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Systematic Review

Umbrella Review of School-Based Nutrition Policy, Systems, and Environmental Strategies to Improve Nutrition and Reduce the Risk of Obesity Among School-Aged Children in the United States

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Abstract

Background/Objectives: School-based nutrition policy, systems, and environmental (PSE) strategies have the potential to improve children's nutrition and reduce the risk of obesity. This umbrella review synthesized evidence from systematic reviews examining school-based PSE strategies and their associations with nutrition- and weight-related outcomes among school-aged children in the United States. **Methods**: PubMed was searched for systematic reviews and meta-analyses (2010–2026). Screening and extraction were conducted in duplicate. Methodological quality was assessed using an adapted AMSTAR 2. The review was registered (PROSPERO-2026 CRD420261387630). **Results**: Eighteen systematic reviews were included. PSE strategies examined included: breakfast after the bell (BATB), school nutrition policies, local food initiatives, cafeteria environment changes, and universal free school meals (UFSM). Consistent evidence supported positive associations with meal participation for BATB, food environment policies, and UFSM. Evidence also suggested improvements in school meal consumption and/or diet quality with BATB, food environment policies, local food initiatives, and some cafeteria environment changes. Few studies examined food security or weight-related outcomes. Research among subpopulations was generally limited, with the strongest evidence for BATB and food environment policies improving meal participation and nutrition outcomes among students from lower-income households. Four out of the eighteen reviews were of high or moderate quality based on the adapted AMSTAR rating. **Conclusions**: Multiple school-based nutrition PSE strategies were associated with positive associations regarding school meal participation and consumption, but more research is needed to examine food security or weight-based outcomes. Future research should prioritize strong study designs and objective measures, as well as evaluate impacts on subpopulations at greatest risk for adverse health outcomes. Finally,

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multicomponent PSE strategies with sufficient dose and duration should be implemented to maximize effectiveness.

Keywords: school meals; universal free school meals; breakfast after the bell; farm to school; school gardens; choice architecture; competitive foods; food insecurity; obesity

1. Introduction

Childhood obesity continues to be a major public health issue in the United States (U.S.), with approximately 1 in 5 children diagnosed with obesity [1]. This can have both short- and long-term implications, as excess weight in childhood is associated with increased risk of type 2 diabetes [2], cardiovascular disease [3], and certain types of cancer [4], as well as poorer mental health [5] and cognitive functioning [6]. Importantly, obesity during childhood tends to persist into adulthood; research suggests that children who experience obesity are five times more likely to have obesity as adults [7]. Therefore, interventions that focus on addressing unhealthy weight gain during childhood are critical.

While the determinants of childhood obesity are complex and multifactorial, substantial evidence indicates that children's nutrition (including access to healthier foods, food security, and diet quality) plays a key role in the prevention of obesity [8,9]. Further, nutrition is recognized as one of the most important modifiable determinants of chronic diseases [9]. Importantly, there is strong evidence that dietary patterns acquired during childhood are likely to persist into adulthood [10]. Therefore, opportunities to promote healthy eating among children may help to reduce the risk of obesity and related adverse health outcomes in childhood as well as later in life.

Policy, systems, and environmental change (PSE) strategies to improve children's nutrition emphasize sustainable population-level changes to support healthier eating environments [11]. Because U.S. children spend a substantial amount of time in K-12 school settings (i.e., 6 to 7 h per weekday), PSE strategies focused on supporting healthy eating and reducing the risk of excess weight gain can be particularly impactful [12]. However, prior to broadscale implementation of PSE strategies, it is essential to evaluate the evidence to determine which strategies are most effective at promoting healthy dietary behaviors and preventing obesity among children, as well as to identify gaps for future research. Therefore, the purpose of this umbrella review was to synthesize the findings from systematic reviews and meta-analyses examining school-based PSE strategies in the U.S. designed to improve diet-related student outcomes, including school meal participation and consumption, food security and healthier food access, diet quality, and childhood weight status.

2. Materials and Methods

A PubMed search for systematic reviews and meta-analyses published from 2010 (post-implementation of the Healthy Hunger-Free Kids Act) through February 2026 was conducted. A combination of relevant indexing terms (MeSH terms) and text words was used to identify reviews examining PSE strategies to improve child nutrition. Specifically, this study focused on food access (e.g., participation in school meals and the availability of healthier foods in schools), dietary intakes (e.g., school meal consumption and diet quality), food security, and the prevention of childhood obesity among school-aged children.

To be included in this umbrella review, the papers had to be peer-reviewed reviews or meta-analyses that involved school-aged children (grades K-12) in the U.S. The papers also had to be published in English. Reviews covering a broader age range or other countries were included if results specific to school-aged children in the U.S. could be extracted and

were independently summarized. Reviews were excluded if they were not published in English, conducted exclusively outside of the U.S., focused only on populations outside of school-aged children (e.g., college, pre-K and younger, or adults), did not focus on PSE strategies (e.g., clinical interventions or nutrition education alone), were conducted outside of the school year (e.g., summer feeding programs), or presented data that was combined with other countries or age groups so that the relevant results could not be easily extracted. This umbrella review was registered with the International Prospective Register of Systematic Reviews (PROSPERO 2026 CRD420261387630). There were no major deviations from the registered protocol.

Two reviewers used Covidence to independently screen titles, abstracts, and full texts for eligibility. Specifically, reviews were examined to first determine if they examined school-aged children (grades K-12) in the U.S. Then, the review was examined to confirm that at least one included PSE strategy was examined within the review. Lastly, if the review included multiple countries, both the manuscript and all included tables were examined to determine if U.S.-based data could be extracted (e.g., results that discussed specifically U.S.-based findings or a table that separated results by country). This enabled all content relevant to each PSE strategy within the U.S. context to be analyzed. Discrepancies were discussed by the entire research team until consensus was reached. Data were then extracted from each publication initially by a single reviewer, followed by a second reviewer to affirm findings or identify errors for further review. The data extracted included the citation information, PSE exposures, and child-related outcomes of interest. The outcomes included both primary and subpopulation findings where available.

Study quality was assessed using an adapted AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) [13]. This 16-item instrument evaluates seven critical and nine non-critical domains that may impact the validity of a systematic review or meta-analysis. The seven critical domains were (1) establishing methodology prior to conducting the review; (2) using a comprehensive search strategy; (3) listing and justifying excluded studies; (4) using appropriate techniques for assessing risk of bias for the included publications; (5) combining results of meta-analyses with appropriate methodology; (6) accounting for risk of bias when interpreting and/or discussing results; and (7) investigating publication bias when quantitative synthesis is performed. In this umbrella review, the research team adapted part of these critical domains and made a priori modifications to better align with the research context. Specifically, two items were elevated to critical domains, including (1) providing detailed information on Population, Intervention, Comparison, and Outcome (PICO) in the research questions and inclusion criteria, and (2) reporting conflicts of interest. Explicitly incorporating PICO components was essential for developing structured search strategies, while transparently reporting conflicts of interest was important for minimizing potential institutional bias. Conversely, two items were downgraded to non-critical domains, including (1) listing and justifying the excluded studies and (2) investigating publication bias when quantitative synthesis is performed. Although the existing literature commonly includes PRISMA flow diagrams reporting the numbers and reasons for excluded studies, study-by-study lists of full-text exclusions are rarely presented in published reviews within public health nutrition reviews. In addition, assessments of publication bias rely heavily on statistical and graphical methods, and the lack of quantitative syntheses or meta-analyses limited the feasibility of conducting such assessments. For these reasons, treating these two items as critical domains was considered methodologically inappropriate for this review of PSE strategies related to students' nutrition and weight-related outcomes, which included evidence primarily from narrative synthesis. These modifications were made prior to the appraisal process.

The overall quality rating for each review article was determined as: critically low—more than one critical weakness (with or without non-critical weaknesses); low—one critical weakness (with or without non-critical weaknesses); moderate—more than one non-critical weakness; and high—no or only one non-critical weakness, in line with the original AMSTAR 2 rating system. Reliability tests were conducted to compare the rating accuracy among peer reviewers [13]. See Supplemental Table S1 for the quality assessments of the included reviews.

References for individual papers included in each identified systematic review were also extracted to identify overlap in systematic review coverage. Using standard methodology for umbrella reviews [14], the research team summarized the overlap and provided this information in a narrative description by PSE strategy (Supplemental Table S2a–e).

This review was part of a larger effort by Healthy Eating Research (HER) to develop a national research agenda for PSE interventions to promote food security, diet quality, and healthy weights among U.S. children, adolescents, and families. In addition to the present review, three additional reviews examined the evidence and research gaps across: (1) Early Childhood; (2) Family and Community Nutrition Supports; and (3) Shaping the Food Environment. Collectively, these four reviews covered distinct interventions to provide comprehensive coverage of the research landscape while minimizing overlap. All reviews followed an agreed-upon search and extraction methodology developed by HER staff, the writing team of the four reviews, and other advisors to ensure consistency across reviews.

3. Results

3.1. Study Selection

The literature search yielded 883 publications from PubMed. A total of 276 duplicates were removed by Covidence. Title and abstract screening excluded 465 publications, resulting in 142 full-text articles assessed for eligibility. Among these, 124 publications were excluded for the following reasons: inability to disaggregate other countries or populations from the included study population ($n = 37$); did not use an included study design (e.g., not a systematic review or meta-analysis) ($n = 16$); did not examine PSE strategies ($n = 41$); were not written in English ($n = 5$); did not examine an included outcome of interest ($n = 2$); were not conducted in schools during the school year (e.g., summer feeding programs) ($n = 2$); was not conducted in the U.S. ($n = 1$); was not peer-reviewed ($n = 1$); and was not conducted among school-aged children ($n = 1$). There were no meta-analyses that met the inclusion criteria (while some of the included reviews included meta-analyses, the results specific to the inclusion criteria for the present umbrella review could not be extracted). A total of 18 systematic reviews with U.S. based literature were included in the final synthesis (Figure 1).

3.2. Study Characteristics

This umbrella review included 18 systematic reviews published between 2014 and 2026 [15–32]. Multiple PSE strategies were identified in the review: (1) school meal programs, including the National School Lunch Program, School Breakfast Program, and afterschool programs; (2) Farm to School activities, including school gardens and local food procurement; (3) school nutrition policies, including local nutrition policies (e.g., local school wellness policies), nutrition standards, and policies concerning competitive foods (i.e., snacks and beverages sold in schools in vending machines, à la carte, school stores, etc.); and (4) cafeteria environment changes (e.g., choice architecture interventions). The definitions of each PSE strategy are included in Table 1.

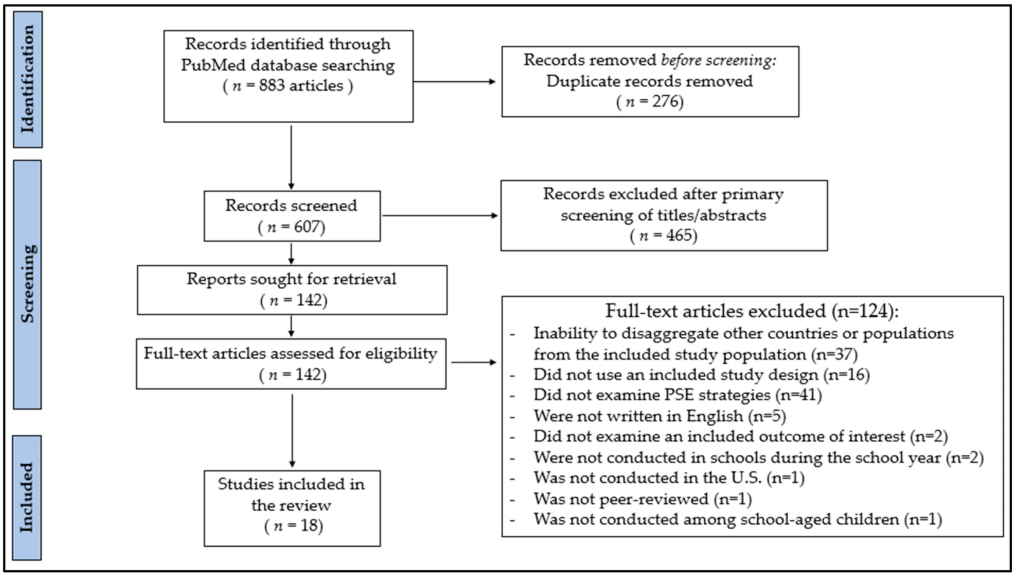


Figure 1. Flowchart for Umbrella Review.

Table 1. Definition of Policy, Systems, and Environmental change (PSE) Strategies in Schools Implemented in the Reviews Included Within the Umbrella Review.

PSE Categories	Strategies Included	Definitions
Breakfast After the Bell	Breakfast in the Classroom Second Chance Breakfast Grab and Go Breakfast	Breakfast offered to students after the beginning of the school day, which can include one or more of these options: breakfast in the classroom (i.e., breakfast delivered and served to students in the classroom); second chance breakfast (i.e., a breakfast period integrated into the school day, typically after the first or second period); and grab and go breakfast (i.e., a portable breakfast often served on mobile carts that students can eat on their way to class or in the classroom).
Local Food Initiatives	Farm to School	Initiatives that include procurement and promotion of locally grown foods in the cafeteria and/or experiential food and agriculture education activities.
	School Gardens	Hands-on gardening programs accessible to students that typically include experiential learning opportunities focused on nutrition or garden education.
School Nutrition Policies	School Meal Standards	Federal nutrition standards for the NSLP and SBP (i.e., the HHFKA created strong guidelines for: (1) what schools must serve, including whole grains, fruits, a variety of vegetables, a meat/meat alternative, and milk, with limits on sodium and saturated fats; and (2) what students must take for it to be a reimbursable meal, including at least one fruit or vegetable, in addition to two other meal components).
	Competitive Food Policies (including Smart Snacks)	Nutrition standards for snacks and beverages sold during the school day outside of the school breakfast and lunch programs, including in vending machines, snack bars, and à la carte lines (e.g., currently there are federal standards for competitive foods called "Smart Snacks" that were implemented as part of the HHFKA, and prior to this, competitive food policies were implemented at the local or state level).
	Local nutrition policies	Nutrition policies regarding the foods available in the cafeteria that go above and beyond federal guidelines. These are implemented at the school or district level through local school wellness policies [1] or other initiatives.

Table 1. *Cont.*

PSE Categories	Strategies Included	Definitions
Cafeteria Environment Changes	Choice Architecture Strategies	Strategies that "nudge" students towards healthier options through changes to the cafeteria layout, such as through the order of foods on the lunch line (e.g., placing fruits or vegetables at the front of the line) or the visibility of foods (e.g., placing white milk in front of chocolate milk).
	Longer Lunch Periods	Policies that require minimum lunch period lengths and/or seated time in the cafeteria.
	Recess Before Lunch	Scheduling recess prior to lunch instead of after lunch.
	School Meal Strategies	Changes to the foods offered and/or opportunities to try new foods, including taste tests, pre-slicing fruits, offering a greater number of menu choices, or serving more culturally appropriate foods for diverse student populations.
Universal Free School Meals (UFSM)	School or District-Level Free Meal Policies	Policies that provide free meals to all students within a school or school district, implemented in higher poverty schools/districts through provisions including CEP or Provisions 1, 2, or 3.
	Federal or State-Level Free Meal Policies	Policies that provide free meals to all students nationally or within an entire state within schools participating in the NSLP.

CEP = Community Eligibility Provision. HHFKA = Healthy, Hunger-Free Kids Act of 2010. NSLP = National School Lunch Program. SBP = School Breakfast Program. [1] Local school wellness policies are required for all school districts participating in the federal school meal program and must address nutrition education; standards for foods sold and served during and outside of the school day; limits to food marketing on campus; and access to physical activity and physical education.

3.2.1. Breakfast After the Bell

Three reviews examined BATB initiatives, including breakfast in the classroom, grab-and-go breakfast, and second chance breakfast (Table 2) [15,22,27]. Two reviews evaluated school breakfast participation [15,22], one assessed weight-related outcomes [15], and two examined school meal consumption/dietary quality [15,27]. None of the reviews examined food security. When examining the number of overlapping publications across the reviews, all 13 of the publications included in the Hecht et al. review examining BATB [15] were also included in the Olarte et al. review [15], and among the two BATB publications examined in the Palmer et al. review [27], one was also included in the Olarte et al. review and the other citations were not included in the other reviews (Supplemental Table S2a).

The two reviews examining breakfast participation consistently found that BATB increased participation (the comparator group varied across the studies, with some studies having control schools with traditional breakfast in the cafeteria, others with pre/post-only design within the included schools, etc.) [15,22]. Evidence examining school meal consumption and/or diet quality was limited to breakfast in the classroom among elementary school students [15,27]. Findings suggested reductions in overall food waste following implementation of breakfast in the classroom, although changes in individual meal components were inconsistent [26]. Other studies reported improvements in several measures of dietary quality, while some found increased caloric intake [14]. However, some studies found increased caloric intake [15]. Findings for weight-related outcomes were mixed [15]; of the four studies examining BMI or weight status, two found increases in BMI or weight-related outcomes following BATB implementation, while two found no evidence of increased weight [15].

When examining subpopulations, the review by Olarte et al. found similar increases in breakfast participation across elementary, middle, and high school students and across urban, suburban, and rural settings following implementation of BATB [15]. When exam-

ining differences in participation by socioeconomic status, benefits were observed among students both eligible and ineligible for free or reduced-price meals (FRPM), although increases were often greatest among students from lower-income households who were FRPM-eligible [15]. The review by Hecht et al. found similar increases in breakfast participation across studies that included populations diverse in age and geography [22]. One study included in Hecht et al. found that the positive effect of grab-and-go breakfast on participation did not vary by students' racial or ethnic background or FRPM eligibility. Few studies examined subgroup differences for weight-related outcomes [15]; Olarte et al. summarized findings from a single study that reported an increased risk of overweight following breakfast in the classroom specifically among female elementary students, with point estimates higher for weight-related outcomes among elementary students from racial and ethnic minority and low-income backgrounds [33].

3.2.2. School Nutrition Policies

Nine reviews examined school nutrition policies (Table 2), including two that only examined competitive food policies [19,25]; one that examined both competitive food policies and additional local nutrition policies [28]; one that examined only federal school meal standards [32]; one that examined both federal school meal standards and local nutrition policies [17]; and four that examined all school nutrition policies (i.e., competitive food policies, local nutrition policies, and federal school meal standards) [16,22,24,30]. None of the reviews exclusively examined local nutrition policies (i.e., those that went beyond federal regulations). One review assessed participation [22], seven reviews assessed school meal consumption/dietary quality [16,17,19,24,25,28,30], and three reviews assessed weight outcomes [19,25,32]. None of the reviews examined food security. When examining the overlap in publications across the included reviews, less than a fifth of publications were in two or more reviews (Supplemental Table S2b).

Overall, the evidence suggested that school nutrition policies were associated with positive health impacts for students. One review examined participation and found that competitive food policies and local nutrition policies were associated with increased participation in school meals [22]. This same review found only a limited number of studies examining stronger nutrition standards and participation, with three studies finding no association and one study finding a positive association with school meal participation [22]. Two reviews also found that school nutrition policies that set strong standards for school meals and competitive foods were associated with healthier school food environments [19,24]. Seven reviews specifically examined the relationship between stronger nutrition policies and school meal consumption and found improvements in school meal consumption [16,17,19,24,25,28,30]. Of the seven reviews that examined student consumption/diet quality (including the selection, and/or consumption of healthier foods), one found increases in fruit and vegetable purchases [17], three found increases in fruit and vegetable consumption [16,17,30], and four found reduced calorie and sugar-sweetened beverage intake [19,25,28,30], with only one study finding mixed or no association for changes in student food selection [24].

Three reviews examined the relationship between school nutrition policies and weight-related outcomes, including two reviews that examined competitive food policies [19,25] and one examining federal school meal standards [32], and the overall results were mixed. Chriqui et al. identified two longitudinal studies that reported improved trends after competitive food policy implementation, including one that reported no significant association between policy implementation and student weight, and one that reported higher weight outcomes after implementing stronger nutrition policies [19]. Similarly, Sildén et al. concluded that the evidence linking competitive food policies to weight outcomes was incon-

clusive, as most studies found no direct association [25]. The review that reported that the associations between restricting competitive foods and student weight were in the expected direction also noted that the studies were limited due to relying on correlational findings and/or self-reported data [25]. Ferris et al. examined school nutrition policy related to federal school meals standards as part of the Healthy Hunger Free Kids Act (HHFKA) and identified eight studies showing beneficial effects on healthy weight outcomes, nine with mixed findings across subgroups of participants (based on participant sex, income, rurality, age, and implementation characteristics), and one study reporting no association [32].

When examining differences among subpopulations, the reviews found that the effect of school nutrition policies appeared to be consistent across grade levels overall. Four reviews examined differences in the effects of school nutrition policies by socioeconomic status, including one review examining federal school meal standards [32], one examining federal school meal standards and local nutrition policies [17], and three examining all nutrition policy exposures (i.e., competitive foods, local nutrition policies, and federal nutrition policies) [22,24]. In one review that examined all three nutrition policy exposures, students from lower-income households exhibited a greater increase in school meal participation after implementing stronger nutrition policies [22]. The three other reviews (including one examining just federal school meal standards, one examining federal school meal standards/local nutrition policies, and one examining all nutrition policy exposure) similarly found greater improvements in dietary quality among students from lower-income households when compared to students in higher-income households [17,24,32]. Differences by race/ethnicity were also reported across four reviews: racial/ethnic minority students experienced greater increases in school meal participation with all three nutrition policies [21], greater improvements in dietary quality with all three nutrition policies as well as specifically with stronger competitive food policies [23,24], and greater improvements in weight-related outcomes with stronger federal school meal standards [31]. Few studies examined differences by urbanicity, and no differences were observed.

3.2.3. Local Food Initiatives

Five reviews examined local food initiatives, including Farm to School and school gardening activities (Table 2) [18,20–22,26]. Among these, two examined the association between Farm to School programs and weight, diet quality, and program participation [22,26], two reviews examined school gardening in association with diet quality and nutrition-related outcomes [18,20], and one review examined both Farm to School and school garden-related activities in association with weight, diet quality, and program participation [21]. There was only minimal overlap in publications across the included reviews, with less than a fifth of the publications in two or more reviews (Supplemental Table S2c).

Two reviews examined school meal participation and found that Farm to School and school garden-related activities may have a positive impact on school meal participation, but the evidence was limited and heterogenous [21,22]. Conversely, the reviews found that Farm to School and school gardens had a positive impact on fruit and vegetable selection and consumption. All four reviews that examined diet outcomes, operationalized as selection and consumption of combined fruit and vegetable or only vegetables [18,20,21,26], found positive associations. Specifically, 12 studies included in the reviews found a positive association in fruit and vegetable selection/variety and consumption and additionally, 12 studies found positive associations with just vegetables. The results examining selection and consumption of just fruit were mixed; across two reviews, six studies found positive associations in selection and consumption and six studies found no change, an inverse association, or inconsistent results [21,26]. Broader diet quality was examined in a limited number of studies within two of the reviews [21,26]; in one review [26], one study found a

positive impact on diet quality [34], while in another review, two studies found no change in diet quality [21]. Lastly, the Coakley et al. review examined the intake of "healthy" foods (e.g., fish), and three studies found farm-to-school programs were associated with increased consumption [26].

Two reviews examined weight outcomes, including BMI and obesity, and results were limited [21,26]. The review by Coakley et al. included one study that found greater perceived student weight loss with a Farm to School program based on parent perceptions [26]. A review by Prescott et al. found that in four studies, local food initiatives (including both Farm to School and school gardens) were not associated with BMI or BMI z-scores in the intervention groups compared to the usual practice/no intervention control groups [21]. However, one study within the review did find a beneficial impact on the prevalence of overweight assessed using BMI z-scores [35].

When examining subpopulations, no differences were found when examining the differential effects of Farm to School or school gardening activities on student meal consumption, diet quality, or weight-related outcomes based on the student's race and ethnicity.

3.2.4. Cafeteria Environment Changes

Six reviews examined changes to the cafeteria environment, such as using choice architecture strategies, providing greater menu choices, pre-slicing fruits, and scheduling recess before lunch (Table 2) [16,22,24,27,28,31]. Five of the reviews assessed school meal consumption/diet quality [16,24,27,28,31] and one evaluated program participation [22]. None of the included reviews examined food security or weight outcomes. There was moderate overlap in the publications included in the reviews, with about a third of citations included in two or more of the reviews (Supplemental Table S2d).

One review examined cafeteria environment changes and associations with school meal program participation [22]. The review included school meal strategies (e.g., taste tests) and cafeteria-level strategies (i.e., implementing choice architecture techniques and longer lunch periods). While the result suggested these strategies improved school meal participation, the review concluded that there was limited evidence overall due to the small number of studies examining each strategy and few studies with a low risk of bias.

Five reviews examined the effect of cafeteria environment changes on school meal consumption and diet quality [16,24,27,28,31]. Overall, several cafeteria environment changes led to improvements in the selection and consumption of healthier foods. Specifically, there was evidence that the following strategies were beneficial: increasing food options, improving meal palatability and cultural appropriateness, providing pre-sliced fruits, increasing the duration of lunch, and having recess before lunch. However, there was mixed evidence on the effectiveness of choice architecture strategies.

When examining subpopulations, overall similar effects were typically observed across grade levels, although evidence was strongest in elementary school settings. Limited evidence was available on disparities by income, urbanicity, and race/ethnicity.

3.2.5. Universal Free School Meals

Two systematic reviews examined universal free school meals (Table 2), with the majority of studies evaluating the Community Eligibility Provision (CEP) [23,29]. Both reviews examined school meal participation and weight outcomes. One review examined school meal consumption/diet quality as well as food security [23]. There was minimal overlap between the two reviews, with only one publication examining school meal participation included in both reviews (Supplemental Table S2e).

Both reviews examined school meal participation in relation to UFSM policies and found consistent evidence for increased school meal participation following implementation

of UFSM policies. Specifically, among the 15 U.S.-based studies identified in the Cohen et al. review, 14 found a positive association between UFSM policies and free breakfast and/or lunch participation [23]. Three of the six studies reviewed by Spill et al. examined school meal participation in relation to school-level CEP participation, and all observed increases in meal participation [29].

Only the Cohen et al. review examined diet-related outcomes in relation to UFSM policies [23]. Specifically, three studies and one government report examined diet quality in relation to free breakfast, one study examined diet quality within CEP schools, and two studies examined CEP in relation to food insecurity. Overall, these studies found no change in breakfast-skipping behaviors and an improvement in diet quality among students in schools with free breakfast. Additionally, diet quality among students attending CEP schools was within recommended limits, and school-level CEP participation was associated with improvements in food security.

Both reviews examined weight outcomes in relation to UFSM, but only a limited number of studies were identified in the reviews. One study found a reduction in obesity prevalence among students in CEP-participating schools, and two found no association between UFSM and adverse obesity-related outcomes. Overall, the reviews concluded that UFSM policies do not have adverse impacts on obesity-related outcomes, and the limited evidence to date suggests that UFSM policies may be protective against increases in obesity.

When examining subpopulations, both reviews examined differences by poverty levels and overall found greater increases in participation among students not previously eligible for FRPM. The Spill et al. review noted the race and ethnicity of the student populations for each study in a table but did not summarize findings by race or ethnicity. One study identified in the Cohen et al. review modeled weight-related outcomes by income level and predicted a decline in obesity prevalence among higher-income students [36].

3.2.6. Methodological Quality Assessment of Included Reviews

Among the 18 included articles, one was rated as high quality [28], three as moderate quality [18,26,29], seven as low quality [16,21,23,24,27,31,32], and seven as critically low quality [15,17,19,20,22,25,30] (Supplemental Table S1). Common critical methodological flaws that contributed to low quality ratings included failure to: establish the review methodology a priori ($n = 8$); use appropriate methods to assess risk of bias in the included studies ($n = 6$); account for risk of bias when interpreting and/or discussing the findings ($n = 6$); and provide sufficient PICO information in the research questions and inclusion criteria ($n = 5$). In addition, more than half of the included articles did not meet several non-critical domains, including listing and justifying excluded studies ($n = 15$), reporting funding sources for included studies ($n = 13$), performing study selection in duplicate ($n = 9$), and explaining observed heterogeneity adequately ($n = 9$). Other commonly unmet non-critical domains included performing data extraction in duplicate ($n = 8$), justifying the selection of study designs for inclusion ($n = 7$), and describing included studies with sufficient details ($n = 4$). Among the seven articles rated as critically low quality, each failed to meet five to ten AMSTAR 2 items, including multiple critical domains. Among the seven articles rated as low quality, each failed to meet three to six AMSTAR 2 items, with only one critical domain unmet. The reliability tests showed an 89.2–95.8% consistency across four raters. Compared to the quality ratings using the original AMSTAR 2 (high: $n = 1$; moderate: $n = 1$; low: $n = 4$; and critically low: $n = 12$), the modified instrument elevated the ratings of included review articles.

Table 2. Characteristics of Studies Included in the Umbrella Review.

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
Berezowitz et al. [20]	Local Food Initiatives (school gardens)	Start of the literature through May 2013	11	N/A	Majority of studies found increased consumption of fruits and vegetables: seven studies measured self-reported fruit and vegetable intake (five found increases and two found no change), and the remaining studies found positive impacts on predictors of fruit and vegetable consumption.	N/A	N/A
Chriqui et al. [19]	School Nutrition Policies (local nutrition policies, competitive foods)	January 2005–March 2013	24	Limited (mixed evidence)	Majority of studies found increased consumption of healthier foods.	N/A	Majority of studies found school nutrition policies were associated with healthier school food environments.
Coakley et al. [26]	Local Food Initiatives (Farm to School)	2002–2025	9	Limited (one study found perceived improvements)	Majority of studies found increased consumption of vegetables (limited evidence found improvements in diet quality): local food procurement was associated with increases in children's vegetable intake (particularly among children with low intakes and with more intensive exposure to Farm to School), but was not associated with fruit intake.	N/A	Limited evidence suggested perceived increases in school meal participation; 17% of participating School Food Authorities reported increased participation in the 2019 Farm to School Census and 41% reported it in the 2023 Census.
Cohen et al. (2021) [16]	(1) School Nutrition Policies (school meal standards, competitive foods) (2) Cafeteria Environment Changes	Start of the literature through May 2021	80	N/A	(1) School Nutrition Policies: Healthier school meal standards and restricting competitive foods associated with increased consumption of school meals. (2) Cafeteria Environment Changes: Greater menu choices, improved palatability/cultural appropriateness, pre-slicing fruits, and recess before lunch associated with increased consumption of school meals. Mixed associations with taste tests, choice architecture. Limited evidence with lunch duration (overall suggests increased meal consumption).	N/A	N/A

Table 2. *Cont.*

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
Cohen et al. (2021) [23]	UFSM [b]	Start of the literature through December 2020	25	Limited (evidence suggests no adverse associations with BMI)	Limited (evidence suggests greater consumption of nutritionally substantive breakfasts and improved diet quality).	Limited (both studies examining food security found improvements associated with CEP).	Majority of studies found increased participation: among 15 U.S. studies, 14 found increased participation, and one reported mixed findings.
Hecht et al. [22]	(1) BATB (2) School Nutrition Policies (local nutrition policies, school nutrition standards, competitive foods) (3) Cafeteria Environment Changes (4) Local Food Initiatives (Farm to School)	Start of the literature through January 2022	34	N/A	N/A	N/A	(1) BATB: Increased participation. (2) School Nutrition Policies: Restricting competitive foods is associated with increased participation. Limited evidence examining stronger school meal standards and local nutrition policies (evidence suggests neutral or increased participation). (3) Cafeteria Environment Changes: Limited evidence (choice architecture associated with mixed results). (4) Local Food Initiatives: Limited evidence found no association with participation.

Table 2. *Cont.*

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
Olarte et al. [15]	BATB	Start of the literature through December 2022	37	Limited evidence: among the four studies that examined BMI or weight, two found increases, and two found no evidence of increased weight.	Mixed: nine studies examined consumption or diet quality. The review concluded that BATB improved diet quality, but several pre-HHFKA studies found increased caloric intake, likely because some students ate breakfast both at home and at school. One study found decreased food waste.	N/A	Increased: All 22 studies found increased participation.
Ferris et al. [32]	School Nutrition Policies (school meal standards)	Start of the literature through July 2024	25	Mixed results: six studies reported mixed findings, two found beneficial associations, and two found no association; none reported adverse findings.	N/A	N/A	N/A
Karpouzis et al. [18]	Local Food Initiatives (school gardens)	January 1987–February 2022	10	N/A	Majority of studies found increased consumption of healthier foods.	N/A	N/A
Mansfield & Savaiano [17]	School Nutrition Policies (local nutrition policies, school meal standards)	2006 to 2016	31	N/A	Majority of studies found increased consumption of healthier foods.	N/A	Limited evidence: two studies found declines in participation after implementing policies limiting flavored milk.

Table 2. *Cont.*

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
Merlo et al. [24]	(1) School Nutrition Policies (school meal standards, competitive foods) (2) Cafeteria Environment Changes	2010–2021	97	N/A	(1) School Nutrition Policies: Mixed findings: among interventions evaluating school meal standards, seven of eight measuring selection found at least one favorable change, but six also found at least one unfavorable change; 9 of 14 studies measuring dietary intake found at least one favorable change, while 10 also found at least one unfavorable change. (2) Cafeteria Environment Changes: The majority of studies examining taste tests, incentivizing students to try foods, improving the palatability of foods, and recess were associated with increased selection and/or consumption. Limited evidence suggested pre-slicing fruits was associated with increased consumption.	N/A	(1) School Nutrition Policies: Majority of studies found school nutrition policies were associated with healthier school food environments. (2) Cafeteria Environment Changes: N/A
Marcano-Olivier et al. [31]	Cafeteria Environment Changes	After 2000 (end date not reported)	24	N/A	Generally favorable but inconsistent evidence for choice architecture strategies: across the full review, 17 of 25 studies reported increased selection of targeted healthier foods, and 11 reported improved consumption (favorable strategies included making less healthy choices more effortful, posters or videos, verbal prompts, meal preordering, changes to serving order, smarter lunchrooms, greater fruit and vegetable variety, and attractive food names).	N/A	N/A
Micha et al. [30]	(1) School Nutrition Policies (competitive foods)	Start of the literature through March 2017	4	N/A	Limited evidence found no significant change in sugar-sweetened beverage intake at school	N/A	N/A

Table 2. *Cont.*

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
Palmer et al. [27]	(1) BATB (2) School Nutrition Policies (school meal standards) (3) Cafeteria Environment Changes	2002–2012	19	N/A	(1) BATB: limited evidence from two Breakfast in the Classroom studies: one found decreased total breakfast waste following implementation, while the other identified factors associated with milk waste during BIC. (2) School Nutrition Policies: Limited and mixed evidence: lunch after recess was associated with increased milk consumption, while removing flavored milk was associated with decreased milk consumption and increased water consumption. (3) Cafeteria environment changes: The majority of studies examining the palatability of foods served were associated with increased consumption. Studies examining choice architecture were mixed. Limited evidence examining recess before lunch suggested increased consumption	N/A	N/A
Prescott et al. [21]	Local Food Initiatives (Farm to School)	January 2002–September 2017	21	Limited evidence suggested no association with BMI/obesity.	The majority of studies found increases in healthier food selection. Mixed evidence for healthier food consumption.	N/A	Limited evidence: one study found increased school meal participation.
Sildén et al. [25]	School Nutrition Policies (competitive foods)	2006–2017	26	Majority of studies found no association	Limited evidence suggested reductions in unhealthy beverages (SSBs) with competitive food policies.	N/A	N/A
Spill et al. [29]	UFSM	2012-13 SY through 2024	4	(1) Limited evidence suggested lower prevalence of obesity	N/A	N/A	Limited evidence suggested increased school meal participation.

Table 2. *Cont.*

Citation	PSE Strategy	Dates	Number of Included Studies [a]	Weight	School Meal Consumption/Diet Quality	Food Security	School Meal Participation/ Healthier Food Access
von Philipsborn et al. [28]	(1) School Nutrition Policies (competitive foods) (2) Cafeteria Environment Changes	Start of the literature through January 2018	12	N/A	(1) School Nutrition Policies: Competitive food policies were associated with decreased consumption of SSBs. (2) Cafeteria Environment Changes: Emoticon labeling and small rewards were associated with reduced selection or purchasing of sugar-sweetened milk. Limited evidence found no significant effect of placing plain milk more prominently.	N/A	N/A

[a] Number of unique primary studies examining PSE strategies and outcomes relevant to this umbrella review. For multinational reviews, only U.S.-specific evidence reported separately by the source review was included; no new country-specific synthesis of primary studies was conducted. [b] Universal Free School Meals (UFSM) refers broadly to policies or provisions that offer school meals at no charge to all students within participating schools, districts, or states, including the Community Eligibility Provision (CEP), other federal provisions, and state-level universal school meal policies.

4. Discussion

This umbrella review of 18 systematic review papers comprehensively evaluated school-based PSE strategies to improve nutrition and reduce the risk of excess weight gain among school-aged children in the U.S. This umbrella review found consistent evidence regarding positive associations with school meal participation for the following PSE strategies: providing breakfast after the bell; implementing strong policies that regulate the nutritional quality of meals and competitive foods; and providing universal free meals.

In light of the evidence that school meals are often the healthiest source of food for American children [37], increasing participation and consumption of school meals is a public health priority. This umbrella review found that there are a number of empirically supported PSE strategies to improve participation. These include BATB, strong school nutrition policies, local food initiatives, and several specific cafeteria environment changes (i.e., increasing food options, improving meal palatability and cultural appropriateness, offering pre-sliced fruits, increasing lunch duration, and scheduling recess before lunch). Of note, prior research has also found that sufficient resources for schools that address operational capacity, food preparation skills, staff training, and sustainable procurement practices are also important complements to PSE strategies to enable schools to support the recommended cafeteria environment changes and other school nutrition policies [38]. Further, while participation in school meals is measured by the proportion of students who take a reimbursable school meal, it is also important to measure consumption of that meal, and the nutritional quality of the foods consumed. It is notable that several separate cafeteria environment strategies were associated with greater school meal consumption, which highlights the need for multi-component strategies that can have positive synergistic effects [15].

Research among subpopulations was generally limited, with the strongest evidence among students from lower-income households, with BATB associated with greater school breakfast participation and school nutrition policies associated with improvements in both meal participation and nutrition outcomes compared with students from higher-income households.

There were few studies examining food security, and a limited number of studies examined weight outcomes across all the school-based PSE strategies evaluated. Of note, no reviews found a detrimental impact of the PSE strategies presented here on weight-related outcomes. There is promising evidence that strong nutrition standards (e.g., Healthy, Hunger Free Kids Act) are associated with reductions in unhealthy weight gain among subpopulations (e.g., children from low-income households) [39]. However, further research examining weight-related outcomes across PSE strategies, both overall and among subpopulations at greatest risk for obesity, is warranted.

This umbrella review also sheds light on topics with a sufficient number of studies to warrant one or more systematic reviews, but the reviews note inconsistent findings. This is the case for the broad category of "farm to school" initiatives. The term farm to school encompasses a range of specific activities including local procurement, field trips to local farms, taste tests, nutrition education initiatives, school gardens, etc. The challenge is that some of these are low-dosage and low-intensity, meaning that students may have low exposure levels, only experience a few components, or only be exposed to the intervention for a short time. Similarly, research on the effectiveness of choice architecture strategies (often referred to as "Smarter Lunchroom" techniques) had mixed results. It is possible these cafeteria nudges are more effective when combined with other interventions. Other cafeteria environment changes were found to be more effective, including increasing the number of choices, enhancing the palatability of foods, and recess before lunch. Overall,

this highlights the need for multi-component PSE interventions with greater intensity and duration.

This umbrella review also highlights PSE strategies with promising but limited evidence, suggesting that more research is warranted. In particular, while there is growing evidence regarding UFSM and its impact on diet quality and food security, additional studies should be conducted among diverse student populations. Further, more research examining competitive food policies and their impact on meal participation, diet quality, and weight outcomes is also necessary. More BATB studies are needed specifically in middle and high school settings, and research should also examine the impact on diet quality. Overall, there is also a need for more studies examining the differential impact of PSE strategies across subpopulations at greatest risk for poor diet quality, food insecurity, and obesity. This is particularly important as school meal policies may have different effects by socioeconomic status, household food insecurity, and other social determinants. In fact, some recently published studies suggest that policies including UFSM may reduce food insecurity among households that are near-eligible for FRPM [40–42].

Further, research is needed that examines the combined impact of nutrition PSE strategies. For example, implementing UFSM and BATB with strong nutrition standards for school meals, while limiting competitive foods, and integrating more local and minimally processed food options may be particularly impactful when implemented together and should be examined where feasible.

Key gaps in research were identified through this umbrella review. For example, systematic reviews were not identified for some commonly implemented PSE strategies in schools, including evaluations of other USDA programs for school-aged children (e.g., Supper Program, Fresh Fruit and Vegetable Program, etc.). Other PSE strategies or complementary areas that are gaining attention and are in need of research include examining ultra-processed foods in schools, evaluating the newly updated USDA school meal standards (which placed limits on added sugars, further restrictions on sodium, and expanded options for milk) [43], and estimating the economic return on investment of school-based PSE strategies. This umbrella review also identified that research with high-quality, objective measures for both exposures and outcomes is needed; evidence was often limited by small samples, short follow-up, inconsistent outcome measures, and weak study designs that often made causal conclusions difficult. Future research should consider analyzing existing national datasets to potentially answer these questions with robust, nationally representative samples, and newly conducted data should take thoughtful approaches that prioritize larger sample sizes with longer follow-up periods and, where feasible, utilize the same high-quality outcome measures as prior research studies for consistent measurements across studies.

Some of the PSE strategies in this review that demonstrated positive impacts should be considered as legislation at the state or federal level. For example, UFSM laws are currently in place in nine states, and many more states have introduced legislation for UFSM [44]. The amount of time that students have to eat lunch is another feasible policy target. For example, ten states and Washington, D.C., currently have policies related to seated time in the cafeteria, although only half make it a requirement that students have at least 20 min to eat lunch after sitting down [45]. Further, policymakers at the state and federal level should consider expanding access to CEP, as well as complementary policies to address current school-level barriers to participation in this provision, such as improving reimbursement rates for school meals [46].

The results of this umbrella review also have important implications for district-level policies. School administrators and local wellness committees should consider ways to combine policies with the strongest evidence base. Based on the evidence from the system-

atic reviews evaluated in the present umbrella review, schools should strongly consider maximizing CEP enrollment within a district (e.g., combining lower- and higher-income schools so that more schools can be enrolled in CEP), integrating BATB models to expand access to school breakfast, and implementing policies with minimum seat time requirements to ensure all students have sufficient time to eat the healthier meals provided by schools.

There were a number of strengths and limitations to this umbrella review. First, only PubMed was searched for this umbrella review to maintain a consistent methodology across the four companion Healthy Eating Research umbrella reviews. Because this review exclusively targeted peer-reviewed systematic reviews evaluating health- and nutrition-related outcomes (e.g., meal participation, intake, diet quality, food security, and weight status), PubMed was selected as the primary database given its comprehensive indexing of public health, clinical, and nutrition literature. However, relying on a single database remains a limitation of the present umbrella review, and it is possible that relevant systematic reviews indexed exclusively in non-biomedical, education (e.g., ERIC), or policy databases may have been missed. Second, because this umbrella review only examined reviews, it is possible that new individual studies have become available since those reviews were published and thus were not considered in the present umbrella review. However, the included reviews were primarily published within the last few years and thus likely captured the majority of recent studies. Third, because this umbrella review exclusively evaluated systematic reviews, overlap in the individual studies included within the reviews by PSE strategy means that the overall findings of the review relied on a smaller number of independent studies. Therefore, this should be considered when interpreting findings from the umbrella review (e.g., while multiple reviews consistently reported positive associations between BATB and participation rates, this in part reflected repeated synthesis of the same primary literature). Lastly, as only four of the 18 included systematic reviews met high or moderate AMSTAR 2 quality criteria, all findings should be interpreted with appropriate caution. Strengths of this umbrella review included standardized search methodology, a comprehensive approach to examining school nutrition PSE strategies, and a focus on examining the differential impact on subpopulations, where available. This umbrella review was also strengthened by its ability to comprehensively review the existing literature to identify key research gaps in the field of school nutrition PSE strategies to inform future research.

5. Conclusions

In conclusion, multiple school-based nutrition PSE strategies have demonstrated consistent positive associations with school meal participation and nutrition-related outcomes. These warrant attention from policymakers, state child nutrition departments, and school administrators. Although there is promising evidence that school-based initiatives can support food security and improve weight-related outcomes, these public health challenges likely require a multi-sector, multi-component approach that should include, but not rely solely on, school-based PSE changes. Future research should prioritize stronger study designs, including longitudinal and quasi-experimental or randomized studies, as well as standardized measures, measurement of PSE strategies in place outside of the school, and more attention to subgroup and equity effects. Priority should be given to studies that combine PSE strategies with sufficient dose and duration to maximize the effectiveness and reach among all school-aged children, and funding opportunities that support studies with longer duration and intensity will be necessary to conduct this type of higher-impact research.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu18223771/s1; Table S1: Quality assessments of the included reviews based on AMSTAR 2 ratings; Table S2a–e: Publications examining school-based PSE strategies cited in the systematic reviews included within the umbrella review (Table S2a: Breakfast After the Bell; Table S2b: School Nutrition Policies; Table S2c: Local Food Initiatives; Table S2d: Cafeteria Environment Changes; Table S2e: Universal Free School Meals).

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Abbreviations

The following abbreviations are used in this manuscript:

BATB	Breakfast after the bell
CEP	Community Eligibility Provision
HHFKA	Healthy, Hunger-Free Kids Act of 2010
NSLP	National School Lunch Program
PSE	Policy, systems, and environmental change
SBP	School breakfast program
UFSM	Universal free school meals

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