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School Nutrition Environment and Services: Policies and Practices That Promote Healthy Eating Among K-12 Students

CAITLIN MERLO, MPH, RDN^a, BRIANNA L. SMARSH, MPH, RDN^b, XIANGXUE XIAO, PhD^c

^aHealth Scientist, Healthy Schools Branch, Division of Population Health, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Atlanta, GA.

^bHealth Scientist, Division of Nutrition, Physical Activity, and Obesity, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Atlanta, GA.

^cStudent Department of Epidemiology and Biostatistics, School of Public Health, University of Nevada Las Vegas, Las Vegas, NV.

Abstract

BACKGROUND: Changes to policies at the federal, state, and local levels over the last decade have influenced the school nutrition environment and services.

METHODS: This systematic review includes an analysis of individual research articles and government reports published from 2010 to 2021 that examine interventions to improve the school nutrition environment and services and increase the availability, selection, and consumption of healthier foods and beverages in K-12 schools in the United States.

RESULTS: Nutrition standards for school meals and food outside of meals improved access to healthier options in school. Providing school nutrition professionals with professional development, improving the palatability of school meals, offering taste tests, pre-slicing fruit, providing recess before lunch, offering incentives for trying healthier options, and providing

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Address correspondence to: Caitlin L. Merlo, MPH, RDN, Health Scientist, (ihb7@cdc.gov), Healthy Schools Branch, Division of Population Health, National Center for Chronic Disease Prevention & Health Promotion, Centers for Disease Control and Prevention, Atlanta, GA.

Conflict of Interest

No authors of this paper have any conflict of interest.

Human Subjects Approval Statement

Preparation of this paper did not involve primary research or data collection involving human subjects, and therefore, no institutional review board examination or approval was required.

SUPPORTING INFORMATION

The following Supporting Information is available for this article:

Table S1. School Meals Citations.

Table S2. School Meals Supplemental Table.

Table S3. School Nutrition Environment Citations.

Table S4. School Nutrition Environment Supplemental Table.

Additional supporting information may be found online in the Supporting Information section at the end of the article.

access to drinking water resulted in increased selection and consumption of healthier items. There were inconclusive or mixed findings for some intervention strategies including adequate seat time for meals.

CONCLUSIONS: Despite demonstrated improvements to school meal programs and competitive foods, more work is needed to change the selection and consumption of healthier options among K-12 students. Schools can use multiple interventions to improve the school nutrition environment and services and help students adopt food and beverage choices that support health.

Keywords

school nutrition; school meals; students; policies; healthy eating; professional development

The school nutrition environment and services can influence the foods and beverages students can access throughout the school day. Prior to the COVID-19 pandemic, more than 33 million students participated in federal school meal programs (SMP) every day, and the pandemic reinforced the important role that these programs play in household food and nutrition security.^{1,2} SMP were positioned as “essential services” because of their critical role in safeguarding the health and wellbeing of children, families, and communities.¹⁻³

To guide research and programmatic efforts related to nutrition environment and services, the Centers for Disease Control and Prevention (CDC) uses its Comprehensive Framework for Addressing the School Nutrition Environment and Services (CFASNE).⁴ We examined interventions aligned with CFASNE, which includes the ways that students have access to foods and beverages during the school day, the messages that they see and hear about good nutrition, and the opportunities to learn about and practice healthy eating (Figure 1).

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

CDC published recommendations about the school nutrition environment and services in 2011.⁵ The Healthy, Hunger-Free Kids Act of 2010 required changes to the school nutrition environment and services, including updated nutrition standards for school meals and other foods and beverages offered and sold outside of meal programs, training requirements for school nutrition professionals, requirements for drinking water access, and guidance on addressing food and beverage marketing (FBM) in schools.⁶⁻¹⁰ While local school districts and schools are responsible for implementing SMP in accordance with state and federal regulations, districts and schools differ in menu planning and food preparation practices, and SMP vary by site.

We aimed to answer the following question: What changes to the school nutrition environment and services increase the availability, selection, and consumption of healthier foods and beverages in K-12 schools in the United States? We examined professional development (PD) for school nutrition professionals and most components of CFASNE other than nutrition education, which is covered in a separate article of this special issue.

METHODS

The introduction and methods article to this special issue gives more details about the two-phase approach we used for identifying articles from existing systematic reviews (Phase 1) and searches for individual articles (Phase 2).¹¹ First, we searched The Community Guide website¹² to identify CPSTF systematic reviews and topics (2010–2021) that aligned with our research question and identified 2 that aligned with our research question: (1) a recommendation for school gardening¹³ and (2) a conclusion of insufficient evidence to support interventions to increase access to drinking water in schools based on too few studies.¹⁴ Accordingly, we excluded articles about school gardening and decided to look for additional school-based interventions to increase water access.

We also identified 3 topics, including 2 recommendations that did not fully align with our research question. The CPSTF determined there was sufficient evidence to recommend interventions addressing school meal or fruit and vegetable snack components on their own or with competitive foods (eg, foods sold during school hours a la carte, or through vending machines, fundraisers, or school stores).¹⁴ Nonetheless we updated searches related to these topics to identify studies that could reflect impacts from the updated nutrition standards for school meals (in effect SY 2012–2013)⁹ and competitive foods (in effect SY 2014–2015), and foods offered as a reward.^{7,14}

Table 1 presents the search terms and dates for each phase. To be eligible for consideration, articles had to describe school-based nutrition interventions (policy, program, systems change, environmental change); include relevant outcomes including changes in access to healthy foods and beverages; increased selection and consumption of fruits, vegetables, whole grains, and water; decreased selection and consumption of sugar-sweetened beverages (SSBs); or decreased intake of sodium, added sugars, and saturated fat; and meet all other criteria described in Table 1 of the introduction and methods article.¹¹

For each included article, reviewer pairs met to reconcile any differences in extraction and risk of bias assessment and reached 100% agreement. Additional details about systematic review methods, documentation, data extraction, and risk of bias assessment can be found in the introduction and methods article of this special issue.¹¹

In Phase 1, we identified 7 anchor review articles that focused on nutrition interventions; within these reviews, we identified 104 individual qualifying articles describing school nutrition interventions (Figure 2). During data extraction, subject matter experts identified 22 interventions that included nutrition components from other anchor review articles (eg, reviews about multicomponent obesity prevention interventions). Of these 126 qualifying articles, 11 were excluded for being out of scope ($n = 7$) or wrong study design ($n = 4$), and 27 were determined to be better suited for a different systematic review in the special issue, leaving 88 articles included from Phase 1.

In Phase 2, we included a total of 119 articles, as described in figure 3 of the introduction and methods article.¹¹ Of these, 12 articles were coded as having nutrition interventions (Figure 2): 1 article was excluded because it was a duplicate from Phase 1, and 4 articles

were determined to be better suited for a different article within this special issue (eg, used a multicomponent approach), leaving 7 articles from Phase 2 for inclusion.

In addition to the peer-reviewed literature, we identified a priori the School Nutrition and Meal Cost Study (SMNCS), a nationally representative evaluation of SMPs following the adoption of updated nutrition standards, adding 2 articles to the total number of articles reviewed.^{15,16} Reviewer pairs conducted a risk of bias (RoB) assessment and double-extracted and reconciled extraction as described above. Of the qualifying articles and reports identified for inclusion across Phases 1 and 2, 97 were ultimately included in this review.

We conducted a qualitative synthesis comparing how many interventions reported statistically significant outcomes that were considered in the expected direction (ie, improve availability, selection, and consumption of healthier foods and beverages or reduce availability, selection, and consumption of less healthy foods and beverages), and how many reported null findings, or findings in the unexpected direction. Examples of outcomes in the expected direction included increased availability, selection, and consumption of healthier options (eg, whole grains); decreased plate waste; and decreases in the availability of less nutritious foods (eg, candy).

FINDINGS

This systematic review includes 97 articles representing 121 interventions from 96 unique studies: 101 interventions (81 articles, 80 studies) to improve the nutritional quality and consumption of school meals (Table 2) and 20 interventions (19 articles, 19 studies) addressing the school nutrition environment beyond the foods and beverages available to students through school meals (Table 3). We grouped these articles into 14 intervention categories (10 for school meals, 4 for school nutrition environment) and have presented results for each intervention category. Three articles (3 studies) were included in both groups. The Supplemental tables (Tables S1–S4) include detailed information about each included study, including intervention components and characteristics, population demographics, and RoB assessments.

Interventions to Improve School Meals Programs

Nutrition standards for school meals.—Nineteen interventions (17 studies, 16 articles) examined nutrition standards for school meals (Table 2).^{15–30} Several interventions generally demonstrated positive changes in the nutritional quality of meals and mixed findings for student selection of key food groups and for dietary intake. Sixteen focused on the implementation of federal nutrition standards required by the Healthy, Hunger-Free Kids Act of 2010 (HHFKA),⁹ 2 addressed the nutrition standards recommended by the Institute of Medicine,^{24,31} and 1 intervention examined a chocolate milk ban.²⁸ Five interventions examined changes to foods and beverages in SMPs^{15,24,30}; 4 found at least one positive change to the nutritional quality of meals available to students following implementation of nutrition standards,^{15,24} and 2 found changes in the undesired direction for some of the key nutrients.²⁴ Of the 8 interventions that examined changes in students' food selection, 7 found positive changes in at least 1 food group or key nutrient,^{17,18,20,23,26,27,29} and 6

found at least 1 change in the unexpected direction.^{18,23,26–29} Nine of the 14 interventions that measured changes in dietary intake found positive changes for at least 1 food group or key nutrient,^{16,18,20,23,25–27,29} and 10 found at least 1 change in the unexpected direction.^{16–18,20,21,23,27–29}

Taste tests, incentives/rewards, improving palatability, pre-sliced fruit, recess before lunch.—A variety of strategies were used to increase the selection and consumption of school meals, with several interventions generally demonstrating positive outcomes. Seven interventions (7 studies, 7 articles) focused on providing taste tests to students^{32–38}; 6 measured changes in dietary intake, with 5 showing 1 or more positive changes (eg, increases in consumption of fruits and vegetables).^{32,34,36–38} Fourteen interventions (14 studies, 15 articles) examined using small incentives and rewards to influence students' selection and consumption of school meals^{37–51}; all 6 that measured changes in selection found an increase in selection of 1 or more healthier options,^{44–50} and all 9 that measured changes in consumption found an increase in selection of 1 or more healthier options.^{37–44,51} Nine interventions (9 studies, 10 articles) examined strategies to improve the palatability of school meals (eg, hiring chefs to prepare meals, adding spices and herbs to vegetables, and incorporating new menu items)^{52–61}; 8 found an increase in the consumption of 1 or healthier food groups,^{52–60} but 2 found a decrease.^{57,61} All 3 interventions (3 studies, 3 articles) that pre-sliced fruit for students found increased fruit consumption.^{62–64} Of the 5 interventions (5 studies, 5 articles) that provided students with recess before lunch,^{62,65–68} 4 found improvements in dietary intake at lunch.^{62,66–68}

Behavioral design.—Twenty-five interventions (23 studies, 22 articles) used behavioral design strategies to influence students' selection and consumption of school meals.^{24,51,59,62,69–86} Studies used 1 or more strategies including placement of items on the serving line, signage, and prompts to encourage consumption, changing portion sizes, improving food presentation and display, and using creative names for menu items. Sixteen interventions measured changes in students' selection of foods and beverages with 15 finding improvements in selection of 1 or more food groups.^{59,69,72–76,79–85} Twenty-two interventions measured changes in consumption of school meals^{59,62,69–86}; 15 interventions found increases in consumption of 1 or more food groups or key nutrients.^{51,59,62,69,71,73–77,79,81,82,85,86}

Increasing choices, lunch duration.—We examined 2 intervention strategies that had inconclusive findings: increasing the number of choices students have in the cafeteria and the amount of seated time students have to eat their lunch. Five interventions (5 studies, 5 articles) increased students' choices during school meals.^{62,87–90} Two interventions found an increase in fruit and/or vegetable consumption,^{62,88} 3 found no changes in at least one measure,^{62,89,90} and 2 found a decrease in consumption from 1 or more healthier food groups.^{87,89} Two interventions (2 studies, 2 articles) examined the association between time to eat school meals and food selection and intake^{62,91}; 1 found no association⁶² while the other found that a shorter lunch period (ie, less than 20 minutes of seated time) was associated with lower consumption of entrées, milk, and vegetables.⁹¹

Professional development (PD) for school nutrition staff.—Twelve interventions (12 studies, 12 articles) provided school nutrition staff with PD opportunities to deliver quality school meals.^{24,54,55,59,63,70,80,85,92–95} PD focused on using new equipment, new recipes, nutrition standards, and ways to display and promote menu items (eg, behavioral design). Three interventions measured changes in staff nutrition knowledge, attitudes, and perceptions (KAP), and results were mixed.^{93–95} All 4 interventions that examined changes to the cafeteria environment found positive changes including increases in practices to promote healthier options^{93,94} and improvements to the nutrient content of school meals.²⁴ However, 2 interventions found at least 1 change in the unexpected direction.²⁴ Seven interventions examined changes in students' selection of foods following PD interventions—all 7 reported improved student selection of 1 or more food groups.^{54,59,63,80,85,93} Eight interventions measured changes in the consumption of foods served as part of a school meal—6 interventions found positive results for consumption of 1 or more food groups.^{54,59,63,85,92} One intervention measured changes in school meal participation and found no changes in participation.⁹⁴

Interventions to Improve the School Nutrition Environment

Nutrition standards for competitive foods.—Twelve interventions (11 studies, 11 articles) examined nutrition standards for competitive foods (eg, a la carte items, vending machines) (Table 3).^{35,96–105} Interventions examined how policy changes enacted at federal, state, district, or school levels affected availability of competitive foods,^{35,96,102,104} students' dietary intake,^{96–100,102,104,105} and/or body weight status.^{96,100,101,103,105} All four interventions that measured environmental changes found positive outcomes including an increased availability of healthier foods and beverages,^{35,96,102} decreased vending machine access during meal periods,¹⁰⁴ and reduced availability of soda vending machines.¹⁰⁴ Seven interventions examined students' dietary outcomes; 5 had positive findings,^{97,99,100,102,105} 4 had no changes for at least 1 dietary outcome,^{96–98,102} and 2 had changes in the unexpected direction.^{98,102} Six interventions examined changes in weight status with mixed results.^{96,100,101,103,105}

Classroom celebrations and rewards.—Three interventions (3 studies, 3 articles) addressed classroom celebrations and rewards^{32,106,107}; strategies included establishing nutrition standards for classroom foods and beverages, providing teachers with non-food reward boxes, providing PD for teachers, and self-assessment and action planning to change practices. One study found an increase in the number of schools that had policies for food as a reward in the classroom and food offered at classroom parties and celebrations after the intervention,¹⁰⁷ 1 study found no significant changes to foods brought for classroom or school-wide events,¹⁰⁶ and 1 study found a mix of small improvements and no changes in the consumption of healthier food items.³²

Food and beverage marketing.—One study reported on schools' efforts to assess whether FBM practices in schools¹⁰⁸ were compliant with federal regulations for local school wellness policies⁸ and on their efforts to improve the school nutrition environment and decrease the number of noncompliant instances of FBM. Through the process of assessing current practices and providing technical assistance on replacing marketing that

was not compliant, schools were able to improve the school nutrition environment and decrease the number of noncompliant instances of FBM.

Access to drinking water.—Four interventions (4 studies, 4 articles) focused on increasing access to drinking water in schools^{109–112}; all 4 provided students with access to free drinking water in cafeterias using water jets, water dispensers, or bottleless water coolers and provided cups near the water dispensers. Two interventions included promotional activities and provided incentives (ie, reusable water bottles) to students.^{109,110} Only 1 study measured changes in KAP about water; it found no significant changes after the intervention.¹¹² Two interventions showed an increase in water intake,^{109,110} and 1 study showed an increase in the number of times that students selected water.¹¹² Three interventions did a secondary analysis to examine whether increased access to drinking water resulted in students replacing their intake of other beverages including milk and SSBs; 1 study found no change in SSB intake,¹¹⁰ 2 interventions found no change in milk consumption or selection,^{110,112} and 1 found decreases in milk selection.¹¹¹

DISCUSSION

This systematic review examined interventions representing multiple components of the school nutrition environment and services as outlined in CDC's CFASNE. While results from individual interventions were often mixed, there were consistent findings for some interventions.

Interventions to Improve School Meals Programs

Across the 101 interventions focused on improving school meals, several interventions emerged as having evidence of effectiveness for 1 or more outcomes. Findings from the nationally representative SNMCS demonstrated that nutrition standards for school meals improved the overall nutritional quality of the meals served including increases in fruits, vegetables, and whole grains and decreases in sodium, refined grains, and empty calories.¹⁵ However, the research on interventions designed to impact student selection and consumption was mixed. These findings could suggest that improving quality and access to school meals is not enough to change overall consumption behaviors, and additional strategies might be needed to change students' behaviors.

Increasing the number of menu choices students have, offering taste tests, providing incentives or rewards for trying certain foods, and pre-slicing fruit are strategies that generally showed evidence of positively influencing students' dietary behaviors. Across these strategies, most studies had a mix of positive or null results, with very few studies reporting outcomes in the unexpected direction. Many of these strategies require minimal financial resources for implementation, but staff time and training are needed. While there is evidence to suggest that using these strategies may improve participation rates in SMPs,¹⁶ some questions remain about long-term impact and sustainability of some behavioral design interventions. For example, will students continue to make healthier choices if they no longer receive rewards? And what is the impact of incentivizing healthier food items on student's intrinsic motivation to select, consume, and enjoy the food?

The timing of school meals can affect how much students eat. Of the 5 interventions that examined scheduling recess before lunch, 4 found a benefit in at least 1 dietary behavior (eg, fruit and vegetable consumption, milk consumption). Having recess before lunch may help students build an appetite by playing first and prevent students from rushing through mealtime so that they can get to recess faster. However, scheduling challenges can be a barrier to implementing this practice. Staggered lunch schedules can help address long lines and waiting times.

Ensuring students have at least 20 minutes of seated lunch time and at least 10 minutes to eat breakfast has been recommended to allow students to have enough time to socialize with friends and eat their food.⁵ Our review includes 2 papers about lunch duration, 1 of which did not find an effect on the amount of food consumed. More research in this area would help provide an understanding of how much seated time is desirable and feasible for students in different grade levels in the context of acclimating to new meal patterns with more fruits, vegetables, and whole grains. In addition, those designing interventions regarding seated time may consider the importance of social and emotional aspects of meal periods such as socializing with friends.

This systematic review examined a range of behavioral design strategies—interventions aimed at nudging students to select and consume healthier options—including rearranging the serving line, using signage and prompts to encourage consumption, changing portion sizes, presenting foods in attractive ways, and using creative names for menu items. Most studies had a mix of positive or null results, with a few studies finding results in the unexpected direction. Implementation of behavioral design principles can help create a more pleasant eating environment but should not take the place of changes to improve the nutritional quality and palatability of school meals.

Annual PD is required of all school nutrition staff,¹⁰ and our review found that PD can have a positive impact on the school nutrition environment as well as students' selection and consumption of healthier options. PD can focus on improving the presentation and palatability of meals, including new food preparation techniques, developing new or revised procurement policies, training on new equipment, or behavioral design strategies to present food in appealing ways. Public and private funding opportunities exist to support PD including scratch cooking and infrastructure improvements, such as kitchen equipment grants.¹¹³ Lessons learned from past emergencies, particularly the COVID-19 pandemic, will be paramount in strengthening PD opportunities for school nutrition staff, especially as schools update training, policies, and procedures for disaster preparedness, response, and recovery.^{3,114,115}

Interventions to Improve the School Nutrition Environment

Findings from interventions addressing nutrition standards for competitive foods indicate improvements in the school nutrition environment (ie, items offered to students beyond school meals) but mixed results for dietary intake. This is similar to a recent Community Guide finding of insufficient evidence for healthier snack food and beverage interventions on dietary intake.^{14,116} This suggests that limiting access to less healthy foods and beverages at school may not be sufficient to change students' selection or consumption behaviors,

which supports existing evidence that comprehensive school nutrition programs are needed to improve the nutritional status of students.¹¹⁷ Of note, only 1 included study examined implementation of the US Department of Agriculture Smart Snacks standards⁹⁸ which went into effect in school year (SY) 2014 to 2015, and only 3 interventions addressed healthier school celebrations and rewards. Additional research could explore the effects on dietary intake of Smart Snacks standards for competitive foods and for other foods offered during the school day.

FBM has been shown to influence children's preferences and dietary intake^{118,119} and is commonly found in schools.¹²⁰ The 1 study in this systematic review that addressed FBM found a decrease in the number of instances that FBM did not align with nutrition standards, and that removing or replacing noncompliant marketing was not resource intensive¹⁰⁸; however, schools may need technical assistance to identify marketing that does not align with federal nutrition standards. Schools can address FBM in a variety of ways, including leveraging wellness policies to limit or exclude certain FBM content and providing education to students and staff about how to identify deceitful marketing practices.^{121,122}

Consumption of SSBs has been linked to certain health outcomes (eg, weight gain, dental caries), and there is evidence that water substitution can reduce SSB intake.^{123–126} More than 1 in 5 children and adolescents do not drink any water during the day, and about half of school-age children are underhydrated.^{127,128} Our review suggests that increasing access to drinking water with promotion efforts improves water consumption. However, there was minimal evidence of students drinking water in place of other beverages (eg, soda, juice).

Limitations

The introduction and methods article and the start of this special issue outlines some limitations of our systematic review's overall methodology, including the potential for social desirability bias and detection bias inherent in studies that do not use blinding, and our inability to present standardized outcomes or measures of effect size.¹¹ Five additional limitations should be noted. First, there were a small number of interventions for certain topics resulting in insufficient evidence. Second, across all topics in the review, most of the studies had a quasi-experimental design. However, for interventions where randomization is not feasible (eg, examining impact of federal nutrition policy changes), high-quality quasi-experimental designs increase validity of intervention results. Third, more than half of the studies examining nutrition standards for school meals had moderate to high risk of bias. Fourth, very few studies included in this systematic review were done in high schools. Given high school students have lower overall diet quality and are more independent in their food choices relative to other school age groups,¹²⁹ it is important to understand more about interventions that can support healthy eating among these students. Fifth, inclusion of multiple outcome measures and different approaches to measuring outcomes in the included studies presented challenges in synthesizing results across interventions.

IMPLICATIONS FOR SCHOOL HEALTH

The evidence presented in this systematic review identified interventions that demonstrated positive changes to SMPs and competitive foods since the passage of HHFKA in 2010. While improvements to the school nutrition environment and services can reach all students, they can be especially impactful for students who eat school meals, particularly those who qualify for free or reduced-price meals.

The CPSTF recommends Healthy School Meals for All (ie, free school meals for all students) to increase participation in school meals and reduce school absenteeism.¹³⁰ Providing school meals at no cost can also reduce stigma and bullying for students and protect household food and nutrition security because families can reallocate those funds and increase their purchasing power for other basic needs.¹³¹ While the benefits of expanding access to school meals have been documented, findings from this review suggest that more work needs to be done to support students in selecting and choosing healthier options at school. Strategies to improve the appeal of school meals include improving the palatability of school meals, exposing students to new foods through taste tests, and pre-slicing fruit so that it is easier to eat. Offering recess before lunch and ensuring adequate seat time may help students eat more of the school lunch and improve dietary intake. School districts can support school nutrition professionals in receiving ongoing professional development on these strategies.

Schools can address other parts of the school nutrition environment, including competitive foods, foods offered as rewards or during school celebrations, and FBM through local school wellness policies. USDA requirements for wellness policies state that foods and beverages sold during the school day must align with Smart Snacks standards, and that districts must establish nutrition standards for foods and beverages that are offered to students, including as rewards and during celebrations.⁸ A recent study of wellness policies suggests that these are areas for improvement as most district policies do not address nutrition standards for celebrations or food marketing, or have weak requirements only.¹³² School leaders, school nutrition professionals, teachers, and families can work together to ensure that wellness policies are put into place and that progress in meeting goals is regularly assessed and documented.

Access to drinking water is an important component of the school nutrition environment and school services that is often overlooked. Disparities in access to, and intake of, safe drinking water exist across the United States, disproportionately affecting some groups and geographic locations as a result of persistent disparities and recent historical events such as the COVID-19 pandemic (eg, school closures, drinking fountains turned off) and major weather events.^{133–135} Furthermore, research shows that negative perceptions about the safety of drinking water, including at school, are common among youth, particularly Black and Hispanic students and those from lower-income households.^{136,137} Schools can advance health equity and improve water consumption among students by promoting and providing water, for free, throughout the school day.

Conclusions

Several interventions including providing school nutrition professionals with ongoing PD, improving the palatability of school meals, offering taste tests of menu items, pre-slicing fruit, providing recess before lunch, and offering incentives or rewards for trying healthier options have resulted in an increase in selection and consumption of healthier items at school. Several strategies to create a nutrition environment that supports students in making healthy choices outside of SMPs were promising and merit more exploration including consistently implementing Smart Snacks for competitive foods, ensuring foods offered at classroom celebrations or for rewards support student health, and ensuring that students receive consistent messages about good nutrition while they are at school. Using multiple approaches to improve the school nutrition environment and services can provide students with multiple opportunities to learn about and adopt food and beverage choices that support health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Centers for Disease Control’s Comprehensive Framework for Addressing the School Nutrition Environment and Services

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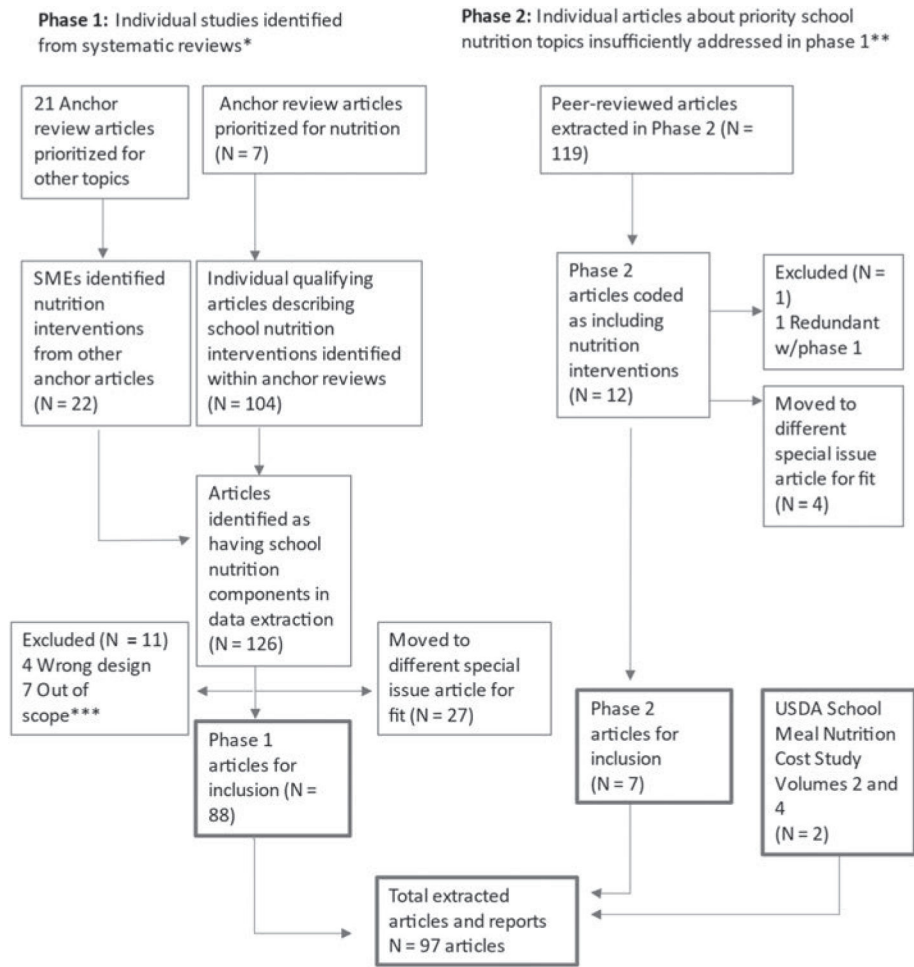


Figure 2. Identifying articles describing school-based interventions to the nutrition environment.

Abbreviations: SME, subject matter expert; USDA, United States Department of Agriculture.

*See introduction and methods article for full project flow chart.

** Topics prioritized for inclusion in Phase 2: Smart Snacks nutrition standards for foods sold in schools, nutrition standards for classroom celebrations, use of food as a reward, drinking water in schools, and food marketing.

***Out of scope: Wrong outcomes, process data only, single point in time cross-sectional, wrong date, or wrong topic.

Table 1.

Search Strategy Used to Identify Peer-reviewed Publications about the Nutrition Environment and Services

Topic	Medline Strategy [†]
Phase 1 : Nutrition Environment Run June 2018	Food services/ OR Food/ OR Beverages/ OR Food Dispensers, Automatic/ OR Diet/ OR (Food* OR beverage* OR nutrition OR diet*OR meal*OR lunch*OR breakfast*OR fruit*OR vegetable*OR snack*OR garden* OR cafeteria* OR (healthy ADJ2 eat*) OR (healthy ADJ2 choice*) OR drinking fountain* OR drinking water OR (access* ADJ3 water) OR water fountain* OR vending machine* OR food dispenser*).ti,ab. AND exp Schools/ OR (primary school* OR secondary school* OR high school* OR middle school* OR elementary school* ORK-12ORstudent*).ti,ab. AND Review.pt OR meta analys*.pt OR (Review OR meta analys* OR metaanalys* OR evidence*).ti 2010-current; English
Phase 2: Nutrition standards for competitive foods following implementation of US Department of Agriculture's Smart Snacks standards Run March 2020	(food* ADJ5 celebrat*) OR (food* ADJ5 party) OR (food* ADJ5 parties) OR (food* ADJ5 festival*) OR (food* ADJ5 reward*) OR (food* ADJ5 advertis*) OR (food ADJ5 promot*) OR (food* ADJ5 market*) OR competitive food* ORjunkfood* OR smart snack* OR snackfood* OR snacking OR vending machine* OR food vendor* OR food dispenser* OR (food* ADJ5 fundrais*) OR bake sale* OR food sale* OR ((beverage* OR soft drink* OR soda*) ADJ5 (sale* OR market* OR vending OR dispenser* OR promot* OR advertis*)) AND School* AND Journal article.pt Limit English; 2010-
Phase 2: Trainings and professional development for school food services staff Run March 2020	(School* AND (children OR adolescent* OR teenager*)) OR (primary school* OR secondary school* OR high school* OR middle school* OR elementary school* OR kindergarten*) AND (Food service* ADJ5 (staff OR worker* OR chef* OR employ* OR planner*)) OR (cafeteria* ADJ5 (staff OR worker* OR chef* OR employ* OR planner*)) OR (foodservice* ADJ5 (staff OR worker* OR chef* OR employ* OR planner*)) OR food worker* OR food manager* OR school nutritionist* OR school dietician* OR food handler* OR Food preparation OR menu plan* OR (health* ADJ5 meal*) OR nutrition program* OR (nutrition* ADJ2 standard*) OR (nutrition* ADJ2 guideline*) OR (school* ADJ2 lunch*) OR lunch program* OR (school* ADJ2 breakfast*) OR (school* ADJ2 meal*) OR portion size* OR feeding behavior* AND (career development or training or trained or professional development or ((employ* or staff* or worker* or professional or personnel) ADJ5 education)) Limit English; 2010-
Phase 2: Drinking water in schools Run March 2020	School* AND (drink* ADJ2 water) OR water fountain* OR drinking fountain* OR water availability OR (access* ADJ2 water) OR (bottle* ADJ2 water) OR (intake ADJ2 water) OR water jet* OR water station* OR water supply OR water intervention* AND journal article.pt. or review.pt. Limit English; 2016-

[†]This Medline search strategy was run first and yielded the largest number of independent citations. It was then modified for subsequent queries in PsycInfo (OVID), CINAHL (EBSCO), Scopus, ERIC (ProQuest), Education Database, and Sociological Abstracts.

Table 2.

Interventions to Improve Quality and Consumption of School Meals

Intervention [‡] N=101	Study Design N=97	No. Articles N=97	Study Participant Characteristics			Intervention Outcomes +: Supports Hypothesis [†] -: No Effect, -: does not support hypothesis			
			School Level	Location Type	Race/Ethnicity [§]	Knowledge, Attitudes, Perceptions ^{//}	Environmental Changes ^{//}	Selection ^d	Consumption ^{//}
Nutrition standards for school meals (N=19)	RCT/CCT (n=1) QED [¶] (n=16)	(N=16)	Elementary (n=8)	Urban (n=5) Rural (n=0)	Majority White (n=5)	Total: 0	Total: 5 + (n=4) = (n=5) -(n=2)	Total: 8 + (n=7) = (n=6) -(n=6)	Total: 14 + (n=9) = (n=8) -(n=10)
			Middle (n=0)	Suburban (n=1)	Majority Black (n=0)				
			High (n=0)	Not reported (n=9)	Majority Hispanic/Latino (n=3)				
			Multiple (n=9)	Nationally representative (n=2)	Majority racial and ethnic minority groups (n=5) Not reported (n=4)				
Taste tests (N=7)	RCT/CCT (n=2) QED(n=5)	(N=7)	Elementary (n=6)	Urban (n=1) Rural (n=1)	Majority White (n=3)	Total: 2 + (n=2) =(n=2) -(n=0)	Total :0	Total: 1 + (n=1) =(n=1) -(n=0)	Total: 6 + (n=5) = (n=2) -(n=0)
			Middle (n=1)	Suburban (n=1) Not reported (n=4)	Majority (n=0)				
			High (n=0)	Multiple (n=0)	Majority Hispanic/Latino (n=1)				
			Not reported (n=0)	Multiple (n=0)	Majority racial and ethnic minority groups (n=3) Not reported (n=0)				
Incentives/rewards (N=14)	RCT/CCT (n=3) QED(n=11)	(N=15)	Elementary (n=8)	Urban (n=6) Rural (n=1)	Majority White (n=9)	Total: 0	Total :0	Total: 6 + (n=6) = (n=2) -(n=3)	Total: 9 + (n=9) = (n=2) -(n=0)
			Middle (n=0)	Suburban (n=3)	Majority Black (n=3)				
			High (n=0)	Not reported (n=4)	Majority Hispanic/Latino (n=0)				
			Multiple levels (n=5)	Not reported (n=1)	Majority racial and ethnic minority groups (n=1) Not reported (n=1)				
Improve palatability (N=9)	RCT/CCT (n=1) QED(n=8)	(n=10)	Elementary (n=2)	Urban (n=5) Rural (n=1)	Majority White(n=3)	Total: 2 + (n=2) =(n=2) -(n=0)	Total: 0	Total: 5 + (n=4) = (n=2) -(n=2)	Total: 9 + (n=5) =(n=2) -(n=2)
			Middle (n=1)	Suburban (n=1)	Majority Black (n=2)				
			High (n=2)	Not reported (n=2)	Majority Hispanic/Latino (n=2)				
			Multiple (n=4)	Not reported (n=0)	Majority racial and ethnic minority groups (n=1) Not reported (n=1)				
Pre-slice fruit (N=3)	RCT/CCT (n=1) QED (n=2)	(N=3)	Elementary (n=2)	Urban (n=2) Rural (n=0)	Majority White(n=1)	Total: 0	Total: 0	Total: 2 + (n=1) =(n=1) -(n=0)	Total: 2 + (n=2) =(n=0) -(n=0)
			Middle (n=0)	Suburban (n=0)	Majority Black (n=0)				
			High (n=0)	Not reported (n=1)	Majority Hispanic/Latino (n=0)				
			Multiple (n=0)	Not reported (n=1)	Majority racial and ethnic minority groups (n=1) Not reported (n=1)				
Recess before lunch (N=5)	RCT/CCT (n=0) QED(n=5)	(N=5)	Elementary (n=5)	Urban (n=1) Rural (n=1)	Majority White(n=1)	Total :0	Total: 0	Total: 0	Total: 4 + (n=4) = (n=2) -(n=1)
			Middle (n=0)	Suburban (n=0)	Majority Black (n=0)				
			High (n=0)	Not reported (n=2)	Majority Hispanic/Latino (n=0)				
			Multiple (n=0)	Multiple (n=1)	Majority racial and ethnic minority				

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Intervention [‡] N=101	Study Design N=97	No. Articles N=97	Study Participant Characteristics			Intervention Outcomes +: Supports Hypothesis [†] =: No Effect, -: does not support hypothesis				
			School Level	Location Type	Race/Ethnicity [§]	Knowledge, Attitudes, Perceptions ^{//}	Environmental Changes ^{//}	Selection ^d	Consumption ^{//}	
Behavioral design (N=25)	RCT/CCT (n=5) QED(n=18)	(N=22)	reported (n=0)	Elementary (n=10) Middle (n=1) High (n=2) Multiple (n=1) Not reported (n=1)	Urban (n=8) Rural (n=3) Suburban (n=5) Multiple (n=1) Not reported (n=6)	groups (n=2) Not reported (n=2) Majority White(n=6) Majority Black (n=2) Majority Hispanic/Latino (n=3) Majority racial and ethnic minority groups (n=5) Not reported (n=4) Race/ethnicity varies (n=3)	Total: 1 + (n=1) =(n=0) -(n=0)	Total: 2 + (n=3) =(n=2) -(n=2)	Total: 16 + (n=15) =(n=6) -(n=1)	Total: 22 + (n=15) = (n=12) -(n=4)
Increasing choices (N=5)	RCT/CCT (n=0) QED(n=5)	(N=5)	Elementary (n=3) Middle (n=0) High (n=0) Multiple (n=2) Not reported (n=0)	Urban (n=4) Rural (n=0) Suburban (n=0) Multiple (n=0) Not reported (n=1)	Majority White (n=0) Majority Black (n=2) Majority Hispanic/Latino (n=1) Majority racial and ethnic minority groups (n=1) Not reported (n=1)	Total: 0	Total: 0	Total: 1 + (n=1) =(n=0) -(n=0)	Total: 5 + (n=2) =(n=3) -(n=2)	
Lunch duration (N=2)	RCT/CCT (n=0) QED (n=2)	(N=2)	Elementary (n=1) Middle (n=0) High (n=0) Multiple (n=1) Not reported (n=0)	Urban (n=2) Rural (n=0) Suburban (n=0) Multiple (n=0) Not reported (n=0)	Majority White (n=0) Majority Black (n=0) Majority Hispanic/Latino (n=0) Majority racial and ethnic minority groups (n=2) Not reported (n=0)	Total: 0	Total: 0	Total: 1 + (n=1) =(n=1) -(n=0)	Total: 2 + (n=1) =(n=1) -(n=0)	
Professional development for school nutrition staff (N=12)	RCT/CCT (n=4) QED(n=8)	(N=12)	Elementary (n=1) Middle (n=1) High (n=0) Multiple (n=9) Not reported (n=1)	Urban (n=4) Rural (n=2) Suburban (n=3) Not reported (n=3)	Majority White(n=3) Majority Black (n=0) Majority Hispanic/Latino (n=3) Majority racial and ethnic minority groups (n=2) Not reported (n=3) Race/ethnicity varied (n=1)	Total: 3 + (n=2) =(n=3) -(n=0)	Total: 4 + (n=4) =(n=3) -(n=2)	Total: 7 + (n=7) =(n=3) -(n=0)	Total: 3 + (n=0) = (n=6) -(n=0)	

Abbreviations: QED, quasi-experimental design; RCT/CCT, randomized control trial or controlled clinical trial.

[†] Examples of outcomes that support the hypothesis and would be coded (+): increased nutrition knowledge; increased availability of healthier options (eg, whole grains); increased consumption of fruits, vegetables, whole grains; increased intake of fiber; decreased intake of sodium, added sugars, saturated fat, and SSBs (eg, soda); decreased plate waste; decreased availability of less nutritious foods (eg, candy).

[‡] Interventions refers to the set of practices/policies/approaches tested within a study. If a research study included multiple intervention arms, each arm counted separately towards a given outcome in this table. Intervention categories are not mutually exclusive; that is, studies could count towards more than one category.

[§] Majority defined as >50% of the student population.

^{//} Totals for measured outcomes may exceed the number of interventions evaluating a given outcome because a single intervention may be counted more than once if it reports mixed findings; for example, an intervention that reported increased consumption of fruits but not vegetables would

count as both a (+) and (=) for dietary intake. Similarly, the number of interventions may exceed the number of articles since a study may have more than one intervention arm.

QED includes 2-group cohort, including regression discontinuity; 1-group cohort; interrupted time series; and repeat cross-sectional.

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Table 3.

Interventions to Improve the School Nutrition Environment

Intervention [‡] N = 20	Study Design N= 19	No. Articles N = 19	Study Participant Characteristics			Intervention Outcomes +: Supports Hypothesis, † -: No Effect, -: Does Not Support Hypothesis		
			School Level	Location Type	Race/ Ethnicity [§]	Knowledge, Attitudes, Perceptions ^{//}	Environmental Changes ^{//}	Dietary Outcomes ^{//}
Implement nutrition standards for competitive foods (N=12)	RCT/CCT (n=2) QED [¶] (n=9)	(N =11)	Elementary (n=0) Middle (n=5) High (n=2) Multiple (n=4) Not reported (n=0)	Urban (n=3) Rural (n=2) Suburban (n=1) Multiple (n= 1) Not reported (n=4)	Majority White (n=5) Majority Black (n=0) Majority Hispanic/Latino (n=3) Majority racial and ethnic minority groups (n=2) Not reported (n=1)	Total: 0	Total: 4 + (n=4) = (n=1) - (n=1)	Total: 7 + (n=5) = (n=4) -(n=2)
Use classroom celebrations and rewards that support student health (N=3)	RCT/CCT (n=1) QED (n=2)	(N=3)	Elementary (n=1) Middle (n=0) High (n=0) Multiple (n=2) Not reported (n=0)	Urban (n=1) Rural (n=0) Suburban (n=0) Not applicable(n=0) Not reported (n=2)	Majority White (n=0) Majority Black (n=0) Majority Hispanic/Latino (n=2) Majority racial and ethnic minority groups (n=0) Not reported (n=1)	Total: 1 + (n= 1) =(n=1) - (n=0)	Total: 2 + (n= 1) =(n= 1) - (n=0)	Total: 1 + (n=1) =(n= 1) -(n=0)
Assess food and beverage marketing (N=1)	RCT/CCT (n=0) QED(n=1)	(N=1)	Elementary (n=0) Middle (n=0) High (n=0) Multiple (n= 1) Not reported (n=0)	Urban (n=1) Rural (n=0) Suburban (n=0) Not reported (n=0)	Majority White(n=1) Majority Black (n=0) Majority Hispanic/Latino (n=0) Majority racial and ethnic minority groups (n=0) Not reported (n=0)	Total: 0	Total: 1 + (n=1) =(n=0) -(n=0)	Total: 0
Increase access to drinking water (N=4)	RCT/CCT (n=1) QED (n=3)	(N=4)	Elementary (n=0) Middle (n=2) High (n=0) Multiple (n=2) Not	Urban (n=3) Rural (n=0) Suburban (n=0) Not reported (n=1)	Majority White (n=0) Majority Black (n=0) Majority Hispanic/Latino (n=1)	Total: 1 + (n=0) =(n=1) -(n=0)	Total: 0	Total: 4 + (n=3) =(n=2) -(n=1)

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Intervention [‡] N = 20	Study Design N= 19	No. Articles N = 19	Study Participant Characteristics			Intervention Outcomes +: Supports Hypothesis, [†] -: No Effect, -: Does Not Support Hypothesis		
			School Level	Location Type	Race/Ethnicity [§]	Knowledge, Attitudes, Perceptions ^{//}	Environmental Changes ^{//}	Dietary Outcomes ^{//}
			reported (n=0)		Majority racial and ethnic minority groups (n=3) Not reported (n=0)			

Abbreviations: QED, quasi-experimental design; RCT/CCT, randomized control trial or controlled clinical trial.

[†]Examples of outcomes that support the hypothesis and would be coded (+): increased nutrition knowledge; increased availability of healthier options (eg, whole grains); increased consumption of fruits, vegetables, whole grains; increased intake of fiber; decreased intake of sodium, added sugars, saturated fat, and SSBs (eg, soda); decreased plate waste; decreased availability of less nutritious foods (eg, candy).

[‡]Interventions refers to the set of practices/policies/approaches tested within a study. If a research study included multiple intervention arms, each arm counted separately towards a given outcome in this table. intervention categories are not mutually exclusive; that is, studies could count towards more than one category.

[§]Majority defined as >50% of the student population.

^{//}Totals for measured outcomes may exceed the number of interventions evaluating a given outcome because a single intervention may be counted more than once if it reports mixed findings; for example, an intervention that reported increased consumption of fruits but not vegetables would count as both a (+) and (=) for dietary intake. Similarly, the number of interventions may exceed the number of articles since a study may have more than one intervention arm.

[¶]QED includes 2-group cohort, including regression discontinuity; 1-group cohort; interrupted time series; and repeat cross-sectional.