Most included studies were implemented in urban or suburban settings; it remains unknown if similar interventions would be successful in rural settings.

It is unclear why snack food and beverage interventions have insufficient evidence whereas multicomponent meal and snack interventions are considered effective. It is possible snack food and beverage interventions were implemented with less fidelity when implemented alone. Another possibility is the included studies preceded evaluations of Smart Snacks in Schools standards (2014–2015 school year)<sup>73</sup> because they are too recent to have published reports. Further, interventions changing school meals might have a greater impact on total day dietary and weight-related outcomes than interventions focusing on snacks. Regarding water interventions, research is needed to determine effective intervention components (e.g., adding water fountains, allowing water bottles in class). For the two interventions with sufficient evidence, future studies should examine which combinations of components are most effective and sustainable.

## Limitations

This review has several limitations. First, most articles were from peer-reviewed literature and there is a potential publication bias. However, not all studies reported positive effects. The team attempted to address this by searching gray literature, but only one dissertation met the inclusion criteria. Second, a formal meta-analysis was not possible, owing to varied study designs, only a few studies reporting CIs or SEs, and reported measures being heterogeneous. Third, not all policy and observational studies included a pre-intervention measure. A small number of included studies were observational studies of existing laws that met inclusion criteria. Fourth, most dietary outcomes are based on self-reported data (validated instruments were used but the psychometrics of the instruments were often not reported). Lastly, the team reported the data point closest to the conclusion of the intervention because too few studies reported maintenance. Therefore, maintenance or improvement is unknown.

## CONCLUSIONS

School nutrition environments may facilitate the development of healthy eating habits. Federal programs and policies that can support these recommended intervention include school meal nutrition standards that went into effect during the 2012–2013 school year through the Healthy, Hunger-Free Kids Act and funding provided by the U.S. Department of

Agriculture Fresh Fruit and Vegetable Program.<sup>74,75</sup> CDC has examples of comprehensive approaches to address the school nutrition environment.<sup>4</sup> When selecting an intervention, implementers may need to adapt the intervention to their school population. Findings from this review can inform researchers, school administrators, and public health decision makers about effective interventions to improve students' dietary behaviors and weight-related outcomes.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## ACKNOWLEDGMENTS

The work of Devon L. Okasako-Schmucker was supported with funds from the Oak Ridge Institute for Science and Education.

The authors acknowledge staff from the Centers for Disease Control and Prevention (CDC) library for assistance with the systematic literature search, and the Community Guide Branch at CDC for scientific, dissemination, and editorial assistance.

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of CDC/the Agency for Toxic Substances and Disease Registry. The content expressed in this paper is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute, the NIH, or HHS.

HRW, RKCF, LRB, and DLO-S led the evidence acquisition, synthesis of evidence, data analysis, and writing of the manuscript. CM provided guidance, subject matter input, and manuscript editing. SLM, YW, CAP, KG, and EO provided conceptualization oversight and manuscript editing.

Part of Youfa Wang's effort was supported by research grants from the NIH (U54 HD070725, R03HD090387).

No financial disclosures were reported by the authors of this paper.

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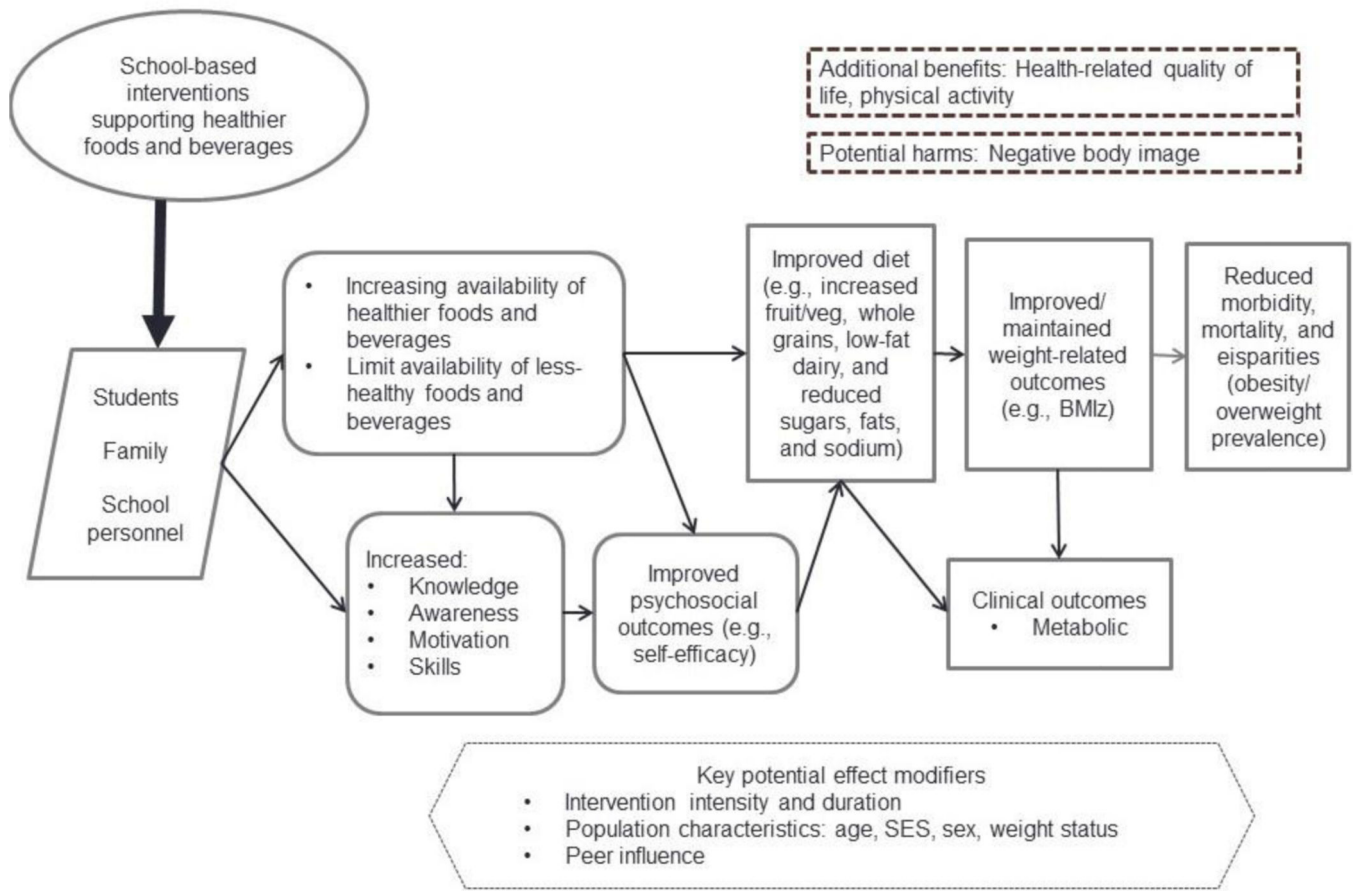
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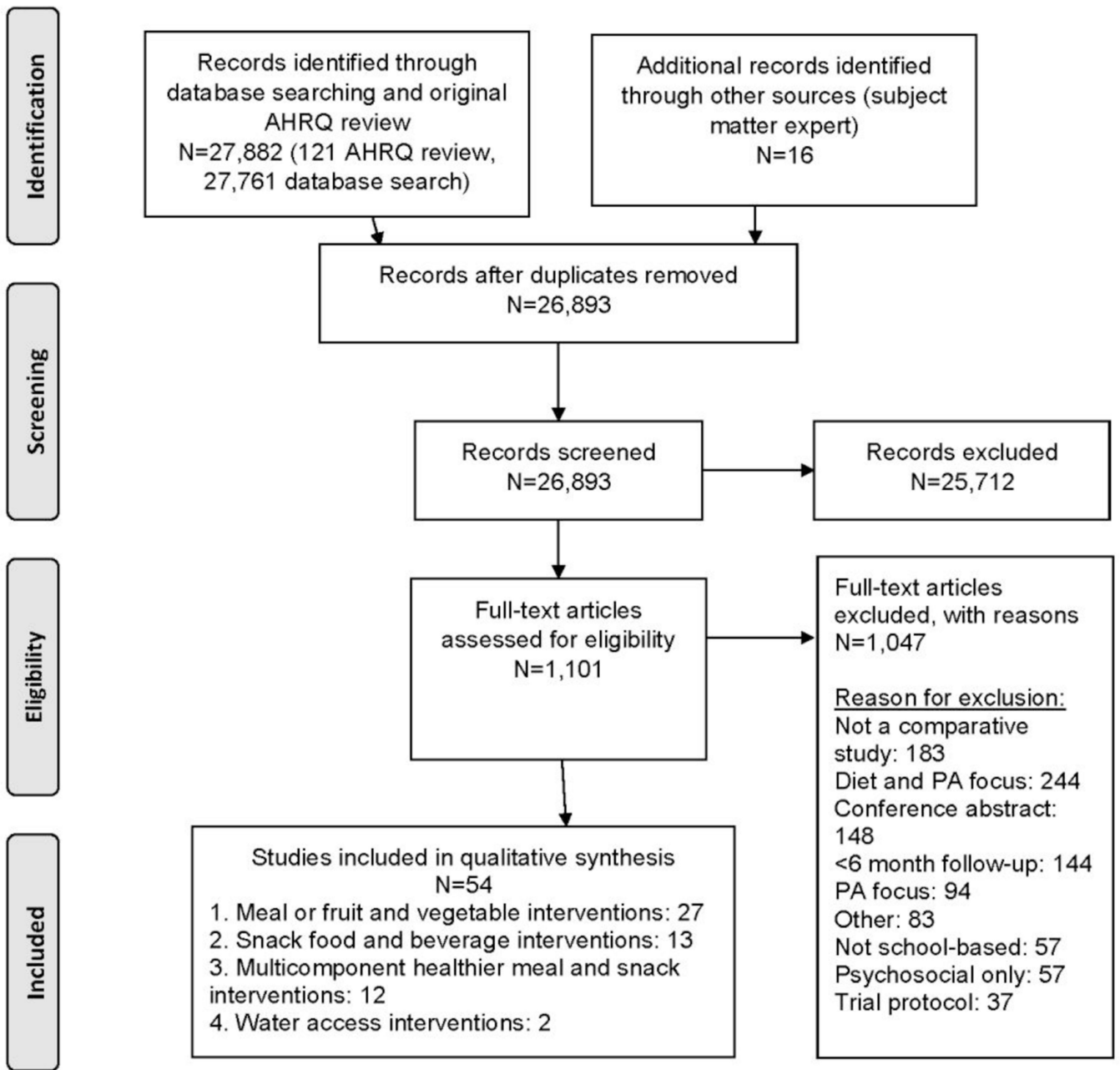
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**Figure 1.** Analytic framework: hypothesized ways school dietary interventions can improve diet and weight-related outcomes.



**Figure 2.**  
PRISMA flowchart.  
AHRQ, Agency for Healthcare Research and Quality.

**Table 1.**

Location, Intervention Characteristics, and Intervention Components From Included Studies

Characteristic	Meal or fruit and vegetable interventions (n=27)	Snack foods and beverages interventions (n=13)	Multicomponent healthier meal and snack interventions (n=12)	Water access interventions (n=2)
<b>Country</b>				
Australia	1 <sup>37</sup>	0	0	0
Canada	2 <sup>28,29,43</sup>	0	3 <sup>61,62,64</sup>	0
Europe	8 <sup>18-21,26,31,41,42</sup>	0	0	1 <sup>69</sup>
Taiwan	1 <sup>22</sup>	0	0	0
United Kingdom	1 <sup>33</sup>	0	3 <sup>57,67,68</sup>	0
U.S.	14 <sup>16,17,23-25,27,30,32,34-36,38-40</sup>	13 <sup>44-56</sup>	6 <sup>58-60,63,65,66</sup>	1 <sup>70</sup>
<b>Setting</b>				
School only	25 <sup>16-43</sup>	13 <sup>44-56</sup>	10 <sup>58-63,65-68</sup>	2 <sup>69,70</sup>
School plus home	2 <sup>21,42</sup>	0	2 <sup>57,64</sup>	0
<b>Degree of urbanization</b>				
Urban/suburban	7 <sup>23-25,27,35,38,41</sup>	1 <sup>46</sup>	4 <sup>57,58,65,66</sup>	2 <sup>69,70</sup>
Mixed urban to rural	7 <sup>16,32,34,36,37,39,40</sup>	11 <sup>44,45,47-55</sup>	4 <sup>59,61-63,66</sup>	0
Rural only	2 <sup>28,29,43</sup>	0	1 <sup>60</sup>	0
Not reported	11 <sup>17,18,19,20,21,22,26,30,31,33,42</sup>	1 <sup>56</sup>	3 <sup>64,67-68</sup>	0
<b>Components</b>				
School breakfast	3 <sup>16,21,37</sup>	–	1 <sup>61</sup>	–
School lunch	11 <sup>22,23,24,25,26,31,35,38,39,40,42</sup>	–	12 <sup>57-68</sup>	–
Fruit and vegetable program	14 <sup>18-20,27-30,32-36,41-43</sup>	–	2 <sup>57,58</sup>	–
Competitive foods and beverages	–	13 <sup>44-56</sup>	9 <sup>59-67</sup>	–
Celebrations and rewards	–	0	5 <sup>57,58,61,64,65</sup>	–
Water access	–	0	2 <sup>61,64</sup>	2 <sup>69,70</sup>
Healthy food/beverage marketing	3 <sup>35,37,42</sup>	1 <sup>44</sup>	6 <sup>57,58,60,61,64,65</sup>	0
Healthy eating learning opportunities	8 <sup>19,21,26,31,35,37,41,42</sup>	1 <sup>44</sup>	6 <sup>57,58,60,61,64,65</sup>	1 <sup>69</sup>

**Table 2.**

## Selected Dietary Outcomes and Obesity Prevalence by Intervention Category

Outcomes	Meal or fruit and vegetable interventions	Snack foods and beverages interventions	Multicomponent healthier meal and snack interventions	Water access interventions
Dietary outcomes				
Fruit and vegetable intake (total day)				
Study arms, n	9	1	4	NR
Median change (IQR or range)	Relative change: 20 (IQR: 4.3, 38.5)	0.14	Relative change: 15 (range: 1.0, 45.0)	–
Sugar-sweetened beverage (servings/day)				
Study arms, n	NR	3	2	1
Median change (range) or other result	–	0.03 (–0.33, 0.08)	Range: –0.3, –0.2	no change <sup>a</sup>
Water (glasses/day)				
Study arms, n	NR	1	NR	1
Change	–	Increase 0.7 servings/week (NS)	–	1.1
Weight-related outcomes				
BMI z-score				
Study arms, n	3	1	2	2
Median change (range) or other result	0.01 (–0.14, 0.03)	–0.10	–0.01, “no intervention effects” <sup>a</sup>	Range: –0.004, –0.016
Obesity prevalence				
Study arms, n	1	3	2	NR
Change	pct pts: –7.7	Beta: 0.0, Elementary: 4 strong laws <sup>b</sup> OR=0.57 (95% CI=0.34, 0.97) 2–3 strong laws <sup>b</sup> OR=0.57 (95% CI=0.36, 0.90) Middle and High: No change <sup>a</sup>	pct pts: –1.0, OR <sup>c</sup> =0.85 (95% CI=0.59, 1.2)	–
Overweight prevalence				
Study arms, n	NR	3	1	NR
Change	–	Beta: –2.8 Elementary: 4 strong laws <sup>b</sup> OR=1.0 (95% CI=0.59, 1.8) 2–3 strong laws <sup>b</sup> OR=0.97 (95% CI=0.61, 1.5) Middle: 4 strong laws <sup>b</sup> OR=0.76 (95% CI=0.57, 0.99) 2–3 strong laws <sup>b</sup> OR=0.70 (95% CI=0.55, 0.90) High: 4 strong laws <sup>b</sup> OR=1.1 (95% CI=0.73, 1.2)	OR <sup>d</sup> =0.92 (95% CI=0.73, 1.2)	–

Outcomes	Meal or fruit and vegetable interventions	Snack foods and beverages interventions	Multicomponent healthier meal and snack interventions	Water access interventions
		CI=0.79, 1.6) 2–3 strong laws <sup>b</sup> OR=1.2 (95% CI=0.90, 1.6)		
Overweight/obesity prevalence combined <sup>e</sup>				
Study arms, n	5	1	2	2
Median change (IQI) or other result	pct pts: -9.6 (-10.7, -1.6)	OR <sup>f</sup> =1.01 (95% CI=0.80, 1.3)	Range: -0.01, 0.6	AOR <sup>g</sup> =0.69 (95% CI=0.48, 0.98) Girls -0.6 pct pts ( <i>p</i> <0.10) Boys -1.2 pct pts ( <i>p</i> 0.01)

<sup>a</sup>Study authors reported results qualitatively.

<sup>b</sup>Compared to 0 or 1 law.

<sup>c</sup>Odds of being obese when exposed to average guidelines compared to below average guidelines or when exposed to above average guidelines compared to average guidelines.

<sup>d</sup>Odds of being overweight when exposed to average guidelines compared to below average guidelines or when exposed to above average guidelines compared to average guidelines.

<sup>e</sup>Studies in overweight/obesity prevalence combined were independent of studies in obesity prevalence alone or overweight prevalence alone.

<sup>f</sup>Odds of being overweight/obese when exposed to strong law compared to no law.

<sup>g</sup>Odds of being overweight/obese when exposed to intervention compared to no intervention.

NR, not reported; IQI, interquartile interval, pct pts, percentage points.

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