

Strategies to Address Food Waste in K-12 Schools: A Narrative Review

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INTRODUCTION:

Approximately one-third of all food produced globally for human consumption is lost or wasted, which is equivalent to about 1.3 billion tons of food per year, according to the Food and Agricultural Organization of the United Nations (UN) (Food and Agriculture Organization [FAO], 2019). Food that gets spilled or spoils during production, storage, processing, and distribution stages of the food system and before a food reaches its final product or retail stage is considered food loss (FAO, 2019). Food that is fit for human consumption but is not consumed (or is discarded) by retailers or consumers is considered food waste. The United States (US) has pledged to reduce food waste by half by 2030 (United States Department of Agriculture [USDA], 2021) to help achieve the UN's sustainable development goal to reduce food loss and ensure sustainable consumption and production patterns (UN Department of Economic and Social Affairs, 2015).

Food waste challenges the dimensions of sustainability: it is a growing social, ethical, environmental, and economic problem (Derqui et al., 2020). Americans waste more than 50% more food compared to 50 years ago despite millions of Americans experiencing food insecurity (Coleman-Jensen et al., 2020; Gunders, 2017). According to the US Department of Agriculture's (USDA) Economic Research Service, most of that waste (31%) occurs at the retail and consumer levels (USDA, 2021). The National School Lunch Program (NSLP) and the School Breakfast Program (SBP) provide a unique consumer-level opportunity to reduce food waste in schools (Byker Shanks et al., 2017; Elnakib et al., 2020; USDA, 2017a). The NSLP is the largest school lunch source in the US, with 99% of public schools participating in the program, providing lunch to over 30 million students nationwide (USDA, 2017b). A 2019 report found that food thrown away in school cafeterias amounted to 530,000 tons or costs over 1.7 billion dollars per school year (World Wildlife Fund, 2019).

There have been several systematic reviews of interventions focused on the NSLP and/or interventions to the cafeteria environment included nudging, changes in cafeteria arrangement, food presentation, and food choice; however, they do not focus on food waste as a primary outcome, and most did not include the SBP (Cohen et al., 2021; Marcano-Olivier et al., 2020; Meiklejohn et al., 2016; Metcalfe et al., 2020; Mumby et al.,



2018). Typically, researchers measure consumption by subtracting the ounces or grams of food left on a student's tray from the amount of food the student was served (Cohen et al., 2015; Hubbard et al., 2015; Miller et al., 2015; Williamson et al., 2013). Many of these studies only report consumption data without clearly identifying how much food was selected or wasted; thus, making it difficult for food waste study comparisons.

To date, Byker Shanks et al. (2017) have conducted the only food waste systematic review on the NSLP, which included 53 studies from 1978 to 2015 and assessed varying objectives, methods, and results. Studies identified by the review included a variety of research designs including cross-sectional, mixed methods, longitudinal, interventions with a pre-post or pre-post-follow-up, quasi experimental, and randomized controlled trials. The studies' aims ranged from evaluating the effects of programs on food consumption and/or waste to generally assessing food waste. A more recent study (Cohen et al., 2021) which used the Social Ecological Framework to assess the influences of different interventions on school meal consumption, found a total of 96 studies that included initiatives, interventions, and policies and their impact on school meal consumption. Since this study focused on consumption and not food waste, it was difficult to discern which initiatives, interventions, or policies would increase consumption while decreasing waste. To date, there has not yet been a review that specifically evaluates the literature of food waste reduction interventions in the school setting and identifies gaps where future research is needed.

Child nutrition professionals can be advocates for food waste reduction within the school environment by leading implementation and evaluating effective changes aimed at curbing food waste (Elnakib et al., 2020; Spiker et al., 2020). There is a need to assess interventions that improve student intake without generating more waste in the school setting. In particular, we chose to target this review on small-scale interventions that child nutrition professionals could easily adapt and implement. A narrative review also presented an opportunity to provide a broad perspective on the topic and identify thematic strategies child nutrition professionals can consider. Therefore, the purpose of this review was to provide a narrative summary of the literature describing modifications and interventions conducted at the school level to the breakfast and lunch environment aimed at decreasing food waste in K–12 schools in the US.

METHODS:

Search Strategy

This narrative review was exempt from institutional review board review because there was no interaction with human subjects. The literature search for this narrative review was conducted in PubMed, Web of Science, Education Sources, and Education Research Information Center databases. The search strategy, figure 1, was developed with support from a university's health science librarian. The final search strategy included terms and keywords used in various combinations. Search terms for food waste searches included: food AND (waste* OR wasting OR repurpos* OR loss* OR donat*) OR plate waste OR food waste. Search terms for K–12 schools included: NSLP OR National School Lunch Program OR NSBP OR National School Breakfast Program OR lunchroom OR lunch program OR cafeteria OR free or reduced lunch. The search was limited to English-



language peer-reviewed articles published from January 1, 2000, through October 31, 2020. The database search strategy resulted in an initial total of 433 records.

Study Selection

Study screening and selection was completed using Rayyan (<http://rayyan.qcri.org>), an open access free web-based application designed to expedite initial screening of abstract and titles during a review process (Ouzzani et al., 2016). After duplicated search results were excluded, the resulting article titles were all reviewed by a group of five Masters of Public Health (MPH) students who screened the articles for study objectives, and population. Any discrepancies from the students' reviews of article titles, study objectives, and population were discussed among the authors. This process was repeated for the review of abstracts of the records retained after the title review. Studies that did not focus on school meals, food waste and any retracted studies were eliminated. Based on abstracts, 65 articles were eliminated for lack of empirical data, lack of intervention or modification of the school/lunchroom environment, geographic location (i.e., outside of the US), no focus on food waste, and/or conducted outside of a K–12 school setting (e.g., higher education, free-living, adult population).

Our search identified some studies that used measures of weighing food waste as a proxy for food consumption or observed consumption directly. Interventions with reported outcomes focusing on the consumption of foods but no report of food waste as a measured outcome were not included within the review. Consumption as a measure requires knowledge of servings prepared for the day, the unserved supply, servings given to students, and the number of students in attendance. Because of these inconsistent and school-specific variables, the authors determined using consumption data would provide an inaccurate assessment of food waste. Therefore, the authors chose to focus on studies that explicitly reported food waste as an outcome and excluded studies that only reported consumption as an outcome.

Studies describing food waste following changes in response to national school meal regulations (i.e., The Health Hunger-Free Kids Act of 2010) were not included, given that the intent of this manuscript is to focus on interventions or modifications to the school environment that a child nutrition professional or school district could feasibly implement. The implications of federal policy changes on food waste have been described and reviewed elsewhere (Cohen & Schwartz, 2020; Cohen et al., 2014; Mansfield & Savaiano, 2017; Schwartz et al., 2015). The authors included peer-reviewed literature and excluded lay-media (i.e., newspaper, magazine, blogs) and governmental reports. Conference abstracts were excluded as their brevity limited extraction of key data for this review; however, the authors made efforts to examine if a relevant conference abstract was later published as a full peer-reviewed article by searching for the authors and specifics of the study. If the study design, analysis, or outcomes were unclear, the report was advanced to the next round of review. The process was again repeated for the full-text review of the records retained after the abstract review. Lastly, a snowball strategy allowed for examination of references in identified articles and inclusion or exclusion as relevant.

Data Extraction



A Google Sheet spreadsheet (Google LLC) was used to collaborate on the data extraction from the included studies in real-time. Specific data extracted from each study were noted in separate columns within the spreadsheet. The variables of interest (study location, type of school (elementary, middle, high school), grade level(s), sample size, demographics of district, school, and/or sample, if the intervention targeted food waste at breakfast and/or lunch, the length of the modification or intervention described in the study, how food waste was measured, a brief description of the modification or intervention, and summary of the impact of the modification or intervention on food waste) were thoroughly summarized within the Google Sheet by MPH students and reviewed for completeness by each of the authors. MPH students had been trained on how to complete the Google Sheet and supported by the authors if issues arose. Reliability of the data was ensured by the authors completing the same process with the student and comparing their results with the student Google Sheets.

RESULTS:

In total, 19 articles met all inclusion criteria and were included in this narrative review. Two studies that described the same intervention were grouped together as one in Table 1 (Marshall et al., 2019; Sharma et al., 2019). The included studies were grouped by the authors into three thematic groups based on the common modifications or interventions examined: educational programs (n=7); (**Table 1**), cafeteria changes (n=9); (**Table 2**), and meal schedule changes (n=3); (**Table 3**). Brief descriptions of the modifications or interventions and changes in food waste are presented in **Tables 1–3**. Among the 19 studies reviewed, 11 demonstrated desired outcomes (Adams et al., 2016; Bergman et al., 2004a; Bergman et al., 2004b; Farris et al., 2019; Machado et al., 2020; Marshall et al., 2019; Prescott et al., 2019a; Sharma et al., 2019; Tanaka et al., 2005; Wansink et al., 2013; Yoder et al., 2015); that is, decreases in food waste, ranging from 3% to 48% of food waste decreased. Three studies demonstrated undesired outcomes (Hanks et al., 2014; Marlette et al., 2005; Wansink et al., 2015); such as, increases in food waste. Three studies documented a neutral change (Hubbard et al., 2015; Hudgens et al., 2017; Serebrennikov et al., 2020), indicating that there was no increase or decrease in food waste. The remaining two studies had mixed results (Bean et al., 2018; Blondin et al., 2018) showing the food waste decreased in some capacities and increased under certain circumstances.

Studies were largely conducted in elementary schools (68%), four studies were conducted in middle schools, one study in a private residential school, and one study in a high school. Studies varied from single site interventions to multi-site interventions across a school district(s). All but two studies (Blondin et al., 2018; Farris et al., 2019) targeted lunch as opposed to breakfast for modifications or intervention. Length of the observed modification or change varied widely as some modifications were permanent while others were assumed to be short-term pre-post observations only for research purposes. The studies examined used a variety of accepted methodology for quantifying food waste measurement, but digital photography was the most used method.

DISCUSSION:

This narrative review highlights the strategies and results of food waste reduction from 19 interventions in the NSLP and SBP. Interventions varied greatly from comprehensive educational programs to small food presentation changes such as slicing fruit versus serving whole fruits. Slightly more than half (58%) of studies reviewed had interventions that resulted in decreases in food waste, whereas the remaining studies reported increases or no significant change in food waste. The studies reviewed included three intervention themes, which were educational programs and, changes to the cafeteria environment and meal schedule. Of the three themes, meal schedule changes were most consistently associated with decreases in food waste. These schedule changes included recess before lunch or longer lunch period interventions (Bergman et al., 2004a; Bergman et al., 2004b; Tanaka et al., 2005).

The three studies assessing meal schedule changes all had positive results for decreasing food waste, despite it being the category with the fewest studies overall. A recent nationally representative comprehensive assessment of the NSLP and SBP, the School Nutrition and Meal Cost Study, specifically found that lunch periods that started at noon or later were associated with less food waste than earlier lunch periods (Fox et al., 2019). More studies are needed to confirm these findings; however, this is a promising approach and requires very little from administration or school nutrition programs compared to other food waste reduction strategies reviewed. Despite reductions in food waste, previous qualitative research has reported some resistance to placing recess before lunch or extending the lunch period by administrators, school nutrition personnel, teachers, and parents (Rainville et al., 2006). Most common concerns were logistics and academic time constraints. Due to these findings, the framing of meal schedule changes to address food waste and these barriers could include benefits such as food service operational efficiency and cost savings (Buzby & Guthrie, 2002). In addition, future studies should evaluate the effects of meal schedule changes and academic achievement, to potentially provide further reasons for advocating for these changes.

While half of the studies focused on full meal components, half evaluated food waste solely in vegetables, fruit, or milk. Many children do not meet the recommendations for these food groups (United States Department of Health and Human Services & USDA, 2015), and therefore these may be a higher priority for health professionals. Fruits, vegetables, and milk specifically, are also commonly reported as the most wasted in school cafeterias (Buzby & Guthrie, 2002; Byker Shanks et al., 2017; Fox et al., 2019; Ralston et al., 2008). In studies that evaluated full meal components, some studies evaluated each food group for food waste, but others reported food waste only as the whole meal. Studying each meal component is important for understanding what food groups may be competing for consumption.

All but six interventions were focused on elementary ages, except six studies. There may be a greater need for food waste reduction interventions in younger grade levels as younger children are more likely to waste school lunch foods (Fox et al., 2019, Niaki et al., 2017; Tran, 2009). However, when addressing food waste, it may be important to consider that different intervention strategies may have differing effects by age. For example, using offer versus serve is associated with lower food waste in elementary ages, but not for middle-school and

high-school ages (Fox et al., 2019). More research is needed about food waste in middle-school and high-school students to develop appropriate interventions which would be effective for those ages. Few studies reported a rationale for selecting one food waste reduction strategy over another. Future studies should examine barriers, motivators, and perspectives of students regarding food waste and tailor strategies accordingly before implementation (Haas et al., 2014; Zhao et al., 2019).

In this review, studies which focused on changes to the cafeteria environment were the least successful but were the most common. The studies with successful decreases in food waste focused on salad bar placement, consuming breakfast in the classroom versus in the cafeteria, and the slicing of fruit offerings instead of serving whole fruit items. This narrative review focused on individual interventions or changes; however, in practice schools may implement multiple strategies or changes simultaneously. Additional studies are needed to examine implementation and efficacy of multiple strategies to determine if synergistic effects occur.

Educational program interventions had mixed success and mostly focused on vegetable and/or fruit food waste. These programs varied widely in scope and focus, and included education on sustainable food systems, school gardening and farm to school, nutrition education, health promotion, and role modeling. The impact of education interventions in the school setting has shown mixed results. Previous reviews on nutrition education programs have shown that programs delivered by teachers can have a modest effect on nutrition knowledge and eating behaviors (Cotton et al., 2020). In addition to teacher delivery, effectiveness depends on program duration, focusing on a few nutrition-related outcomes, the appropriate use of theoretical frameworks, fidelity, support from school leadership, changes in the school food environment, and engaging caregivers (Cotton et al., 2020; Dudley et al., 2015; Meiklejohn et al., 2016; Murimi et al., 2018, Peralta et al., 2016). These strategies have been shown effective only for nutrition-related outcomes and do not necessarily apply to decreasing food waste. In the four studies included in this review which decreased food waste, one was conducted with middle school students, three with elementary students, the middle school study program was student driven, and each lasted six months to one year. All studies were focused on a different educational topic: sustainable food systems, farm to school involvement, adult role modeling of food consumption, and health promotion. More consistency in educational intervention strategies is needed to understand how these program interventions may be used to effectively reduce food waste in school meal programs, and if the strategies used in nutrition focused education programs can be applied to programs targeting food waste as an outcome.

While not food waste interventions, and therefore not included in this review, studies evaluating the effects of the HHFKA and the School Nutrition and Meal Cost Study have both contributed important findings to food waste. Studies on food waste after the implementation of the HHFKA have found that overall, food waste has remained the same or lowered (Cohen et al., 2014; Mansfield & Savaiano, 2017; Schwartz et al., 2015), implying that federal policy change can be an effective implementation strategy for decreasing or at minimum, maintaining school food waste levels. The School Nutrition and Meal Cost study observed plate waste in 165 schools participating in the NSLP and 154 schools participating in the SBP (Fox et al., 2019). Additional associations were found for food waste not previously mentioned in the HHFKA studies, including increased

fruit and vegetable waste with the use of cycle menus, increased dairy waste where school foodservice directors perceived meeting the HHFKA standards as challenging, and increased waste for calories and dairy foods in schools that offered free lunches to all students (Fox et al., 2019). Conducting a nutrition education activity in a classroom or foodservice area was associated with decreases in food waste for many food groups, and offering raw vegetables daily was associated with less waste of fruits and vegetables. Child nutrition professionals can adapt and implement these policy-oriented strategies along with intervention strategies included in this review to effectively address food waste in their programs.

There were few studies on food donations to decrease food waste in schools such as share tables, backpack programs, and food donations of excess food to eligible non-profit organizations which are allowed and strongly encouraged by the USDA (Zhao et al., 2019). These strategies could be implemented in schools to potentially decrease waste, while also impacting student and community food security. A study conducted in one state found that school nutrition and food recovery staff are supportive of these types of initiatives, however food safety, potential food recovery costs, and logistical challenges were noted as barriers (Prescott et al., 2020a). While approximately half of schools across the U.S. have policies on share tables, few states provide clear information on outreach to the school community, limiting the potential for food recovery impact (Prescott et al., 2020b).

There was also a lack of studies assessing pre-consumer waste in the school environment. Pre-consumer waste can make up 4–10% of all food purchases and includes all waste in school kitchens including overproduction, trim waste, expiration, spoilage, overcooked items, contaminated items, and dropped items. While rates of plate waste (post-consumer) are higher and more consistent than pre-consumer waste rates (Byker Shanks et al., 2017; Prescott et al., 2019b), a recent study evaluating pre-consumer waste in schools showed schools sporadically have higher rates of pre-consumer waste due to difficulties in predicting student demand (Prescott et al., 2019b). More schools engaging in food recovery and donation programs such as those mentioned above could help to mitigate this waste and have a small but important impact on the total amount of food being wasted in the school environment.

CONCLUSIONS & APPLICATIONS:

Conclusions made in this narrative review are limited to the studies retrieved by the search terms (**Figure 1**). Articles were identified describing food waste before and after implementation of the HHFKA; however, it was our goal to focus on studies describing interventions that a school or school district could implement rather than changes in food meal patterns or federal policy changes. Articles evaluating food consumption were identified, but ultimately rejected due to a lack of research supporting consumption as a proxy for food waste.

By reducing food waste, schools can be contributors to a more sustainable food system. It is important to note that not all interventions that increase consumption have led to a decrease in food waste, that is why it is important for child nutrition management professionals to assess both food waste as well as student consumption when implementing new interventions. Child nutrition professionals can advocate for lunch time policy changes to improve food service operational efficiency and cost savings while decreasing waste. Additionally, lunchroom environment changes can impact food waste while increasing student consumption. However, more research is needed to make stronger recommendations. Educational programs can play an important role in improving student knowledge and attitudes towards fruits and vegetables, however their success with food waste reduction need studies with more consistency with more diverse students. Food recovery programs policy initiatives such as share tables can be a strategy where child nutrition professionals can share their expertise to efforts that decrease food waste and improve food security (Hayes et al., 2018). While these initiatives may come with logistical challenges, child nutrition management professionals are uniquely poised to help schools overcome these challenges (Martin, 2017). Future efforts should focus on identifying best practices for marketing and outreach for student and school staff engagement in implementing policy changes. Our findings underscore the need for future research on this topic as several gaps were identified. Research should examine pre-consumer waste in the school environment as well as the impact of additional currently used strategies and the synergistic effects of multiple food waste reduction strategies simultaneously employed. Effective policies and interventions to reduce waste and redirect surplus food within K–12 schools may have the potential to reduce food costs, benefit the environment, and improve food security.

Limitations exist in this narrative review. The search terms used may not have captured relevant articles. Additionally, excluding non-peer reviewed studies may have limited the scope of this narrative review and eliminated important perspectives. Although many of the studies in this thematic category were unsuccessful in reducing food waste, the strategies and changes implemented shouldn't be ruled out entirely. This review found only a limited number of intervention studies and those studies examined varied widely in food waste reduction strategies. Due to the large degree of variability in cafeteria changes, and the variety of data collection and measurement methods used, it is not appropriate to rule out one intervention or change as ineffective.

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ABSTRACT

PURPOSE/OBJECTIVES

As child nutrition professionals broaden their focus to support sustainability, including food waste, there is a need to assess interventions that improve student school meal consumption in schools participating in the National School Lunch Program and School Breakfast Program without generating more food waste. The purpose of this review was to provide a narrative summary of the literature describing modifications and interventions to the school breakfast and lunch environment aimed at decreasing food waste in K–12 schools in the United States.

METHODS

This narrative review was limited to studies conducted in the United States within the past two decades (i.e., 2000 to 2020). Nineteen articles met the criteria of English-language peer-reviewed articles on food waste in schools based on a search conducted using four research databases.

RESULTS

Studies were grouped by the authors into three thematic groups: educational programs (n=7), cafeteria changes (n=9), and meal schedule changes (n=3). Studies were largely conducted in elementary schools, focused primarily on food waste at the lunch-time meal, and varied in measurement of food waste. Eleven studies reported decreases in food waste, three studies reported increases in food waste, two studies reported mixed results, and three reported no change. Of the three thematic groups, meal schedule changes were most consistently associated with decreases in food waste.

APPLICATIONS TO CHILD NUTRITION PROFESSIONALS

For a comprehensive understanding of food waste in schools, future research could further examine food waste reduction strategies (i.e., share tables, and food donation programs). Child nutrition professionals can be advocates for food waste reduction within the school environment by leading the implementation of effective changes aimed at curbing food waste.

REFERENCES

- Adams, M. A., Bruening, M., Ohri-Vachaspati, P., & Hurley, J. C. (2016). Location of school lunch salad bars and fruit and vegetable consumption in middle schools: A cross-sectional plate waste study. *Journal of the Academy of Nutrition and Dietetics*, 116(3), 407–416. <https://doi.org/10.1016/j.jand.2015.10.011>
- Bean, M., Brady Spalding, B., Theriault, E., Dransfield, K., Sova, A., & Dunne Stewart, M. (2018). Salad bars increased selection and decreased consumption of fruits and vegetables 1 month after installation in Title I elementary schools: A plate waste study. *Journal of Nutrition Education and Behavior* 50(6), 589–597. <https://doi.org/10.1016/j.jneb.2018.01.017>
- Bergman, E. A., Buerge, N. S., Englund, T. F., & Femrite, A. (2004a). The relationship of meal and recess schedules to plate waste in elementary schools. *Journal of Child Nutrition and Management*, 28(2), 1–10.
- Bergman, E. A., Buerge, N. S., Englund, T. F., & Femrite, A. (2004b). The relationship between the length of the lunch period and nutrient consumption in the elementary school lunch setting. *Journal of Child Nutrition and Management*, 28(2). <https://pubag.nal.usda.gov/catalog/4777874>
- Blondin, S. A., Goldberg, J. P., Cash, S. B., Griffin, T. S., & Economos, C. D. (2018). Factors influencing fluid milk waste in a breakfast in the classroom school breakfast program. *Journal of Nutrition Education and Behavior*, 50(4), 349–356. <https://doi.org/10.1016/j.jneb.2017.12.006>
- Bontrager Yoder, A. B., Foecke, L. L., & Schoeller, D. A. (2015). Factors affecting fruit and vegetable school lunch waste in Wisconsin elementary schools participating in Farm to School programmes. *Public Health Nutrition*, 18(15), 2855–2863. <http://doi.org/10.1017/S1368980015000385>
- Buzby, J. C., & Guthrie, J. F. (2002). Plate waste in school nutrition programs: Final report to Congress. U.S. Department of Agriculture, Economic Research Service. <https://www.ers.usda.gov/publications/pub-details/?pubid=43132>
- Byker Shanks, C., Banna, J., & Serrano, E. L. (2017). Food waste in the National School Lunch Program 1978–2015: A systematic review. *Journal of the Academy of Nutrition and Dietetics*, 117(11), 1792–1807. <https://doi.org/10.1016/j.jand.2017.06.008>
- Cohen, J. F., Richardson, S., Parker, E., Catalano, P. J., & Rimm, E. B. (2014). Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *American Journal of Preventive Medicine*, 46(4), 388–394. <https://doi.org/10.1016/j.amepre.2013.11.013>
- Cohen, J. F., Richardson, S. A., Cluggish, S. A., Parker, E., Catalano, P. J., & Rimm, E. B. (2015). Effects of choice architecture and chef-enhanced meals on the selection and consumption of healthier school foods: A randomized clinical trial. *JAMA Pediatrics*, 169(5), 431–437. <http://doi.org/10.1001/jamapediatrics.2014.3805>
- Cohen, J., & Schwartz, M. B. (2020). Documented success and future potential of the Healthy, Hunger-Free Kids Act. *Journal of the Academy of Nutrition and Dietetics*, 120(3), 359–362. <https://doi.org/10.1016/j.jand.2019.10.021>
- Cohen, J. F., Hecht, A. A., Hager, E. R., Turner, L., Burkholder, K., & Schwartz, M. B. (2021) Strategies to improve school meal consumption: A systematic review. *Nutrients*, 13(10), 3520. <https://doi.org/10.3390/nu13103520>
- Coleman-Jensen, A., Rabbitt, M. P., Gregory, C. A., & Singh, A. (2020). Household food security in the United States in 2019. U.S. Department of Agriculture, Economic Research Service. <https://www.ers.usda.gov/publications/pub-details/?pubid=99281>
- Cotton, W., Dudley, D., Peralta, L., & Werkhoven, T. (2020). The effect of teacher-delivered nutrition education programs on elementary-aged students: An updated systematic review and meta-analysis. *Preventive Medicine Reports*, 20. <https://doi.org/10.1016/j.pmedr.2020.101178>
- Derqui, B., Grimaldi, D., & Fernandez, V. (2020). Building and managing sustainable schools: The case of food waste. *Journal of Cleaner Production*, 243. <http://doi.org/10.1016/j.jclepro.2019.118533>
- Dudley, D. A., Cotton, W. G., & Peralta, L. R. (2015). Teaching approaches and strategies that promote healthy eating in primary school children: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, 12. <https://doi.org/10.1186/s12966-015-0182-8>
- Elnakib, S., Landry, M. J., Farris, A., & Coombs, C. (2020). Food waste in K–12 schools: An opportunity to create more equitable and sustainable food systems. *Journal of Nutrition Education and Behavior*, 52(5), 463. <https://doi.org/10.1016/j.jneb.2020.03.004>
- Farris, A. R., Roy, M., Serrano, E. L., & Misyak, S. (2019). Impact of breakfast in the classroom on participation and food waste. *Journal of Nutrition Education and Behavior*, 51(7), 893–898. <https://doi.org/10.1016/j.jneb.2019.04.015>

- Food and Agriculture Organization of the United Nations. (2019). The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. <https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1242090/>
- Fox, M. K., Gearan, E., Cabili, C., Dotter, D., Niland, K., Washburn, L., Paxton, N., Olsho, L., LeClair, L., & Tran, V. (2019). School nutrition and meal cost study final report volume 4: Student participation, satisfaction, and dietary intakes. U. S. Department of Agriculture Food and Nutrition Service, Office of Policy Support. <https://fns-prod.azureedge.us/sites/default/files/resource-files/SNMCS-Volume4.pdf>
- Gunders, D. (2017, August 16). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill. Natural Resources Defense Council. <https://www.nrdc.org/resources/wasted-how-america-losing-40-percent-its-food-farm-fork-landfill>
- Hanks, A., Just, D., & Wansink, B. (2014). Chocolate milk consequences: A pilot study evaluating the consequences of banning chocolate milk in school cafeterias. *PLoS One*, 9(4). <https://doi.org/10.1371/journal.pone.0091022>
- Haas, J., Cunningham-Sabo, L., & Auld, G. (2014). Plate waste and attitudes among high school lunch program participants. *Journal of Child Nutrition and Management*, 38(1). <https://schoolnutrition.org/journal/spring-2014-plate-waste-and-attitudes-among-high-school-lunch-program-participants/#full-article>
- Hayes, D., Contento, I. R., & Weekly, C. (2018). Position of the Academy of Nutrition and Dietetics, Society for Nutrition Education and Behavior, and School Nutrition Association: Comprehensive nutrition programs and services in schools. *Journal of the Academy of Nutrition and Dietetics*, 118(5), 913–919. <https://doi.org/10.1016/j.jand.2018.03.005>
- Hubbard, K. L., Bandini, L. G., Folta, S. C., Wansink, B., Eliasziw, M., & Must, A. (2015). Impact of a Smarter Lunchroom intervention on food selection and consumption among adolescents and young adults with intellectual and developmental disabilities in a residential school setting. *Public Health Nutrition*, 18(2), 361–371. <http://doi.org/10.1017/S1368980014000305>
- Hudgens, M., Barnes, A., Lockhart, M., Ellsworth, S., Beckford, M., & Siegel, R. (2017). Small prizes improve food selection in a school cafeteria without increasing waste. *Clinical Pediatrics*, 56(2), 123–126. <https://doi.org/10.1177/0009922816677546>
- Kinderknecht, K., Harris, C., & Jones-Smith, J. (2020). Association of the Healthy, Hunger-Free Kids Act with dietary quality among children in the U.S. National School Lunch Program. *JAMA*, 324(4), 359–368. <https://doi.org/10.1001/jama.2020.9517>
- Machado, S., Burton, M., Loy, W., & Chapman, K. (2020). Promoting school lunch fruit and vegetable intake through role modeling: A pilot study. *AIMS Public Health*, 7(1), 10–19. <https://doi.org/10.3934/publichealth.2020002>
- Mansfield, J. L., & Savaiano, D. A. (2017). Effect of school wellness policies and the Healthy, Hunger-Free Kids Act on food-consumption behaviors of students, 2006-2016: A systematic review. *Nutrition Reviews*, 75(7), 533–552. <https://doi.org/10.1093/nutrit/nux020>
- Marcano-Olivier, M. I., Horne, P. J., Viktor, S., & Erjavec, M. (2020). Using nudges to promote healthy food choices in the school dining room: A systematic review of previous investigations. *Journal of School Health*, 90(2), 143–157. <https://doi.org/10.1111/josh.12861>
- Marlette, M. A., Templeton, S. B., & Panemangalore, M. (2005). Food type, food preparation, and competitive food purchases impact school lunch plate waste by sixth-grade students. *Journal of American Dietetic Association*, 105(11), 1779–1782. <https://doi.org/10.1016/j.jada.2005.08.033>
- Marshall, A., Bounds, G., Patlovich, K., Markham, C., Farhat, A., Cramer, N., Ocegüera, A., Croom, T., Carrillo, J., & Sharma, S. (2019). Study design and protocol to assess fruit and vegetable waste at school lunches. *Behavioral Sciences*, 9(9). <https://doi.org/10.3390/bs9090101>
- Martin, D. S. (2017). Food waste: A solvable problem. *Journal of the Academy of Nutrition and Dietetics*, 117(8). <https://doi.org/10.1016/j.jand.2017.05.023>
- Meiklejohn, S., Ryan, L., & Palermo, C. (2016). A systematic review of the impact of multi-strategy nutrition education programs on health and nutrition of adolescents. *Journal of Nutrition Education and Behavior*, 48(9), 631–646. <https://doi.org/10.1016/j.jneb.2016.07.015>
- Metcalfe, J. J., Ellison, B., Hamdi, N., Richardson, R., & Prescott, M. P. (2020). A systematic review of school meal nudge interventions to improve youth food behaviors. *International Journal of Behavioral Nutrition and Physical Activity*, 17(1). <https://doi.org/10.1186/s12966-020-00983-y>

- Miller, N., Reicks, M., Redden, J. P., Mann, T., Mykerezzi, E., & Vickers, Z. (2015). Increasing portion sizes of fruits and vegetables in an elementary school lunch program can increase fruit and vegetable consumption. *Appetite*, 91, 426–430. <https://doi.org/10.1016/j.appet.2015.04.081>
- Mitka, M. (2012). Meal programs questioned. *JAMA*, 308(18). <https://doi.org/10.1001/jama.2012.33468>
- Mumby, S., Leineweber, M., & Andrade, J. (2018). The impact the Smarter Lunchroom Movement strategies have on school children's healthy food selection and consumption: A systematic review. *Journal of Child Nutrition and Management*, 42(2). <https://schoolnutrition.org/journal/fall-2018-the-impact-the-smarter-lunchroom-movement-strategies-have-on-school-childrens-healthy-food-selection-and-consumption-a-systematic-review/#full-article>
- Murimi, M. W., Moyeda-Carabaza, A. F., Nguyen, B., Saha, S., Amin, R., & Njike, V. (2018). Factors that contribute to effective nutrition education interventions in children: A systematic review. *Nutrition Reviews*, 76(8), 553–580. <https://doi.org/10.1093/nutrit/nuy020>
- Niaki, S. F., Moore, C. E., Chen, T.-A., Cullen, K. W. (2017). Younger elementary school students waste more school lunch foods than older elementary school students. *Journal of the Academy of Nutrition and Dietetics*, 117(1), 95–101. <https://doi.org/10.1016/j.jand.2016.08.005>
- Ouzzani, M., Hamady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systemic Reviews*, 5(1), 1–10. <https://doi.org/10.1186/s13643-016-0384-4>
- Peralta, L. R., Dudley, D. A., & Cotton, W. G. (2016). Teaching healthy eating to elementary school students: A scoping review of nutrition education resources. *Journal of School Health*, 86(5), 334–345. <https://doi.org/10.1111/josh.12382>
- Prescott, M. P., Burg, X., Metcalfe, J. J., Lipka, A. E., Herritt, C., & Cunningham-Sabo, L. (2019a). Healthy planet, healthy youth: A food systems education and promotion intervention to improve adolescent diet quality and reduce food waste. *Nutrients*, 11(8). <https://doi.org/10.3390/nu11081869>
- Prescott, M. P., Herritt, C., Bunning, M., & Cunningham-Sabo, L. (2019b). Resources, barriers, and tradeoffs: A mixed methods analysis of school pre-consumer food waste. *Journal of the Academy of Nutrition and Dietetics*, 119(8), 1270–1283. <https://doi.org/10.1016/j.jand.2019.03.008>
- Prescott, M. P., Grove, A., Bunning, M., & Cunningham-Sabo, L. (2020a). A systems examination of school food recovery in Northern Colorado. *Resources, Conservation and Recycling*, 154. <https://doi.org/10.1016/j.resconrec.2019.104529>
- Prescott, M. P., Grove, A., Bunning, M., & Cunningham-Sabo, L. (2020b). Characterizing and assessing the quality of state K–12 share table policies as a potential mechanism to reduce food waste and promote food security. *Journal of Nutrition Education and Behavior*, 52(1), 21–30. <https://doi.org/10.1016/j.jneb.2019.10.014>
- Rainville, A. J., Wolf, K. N., & Carr, D. H. (2006). Recess placement prior to lunch in elementary schools: What are the barriers. *Journal of Child Nutrition & Management*, 30(2). <https://schoolnutrition.org/journal/fall-2006-recess-placement-prior-to-lunch-in-elementary-schools-what-are-the-barriers/>
- Ralston, K. L., Newman, C., Clauson, A. L., Guthrie, J. F., & Buzby J, C. (2008). The National School Lunch Program: Background, trends, and issues. U.S Department of Agriculture, Economic Research Service. <https://www.ers.usda.gov/publications/pub-details/?pubid=46046>
- Schwartz, M. B., Henderson, K. E., Read, M., Danna, N., & Ickovics, J. R. (2015). New school meal regulations increase fruit consumption and do not increase total plate waste. *Childhood Obesity*, 11(3), 242–247. <https://doi.org/10.1089/chi.2015.0019>
- Serebrennikov, D., Katare, B., Kirkham, L., & Schmitt, S. (2020). Effect of classroom intervention on student food selection and plate waste: Evidence from a randomized control trial. *PLoS One*, 15. <https://doi.org/10.1371/journal.pone.0226181>
- Sharma, S., Marshall, A., Chow, J., Ranjit, N., Bounds, G., Hearne, K., Cramer, N., Ocegüera, A., Farhat, A., & Markham, C. (2019). Impact of a pilot school-based nutrition intervention on fruit and vegetable waste at school lunches. *Journal of Nutrition Education and Behavior*, 51(10), 1202–1210. <https://doi.org/10.1016/j.jneb.2019.08.002>
- Spiker, M. L., Knoblock-Hahn, A., Brown, K., Giddens, J., Hege, A. S., Sauer, K., Enos, D. M., & Steiber, A. (2020). Cultivating sustainable, resilient, and healthy food and water systems: A nutrition-focused framework for action. *Journal of the Academy of Nutrition and Dietetics*, 120(6), 1057–1067. <https://doi.org/10.1016/j.jand.2020.02.018>
- Tanaka, C., Richards, K. L., Takeuchi, L. S., Otani, M., & Maddock, J. (2005). Modifying the recess before lunch program. *California Journal of Health Promotion*, 3(4), 1–7. <https://doi.org/10.32398/cjhp.v3i4.1776>

- Tran, C. (2009). An assessment of plate waste within Milwaukee public schools' universal free breakfast-in-the-classroom. Hunger Task Force. <https://dpi.wi.gov/sites/default/files/imce/school-nutrition/pdf/assessment-of-plate-waste-in-milwaukee-ufb-bic.pdf>
- United Nations Department of Economic and Social Affairs. (2015). Transforming our world: The 2030 agenda for sustainable development. <https://sdgs.un.org/2030agenda>
- United States Department of Agriculture. (2017a). The National School Lunch Program. <https://www.fns.usda.gov/nslp/nslp-fact-sheet>
- United States Department of Agriculture. (2021). Food loss and waste. <https://www.usda.gov/foodlossandwaste>
- United States Department of Health and Human Services & United States Department of Agriculture. (2015). Dietary guidelines for Americans 2015-2020 eight edition. <http://health.gov/dietaryguidelines/2015/guidelines/>
- Wansink, B., Just, D. R., Hanks, A. S., & Smith, L. (2013). Pre-sliced fruit in school cafeterias: Children's selection and intake. *American Journal of Preventive Medicine*, 44(5), 477–480. <https://doi.org/10.1016/j.amepre.2013.02.003>
- Wansink, B., Hanks, A. S., Just, D. R. (2015). A plant to plate pilot: A cold-climate high school garden increased vegetable selection but also waste. *Acta Paediatr*, 104(8), 823–826. <https://doi.org/10.1111/apa.13028>
- Williamson, D. A., Han, H., Johnson, W. D., Martin, C. K., & Newton, R. L. (2013). Modification of the school cafeteria environment can impact childhood nutrition. Results from the Wise Mind and LA Health studies. *Appetite*, 61(1), 77–84. <https://doi.org/10.1016/j.appet.2012.11.002>
- World Wildlife Fund. (2019). Food Waste Warriors: A deep dive into food waste in US schools. <https://www.worldwildlife.org/stories/food-waste-warriors>
- United States Department of Agriculture. (2017b). National School Lunch Program fact sheet. <https://fns-prod.azureedge.net/sites/default/files/resource-files/NSLPFactSheet.pdf>
- Zhao, C., Panizza, C., Fox, K., Boushey, C. J., Byker Shanks, C., Ahmed, S., Chen, S., Serrano, E., Zee, J., Failkowski, M., & Banna, J. (2019). Plate waste in school lunch: Barriers, motivators, and perspectives of SNAP-eligible early adolescents in the US. *Journal of Nutrition Education and Behavior*, 51(8), 967–975. <https://doi.org/10.1016/j.jneb.2019.05.590>

Table 1. Summary of educational programming modifications and interventions to K-12 schools and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention	Food Waste Measurement/ Tray Observations	Description of Intervention	Summary of Impact on Food Waste ^b
Wansink et al.2015 ³⁸	New York, 2012	High	N/R	1 school, 370 students	School district- 94% White, 2% African American; 19% students FRL	Lunch	2 Months	Quarter Waste Method n=554 trays February (n=179); March (n=194); April (n=181)	Examination of pre/post pilot of a school garden intervention, independent of corresponding educational materials; the impact of incorporating and advertising garden fresh produce	↑ School garden intervention and advertising of garden-fresh produce resulted in increased consumption but significantly increased waste of vegetables.
Yoder et al. 2015 ³⁰	Wisconsin, 2010-2013 Fall 2010 (8 schools), Spring 2011 (8 schools), Fall 2011 (6 schools), Spring 2012 (3 schools) Spring 2013 (7 schools)	Elementary	3 rd -5 th	1877 students (320 third-grade, 1028 fourth grade and 529 fifth grade)	54% male; 78% White, 12% Native American, 3% African American, 3% Hispanic, 1% Other; 49% students FRL; 66% students NSLP	Lunch	N/R	Digital Photography 7117 trays	Examination of F/V waste from student school lunch trays in schools involved in Farm to School programs.	↓ A slight decrease in waste was observed commensurate with time in the Farm to School program.
Prescott et al.2019 ²⁹	Colorado, 2017	Middle	6 th -8 th	2 schools, 1 district n=268 students educated n=426 peer-education	School A: 45% White, 48% Hispanic, 7% Non-White/ Non-Hispanic School B; 82% White, 8% Hispanic, 10% Non-White/ Non-Hispanic	Lunch	6 months	Digital Photography pre-intervention (n = 256) post-intervention (n = 236) Five-month follow-up (n = 286)	Impact of a student-driven sustainable food systems education and promotion intervention on adolescents' food selection, consumption, and waste behaviors, particularly for fruits and vegetables, during school lunch	↓ Students who participated in the intervention wasted significantly less salad bar vegetables compared to control.

Table 1. Summary of educational programming modifications and interventions to K-12 schools and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention	Food Waste Measurement/ Tray Observations	Description of Intervention	Summary of Impact on Food Waste ^b
Sharma et al. 2019 ²⁷ Marshall et al. 2019 ²⁸	Texas, AY 2017-2018	Elementary	4 th -5 th	3 schools; 115 students; (76 treatment (School 1 – 44, School 2 – 32) and 39 control)	70-84% Hispanic, 7.4-20% African American, 1.2-8.9% White, 1-6.1% Other race; average 90% students FRL	Lunch	1 AY	Weight Method 1,625 trays observed 425 at wave 1 (baseline), 429 at wave 2 (end of fall) 356 at wave 3 (start of spring) 412 at wave 4 (end of spring)	Evaluate food waste following a school-based health promotion program (Brighter Bites) including access to F/V with nutrition education in school and at home	↓ Children who participated in a school-based health promotion intervention had decreased F/V waste compared to control students.
Machado et al. 2020 ³¹	Oregon, AY 2016-2017	Elementary	K-5 th	~ 400 students	57% non-White; 90% students FRL	Lunch	1 school year	Digital Photography 566 trays at baseline, 231 at follow-up (40.8% retention/59.2% attrition)	Evaluate the acceptability and initial outcomes of an adult role modeling intervention on lunchtime fruit and vegetable consumption	↓ Role modeling in the school cafeteria setting associated with decreased plate waste.
Serebrennikov et al. 2020 ⁴¹	Midwestern State, Fall 2016	Elementary	2 nd	98 students (62 treatment/36 control) 135 students (start) 72.6% retention /27.4% attrition	43% female; 91% White; average age 8	Lunch	6 weeks	Digital Photography	Effectiveness of a classroom nutrition education program on the food selected and wasted by the elementary school students in school lunchrooms	⊕ The classroom nutrition program had no effect on the food selected and food wasted by the students in the treatment group in school lunchrooms.

^a Abbreviations: N/R, Not Reported; F/V, fruits and vegetables; AY, Academic Year; FRL, free/reduced-price lunch
^b ↓, decrease in food waste; ⊕, no change in food waste; ↑, increase in food waste

Table 2. Summary of cafeteria environment modifications and interventions to K-12 schools and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention / Modification	Food Waste Measurement/ Tray Observations	Description of Intervention / Modification/ Assessment	Summary of Impact on Food Waste ^b
Marlette et al. 2005 ⁴⁰	Kentucky, 2002	Middle	6 th	743 students, 3 schools (369 Spring 2002, and 374 Fall 2002)	50% male (spring), 52% male in fall; 82% White (spring), 86% White (fall)	Lunch	2 semesters	Plate Waste Method, 4,117 lunch items selected	Influence of food preparation methods and competitive purchases on school lunch plate waste	↑ Competitive food purchase had a significant effect on plate waste for fruit, grain, meat, and mixed dish groups. Plate waste was significantly higher among students buying competitive foods with their school lunch than students, who bought only the school lunch.
Wansink et al. 2013 ³⁴	New York, 2011	Middle	6 th -8 th	2150 students	Predominantly white, 13-44% students FRL	Lunch	1 week	Direct Observation; Tray Waste n=640	Impact of fruit slicers in lunchrooms and instructing staff to use them when students request fresh fruit	↓ Use of fruit slicers associated with significantly reduced fruit waste.
Hanks et al. 2014 ³⁹	Oregon, AY 2010-2011 (control) 2011-2012 (intervention: no chocolate milk)	Elementary	K-5 th	11 elementary schools; 1 district (food waste baseline was collected from 5 NY state schools comparison measures included 10 midwestern schools)	85% White, 8% Hispanic/Latino; 1% African American; Median household income \$52,762; 22% of families below the poverty level	Lunch	Permanent change, waste measured between two school years	Quarter Waste Method, no specific tray # n=44	Comparison of pre/post milk waste following removal of flavored milk from cafeterias	↑ Elimination of flavored milk was associated with an increase in milk waste.
Hubbard et al. 2015	Massachusetts, 2011-2012	Private Residential	N/R	51 students; 1 school (n=43 after exclusions)	80% of families at/below the poverty level; student ages 9-22	Lunch	4 months	Digital Photography 860 trays measured (664 observations used for analysis)	Adapted Smarter Lunchroom strategies including nudging; Enhanced	⊙ Plate waste was not significantly changed.

Table 2. Summary of cafeteria environment modifications and interventions to K-12 schools and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention / Modification	Food Waste Measurement/ Tray Observations	Description of Intervention / Modification/ Assessment	Summary of Impact on Food Waste ^b
				84.3% retention					communication of menu choices, less healthy entree items moved to the back counter, fruit moved to the beginning on serving line as were healthy entree items, unbundling of side dishes from entree items, desserts kept behind the counter. Activities to support these changes: prompting by servers, creation of f/v artwork for the dining hall, test tastes, logo naming and branding.	
Adams et al. 2016 ³²	Phoenix, AZ, 2013	Middle	N/R	533 students; 6 schools, 2 districts (503 students completed both pre and post lunch weights)	Inside Sample: 52% Female; 17.3% White, 11.2% African American, 5.4% American Indian, 3% Asian, 27.6% Other, 35.4% Hispanic Outside Sample: 52% Female; 21.8% White, 5.9% African American, 8.4% American Indian, 1.7% Asian, 13% Other, 48.5% Hispanic	Lunch	2 months	N/R, no specific tray #	Comparison of schools with differing salad bar placements: inside vs outside the line (before/after the point of purchase)	↓ Schools with salad bars after (outside the line) the point of purchase wasted less F/V.

Table 2. Summary of cafeteria environment modifications and interventions to K-12 schools and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention / Modification	Food Waste Measurement/ Tray Observations	Description of Intervention / Modification/ Assessment	Summary of Impact on Food Waste ^b
Hudgens et al. 2017 ⁴²	Ohio, AY 2014-2015	Elementary	K-6 th	111 students at baseline, 96 at follow-up	98% African American, 1% Caucasian; 94% students FRL	Lunch	1 week	Direct Observation, 111 trays baseline, 96 tray follow up	Evaluate food waste following implementation of "Power Plate" reward program; Students receive a small prize for selecting a "Power Plate" consisting of a fruit, vegetable, plain fat-free milk, entrée, and whole grain	⊕ Implementation of a reward program for selecting "Power Plate" components increased selection without increasing waste.
Bean et al. 2018 ⁴⁴	Central Virginia, AY 2015-2016	Elementary	1 st -5 th	17 schools 2,329 fourth- and fifth-grade students	Title 1 schools; >95% African American	Lunch	1 month	Digital Photography 282 plates (trays) at baseline, 443 at follow-up	Comparison of food waste pre/post addition of a salad bar	↑ Addition of a salad bar / slightly increased fruit waste. ↓ Food waste decreased when servings were smaller.
Blondin et al. 2018 ⁴³	N/R, 2015	Elementary	3 rd -4 th	6 schools; 20 classrooms ~480 students	Medium, urban school district; 62% Hispanic, 18% Black, 10% White, 5% Asian	Breakfast	3 days	Weight Method, no specific tray #	Assessment of factors at the school, program, classroom, and/or participant level that predict the amount of milk wasted	↑ Total milk waste increased / when juice was offered. ↓ Teacher encouragement to take and/or consume breakfast was associated with an increase in total and served milk waste. When students were engaged in other activities in addition to eating breakfast, total milk waste decreased.
Farris et al. 2019 ³³	Southwest, VA, AY 2014-2015	Elementary	PreK-5 th	7 schools, 1 district 952 students	15.0-49.1% of students FRL	Breakfast	Permanent change	Quarter Waste Method 1,813 meals observed, 861 in the cafeteria and 952 in the classroom	Comparison of pre/post implementation of Breakfast in the Classroom	↓ Food waste (entrée items, juice, and savory snack foods) decreased with Breakfast in the Classroom implementation.

^a Abbreviations: N/R, Not Reported; F/V, fruits and vegetables; AY, Academic Year; FRL, free/reduced-price lunch

^b ↓, decrease in food waste; ⊕, no change in food waste; ↑, increase in food waste

Table 3. Summary of meal schedule modifications and interventions to K-12 and impact on food waste^a

Reference	Study Location/ Year Conducted	Type of School	Grade Level	Sample Size	Demographics of District, School, and/or Sample	Breakfast or Lunch Intervention	Length of Intervention / Modification	Food Waste Measurement/ Tray Observations	Description of Intervention / Modification/ Assessment	Summary of Impact on Food Waste ^b
Bergman et al.2004 ³⁵	Washington, No Year	Elementary	3 rd -5 th	2 schools, 2008 students	N/R	Lunch	10 days	Weight Method, 1119 observations School 1, 889 observations School 2	Examine impact of scheduling recess before and after the lunch period on food waste	↓ Recess scheduled before lunch was associated with decreased food waste.
Bergman et al.2004 ³⁶	Washington, No Year	Elementary	3 rd -5 th	2 schools, 1877 students;	N/R	Lunch	10 days	Weight Method, 1119 observations School 1 (30 min), 758 observations School 2 (20 mins)	Examine the impact of length of lunch period (30min vs 20min) on food waste	↓ A longer lunch period was associated with decreased food waste.
Tanaka et al.2005 ³⁷	Hawaii, AY 2003-2004	Elementary	5 th -6 th	1 school, 307 students,	N/R	Lunch	N/R	Weight Method 152 baseline and 155 post lunch	Examine impact of scheduling recess before and after the lunch period on food waste	↓ Recess scheduled before lunch was associated with decreased food waste.

^a Abbreviations: N/R, Not Reported; AY, Academic Year
^b ↓, decrease in food waste; ∅, no change in food waste; ↑, increase in food waste