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Design and Rationale for Evaluating Salad Bars and Students' Fruit and Vegetable Consumption: A Cluster Randomized Factorial Trial with Objective Assessments

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Abstract

Building healthy fruit and vegetable (FV) consumption habits early in life is critical for primary prevention. However, U.S. youth do not come close to meeting national recommendations for FV intake. School-lunch salad bars are one of the most heavily promoted ways to meet FV guidelines. Contrary to popular belief, no rigorous randomized trials have examined whether salad bars increase students' FV consumption. This paper describes the design and rationale of a federally funded trial to evaluate whether introducing salad bars in elementary, middle, and high schools affects students' FV consumption and waste during lunch. A cluster factorial randomized trial will test new salad bars against waitlist controls, with and without an additional marketing intervention (N=36 schools, N=6804 students: n=12 elementary, n=12 middle and n=12 high schools). Objective plate waste measurements of individual student's selection of FVs, consumption, and waste will be conducted using digital scales. Primary aim includes comparing FV consumption in schools without salad bars to those with new salad bars by grade level. Secondary aims include: a) whether FV marketing impacts the success of salad bars for FV consumption; b) whether salad bars differentially result in more FV waste compared to traditional serving methods; c) cost-benefit of using salad bars for consumption over traditional serving methods. When complete, this study stands to be one of the most definitive on the effectiveness of salad bars and contextual factors impacting their success. Findings will provide evidence for how to best spend limited federal dollars to improve FV intake in schools.

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Keywords

child nutrition; school lunch; fruit; vegetables; cluster randomized trial; intervention

1. INTRODUCTION

Despite persistent public health efforts, children's fruit and vegetable (FV) consumption is less than one-third the recommended amount [1]. On average, children consume a total of 2 to 3 servings of FVs daily [2]. Because youth consume up to 2 meals and a snack at school [3], schools are important venues for encouraging regular FV intake to develop healthy eating habits and to provide critical nutrients that aid in learning, growth, and development [4–7].

The National School Lunch Program (NSLP) serves over 30 million children daily. In 2017, the program served about 4.9 billion lunches in school cafeterias, >70% of which were free or reduced in price for low-income families at risk for nutritional deficiencies [8, 9]. Significant changes to the school meals program were instated in 2010 through the Healthy Hunger Free Kids Act (HHFKA) [10], which requires schools to offer a greater variety and amount of FVs to children and to ensure that NSLP-participating students take a fruit and vegetable with every meal.

Many school nutrition staff perceive salad bars as effective for increasing FV variety and consumption [11]. The Centers for Disease Control and Prevention (CDC) estimated national prevalence of self-serve salad bars in elementary through high schools at 30.5% (range 24.9%–36.9%) in 2014, with more recent estimates for middle and high schools at 44.1% (range 12.8%–91.2%) in 2016 [12, 13]. Public and private entities are working to promote salad bars in all schools. The US Department of Agriculture (USDA), Centers for Disease Control and Prevention (CDC), and professional associations promote salad bars as an effective way to increase access to FVs in accordance with the HHFKA [11, 14–16]. Salad Bars to School (SB2S) has instituted over 5,400 salad bars in schools, with the goal of having a salad bar in every single school [17]. Although never enacted, the “Salad Bars in Schools Expansion Act” (H.R. 2627) in 2015 called for federal funding to expand use, marketing, and technical assistance for establishing school salad bars nationally [18].

In spite of positive perceptions and recommendations from public health organizations, effects of salad bars on students' FV consumption have not been clearly demonstrated. Most research on school salad bars is observational [19–24], with only two published quasi-experimental evaluations. Slusser et al. tested a multi-component intervention in 3 elementary schools and found improvements of “1.12 items per day” in students' self-reported FV consumption with serial recalls between 1998 and 2000 [25]. Wordell et al. modified cafeterias in a multi-component intervention with 2 middle schools in 2009–2010 and found that students' self-reported FV consumption did not differ across arms [26]. No study has rigorously tested the effects of introducing salad bars on students' FV consumption or waste, tested whether existing FV marketing materials enhance salad bars, quantified costs of such efforts, or replicated effects across grade levels [27].

Given the school meals program's vast reach, any system-wide change can have powerful implications, thus the need for clear evidence to inform policies. The purpose of the current paper is to describe the development and design of a federally-funded cluster-randomized trial testing the effectiveness of school salad bars and FV marketing for increasing FV item selection and consumption for elementary, middle, and high school students.

2. MATERIALS AND METHODS

2.1. Design Overview

This trial systematically addresses many gaps in the literature around school lunch salad bars to develop stronger evidence [27]. The evidence can be improved by: i) using rigorous methods to evaluate the effectiveness of introducing salad bars into school cafeterias where they currently do not exist, ii) evaluating the impact of salad bars with and without nutrition marketing components, iii) examining the cost-benefit trade-offs of introducing salad bars and marketing, and iv) evaluating how salad bar placement within the cafeteria (inside vs. outside of serving lines) impacts FV selection, consumption, and waste by grade level. To achieve these aims, we propose to test the independent and joint effectiveness of a 6-week salad bar only intervention with an additional 4-week FV marketing intervention compared to a wait-list control group in a factorial cluster randomized trial. The primary outcomes include weighed amounts of FV that students objectively select, consume, and waste at lunch.

Figure 1 provides an overview of the proposed design for the current study. A total of 36 schools will be included with a pre-intervention phase and two sequential intervention phases to test our primary and secondary aims. High schools (n=12), middle schools (n=12) and elementary schools (n=12) will be studied across the first three years of the project. Each year we plan to sample and intervene in 12 schools to minimize possible confounding from co-interventions that could occur differentially by school year or grade level, affording the ability to evaluate results across grade levels. Schools will be stratified by grade level and randomized using a block randomization (block size: 4) to one of four groups: 1) new salad bar with marketing intervention, 2) new salad bar with waitlisted marketing control, 3) waitlisted salad bar control with marketing intervention, 4) waitlisted salad bar control with waitlisted marketing control. School-level randomization mitigates any potential confounding by measured or unmeasured school-level characteristics (e.g., menus, size, culture, cafeteria management style). In each school, we will collect objective plate waste measures on three occasions per school year (see Figure 2) to estimate the average amounts (weights) of aggregate FV that students select and discard before and after the interventions to evaluate changes in consumption across conditions.

2.2. Hypotheses

Based on previous research and extrapolations from behavioral economics we propose the following hypotheses:

1. We hypothesize that objectively-measured amounts of FVs that elementary, middle, and high school students select and consume after a 6-week salad bar

intervention versus waitlist salad bar control will be greater in schools receiving salad bars (primary aim).

2. Additionally, we hypothesize that in both the salad bar and non-salad bar groups, selection and consumption will increase for students exposed to the 4-week marketing intervention compared to waitlist marketing control for all grade levels (secondary aim).
3. We further hypothesize an interaction between salad bars and marketing components with their joint influence having the strongest effects on students' selection and subsequently consumption because intake is strongly associated with item selection (secondary aim).
4. Children will eat greater amounts of FVs from the salad bar when located inside vs. outside of the serving line (exploratory aim).
5. Students' FV waste will be higher in schools with salad bars and be higher with salad bars placed inside of the cafeteria service line (exploratory aim).
6. Besides the cost of implementing the salad bar, food and labor costs per gram of intake will differ between salad bar and control schools regardless of marketing (exploratory aim).

Our hypotheses for implementing salad bars and for understanding how placement of salad bars affects FV choice and consumption are grounded in a behavioral economics framework [28]. The usual assumption in classical economics and public policy is that people, including children, are always rational. Conversely, behavioral economics rests on the notion that individuals tend to make errors in evaluating choices – errors that many times lead to patterns of unhealthy choices and behaviors. Behavioral economics works by targeting the choice environment to increase or decrease the probability of certain target behaviors over alternative behaviors. This strategy may be more effective than relying on authorities such as parents/caregivers or teachers mandating behavior change. Principles from behavioral economics have been effective when applied to other health behaviors [28–30]. Our hypothesis that FV consumption will increase by implementing salad bars exploits core mechanisms identified in the literature [31, 32]. First, acknowledging that students have diverse taste preferences that vary by background and over time, salad bars potentially offer greater FV item variety (i.e., primary reinforcer) allowing children with diverse backgrounds to find and select more desirable items, or items that look more desirable in context (e.g. raw carrots on salad bar vs. stewed carrots in entrée), resulting in greater consumption while being exposed to novel items [33]. Present-biased preferences between choices posits that individuals make unhealthy choices that appear to place inordinate weight on immediate benefits of an unhealthy option relative to delayed, larger costs in the future (a temporal discounting of relative consequences). Individuals with stronger present-biased preferences tend to choose convenient options and make decisions on impulse, so making FV items more convenient by implementing a salad bar may be more appealing to some students. Status-quo bias states that individuals tend to choose to remain in their current (default) state or make the same choice over and over to obviate the need to re-evaluate available options at each opportunity. Salad bars may appeal to students who tend to use only one lunch line,

without having to make a conscious decision to enter a line with FVs. Recognizing the importance of convenience to school-aged children who are likely to prefer immediate benefits over delayed ones, Hanks et al. tested changes to school lunchroom design to “influence, but not restrict” meal choices by improving the convenience, attractiveness, and norms of foods offered. Students were 13.4% more likely to take a fruit, and 23.0% more likely to take a vegetable than before the makeover [34]. More importantly, students were 18% more likely to actually consume the fruit taken, and 25% more likely to consume their vegetable, implying that food waste was reduced dramatically. Similarly, Hanks, et al. designed an experiment testing two lunch-lines: arranging a healthy line to be more convenient than an unhealthy line resulted in 18% higher sales of healthier foods, and 28% less (51g) unhealthy food consumed. Even though selection of healthy items increased and intake of unhealthy items decreased, students did not consume as much healthy items thereby wasting more [32]. Although status-quo bias and present-biased preferences represent inherent biases in environmental design that can result in unhealthy choices, these examples show that targeted changes to school food environments to achieve healthful eating and limit waste are complex.

2.3. School Sampling

Using data from a previous Arizona-wide survey of nutrition managers [35], schools identified as having never had salad bars will be recruited into the study. We will supplement this list of schools by placing recruitment calls to food nutrition managers in regional school districts and by attending regional school nutrition events to promote the study. Schools participating in the NSLP, with an average daily NSLP participation of 300 or more students (minimum size needed for sampling), willing to provide student identification numbers and basic demographics (gender, grade level, race, ethnicity, free/reduced eligibility) and willing to implement the interventions as designed will be invited to participate in the study. Schools with open campuses for lunch will be excluded (~3% of Arizona schools). We will aim to enroll schools with populations that approximate Arizona public school system for diverse populations including Hispanics and Native Americans.

2.4. Student Sampling

Random samples of students will be selected at each measurement occasion with replacement using the sampling frame provided by schools. We will select serial samples for several reasons: we cannot anticipate if a specific student will bring a lunch or be ill, truant, in detention, or on vacation on any day over three occasions. Student differences across measurement points will be adjusted for in statistical analyses. Based on power analyses assumed rates of data loss (described in detail below), we plan to make 2,268 student contacts per grade level (12 schools x 63 student contacts per measurement wave x 3 measurement waves), for a total of 36 schools and 6,804 student contacts over the course of the project.

Schools will provide lists of students enrolled at the beginning of the school year in each school and their student identification number (ID), sex, age, grade level, ethnic/racial status (as reported to schools by parent/caregivers), and free/reduced meal status. From these lists, a pre-selected random sample of students will be invited to participate. Before each day of

data collection, a recruitment list of randomly selected student IDs from the participating school will be generated and loaded into computer tablets. A power analyses estimated that a random sample of at least 63 students (contacts) equally stratified by grade level would be needed to ensure a representative group of students from each school at each measurement occasion to evaluate our primary aims. We will randomly select a larger sample than needed from the sampling frame list, track response rates, and once we recruit the number of students required for a measurement occasion, recruitment will stop for the day. Sample will be selected from students enrolled in the school and lined up to receive a hot entrée. A cold lunch may include a pre-made salad, which would likely exclude students from visiting the salad bar. Students in special education programs or in-school detention will be excluded, as these students receive and eat lunch under different conditions. As students line up in the cafeteria, multiple research assistants (RAs) will use tablets with card readers (Figure 3) to identify randomly selected students until desired sample size is reached.

To identify eligible students, study RAs will ask all students lined up for lunch to swipe their IDs or enter their ID numbers into the keypad. An app designed by our team will compare each student's ID to a list of randomly selected IDs for that day. The app will show a positive indication for those selected (see Figure 3 for screen shots of our screening and assent system). Those students identified as eligible will be briefly informed of the study activities and that our interest is to learn what students eat during lunch, but not told of the specific food items of interest (i.e., blinded to the study purpose). Students will be invited to participate and assented following this process. Research staff will provide assented students an empty lunch tray and/or cardboard food "boat" with colored barcoded stickers. Barcodes will allow us to connect each tray to a specific participant ID, minimizing data errors and maximizing privacy and speed. In our preliminary studies, we were able to assent students without increasing the time students spent in lunch lines [19, 36]. This approach will allow us to quickly and efficiently monitor students who are ineligible, refuse, or assent into the study. Given the low risk of this study, Arizona State University's institutional review board approved these procedures and allowed for school principals or superintendents to act in loco parentis for parents/caregivers to provide informed consent before data collection in addition to student assent. This study was registered prospectively with [ClinicalTrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT03283033) (ID: NCT03283033).

2.5. Salad Bar Intervention

We will provide freestanding, mobile-insulated Cambro Versa salad bars to half of the schools for use after baseline data collection delivered and installed during winter holiday break. In a previous survey of over 640 schools in Arizona, we found that this type of salad bar was the most common among schools with existing salad bars [35]. These bars allow for several configurations of trays, compress easily for moving through doorways, come in various heights that are acceptable for all grade levels, have sneeze guards that meet government requirements, and can hold temperatures of 41 degrees and below for four hours. Because schools vary in age of construction, size, and cafeteria design, cafeteria size and layout will determine where schools will locate their salad bar in the cafeterias (i.e., inside service line before point of purchase or in the eating area after point of purchase). Salad bars will be placed in cafeterias starting in early January for at least 10 weeks (during

a minimum 6-wk salad bar phase plus a minimum 4-week marketing phase). Because school staff may not know how to use the salad bar or know best practices concerning their use, we will provide brief support to school nutrition staff by implementing a single training session using existing resources available from various resources (e.g. USDA, Cambro, state and local departments of education, The Lunchbox) that will cover the following: salad bar maintenance and sanitation; students' food handling etiquette, menu and layout (but not marketing); preparation and food handling; use for meeting reimbursable meal requirements; and student food handling etiquette. We will limit staff training to salad bar management and actively encourage staff to not promote FV consumption in other ways (e.g., announce and encourage intake during our presence, enroll in other interventions) during the study period other than existing methods in each school. We will obtain the latest training materials from existing resources to deliver a standardized training in English and Spanish. This will be done by developing a checklist of topics and subtopics and developing practice sessions for research staff. Salad bars will remain in the schools after the completion of the study. Waitlist control schools will receive the same salad bar and training session (and marketing) after the last day of data collection occurs.

2.6. Marketing Intervention

Intervention and control schools randomized to the marketing condition will be asked to implement a selected set of strategies to promote FV consumption (see Table 1 for example materials). A minimum 4-week period for the marketing intervention is consistent with previous studies examining the positive impact of social marketing strategies for improving FV consumption among youth [37, 38]. In choosing marketing materials and strategies, consideration will be given to i) ease of availability, ii) cost, iii) feasibility of implementation, and iv) insights from behavioral research [39, 40]. There is no consensus on the right marketing materials to use by developmental stage or grade level to increase FV consumption. To maximize the utility and generalizability of our findings, we will only select printed materials (e.g., posters and table tents) that are readily available at no or low-cost to food service personnel. For example, USDA's Food and Nutrition Services and Team Nutrition program provide free printed and downloadable materials for schools participating in the national school meal programs. Table 1 shows example FV promotion materials are also available from the Produce for Better Health Foundation, Let's Move Salad Bars to Schools, Team FNV, Cooperative Extension, Fruits and Veggies More Matters, American Heart Association, Smarter Lunchrooms Movement and the Chef Ann Foundation. Marketing materials will be selected such that the same materials can be used for promoting FV in salad bar and non-salad bar conditions (i.e., non-specific to salad bars). Other feasible, frequently used strategies such as enticing names and public service announcements will also be included.

We will pretest a range of materials for acceptability and developmental appropriateness with stakeholders. Separate survey assessments for the marketing materials will be conducted with 745 school nutrition and school food service professionals from across the U.S. for 64 randomly selected pieces taken from the sources noted above (i.e., 35 rankings per marketing piece). Additionally, 60 students (i.e., 10 boys and 10 girls separately from elementary, middle, and high schools) from local schools that are not participating in the

study will provided feedback on the highest scoring pieces from professionals. In pretesting, stakeholders will rank existing materials for likability, attractiveness, and perceived impact on FV consumption behaviors. Materials with the top scores from stakeholders will be used. We will make specific recommendations to schools for appropriate placement of materials and strategies, so placements are consistent with behavioral theories for promoting FV consumption. For example, we will advise school staff to place posters and other materials promoting self-selection of FV at or before choice points, and materials promoting consumption of FV, e.g., table tents, will be placed at the point of consumption. Further, each school's cafeteria manager (or proxy) will be asked to keep a simple log of marketing activities such as announcements made, types of FV offered for taste testing, and promotional materials posted and their locations.

2.7. Measurement

Figure 2 expands on Figure 1 showing the measurement and intervention timeline during the school year. Each school participates for one year only. The first plate waste measurement occasion (M1: pre-intervention) will occur in October to November of each school year. Once pre-intervention measures are complete, to test the primary aim, schools will be randomized to either a new salad bar or the salad bar waitlist control condition starting once students return from the winter holiday break. Given that the study is located in the southwest, we do not expect wide seasonal variation in FV offerings. We will measure FVs a second time in each school during the intervention phase to test for differences in amounts selected, consumed, and wasted across conditions. Realistically, we anticipate measurement will occur in mid-February and, assuming assessments at 2–3 schools per week, take about 4 weeks to complete at each measurement occasion (M2-M3 in Figure 2) resulting in some schools having longer intervention phases. After the salad bar intervention condition, schools will retain their new salad bar or waitlist control condition status and will be randomized for a second time to either a new FV marketing or marketing waitlist condition to test for an interaction between the presence vs. absence of salad bars and presence vs. absence of marketing. A third measurement of FV amounts taken, consumed, and wasted will occur in each school during the marketing intervention beginning in mid-March. Figure 2 also shows that measurements 2 and 3 occur late enough for novelty effects from salad bars or marketing to have subsided.

2.7.1 FV Plate Waste Measures—Research staff will undergo 10-20 hrs of training to practice logistics and weighing methods in a mock cafeteria environment before working in school, which will include a special focus on food safety (e.g., using disposable gloves). Assented students will be handed a pre-weighed tray and/or paper boat with a barcode(s) and asked to proceed in their usual manner to get their lunch. After choosing FV items, RAs will guide participating students with a barcode to the measurement table where plate weight will be measured by placing the entire tray with FV items (minus entrée dish), or bagged items alone, or their paper boat for FV items (depending on the school) on a digital scale accurate to 2 g (Figure 4 **top**). Participants' barcodes will be scanned and plate weight will be recorded. After eating, as students approach a garbage bin, RAs attending to the receptacles will collect trays from students with colored barcode stickers, and students will be thanked and allowed to select a small incentive from a grab bag. The collected trays will

be placed on a vertical cart for later weighing outside of the eating area. Remaining FV items will be scraped onto scales for individual post-lunch weighing. Weights of the serving tray, cups, bags, measurement cups, and paper plates will be subtracted from each measurement to produce a net weight. FV weights will include fruit rinds (e.g., peels from whole fruits) if present (Figure 4 **bottom**). Because all students, regardless of school and study condition, will be measured in the same way, potential reactivity due to measurement activities should not differ across conditions or schools. School administrators will be asked not to change their usual routine, emphasize our presence, or attempt to encourage consumption of any specific item during measurement activities. Participants will be blinded. Baseline measures occur prior to randomization. It is not possible to blind staff measuring post-weights. Table 2 provides an overview of our study measures.

2.7.2. Marketing Measures—We will collect detailed information on the number, types, placement, and scope of the marketing efforts using a standardized protocol during baseline, measurement visits, and biweekly fidelity checks (see below). Data collectors will be trained to identify marketing materials and to look for such materials in specific locations. Information will also be collected from the school office on frequency and details of public service announcements promoting FV and from the kitchen staff on frequency and types of FV used for taste testing.

2.7.3. Placement of Salad Bar—As applicable, we will record the placement of salad bar as inside vs. outside the serving line. If the salad bar is placed outside the serving line, we will measure the distance from the point of sale. We will also note if there is a monitor (as required if the SB is used as part of a reimbursable meal).

2.7.4. Cost Measures—Each cost item will be recorded for each school, with costs characterized as either fixed or variable. Fixed costs include those associated with salad bar installation, any other infrastructural cost that does not vary with the amount of FV ordered or consumed by students, and additional training for staff in maintaining a clean cold chain so that fresh FV served in the salad bars is refrigerated, cleaned, stored, and handled properly. Refrigeration and storage infrastructure may represent additional fixed costs depending on facilities available at each school. Variable costs include additional procurement costs for higher volumes of FV, as well as costs associated with increasing the range of items available. An assessment of additional staff labor hours required to prepare FVs and keep a salad bar stocked, cleaned, and the FV presented properly will be conducted. Waste is an additional variable cost as it is assumed to rise in proportion to the amount ordered. A key measure of success for each intervention component will be the proportion of FV selected by students that is consumed (i.e., the amount not wasted).

2.7.5. Intervention and Control Condition Fidelity Checks—Staff will briefly visit intervention and control schools bi-weekly during the intervention phases to ensure fidelity and/or document any variation in the use/quality of salad bars, marketing, or control conditions.

2.7.6. Covariates & Additional Measures—We will quantitatively measure covariates and confounding variables and adjust for them in analyses. To be able to

understand the contextual, qualitative factors related to our findings, we will also collect the measures from schools using a checklist (e.g., for number and types of FVs, location and scope of marketing materials, placement of salad bars inside vs outside of the line), existing data (e.g., student demographics and production records that will allow us to examine the overall composition of the meals and salad bars), and/or photographs (e.g., marketing materials, number and type of FVs on salad bars).

2.8. Sample Size and Power

The proposed study will use a cluster factorial randomized trial design with repeated cross-sections. Using 75 grams (g) to represent 1 serving of FV, we chose to power the study to detect mean between-condition differences (s) as small as 25g (1/3 serving of FV). Data from our prior studies of school salad bars using plate waste measures suggest that 50g is a reasonable estimate for the standard deviation (*SD*) of FV consumption and 0.10 is a reasonable estimate for a school-level intra-class correlation (i.e., within-school clustering). Accepted methods for testing for between-condition differences in change from baseline to any given post-intervention time point for serial samples[41] indicate that within each grade level, a complete-case sample size of $N_c = 12$ schools (6 schools per Salad Bar condition or 3 schools per Salad Bar x Marketing combination) and $N_p = 50$ student contacts with complete data per school at each of 3 time points affords power of 0.92 to detect a mean difference as small as 25g, given $SD = 50g$ (i.e., Cohen's $d = 0.50$) assuming $\alpha = 0.05$ and an autocorrelation between temporally adjacent school means of 0.80. In anticipation of up to 20% loss of students during measurement activities (e.g., a student's tray is not intercepted before he/she disposes of it), we will initiate 63 student contacts ($50 / (1 - 0.20) = 63$) per school at each time point ($N_c \times N_p \times 3$ time points = 2,268 total student contacts per grade level) to ensure a sufficient complete-case sample. We will first use univariate and bivariate statistics and plots to examine distributional characteristics of outcome measures, explore patterns of missingness, and to identify potentially relevant background confounders and covariates. Where appropriate, we will examine reliabilities (e.g., McDonald's ω_T) for composite measures.

3. STATISTICAL ANALYSES

3.1. Primary Aims

Linear mixed models (LMMs) will be used to test the efficacy of the intervention components with fixed effects of Time point (baseline vs. immediate post-test), Salad Bar (control vs. new salad bar), and the Time x Salad Bar interaction to predict FV intake within each school grade level (i.e., elementary, middle, and high school). Models will also include random components for school-specific intercepts (to account for clustering within schools) and for Time x School combination (to account for clustering among students within each school at each time point).[42, 43] Relevant cohort-, school-, and student-level background covariates (e.g., school year, % receiving free/reduced lunch, sex, age, race/ethnicity) will be included in all models to account for differences resulting from serial samples of students over time within the same schools and across schools. We expect a significant Time x Salad Bar interaction such that the increase in FV intake from baseline to immediate post-test (i.e., the Time point effect) will be greater in schools receiving salad bars than in waitlist control

schools. We will also explore differences in intervention effects across grade levels, anticipating the largest Salad Bar x Time effects at the high school level and smallest effects at elementary level.

To evaluate the marketing components, LMMs paralleling those used above, with fixed effects of Time point (either baseline vs. post-marketing follow-up or immediate post-test to post-marketing follow-up), Salad Bar (control vs. salad bar), Marketing (no marketing vs. marketing), and Time x Salad Bar, Time x Marketing, and Time x Salad Bar x Marketing interactions as predictors of FV intake. Random School and Time x School intercept components will be included. We expect Time x Salad Bar x Marketing and Time x Marketing interactions such that increase in FV intake from baseline to post-marketing follow-up will be greatest in salad bar schools also exposed to marketing and weakest in schools receiving neither salad bars nor marketing. We also expect the increase in FV intake from immediate post-test to post-marketing follow-up to be greater in the schools receiving marketing than in those not receiving marketing. Pairwise between-condition differences in change will be also be examined using focused pairwise interaction contrasts (e.g., Time x [Salad Bar + Marketing vs. Control + No Marketing]).

3.2. Secondary Aims

To explore the effect of placement of salad bars for schools receiving salad bars, a LMM framework paralleling will evaluate salad bar placement by testing a Time x Placement (inside line vs. outside line) interaction effect. We hypothesize greater increases in FV intake in schools where the salad bar is inside the line compared to outside of the line.

Because food waste is a critical concern, we will examine this outcome separately. LMMs paralleling those used above will test for a Time x Salad Bar interaction, Time x Salad Bar x Marketing and Time x Marketing interactions, and a Time x Placement interaction on waste. Based on results from our preliminary studies we hypothesize FV waste will (a) decrease in schools with salad bars (vs. those control), (b) decrease in schools receiving marketing campaigns, and (c) increase with the new salad bar inside of the service line (vs. schools with new salad bars outside the service line)[36].

3.3. Missing Data

We will employ an intention-to-treat analysis strategy and will mitigate any potential effects of missingness on estimates of treatment effects (bias) and statistical tests (loss of power) by using full information maximum likelihood (FIML) estimation methods and/or multiply imputed datasets, depending on patterns of missingness observed.

3.4. Economic Analysis

Economic impact will be assessed by comparing cost per gram of FV consumed in control vs. salad bar schools, and for both the marketing and salad-bar treatments for schools randomized to both. The cost index will include both fixed and variable cost components described in Table 2. Fixed costs associated with salad bars will be allocated across all grams consumed for each school at each measurement day. For the marketing treatment, all costs associated with the marketing efforts will be included in fixed costs associated with the

marketing intervention and period of use. It is assumed that there are no incremental costs associated with placement of the salad bar out of the service line as compared to inside the service line.

4. DISCUSSION

Salad bars are being heavily promoted by public and private entities to schools across the United States as a way to meet federal meal guidelines for FVs, to increase FV variety, and to encourage increased consumption of FVs. However, no randomized controlled studies have been conducted on the effectiveness of salad bars on consumption or waste or how fruit and vegetable marketing may enhance salad bar use across grade levels. This study will provide federal/state policy makers and schools with critical information needed to make evidence-based decisions.

School administrators are very sensitive to relative cost of implementing something new in their schools. A 2002 report to Congress estimated that food waste costs from school nutrition programs may be as high as \$600 million per year [44]. On average, students only consume about 60% of the foods served at lunch [45]. Given the enormity of the school meals program, promoting a school meal system-wide strategy without sufficient evidence has significant health-related and economic implications. Greater evidence is needed to support costly policy efforts related to school salad bars.

By systematically evaluating the impact of salad bars on FV consumption, relative to their cost, further justification for (or against) salad bars will be provided for policy makers and administrators to make informed decisions with their limited budgets to increase student FV intake. Further, findings from this study will set the stage for research on how we can best design cafeteria environments to promote FVs and other healthy foods to children in schools.

This project stands to be one of the most definitive studies to date on the effectiveness of salad bars in schools and when its aims are achieved, it will address: 1) whether introducing salad bars help to increase FV consumption, 2) whether existing marketing materials modify the relationship between salad bars and students' FV consumption, 3) whether salad bars and marketing have any joint effect on students' FV waste, 4) whether evidence supports a cost-benefit of salad bars on consumption, and 5) each of these questions by grade level (i.e., elementary to high school). By providing answers to these critical questions, we will inform public policies, school administrators, and health programs related to increasing FVs in schools. Findings will provide evidence for how to best spend limited federal dollars to improve FV intake in schools.

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Figure 1.
Overview of proposed design, experimental conditions and measurement timepoints.

Figure 2.
Timeline of measurement and intervention activities over the school year.

Figure 3.

Photo of tablets used to assent students using digital scanner to link student IDs to tray/boat barcode IDs.

Figure 4.
Examples of weighed FV items before (top) and after lunch (bottom).

Table 1.

Marketing Materials to be Used to Promote Fruit and Vegetable Consumption in Schools with and without Salad Bars

Location in Cafeteria	Type	Example Materials	Sources of Materials
Prior to point of decision to serve (various locations in school and cafeteria)	Informational	Posters; morning announcements	Team Nutrition [39], Team FNV [40], American Heart Association [41], Fruits and Veggies More Matters [42]
Point of decision to serve (lunch line)	Nudges	Taste testing; item tags; enticing names	Smarter Lunch Rooms Movement [43], Cooperative Extension [44]
Point of consumption (table and cafeteria)	Reminders	Table tents; cafeteria announcements	American Heart Association [41], Chef Ann Foundation [45], U.S. Department of Agriculture [46], Team Nutrition [47]

Table 2.

Planned Study Measures and Items

Measures	Item
FV plate waste	Aggregate FV taken (g fresh FV taken from salad bar or service line)
	Aggregate FV consumed (g fresh FV taken - g FV wasted)
	% Aggregate FV wasted (g fresh FV taken - g FV wasted / g fresh FV taken)
Marketing	#, type of print materials used and location
	Frequency & content of Public Service Announcements
	Frequency & types of FV for taste testing
Placement	Inside vs outside the line
	(if outside) <ul style="list-style-type: none"> Distance from point of sale Monitor (y/n)
Cost	Cost of FVs served
	Labor costs (# FTEs)
	Refrigeration cost
	Staff training cost
	Stocking and cleaning cost Fixed costs associated with additional facilities
Covariates	Student contact data <ul style="list-style-type: none"> Gender Grade Free/reduced priced lunch status Race/ethnicity Student's use of salad dressing Student's entrée and other food choice selection
	Actual duration salad bar & marketing interventions (days)
	# and type of entree options selected
	# of hot and cold FVs selected (item variety)
	# and type of milk, other sides, salad dressing (y/n) selected
	# and type of FVs on salad bar (as applicable)
	Availability of competitive foods (y/n)
	Number of serving lines
	Day of week data collected
	Production records: week prior, of, and before measurement
	School year
Additional	School nutrition manager's perception of salad bars Bi-weekly assessment of any variability to condition adherence