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EVALUATION OF A SCHOOL-BASED FRUIT AND VEGETABLE

INTERVENTION USING A DIGITAL PHOTOGRAPHY METHOD

BY

NATALIE RUTH WEISFELD

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE

IN

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UNIVERSITY OF RHODE ISLAND

2018

MASTER OF SCIENCE THESIS

OF

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UNIVERSITY OF RHODE ISLAND
2018

ABSTRACT

Objective: The primary objective is to use digital photography of food to assess if a policy, systems, and environment (PSE) intervention increases the amount and variety of healthful fruits and vegetables consumed at lunch by low-income 5th graders.

Design: Quasi-experimental design.

Participants/Setting: The sample consisted of low-income 5th grade students in the Providence School District, n = 130 (treatment school, n=75, control school, n=55).

Intervention: Both the treatment and control students were assessed at baseline and post intervention to determine amount consumed and variety of fruit and vegetable using a digital photography of food method. Within the treatment school, four out of the six classrooms agreed to participate in the 8-lesson *Student's Take Charge* in-class intervention.

Main Outcome Measures: Consumption of healthful fruits and vegetables (excluded French fries, tomato sauce, and fruit juice) in cups and variety from digital photographs.

Analyses: Consumption differences were assessed using the Mann-Whitney U for between group changes and Wilcoxon signed-rank test for within groups. Pearson chi-square compared variety.

Results: There was a difference between groups for change in consumption of fruit ($p<0.01$); within group analyses showed the treatment group decreased (M=0.12 cups, SD=0.46, p= 0.02) while the control group had a non-significant increase (M=0.12 cups, SD=0.49, p=0.20). There were no differences between or within groups for vegetable consumption ($p>.05$). Within treatment group variety of fruits decreased (Baseline: 59.3% with 1 or 2 fruits; Follow-up: 30.9%), and within the control group, variety of fruits increased (Baseline:11.7% with 1 or 2; Follow-up: 33.3%). Variety of vegetables decreased in the treatment group (Baseline: 49.4% with 1 or 2; Follow-up: 8.6%), and variety of vegetables was minimal at both time points within the control group (Baseline: 6.7%; Follow-up:8.3%). Although at baseline treatment children were more likely to have at least one fruit (59%) or vegetable (49%) than children in the control school (fruit 12%, vegetables 7%; $p<.001$), at follow-up most students in both groups had no fruit (67-

69%) or no vegetables (91-92%) on their trays (p>.05).

Conclusions and Implications: The intervention was not successful in increasing consumption or variety of fruits and vegetables. The observed decrease in fruit consumption in the experimental group may be associated with different fruit options on observation days. Future research should explore changes in the eating environment to increase availability of preferred healthful fruit and vegetable options.

ACKNOWLEDGMENTS

PREFACE

This thesis was prepared in manuscript format following the author guidelines for

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"Evaluation of a School-based Fruit and Vegetable Intervention Using a Digital

Photography Method"

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INTRODUCTION

Children age 9-13 years old are not meeting the minimum recommendations for fruit and vegetable (FV) consumption based on the 2015-2020 Dietary Guidelines for Healthy Americans[1]. Low FV intake and lack of variety have been associated with higher body weight in children[2–5]. It is important for children to consume healthful fruits and vegetables[5]. Healthful fruits and vegetables are those low in saturated fat, sodium, and high in fiber, and excludes items such as French fries, fruit juices, and tomato sauce[5,6]. Thirty one percent of children age 10-17 in the United States were overweight or obese in 2011-2012[7]. The prevalence was slightly lower at 28.3% of all children in Rhode Island being overweight or obese and increased with 38.6% Hispanic children being overweight or obese[3,7]. The Rhode Island Supplemental Nutrition Assistance Program Education (SNAP-Ed) has developed "Students Take Charge!" (STC), a policy, systems, and environment (PSE) program focusing on empowerment and a healthy lifestyle. STC is an in-class PSE curriculum for 5th grade students. Although process data from the pilot year of STC indicated that students had an increased FV consumption, outcome analyses failed to find any dietary changes in FV consumption[8,9].

The lack of effect of STC on intake may be related to the use of a two-item FV survey to measure consumption[8]. Measurement of intake is difficult in children and particularly challenging among 5th graders in low-socioeconomic populations[10,11]. Digital photographic methods such as the Digital Photography of Food Method (DPFM) have been validated to objectively measure consumption, but until now have not been used to assess the effectiveness of PSE interventions in low-income schools[12–14].

The primary aim of this study was to use DFPM to determine if the STC

intervention increased the amount of healthful fruits and vegetables consumed at lunch by low-income 5th graders in an intervention school more than a control school. The secondary aim of this study was to determine whether the STC intervention increases the variety of healthful fruits and variety of vegetables chosen at lunch in the intervention school more than control school.

METHODS

Design

The PSE intervention, "Students Take Charge!" (STC) utilized a 2x2 quasi-experimental design. STC is a research study that was piloted in the previous year and modified based on feedback reported by Lepe et al. in their process evaualtion[9]. The current STC classroom-based program consisted of eight lessons taught by SNAP-Ed educators. The objective was to empower low-income elementary students to increase FV consumption and to choose a variety of FVs. Table 1 provides a brief outline of the lessons and the activities by group. Both the intervention and control students were assessed pre and post school lunch meal at baseline and post intervention by DPFM to determine the amount of healthful fruit and vegetables consumed; variety of healthful fruits and vegetables was determined by the pre-meal DPFM at baseline and follow-up. DPFM allows for objective measurement of consumption and variety of FVs without relying on self-report. Within the treatment school, four out of the six classrooms agreed to participate in the in-class intervention. Two classrooms within the treatment school declined to participate in the education component, but were exposed to environmental changes such as the recipe day in the cafeteria and promotional posters. The treatment group with education received an 8-lesson curriculum, selected a recipe for a fruit or

vegetable item for school lunch, and participated in organizing an all-school taste testing during school lunch on recipe day. The two classrooms that did not participate in the education, participated in taste testing a recipe in the cafeteria and were assessed using DPFM at the two time points. The control school did not receive any intervention. Demographic information was collected from the students in the treatment group with education and the control school only. Demographic information was not collected for the treatment group without education.

Research Question/Hypothesis

All students were from the fifth grade, and all comparisons are baseline to follow-up:

i. Primary: Students in the intervention group will increase the amount of healthful FVs consumed at lunch more than students in the control group.

ii. Secondary: Students in the intervention group will increase the variety of healthful FVs selected at lunch more than students in the control group.

iii. Exploratory: Within the intervention school, the four classes that participated in the STC intervention will increase the amount of healthful FVs consumed at lunch more than the two classes that did not receive the intervention.

Subjects

Providence, Rhode Island is a diverse city[15]. Approximately 179,219 people live in the city of Providence, with 23.4% of the population being under 18 years old[15]. As of April of 2010, 49.8% of the population was white, 16.0% black or African American, 1.4% American Indian and Alaska Native, 6.4% Asian, 0.1% Native Hawaiian and Other Pacific Islander, 6.5% are two or more races, 38.1% are Hispanic or Latino, and 37.6% were white alone not of Hispanic decent[15]. Approximately 29.1% of persons are living in

poverty, and the median household income is $37,501 as of 2015[15]. Providence Public School District's (PPSD) 22 elementary schools adopted a no-fee meal policy as part of a Community Eligibility Provision's pilot program in 2016[16,17]. All students attending PPSD elementary schools have the opportunity to select a school lunch at no cost[17].

Primary and secondary aims included subjects from control and intervention schools, and the exploratory aim only included 5th graders from the intervention school. The intervention school had six, 5th grade classrooms, four of which agreed to have their students participate in the school-based intervention, n=75. DPFM data from the other two classrooms were collected, n=34. These students were exposed to the school-wide taste testing on recipe day and signage promoting FV but did not receive the in-class education, STC. The control school had three 5th grade classrooms that were assessed within two weeks of the intervention school data collection points, n=55. Each classroom had around 25 students however due to absences every student's tray was not photographed, resulting in an overall analytical sample of 164 students. Only students with four pictures, two at baseline pre and post meal, and two at follow-up pre and post meal were included for hypotheses 1 and 3, and only students with one baseline pre-meal photo and one follow-up pre-meal photo were included for hypothesis 2. For hypothesis one, n=75 from the treatment school with education and n=55 from the control school. For hypothesis two, n=81 from the treatment school with education and n=60 from the control school. For the exploratory hypothesis, n=75 from the treatment school with education and n=34 from the treatment school without education group.

Student Eating Environment

Students had access to FV via two avenues in the cafeteria: on the tray line and in

the garden carts. Providence Public School District (PPSD) schools provide students with a garden cart in all cafeterias. The garden cart is a salad bar that consists of an assortment of FVs available to the students without any restriction on quantity. Students were free to select how much and how many FV they would like from these carts. The garden cart placement is different from school to school.

The intervention school had an open-floor plan with a stand-alone garden cart, away from the cafeteria line. Within the treatment school, students enter the cafeteria and follow the tray line to receive their entrée, and a pre-plated fruit or vegetable, depending on the menu for that day, from the cafeteria staff. Once the students received their meal tray, they were able to walk to the garden cart where they served themselves fruits or vegetables. The control school had a closed-floor plan with the garden cart, attached to the end of the line in the cafeteria. Within the control school, students entered the tray line to receive their entrée and pre-plated FVs from the cafeteria staff, and then walked by the garden cart to self-serve FVs on their way out of the service area. Refer to Appendix C and D for placement of garden cart and cafeteria set up of the treatment school and control school.

Procedure

For the STC program, key stakeholders identified two schools in the PPSD. Once the two schools agreed, they were randomly selected as the treatment or control. Students in both schools completed demographic surveys at the same time as the intervention school and were assessed using digital photography during meals at pre and post intervention. This study was approved by the University of Rhode Island Institutional Review Board.

Data collection

The data collection procedures were the same for all three aims. Students were assigned a unique ID number. The students' numbers were then placed on an index card attached to a lanyard with a colored sticker that correlated to their classroom number. The ID sheets and lanyards were locked in a secure cabinet in Room 300 at URI College of Continuing Education (CCE) in Providence, RI.

The research photographers were Registered Dietitians, graduate students, and undergraduate students, all who attended training prior to data collection on DPFM procedures. The procedures were based on Masis et al., Foodwise Project, for data collection methodology[18].

A fixed method was developed and included four cellular phone tripods. The tripods were 14 inches from the table, and a cellular phone was attached and placed at a 45-degree angle. All persons involved were trained on how to prepare the tripod and phone prior to data collection consisting of a written explanations as well as 1-2 verbal meetings prior to data collection, and an overview prior to data collection while at the school. Practice photographs were taken during training and feedback provided until assessors were proficient. The cellular phone cameras were all calibrated prior to data collection in order to insure consistency of the quality of photo and size.

For the intervention group and 2 non-participating classes, data collection occurred at baseline and after the 8th STC lesson, approximately 4 months after baseline. The control group data were collected within a 2-week period of intervention group data. At both baseline and follow-up, photos using the DFPM method were taken before eating ("pre-meal") and after eating ("post-meal").

On each day of data collection, SNAP-Ed researchers confirmed enrolled students in each classroom and assigned ID numbers to new students. Each student was given his or her unique lanyard prior to going to the cafeteria for lunch. The research photographers explained the data collection process to the students. The students were then read a script to explain the data collection process. The same protocol was conducted on subsequent days until all classrooms had data collected.

In the cafeteria in both schools, students are seated by classroom and each classroom was assigned two tables. There were two research photographers per table; each photographer photographed the student's tray across from him/her until the entire tables' photographs were collected. Researchers were given a diagram to help follow protocol as well as the layout of each cafeteria.

During data collection, lists of FVs available to the children were collected each day. The "garden cart" was photographed each day, and the foodservice staff provided a list of pre-plated FVs. In addition each item was referenced according to size (i.e. pieces, 1 whole, or converted to cups compared to a reference photo plated on a scale).

Intervention

STC was an 8-lesson PSE (policy, systems, and environment) intervention focused on fruit and vegetable intake with 5th grade students in the PPSD. The curriculum included 8 lessons (see Table 1). STC encouraged the consumption of healthful fruits and vegetables. The curriculum did not include French fries or juice as part of a healthful diet. This program allowed students to "have a say" in what they are being served in-school, and allowed them the opportunity to try fruits and vegetables in a different way.

Data Analysis

FVs served were identified. Items that were pre-plated followed standardized recipes with standardized portions, and items chosen from the "garden cart" were identified as whole pieces of fruit or vegetables, prepackaged portions in cups, or, for salad items, in relation to a weighed measure and converted to cups. For the purposes of this study, French fries, fruit juice, and tomato sauce were excluded[6]. The visual estimation for consumption is based on the protocol of the FoodWise Project (outlined in Table 2)[18]. Separate sums were calculated for fruits and vegetables; the sum of items per plate (pre-plated and garden cart) were calculated and defined as amount.

The dependent variable for the primary hypothesis was calculated by subtracting the amount of FVs recorded from pre-photo minus the amount in post-photo from both intervention and control schools. This difference was defined as the amount of fruits and amount of vegetables consumed by the student. Students missing pre meal or post meal photos at either time point were excluded.

The secondary hypothesis was analyzed using the variety of fruits selected and variety of vegetables selected for each subject from both the intervention and control schools. The investigator used the pre-meal photo to count the number of fruits (variety) and the number of vegetables (variety). Each different fruit or vegetable was identified as 1 in variety. The total number of different fruits added together is variety of F, and the total number of different vegetables added together is variety of V. The number of students n=141 is greater than the number of students for the primary hypothesis (n=130) due to missing post photos. Eleven children's trays were missing from post-meal assessment due to children leaving prior to data collection.

Within the intervention school, the exploratory hypothesis looked at the amount

of fruit and amount of vegetables consumed by the four 5th grade classes with education compared to the classes that did not receive education. The same method to assess consumption for the primary hypothesis was used.

Statistics

Continuous data were assessed for normalicy; consumption data were not normally distributed (kurtosis > 2) thus non-parametric statistics were utilized for the primary and exploratory hypotheses. Mann-whitney U was used in order to analyze between group changes, and Wilcoxon signed-rank tests were conducted for within group change. In addition, Wilcoxon signed-rank tests were used to compare consumption between groups at baseline. For hypothesis two, variety, Pearson chi-square was used to analyze data. Demographic data at baseline were compared between groups using Pearson chi-square or student's t-tests.

RESULTS

There were no statistically significant differences between group by age, gender, or ethnicity (p>0.05) (see Table 3). The treatment group (n=75) comprised of 47.9% female, 52.1% male, 70.5% Hispanic, and 29.5% non-Hispanic. The control group (n=55) comprised of 45.8% female, 54.2% male, 60.9% Hispanic, and 39.1% non-Hispanic. The total sample (n=130) had 47.0% female, 53.0% male, 66.4% Hispanic, and 33.6% non-Hispanic.

The primary hypothesis of this study was to see if the treatment group with education increased the amount of cups of fruits and amount of cups of vegetables consumed at lunch more than the control group from baseline to follow-up. Data analysis protocol for defining consumption can be seen in Table 2. At baseline, both groups had a

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low intake of fruits and vegetables; the treatment group consumed an average of 0.26 cups of fruit and 0.03 cups (~1/2 tablespoon) of vegetables and the control school consumed an average of 0.11 cups of fruit and 0.04 cups of vegetables. As shown in Table 4, there was a significant difference between groups ($p<0.01$) for fruit consumption with the control school increasing fruit consumption more than the treatment school. There was a significant decrease of 0.12 ± 0.46 cups within the treatment school ($p=0.02$); the control school increased fruit consumption by 0.12 ± 0.49 cups but this was not statistically significant ($p=0.2$). There were no significant differences between ($p=0.13$) or within groups (treatment school; $p=0.41$, control school; $p=0.71$) from baseline to follow-up for vegetable consumption. The treatment school had a non-significant increase in vegetable consumption by 0.01 cups while the control school had a non-significant decrease in vegetable consumption by 0.01 cups from baseline to follow-up.

The secondary hypothesis of this study was to see if the treatment group increased the variety of fruits and vegetables at lunch more than the control school from baseline to follow-up. Variety is defined as the number of different items on the tray for fruits and number of different items for vegetables. At baseline, there was a statistically significant difference in fruit variety between the treatment and control school ($X^2=33.29$, $p<0.001$); a smaller proportion of treatment students had no fruit on their trays (40.7%) than control students (88.3%) (see Table 5). At follow-up, there were no statistically significant differences for fruit variety ($X^2 = 0.22$, $p = 0.90$), 68.1% had no fruits on their trays. At baseline, there was a difference between schools in variety of vegetables ($X^2=30.73$, $p<0.001$); 50.6% of treatment school participants had no vegetables on their tray

compared to 90.3% of control school students. At follow-up, there was no difference in vegetable variety, 91% of participants had no vegetables on their tray (X^2=1.52, p=0.47). The treatment group decreased variety of fruits from baseline to follow-up, but there was no change in the control group (Table 6). The control group increased variety of vegetables but there was no change in the treatment group. A substantial proportion of students 27 to 60% of students had no fruit on their trays at either time point and 48 to 88% of students had no vegetables on their trays at baseline and follow-up.

The exploratory group in the treatment school did not receive formal education, but were exposed to the recipe tasting and the posters around the school. Comparing students in the two classes that did not receive education to the four classes that did, there were no differences between groups for fruit (p=0.32) or for vegetables (p=0.37) as seen in Table 7. As reported above, the treatment group decreased fruit consumption with no change in vegetable consumption. There were no changes within the exploratory group, students consumed 0.27 cups of fruit at baseline, 0.30 cups of fruit at follow-up, and 0 cups of vegetables at both time points.

Due to the significant differences at baseline for both fruit and vegetable variety, further tests were conducted excluding pre-plated items from both the consumption and the variety variables. Tables 8 through 10 show the consumption and variety without pre-plated items, garden cart only. Within the treatment and control school, a majority of FV consumption was of the garden cart items. The treatment school consumed a total of 0.26 cups of fruit at baseline, 0.20 cups were garden cart items, and 0.06 cups were pre-plated item, and at follow-up, 0.14 cups of fruit were consumed, 0.09 from the garden cart, and 0.06 were pre-plated. Within the control school, all fruits at baseline and follow-up were

consumed from the garden cart. Vegetables were minimally consumed at both time points, and a majority were from the garden cart as seen in Table 8. The treatment school consumed a total of 0.03 cups of vegetables at baseline, 0.03 cups were garden cart items, and 0 cups were pre-plated item, and at follow-up, 0.04 cups of vegetables were consumed, 0.02 from the garden cart, and 0.02 were pre-plated. All vegetable consumption from the control school were garden cart items. Variety decreased in groups when pre-plated items were excluded (Table 9). At baseline, only 16.3% of the total sample had at least one fruit on their tray, and 19.9% at follow-up; only 5.7% of the total sample had at least one vegetable on their tray from the garden cart at baseline, and 6.4% at follow-up. At baseline, variety of fruits and vegetables without pre-plated items did not differ between schools (vegetable: X^2=0.01, p=0.94; fruit: X^2=2.30, p=0.13). At follow-up, variety of vegetables without pre-plated items and variety of fruits without pre-plated items also did not differ (vegetable: X^2=0.86, p=0.35; fruit: X^2=3.83, p=0.05). Excluding pre-plated items, there are no within group changes (Table 10).

The decrease of fruit consumption by the treatment school can be seen in Figure 1. At both schools the only fruits served both at baseline and follow-up were oranges, apples, and pears. The greatest differences were for oranges. At baseline in the treatment school 11 students consumed all or a portion of an orange but only 4 students consumed oranges at follow-up. In the control school, 1 student consumed all or a portion of an orange at baseline and 5 at follow-up.

In addition to oranges, pears and apples (see Figure 1), there were other FVs provided at different time points. The treatment school did not provide bananas at baseline or follow-up. Although the control school did not provide bananas at baseline

the school provided them at follow-up (n=13). The pre-plated items were also not consistent at baseline or follow-up within or between schools. This is illustrated by changes in pre-plated fruit items in the treatment school. Blueberries (n=6) and a frozen peach cup (n=6) were pre-plated at baseline accounting for a total of 4.4 cups of fruit consumed. At follow-up, pre-plated applesauce (n=8) and a strawberry cup (n=2) were provided and students consumed a total of 3.9 cups of these pre-plated fruits.

DISCUSSION

This study found that students consumed an average of 0.03 cups (~1/2 tablespoon) of vegetables during school lunch, and consumption appeared to be affected by options available during mealtime. Consumption was slightly better for fruit averaging 0.20 to 0.21 cups. To our knowledge, this is the first PSE intervention to be assessed using a DPFM method. Although the hypothesis that the PSE intervention would improve consumption was not supported, this study aids in understanding the school lunch environment and how it plays a role in eating behavior.

There was a significant change in fruit consumption between groups but no between-group change in vegetable consumption. However, the difference in fruit consumption ± 0.12 cups was small and, as described below, was likely due to changes in fruit offered at different time points. Mean consumption of fruit at baseline was higher at the treatment school than the control school, but this was reversed at follow-up. Perry et al. assessed change in FV consumption and found that children increased their daily FV consumption by 1/3 cups after receiving a nutrition intervention, but this study did not assess change related to school lunch[2,19,20]. Studies in the school lunch environment continue to find FVs to be the most wasted items[21]. Within the literature and consistent

with this study, students have higher intake of fruits than vegetables[1,20,22]. Hubbard and colleagues used DPFM to assess the impact of implementing Smarter Lunchroom strategies in a Massachusetts Residential school[23]. Students increased fruit consumption by 0.18 cups and vegetables by 0.07 cups, demonstrating effectiveness of this intervention[23]. Implementation of Smarter Lunchroom strategies should be considered for future development of STC. However, it is important to note that the STC student sample is Hispanic and lower income than the schools studied within the literature[14,23–25]. Lower income populations are known for having a lower intake of FVs than their higher income counterpart[1,7].

Although this study looked at fruit and vegetable consumption separately, a majority of the literature combines FVs into one variable. For comparative purposes, we combined fruits and vegetables; students consumed 0.24 cups of FVs on average at baseline and 0.23 cups of FVs at follow-up. Martin et al. assessed FVs combined, and found that students selected an average of 1.10 cups of fruits and/or vegetables at lunch, and wasted 0.40 cups ($p<0.005$) on average, consuming 0.70 cups at school lunch[26]. Consumption of FV in STC was lower than found by Martin et al. Amin and colleagues assessed the NSLP environment in two Northeastern elementary schools in a sample of third, fourth, and fifth graders, 84-90% white, and 40-60% of children qualified for free or reduced lunch. The researchers evaluated 944 trays using DPFM before and after implementing the 2012 NSLP guidelines. They found that consumption of FVs averaged from 0.48 cups to 0.54 cups before implementation, and 0.42 cups to 0.47 cups after implementation[25]. Amin and colleagues included fruit juice and mixed dishes in the total consumption of FVs, which may explain the large consumption of FVs compared to this

study. Consumption of FVs varies in children regardless of intervention, but the current study found lower consumption than generally reported in the literature.

The decrease in fruit consumption may be partially explained by different items provided at the different time points. The types of fruits served at baseline and follow-up were not consistent. Children selected and consumed canned fruit in juice in the treatment school at baseline, however canned fruit in juice was not an option at that school at follow-up, which accounted for some of the decrease. The pre-plated item at follow-up for the treatment school was applesauce or strawberries, and students consumed 0.5 cups less of these pre-plated items than the canned fruit in juice offered at baseline. At the control school, bananas were not provided at baseline but were provided at follow-up. Children appeared to chose and consume bananas frequently. A study within a Farm to School participating Wisconsin school found that canned fruits in juice were wasted less than whole fruits, while cooked vegetables were wasted more than raw[27].

Although there were no statistically significant differences in variety from baseline to follow-up between groups, it is important to note that 61% of the total sample did not have a fruit on their tray at baseline, 69% did not have a vegetable at baseline, 68% did not have a fruit at follow-up, and 92% did not have a vegetable at follow-up. According to the NSLP guidelines, a reimbursable meal should include three food groups, with one being a ½ cup portion of an F or V. However, this study only assessed the consumption of healthful FV, excluding French fries, tomato sauce, and fruit juice. This was not able to assess NSLP compliance. Tabak et al. surveyed school foodservice workers finding that most reported that they were not aware of the current NSLP guidelines, and those that were aware struggled to enforce them[28]. Research by Amin et

al found that 15.7% of trays did not have an FV on them when students were not prompted to select one[25]. The current study found a greater proportion of students without healthful FV at both time points (73%). It is important to note that the NSLP considers French fries a vegetable whereas this study excluded French fries from FV consumption and variety due to the STC curriculum encouraging healthier FV choices. A study by Hakim et al. suggests students will select more if they are given an active role in deciding what they will eat, and allowed to choose food according to their preferences[29]. Many studies have suggested that since the 2012 update of the NSLP school guidelines consumption of FV have decreased[25,30].

This study found that variety was very low; 59.6% of students from both schools, and 83.0% of students from both schools did not have a fruit or a vegetable on their tray at either time point. The majority of fruit and vegetable items were from the garden cart that were actively selected by the student. Pre-plating items is not enough to get children to consume FVs. Fruit consumption increased by 0.05 cups when items were pre-plated, and only 0.01 cups when vegetables were pre-plated. Consistent with the literature, this study shows that low-income minority children selected and consumed less fruits and vegetables than their higher income counterpart from the literature[22,31]. This suggests that action needs to be taken at the school foodservice level in order to get children to consume more FVs,

There were no differences within the treatment school comparing students in the four classrooms with education to students in the two classrooms that did not choose to participate. However, the non-participating classes did not consume any vegetables at either time point. The treatment school group without education may have selected fruit

at a greater frequency than vegetables[32].

Strengths and Limitations

A strength of this study is that, to the author's knowledge, this is the first PSE intervention to be assessed using a digital photography method. The study sample is mostly Hispanic, low-income, and from urban areas. This study focused on healthful FV and excluded French fries, tomato sauce, and juice from total FV consumption. However, there were several limitations. The sample size was small, and photographs were taken over multiple days at baseline and follow-up. The items being served at each school were not identical at both time points. Only 3 items, orange, pears, and apples, were consistent from baseline to follow-up. Another limitation is the definition of variety. In this study, variety was defined as different types of fruits and vegetables where as the NSLP and the Dietary Guidelines defined variety by subgroup of fruits and vegetables[33,34]. Other limitations include items missing from photos, students being absent, or withdrawing from school prior to follow-up data collection.

IMPLICATIONS FOR RESEARCH

Although this study did not find significant increases in FV intake associated with the PSE intervention, it is important to note that although these schools are participants in the NSLP, only a small proportion of students had a healthful fruit or a vegetable on their tray. Only 12% of students had 1 or 2 fruits at both time points, and 5% had 1 or 2 vegetables at both time points. In the future, it is recommended that PSE interventions include a component for school foodservice workers. If healthful items are not being provided to the children, they can't consume them. Pre-plating items did not appear to increase FV consumption in this study. Further action is recommended such as allowing

active choice, implementing Smarter Lunchroom strategies, and allowing students to have a choice in the selection of FVs[23,29]. The allowance of active choice may also increase variety selected by students. Making preferred FVs accessible to the children is important to encourage consumption[23,29,35].

TABLES

Table 1: Students Take Charge Lesson Plan and Activities by Group

STC Lesson	Topic	Group		
		T	C	E
Photo Collection		✓	✓	✓
Demographic Surveys		✓	✓	
Lesson 1	MyPlate/Fruits & Veggies you Enjoy	✓		
Lesson 2	Variety of FVs and their Function/Overcoming Barriers to Eating FVs	✓		
Lesson 3	Amounts of F&V/Recipe Reading (25-30 min)	✓		
Lesson 4	Go, Slow, Whoa/Role-playing interviewing adult about favorite Fruit or Veg recipe (25-30 min)	✓		
Lesson 5	Healthy Snack/Taste Tasting & Discussions on slogans/persuasive messages (25-30 min)	✓		
Lesson 6	Winning Recipe Announced/Make Posters (25-30 min)	✓		
Lesson 7	Making Requests & Practice Polling (25-30 min)	✓		
Recipe Tasting Day		✓		✓
Lesson 8	Overview of STC and Recap	✓		
Photo Collection		✓	✓	✓

T=Treatment Group With Education
C=Control Group
E=Treatment Group without Education
✓=Group Exposed

Table 2: Steps for Data Analysis of Consumption

Step 1	The FVs consumed are assessed based on a percentage that is missing from the pre-photo (i.e. pre-plated 4 oz. cup of berries, 25% left in post-meal photo = 1 oz. berries at post, 4oz-1oz = 3 oz. consumed).
Step 2	The graduate student researcher will then use the known pre-plated portions, or reference photos from the "garden cart" to analyze amount on the tray.
Step 3	The graduate student researcher will use the post-meal photo to analyze the amount consumed. This will be done by referencing the pre-meal photo and using the criteria from the FoodWise project to estimate the amount left on the tray.
Step 4	Consumption will be calculated by subtracting the amount in the pre-meal photo and post-meal photo.

Table 3: Demographics of Low-income Fifth Grade Participants Two Providence Public Schools

Categorical Variables	Treatment (n=75)[a]	Control (n=55)[a]	Total (n=130)[a]	t
Age (years)	10.51 ± 0.60	10.58 ± 0.81		0.62
Gender				X^2
Female	36 (47.9%)	25 (45.8%)	61 (47.0%)	
Male	39 (52.1%)	30 (54.2%)	69 (53.0%)	0.92
Total	75 (57.7%)	55 (42.3%)	130 (100%)	
Ethnicity				
Hispanic	53 (70.5%)	33 (60.9%)	101 (66.4%)	
Non-Hispanic	22 (29.5%)	22 (39.1%)	51 (33.6%)	0.29
Total	75 (57.9%)	55 (42.1%)	130 (100%)	

a.   Not all students responded to every question.

* $p<.05$, ** $p<.01$, ***$p<.001$

Table 4: Change in Consumption of Fruits and Vegetables in Cups from Baseline to Follow-up

Variables	Baseline Amount Consumed (Mean ± SD)	Follow-up Amount Consumed (Mean ± SD)	Within Group Change Amount Consumed (Mean ± SD)	Between Group Change (*p*)
Fruits				
Treatment (n=75)[a]	0.26 ± 0.398	0.14 ± 0.285	-0.1220 ± 0.46*	0.009
Control (n=55)[a]	0.11 ± 0.318	0.23 ± 0.466	0.1216 ± 0.49	
Total (n=164)[a]	0.21 ± 0.361	0.20 ± 0.389		
Vegetables				
Treatment (n=75)[a]	0.03 ± 0.211	0.04 ± 0.154	0.0073 ± 0.27	0.130
Control (n=55)[a]	0.04 ± 0.169	0.03 ± 0.236	-0.0114 ± 0.15	
Total (n=164)[a]	0.03 ± 0.173	0.03 ± 0.172		

a. Not all students participated in tray photos.

* p<.05, ** p<.01, ***p<.001

Table 5: Variety of Fruits and Vegetables At Baseline and Follow-up by Group

Variables	Baseline Variety			Follow-up Variety		
	0	**1 to 2**	**Total**	**0**	**1 to 2**	**Total**
Fruits						
Treatment (n=81)[a]	33 (40.7%)	48 (59.3%)	81 (57.4%)	56 (69.1%)	25 (30.9%)	81 (57.4%)
Control (n=60)[a]	53 (88.3%)	7 (11.7%)	60 (42.6%)	40 (66.7%)	20 (33.3%)	60 (42.6%)
Total (n=141)[a]	86 (61.0%)	55 (39.0%)	141 (100%)***	96 (68.1%)	45 (31.9%)	141 (100%)
Vegetables						
Treatment (n=81)[a]	41 (50.6%)	40 (49.4%)	81(57.4%)	74 (91.4%)	7 (8.6%)	81 (57.4%)
Control (n=60)[a]	56 (93.3%)	4 (6.7%)	60 (42.6%)	55 (91.7%)	5 (8.3%)	60 (42.6%)
Total (n=141)[a]	97 (68.8%)	44 (31.2%)	141 (100%)***	129 (91.5%)	12 (8.5%)	141 (100%)

a.   **Not all students participated in tray photos.**
* p<.05, ** p<.01, ***p<.001

Table 6: Change in Variety of Fruits and Vegetables Within Groups from Baseline to Follow-up

	Treatment Group (n=81)		Total
	Baseline		**Total**
	0	**1 or 2**	
Follow-up			
0 Fruits	22 (27.2%)	34 (42.0%)	56 (69.1%)
1 or 2 Fruit	11 (13.6%)	14 (17.3%)	25 (30.9%)
Total Variety of Fruit	33 (40.7%)	48 (59.3%)	81 (100%)*
	Baseline		Total
Follow-up	0	1 or 2	
0 Vegetables	39 (48.1%)	35 (43.2%)	74 (91.4%)
1 or 2 Vegetables	2 (2.5%)	5 (6.2%)	7 (8.6%)
Total Variety of Vegetables	41 (50.6%)	40 (49.4%)	81 (100%)
	Control Group (n=60)		Total
	Baseline		**Total**
	0	**1 or 2**	
Follow-up			
0 Fruit	36 (60.0%)	4 (6.7%)	40 (66.7%)
1 or 2 Fruit	17 (28.3%)	3 (5.0%)	20 (33.3%)
Total Variety of Fruit	53 (88.3%)	7 (11.7%)	60 (100%)
	Baseline		Total
Follow-up	0	1 or 2	
0 Vegetables	53 (88.3%)	2 (3.3%)	55 (91.7%)
1 or 2 Vegetables	3 (5.0%)	2 (3.3%)	5 (8.3%)
Total Variety of Vegetables	56 (93.3%)	4 (6.7%)	60 (100%)***

* p<.05, ** p<.01, ***p<.001

Table 7 Change in Consumption of Fruits and Vegetables in Cups from Baseline to Follow-up within Treatment School Comparing Treatment to Non-treatment Classes

Variables	Baseline Amount Consumed (Mean ± SD)	Follow-up Amount Consumed (Mean ± SD)	Within Group Change Amount Consumed (Mean ± SD)	Between Group Change (*p*)
Fruits				
Treatment (n=75)[a]	0.26 ± 0.398	0.14 ± 0.285	-0.1220 ± 0.46*	0.322
Non-treatment (n=34)[a]	0.27 ± 0.309	0.30 ± 0.434	0.0956 ± 0.44	
Total (n=164)[a]	0.21 ± 0.361	0.20 ± 0.389		
Vegetables				
Treatment (n=75)[a]	0.03 ± 0.211	0.04 ± 0.154	0.0073 ± 0.27	0.374
Non-treatment (n=34)[a]	0.00 ± 0.000	0.00 ± 0.000	0.0000 ± 0.00	
Total (n=164)[a]	0.03 ± 0.173	0.03 ± 0.172		

a. Not all students participated in tray photos.
* p<.05, ** p<.01, ***p<.001

Table 8: Change in Consumption of Fruits and Vegetables in Cups from Baseline to Follow-up Without Pre-plated Items[b]

Variables	Baseline Amount Consumed (Mean ± SD)	Follow-up Amount Consumed (Mean ± SD)	Within Group Change Amount Consumed (Mean ± SD)	Between Group Change (*p*)
Fruits				
Treatment (n=75)[a]	0.20 ± 0.396	0.09 ± 0.266	-0.1117 ± 0.45*	0.002
Control (n=55)[a]	0.11 ± 0.318	0.23 ± 0.466	0.1216 ± 0.49	
Total (n=164)[a]	0.16 ± 0.367	0.15 ± 0.370		
Vegetables				
Treatment (n=75)[a]	0.03 ± 0.209	0.02 ± 0.086	-0.1270 ± 0.23	0.217
Control (n=55)[a]	0.04 ± 0.169	0.03 ± 0.236	-0.0114 ± 0.15	
Total (n=164)[a]	0.03 ± 0.193	0.02 ± 0.166		

a. Not all students participated in tray photos.
b. Pre-plated refers to items plated by cafeteria staff on the tray line.
p<.05, ** p<.01, ***p<.001

Table 9: Variety of Fruits and Vegetables at Baseline and Follow-up Without Pre-plated[b] Items by Group

Variables	Baseline Variety			Follow-up Variety		
	0	**1 or 2**	**Total**	**0**	**1 or 2**	**Total**
Fruits						
Treatment (n=81)[a]	64 (79.0%)	17 (21.0%)	81 (57.4%)	70 (86.4%)	11 (13.6%)	81 (57.4%)
Control (n=60)[a]	54 (90.0%)	6 (10.0%)	60 (42.6%)	43 (71.7%)	17 (28.3%)	60 (42.6%)
Total (n=141)[a]	118 (83.7%)	23 (16.3%)	141 (100%)	113 (80.1%)	28 (19.9%)	141 (100%)
Vegetables						
Treatment (n=81)[a]	77 (95.1%)	4 (4.9%)	81(57.4%)	74 (91.4%)	7 (8.6%)	81 (57.4%)
Control (n=60)[a]	56 (93.3%)	4 (6.7%)	60 (42.6%)	58 (96.7%)	2 (3.3%)	60 (42.6%)
Total (n=141)[a]	133 (94.3%)	8 (5.7%)	141 (100%)	132 (93.6%)	9 (6.4%)	141 (100%)

a. **Not all students participated in tray photos.**
b. Pre-plated refers to items plated by cafeteria staff on the tray line.
* p<.05, ** p<.01, ***p<.001

Table 10: Change in Variety of Fruits and Vegetables Within Groups from Baseline to Follow-up Without Pre-plated Items

	Treatment Group		Total
	Baseline		**Total**
	0	**1 or 2**	
Follow-up			
0 Fruits	58 (82.9%)	12 (14.8%)	70 (86.4%)
1 or 2 Fruit	6 (54.5%)	5 (6.2%)	11 (13.6%)
Total Variety of Fruit	64 (79.0%)	17 (21.0%)	81 (100%)
0 Vegetables	70 (86.4%)	4 (4.9%)	74 (91.4%)
1 or 2 Vegetables	7 (8.6%)	0 (0%)	7 (8.6%)
Total Variety of Vegetables	77 (95.1%)	4 (4.9%)	81 (100%)
	Control Group		**Total**
	Baseline		
	0	**1 or 2**	
Follow-up			
0 Fruit	39 (65.0%)	4 (6.7%)	43 (71.6%)
1 or 2 Fruit	15 (25.0%)	2 (3.3%)	17 (28.4%)
Total Variety of Fruit	54 (90.0%)	6 (10.0%)	60 (100%)
0 Vegetables	55 (91.7%)	3 (5.0%)	58 (96.6%)
1 or 2 Vegetables	1 (1.7%)	1 (1.7%)	2 (3.4%)
Total Variety of Vegetables	56 (93.3%)	4 (6.7%)	60 (100%)

* p<.05, ** p<.01, ***p<.001

Figure 1

Figure 1: Number of Children Who Consumed Fruits Offered by Both Schools at Both Times
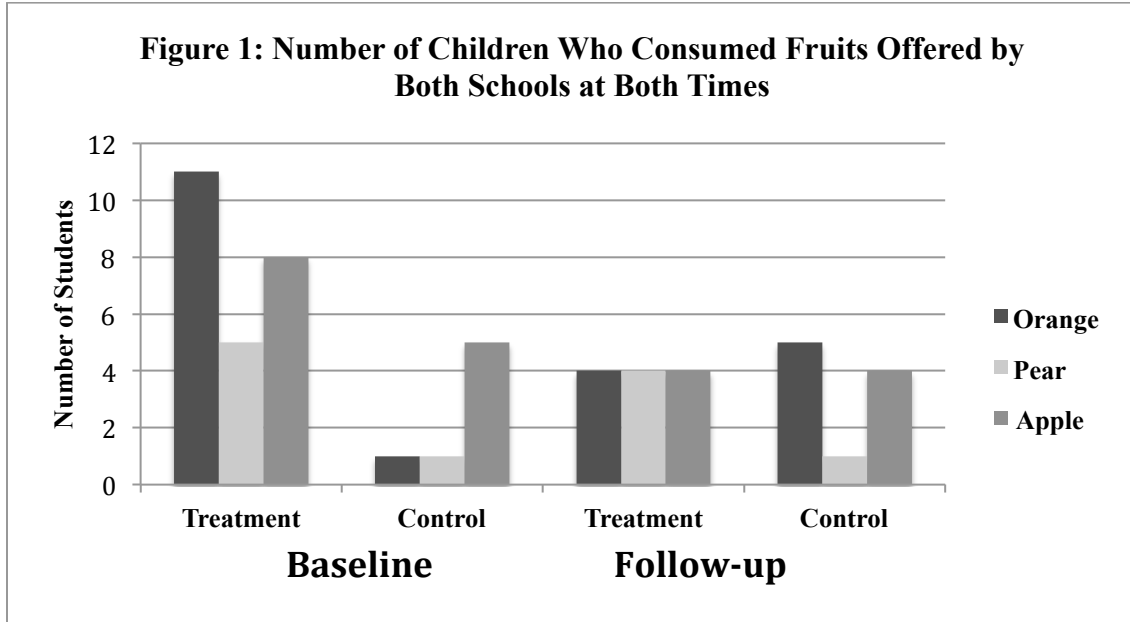
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A. LITERATURE REVIEW

Introduction

As fruit and vegetable (FV) consumption continues to be a problem with elementary aged children, collection of dietary intake data is pertinent[1]. Accurate collection of fruit and vegetable dietary intake data is challenging in children due to the reliance on memory, their limited vocabulary, and the lack ability to identify foods to their food groups[1]. This review will examine current research related to fruit and vegetable consumption and variety among children as well as methods to collect these data, including DPFM, will describe outcomes of the pilot *Student's Take Charge!* (STC) program, the National School Lunch Program, importance of nutrition interventions, and the student-eating environment.

Background of National School Lunch Program (NSLP)

The NSLP is responsible for feeding nutritious, well-balanced meals to more than 31 million children each day in the public school system[2,3]. Research reports that students who participate in the NSLP and the School Breakfast Program (SBP) may consume up to 47% of their daily nutrients from these items provided by the school[4]. In 2012, the USDA made changes to the NSLP regulations[5]. With the new regulations of NSLP in 2012, the requirements for a reimbursable meal changed. The final school meal standards of 2012 limit energy and provide minimum and maximum amount of energy for each age group[6]. The standards also required a serving of fruit or a serving of vegetables daily with a weekly requirement of vegetable subgroups (variety), and students were no longer allowed to refuse fruits and vegetables[4,6]. They had to choose at least one fruit or one vegetable. The new standards were designed to help children improve their dietary

intake[6].

When foodservice workers were interviewed, they reported many barriers to following the new regulations such as increased labor cost, minimal understanding of the current ruling, and the lack of understanding about the new NSLP guidelines, its goals, and its need for participation/support at multiple levels on the part of parents, teachers, school staff, stakeholders, and foodservice workers[7]. Districts who had more support with NSLP tended to be districts reporting greater success with implementing the new NSLP guidelines[7].

Fruit and Vegetable Consumption

FVs are high in fiber, water, and nutrients that are not energy dense. Consuming the recommended amounts of FVs is associated with lower total energy intake/density and increased satiety[8]. Epidemiological studies have shown a positive association between increased FV intake and decreased risk of obesity later in life[9]. Furthermore, children who consume diets rich in FVs are more likely to maintain these habits into adulthood and decrease the likelihood of excessive weight gain in adulthood[10].

According to recent data, the U.S. population on average does not consume the recommended amounts for fruits and vegetables[11]. Children, 9-13 years old consume an average of 1.1 cups of fruit a day compared to the recommendation of 1.5 – 2.0 cups[11]. For vegetables, children ages 9 to 13 eat an average of 1.0 to 1.1 cups of vegetables a day compared to the recommendation of 1.5 to 3.0 cups per day [11].

Variety of Fruits and Vegetables

Many epidemiological and cohort studies support the benefits of consuming adequate amounts of FVs. FVs contain nutrients essential for healthy body function and growth including Vitamin A, C, and K, potassium, magnesium, and phytonutrients, all

which are currently under-consumed in the United States today[11–14]. Based on the 2015-2020 Dietary Guidelines, the U.S. population also does not meet the recommended intake for any subgroups of vegetables, indicating a lack of variety as seen in Table 1[11].

Table 1: Recommendations and Weekly Average Intake of Vegetables for Children 9-13[11]		Weekly Recommendation (cups)	Weekly Average Intake (cups)
Subgroup of Vegetables		**Weekly Recommendation (cups)**	**Weekly Average Intake (cups)**
Dark Green	**Males**	1.5-2.5	0.4
	Females	1.0-2.0	0.4
Red and Orange	**Males**	4.0-7.0	2.1
	Females	3.0-6.0	2.0
Starchy Vegetables	**Males**	4.0-7.0	2.7
	Females	3.5-6.0	2.7
Other	**Males**	3.5-5.5	1.8
	Females	2.5-5.0	1.8

As seen in Table 1, male and female children meet less than 50% of the weekly recommended average intake of any subgroup. About one-third of the intake of fruits comes from fruit juice, and the remaining two-thirds from whole fruits (which includes cut up, cooked, canned, frozen, and dried fruits)[11]. Potatoes and tomatoes are the most commonly consumed vegetables, with potatoes accounting for 21 percent and tomatoes 18 percent of vegetables consumed[11]. This is of concern due to potatoes being a starchy vegetable that is often consumed in its high fat, high sodium form, French fries[11]. Specifically, lower income Americans consume more calorically dense foods than their higher income counterparts and are at a higher risk for disparities due to limited access to resources[15]. This increases the risk of disease due to poor nutritional quality.

Socioeconomic Status (SES) and FV Variety/Consumption

SES during childhood has been shown to be a strong predictor of adult health outcomes[16]. Two common indicators used to classify adolescent SES is parental

education and parental income[17]. A longitudinal study with 896 adolescents found that high-income families reported greater accessibility to FV at home compared to their low-income counterparts (Healthy Eating Index (HEI) FV subscale score 5.0 vs. 4.1, $p<0.001$)[18]. Results suggested a large reason low SES adolescents eat less FV than high SES adolescents is due to the decreased access in the home setting[18]. Likewise, this longitudinal study found that adolescents of higher education parents reported having greater preferences for FV, greater knowledge of FV recommendations, and stronger intentions to meet dietary FV guidelines[18]. Low SES is not only a national issue but also a local problem in Rhode Island.

Thirty-seven percent of the children living in Providence, RI live below the poverty line, 33% receive SNAP benefits (government assistance for purchasing food), and 88% are eligible for free or reduced meals[19].

Access to FVs is limited for low-income families[20]. Based on the HEI 2005, low-income families have lower component scores for total fruits and a statistically significant lower score for total vegetables ($p<0.05$) as compared to their higher income counterparts[20]. Specifically, low-income families have lower consumption of dark leafy greens and orange fruits and vegetables[11]. The Dietary Guidelines report that a majority of vegetable consumption by low-income populations consists of starchy vegetables such as; potatoes, corn, and peas[11].

FV and Obesity

Childhood obesity has been linked to a high prevalence of metabolic syndrome in children, that rises with increased obesity[21]. Obesity is defined as being at or above the 95th percentile on the BMI-for-age growth chart by the Centers for Disease Control (CDC) for children under 18 years old[22,23]. In Rhode Island, 28.3% of children age 10-17

are overweight or obese[24]. Overweight and obesity prevalence in Rhode Island vary by race and ethnicity. Hispanic children from core cities are more likely to be overweight or obese when compared to non-Hispanic white children not living in a core city[25–27]. Increased consumption of fruits and non-starchy vegetables is inversely related with weight change[28]. Specifically, this study observed better weight management with the consumption of each extra daily serving of fruit, and an increase in total vegetable intake was also associated with prevention of weight gain[28]. However, an increased intake of starchy vegetables such as corn, peas, and potatoes was associated with weight gain[28]. One study with children at risk of obesity 8-12 years old showed that an increase in FV intake may lead to a decrease of energy dense foods leading to weight management and decreasing the incidence of obesity[13,14]. Furthermore, children who have healthy dietary habits in adolescence, such as consuming FVs, have a higher likelihood of carrying these habits into adulthood and decreasing their risk of obesity in adulthood[8–10].

School Eating Environment

There are many factors that can influence a child's meal patterns. Research conducted in elementary schools participating in the NSLP found that the classes that had recess before lunch had a higher consumption of FVs compared to students who had recess after lunch[4]. Another study found that children who received recess prior to lunch increased their fruit consumption by 5.1%[29] and increased their likelihood of consuming at least one fruit or vegetable by 10% compared to those who have recess after lunch[30]. A Washington state elementary-school plate waste study found that FV food waste decreased from 40.1% to 27.2% when lunch followed recess[31].

Research shows that there are certain foods that are typically accepted by children more than others such as bananas and French fries[4,32–34]. With the current NSLP

guidelines, reimbursable meals are required to have at least one serving of fruit or vegetables. One study showed that pre-plated vs salad bar items are still wasted at the same frequency as salad bar items at meals[32]. Salad bar items are those that are self-served and self-selected by the child[32]. Their study found canned fruits in juice were wasted less than whole fruits, while cooked vegetables were wasted more than raw[32]. Providing students with a variety of choices both hot and cold may to increase school FV consumption[3].

One approach to create change in in the school lunchroom is CAN (*Convenient, Attractive, Normal)* approach that has been studied be Wansink and colleagues[35]. The strategy focuses on making food more *Convenient* in the lunchroom, this can be done by changing the location where healthier food is served or by pre-packaging items[35]. The *Attractive* component focuses on displaying the healthier foods in more appealing ways[35]. The last part of this strategy is *Normal*[35]. *Normal* can be achieved by using the power of suggestion to make the healthy choice seem more socially acceptable[35]. This can be achieved by having a standardized location on each child's tray for a fruit or a vegetable. The Smarter Lunchroom Movement is an initiative that was designed to help achieve the CAN approach[36,37]. The Smarter Lunchroom Movement changes are simple and low-cost that can easily transform the school environment to promote healthy choices[36]. Changes include displaying whole fruits in attractive bowls or baskets instead of hotel pans, creating descriptive names for FVs, and politely prompting students to select a fruit or a vegetable[37]. Studies assessing the Smarter Lunchroom Movement have found that through this approach, FV sales have increased by 20% in schools[38].

Reporting Methods for Amount and Variety Consumed of FV

Dietary intake can be difficult to assess in children for a number of reasons. Some

common instruments include food frequency questionnaires (FFQ), 24-hour recalls, surveys, dietary records, weighed measures, visual estimation, and digital photography. This section will discuss strengths and limitations of different dietary intake tools commonly used to assess FV consumption in children.

Self-Reporting

The most common dietary intake method is self-reporting dietary intake. Self-reporting includes the use of comprehensive FFQ, 24-hour recalls, and brief surveys such as SNAP-Ed Fruit and Vegetable Checklist. In children, these methods can be difficult due to their limited cognitive ability, difficulty estimating portion sizes, reliance on caretaker to estimate portions, and limited attention span[1,39,40].

Comprehensive FFQs have been used in many studies, but they are long and tedious for young subjects and may require assistance by an adult. These surveys includes items from all food groups in order to capture the habitual intake of the subjects, but this increases the subject burden for studies focusing on fruits and vegetable consumption. The FFQ is a tool that obtains the average intake of items on a day-to-day basis, and therefore may not be as sensitive to change in daily consumption in cups as dietary recall based methods[41]. Nevertheless, FFQs can be self-completed, and are suitable for large scale studies with children[41–43]. In order to obtain an FFQ from a child, participation from caregivers are often necessary due to a child's limited long-term memory[1].

Twenty four-hour recalls are considered the gold standard for self-reported intake. The 24-hour recall has a low-respondent burden, and can be administered over the phone[42]. However, children ages 8 to 10 rely on the caregiver since a child may not be able to quantify food[1]. Limitations to this method include dependence on the subject's memory, bias in reporting "good/bad" foods, difficulty in estimating portion size, and a

single recall is not a good measure of usual diet since it only captures one 24-hour period[1,42,44].

SNAP-Ed uses the SNAP-Ed Fruit and Vegetable Checklist as a self-reporting tool. This survey assesses the number of times fruits and vegetables were consumed in the previous day. This survey has been adapted from the 2-item FV screener[45]. There are six different response choices ranging from "0" to "5 or more times a day". The checklist includes five other items to assess types and quantities of FV consumed on the previous day. However, a limitation to this instrument is its lack of sensitivity to change. There were no changes from pre to post intervention in the pilot year of STC[45]. Specific problems with this survey include memory required to assess previous day's intake and confusion about classification of FVs[45]. These surveys are administered in class as a group in English, which requires the subject to be literate in English to follow along. Lastly, students have difficulty accurately remembering what and how much they consumed on the previous day. As there are many limits to self-reporting, more objective measures are warranted.

Digital Photography

Digital photography provides a quick and unobtrusive method to estimate food intake in cafeteria settings [46–48]. The validity of Digital Photography of Foods Method (DPFM) has been established with both adults and children when compared to the gold standard, weighing of foods on a scale[48]. A study compared weighed plate waste (WPW), digital photography, and digital photography with lunchroom observations to assess the reliability and validity of these methods in school-aged children[48]. Reliability was acceptable for digital photography. FV consumption assessments by DPFM and WPW were highly correlated[49].

The validity has been established in a number of settings including free-living conditions, Head Start settings, school cafeterias, and children's homes[46–48,50]. Martin et al. (2007) reviewed the digital photography method for food estimation, and found that visual estimation from photographs is valid tool for estimating nutrient intake and energy values of food with 5th grade children[50–52]. Another study by Williamson et al. (2003) also showed high correlation of digital photography to weighed and visual estimation of portion sizes[48].

Evaluation of STC Pilot Program

A quasi-experimental study of a pilot STC program in Rhode Island assessed 5th graders in low-income urban schools. This study used the SNAP-Ed Fruit and Vegetable Checklist in order to assess quantity of fruits and vegetables consumed the previous day[45]. Subjects in this study (n=298, n=178) were 35% white, 31% Hispanic, and 26% African American[45]. At baseline, children in the treatment school reported eating fruits 2.34 ± 1.40 times the previous day, and 2.37 ± 1.51 times the previous day in the control school. At follow-up, children in the intervention school reported eating fruits 2.26 ± 1.37 times the previous day, and 2.34 ± 1.58 times a day in the control group. For vegetables, children in the treatment school reported eating vegetables 1.86 ± 1.38 times at baseline and 1.87 ± 1.46 times at follow-up. The control group reported eating vegetables 2.01 ± 1.43 times at baseline and 1.98 ± 1.59 times at follow-up. There were no significant changes in FV consumption between or within groups based on the checklist. However, process evaluation indicated that this intervention was perceived effective in increasing FV consumption by staff and students[53].

Overview of Literature using DPFM

Many studies have used DPFM to analyze meals in schools that participate in

NSLP. These studies include interventions with children, assessing the new NSLP guidelines, the impact of Smarter Lunchroom strategies, analysis of food choices in the lunchroom, and plate waste.

Smith et al. used the digital photography method to compare students' average nutrient intake at lunch to the updated 2012 NSLP standards[4]. Plate waste was estimated from n=899 tray photos from three elementary and two middle schools, grades 1-8, over 23 days of data collection in a cross-sectional study[4]. Tray photos were analyzed using percent increments in relation to reference photos and weighed measures. For fruit, 50% of fresh whole fruit was left uneaten, 37% of canned fruits were wasted, and 40% of total fruits including fruit juice were wasted[4]. This study found that 32% of vegetables selected were wasted, and only 45% of students selected a vegetable[4]. Although there were no statistically significant differences in FV for elementary subjects before and after 2012 NSLP standards, Smith et al. found that less than half of the students selected a vegetable, and students were more likely to select a fruit at lunch[4]. Based on the data from this study, few students' lunch consumption met previous or new NSLP standards, specifically vitamins A and C due to the relatively low intake of vegetables[4].

Another study used DPFM to examine if school meals met the School Meals Intitative and the Institute of Medicine recommendations for children[54]. This cross-sectional study assessed 33 middle schools, grades 4 to 6, to assess average percent wasted[54]. Data collection occurred over 3 days, and n=2049 trays were observed. Martin et al. assessed FVs as one item, and found that students selected an average of 1.1 cups of fruits and/or vegetables at lunch, consumed 0.7 cups, and wasted 0.4 cups (p<0.005) on average[54]. Results from this study suggest that the nutritional quality of school meals can be improved[54]. Children are more likely to discard fruits and vegetables, and less likely to

discard other food categories[54]. Future implications of this study include serving foods higher in nutrient density and lower in energy density[54]. This can be accomplished by adding vegetables into the foods provided to the children, and increasing the variety of FVs offered at lunchtime[54].

Williamson et al. reported selection, plate waste, and changes in intake from Wise Mind and LA Health studies[55]. This randomized control trial used DPFM to report these results[55]. Wise Mind (n=604) and LA Health (n=2015) study focused on modifications to the school cafeteria environment to improve consumption of nutrient dense foods[55]. This study did not report consumption of FV, but found that modification to the school cafeteria is feasible and has the ability to positively influence children's food consumption[55]. The use of DPFM found statistically significant decreases in total fat selected at lunch (Wisemind: -60 ± 10.6; p=0.03; LA Health: -78 ± 10.4; p<0.0001) and fat intake at lunch (Wisemind: -41 ± 5.0; p=0.015; LA Health: -58 ± 8.9; p<0.0001) [55]. This decrease in total fat intake may be due to the increased availability of healthier more nutrient dense items such as FVs[55]. The findings of this study support the hypothesis that modifying the lunch environment can positively impact healthier choices, and supports the decision to change the NSLP guidelines to the current 2012 standards[55].

Hubbard et al. evaluated whether a Smarter Lunchroom intervention could be adapted to increase the selection of FVs for students with intellectual and developmental disabilities[56]. This quasi-experimental study used baseline and follow-up intervention DPFM data[56]. Data collection occurred 5 days at baseline and 5 days at follow-up. Days were matched based on menu items in order to ensure items offered were identical at both time points[56]. There are a total of 644 trays analyzed and subjects, n=43, ranged from 11 to 21 years old with disabilities attending a residential school in Massachusetts[56]. The 3-

month intervention occurred from March to June 2012, and capitalized on environmental changes such as moving fruits to the front of the service line and providing items in separate, attractive bowls[56]. This study found that after the 3-month environmental changes, the daily consumption of total fruits increased by a mean of 0.18 cups ($p=0.008$), canned fruits increased by 0.13 cups ($p=0.02$), and whole fresh fruits increased by 0.05 cups ($p=0.38$) [56]. Selection of raw vegetables significantly decreased by 0.16 cups ($p=0.001$), but intake of total vegetables increased by 0.07 cups ($p=0.14$) [56]. Plate waste significantly decreased for vegetables ($p=0.03$) [56]. What this tells us is that the students selected vegetables they were more likely to eat at follow-up, consumed more, and wasted less[56]. The Smarter Lunchroom intervention significantly increased fruit consumption, and decreased FV plate waste[56].

Schwartz et al. found the new meal regulations increased fruit consumption and did not lead to increased plate waste. [57] This cross sectional study used DPFM to assess 12 urban, low-income, middle schools. Data was collected prior to the changing of the NSLP guidelines in spring 2012, and follow-up data was collected in spring 2013 and 2014[57]. For baseline fruits, n=269, and n=573 trays for follow-up[57]. For baseline vegetables, n=344, and n=479 for follow-up[57]. Generalized linear regression was used to compare selection and consumption of FVs pre and post-policy implementation[57]. This study used percent increment in order to interpret data and did not report consumption or selection in cups[57]. The percentage of students selecting fruits significantly increased from 54% of students to 66% ($p<0.05$) and consumption of fruits remained high pre and post policy implementation[57]. Furthermore, this study found that fruit consumption increased by 9% for each additional fruit that was offered at meal-time[57]. Post-policy implementation, vegetable selection dropped from 68% to 52% ($p<0.05$), however,

students ate 20% (p<0.05) more vegetables post-policy implementation, lowering vegetable waste[57]. This study also looked into which fruits and vegetables were most popular[57]. Based on baseline and follow-up data, 88% of fruit cups, 78% of bananas, 70% of oranges, 56% of pears, and 48% of apples served were consumed[57]. For vegetables, 72% of potatoes (excluding fried), 65% of corn, 46% of beans, 42% of salad, and 38% of broccoli served was consumed[57]. This study indicates that the NSLP updated guidelines have led to more nutritious meals and increased fruit selection without increasing plate waste of FVs[57].

DPFM is a reliable, valid tool in order to look deeper into the breakdown of school meals[48,58,59]. Researchers have been able to use DPFM in a wide variety of settings, including the school lunchroom in order to quantify consumption of school lunch. The findings from these studies suggest the DPFM is an appropriate tool to use amongst low-income 5th graders, and is reliable and effective in the school lunch environment to assess fruit and vegetable consumption and variety[48,58,59].

Conclusion

Accurately measuring dietary intake in children is important due to the low intake of FVs and rising incidence of overweight and obesity[1,11,19,45,53]. Children who do not consume the daily recommendations of FV are more likely to consume excess quantities of energy dense foods that can lead to overweight and obesity[8,13,60]. This review found that DPFM is a valid and reliable dietary intake tool in school aged children[46,48,50,58,61]. DPFM is accurate within the school lunchroom setting, decreases participate burden, and is effective in measuring FVs[4,59,62]. Data shows that children consume an average of 0.4 cups of FVs at lunch, and consume a greater amount of fruits than vegetables[3,4,46,51]. Process data from the pilot year of STC indicated that students had an increased

knowledge in nutrition and perceived making changes but outcome data failed to find changes in FV consumption. This suggests that PSE interventions may need to use objective measures such as DPFM, but no studies have used this objective method for PSE outcome evaluation[45,53].

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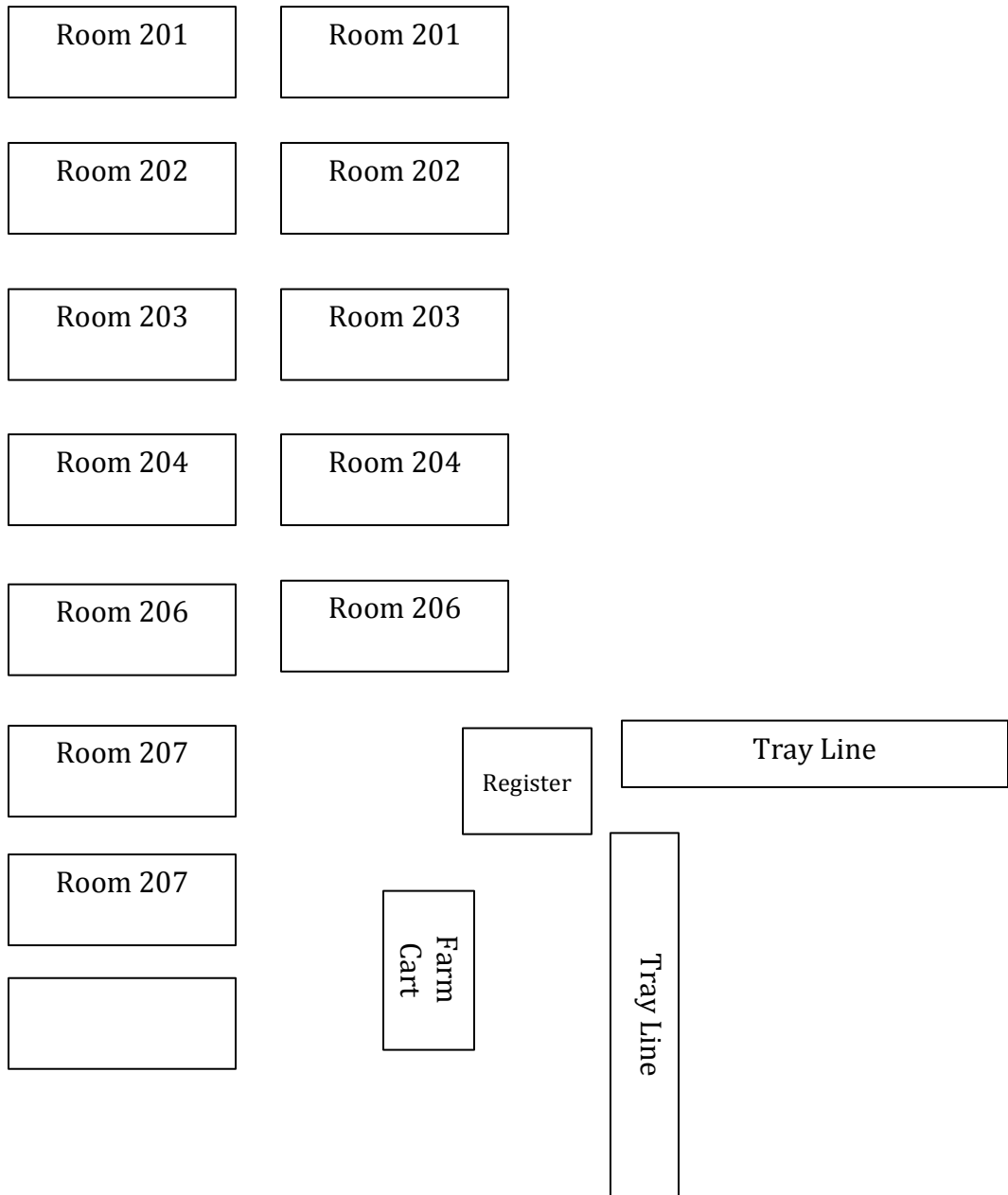
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B. TREATMENT SCHOOL CAFETERIA LAYOUT

| Entrance |

| Room 201 | Room 201 |

| Room 202 | Room 202 |

| Room 203 | Room 203 |

| Room 204 | Room 204 |

| Room 206 | Room 206 |

| Room 207 |

| Register | Tray Line |

| Room 207 |

| Farm Cart | Tray Line |

C. CONTROL SCHOOL CAFETERIA LAYOUT

Entrance

Room 216	Room 216

Not 5th Graders	Not 5th Graders

Room 215	Room 215

Not 5th Graders	Not 5th Graders

Room 214	Room 214

Not 5th Graders	Not 5th Graders

Register

Door   Door

Trayline/Farm Cart

Kitchen