Cut vs Whole Fruit and Vegetable Selection, Consumption, and Waste in K12 School Lunch

by

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ABSTRACT

Objective: Increasing fruit/vegetable (FV) consumption and decreasing waste during the school lunch is a public health priority. Understanding how serving style of FV impacts FV consumption and waste may be an effective means to changing nutrition behaviors in schools. This study examined whether students were more likely to select, consume, and waste FV when FVs were cut vs. whole.

Methods: Baseline data from the ASU School Lunch Study was used to explore associations between cut vs. whole FV serving style and objectively measured FV selection, consumption, and waste and grade level interactions among a random selection of students (n=6804; 47.8% female; 78.8% BIPOC) attending Arizona elementary, middle, and high schools (N=37). Negative binomial regression models evaluated serving style on FV weight (grams) selected, consumed, and wasted, adjusted for sociodemographics and school.

Results: Students were more likely to select cut FVs (IRR=1.11; 95% CI: 1.04, 1.18) and waste cut FVs (IRR=1.20; 95% CI: 1.04, 1.39); however, no differences were observed in the overall consumption of cut vs. whole FVs. Grade-level interactions impacted students' selection of FVs. Middle school students had a significantly higher effect modification for the selection of cut FVs (IRR=1.18; p=0.006) compared to high school and elementary students. Further, high school students had a significantly lower effect modification for the selection of cut FVs (IRR=0.83; p=0.010) compared to middle and elementary students. No other grade-level interactions were observed.

Discussion: Serving style of FV may impact how much FV is selected and wasted, but further research is needed to determine causality between these variables.

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CHAPTER 1

INTRODUCTION

Children and adolescents in America do not eat enough fruits and vegetables (FV).[1, 2] According to the 2020-2025 *Dietary Guidelines for Americans (DGAs)*, 75% of Americans consume diets low in fruits and vegetables.[3] They also report that Healthy Eating Index scores are the lowest among people ages 5-18 years old.[3] The amount of FV consumed by K-12 students has been rising since the early 2000's, thanks to initiatives such as the Farm-to-School grant program, the increased number of farmers markets, and the National School Lunch Program (NSLP). However, FV consumption still falls below recommended amounts.[4, 5] Eating fruits and vegetables has been linked to many health benefits, including better weight control, a healthier gut, decreased cardiovascular disease risk, decreased cancer risk, and decreased type 2 diabetes risk.[4, 6, 7] Fruits and vegetables are also a good source of vitamins, minerals and fiber.[8, 9] Since many kids in the US are eating lunch in school, it is worth investigating how to increase FV consumption and decrease FV waste in this setting.[10]

Schools are required to include a serving of fruits or vegetables on each tray in order to receive reimbursement for the meal from the NSLP, according to the Healthy Hunger-Free Kids Act of 2010 (HHFKA).[11] Lunch periods are typically short, though, so peeling and eating whole FV may not be a practical way to increase consumption of FV.[12] Schools may also offer nutrition education, salad bars, farm-to-school programs, and free and reduced-cost meals through the NSLP, in order to encourage increased FV consumption among their students.

Only a few studies have looked at the serving style (cut or whole) that kids are more likely to select and eat.[13-15] In 2009, Swanson et al. compared the impact of serving sliced apples and oranges to serving whole fruit on elementary schools children's fruit consumption.[13] In 2012, Olsen and colleagues studied children's preferred FV size and cutting style, based on ratings of images of FV cut in different ways.[14] The next year, Wansink et al. studied the impact of introducing apple slicers in school cafeterias to assess if slicing fruit impacted fruit sales, consumption and waste.[15] Overall, findings from these studies demonstrated that students preferred and/or consumed more FV, and wasted less food when FV were cut. No studies have looked at cut vs whole FV selection, consumption and waste by weight. Data on FV serving style can help school food service staff better understand how to prepare fruits and vegetables to ensure they will be eaten.

Purpose of the Study

This study is a secondary data analysis from the School Lunch Study,[16] a larger plate waste study that examined fruit and vegetable consumption in schools that have salad bars and FV marketing. The purpose of the current study is to examine whether there is an association among student FV selection, consumption, and waste when the FV have been served cut up, as opposed to served whole. The results of this study will add to the data on what serving style elementary, middle, and high school students may be more likely to eat, given their limited lunch periods, utensils, and motor skills.

Research Aim and Hypotheses

Study aim: To determine the association between serving style (whole or cut) of FV and FV selection, consumption, and waste among students in elementary, middle, and high school.

Research question 1: Does the serving style of fruits and vegetables in school lunch affect how much FV are selected, consumed, and wasted during the lunch period?

H_1: Students' FV selection and consumption will be higher when FVs are cut as opposed to whole.

H_2: Students' FV waste will be lower when FVs are cut as opposed to whole.

Research question 2: Is there a significant interaction between serving style selection, consumption and waste of FV and student grade group (elementary school grades 1-5, middle school grades 6-8, and high school grades 9-12)?

H_3: Students in elementary school will select and consume more FV when the FVs are served cut or sliced as opposed to whole.

H_4: Students in elementary school will waste less FV when the FVs are served cut or sliced as opposed to whole.

H_5: Students in middle and high school select and consume more whole FV and have less FV waste when their FV is whole.

Definition of Terms

Plate waste study: A study that measures the amount of edible food that subjects discard after a meal

Whole fruit: Fruit that has been minimally processed, if processed, at all

Whole vegetable: Vegetables that have been minimally processed, if processed at all

Sliced/cut fruit: Fruit that has been cut into at least two pieces before being served

Sliced/cut vegetable: Vegetables that have been cut into at least two pieces

Food accessibility: Refers to foods being prepared in a way that makes them ready to eat

Food availability: Refers to the presence of foods in a setting

Feeding style: The attitude(s) that parents or other authority figures have in regard to what and how much a child eats

Feeding practices: The techniques a parent or authority figure use in order to get a child to eat or not eat certain foods

Fruit/vegetable selection: The fruits/vegetables that students take from the serving line

Fruit/vegetable consumption: The amount of fruits/vegetables that students eat during lunch

Fruit/vegetable waste: The amount of fruits/vegetables left on the tray or meal container to be discarded after the lunch period

CHAPTER 2

REVIEW OF LITERATURE

Overview of FV Consumption Among Youth in US

The United States Department of Agriculture (USDA) recommends that children and adolescents ages 2-18 years old eat 1 to 2 ½ cups of fruit per day and 1 to 4 cups of vegetables per day, depending on their age, sex and activity level.[3] However, many Americans in that age range are not meeting the minimum recommended amounts.[3] The National Health and Nutrition Examination Survey (NHANES) data from 2007 to 2010 indicated that Americans of all ages consume an average of 1.1 cups of fruit per day and 1.5 cups of vegetables per day.[2] Children ages 4-18 who were surveyed during this period consumed an average of 0.8-1.5 cups of fruit per day and 0.8-1.3 cups of vegetables per day.[2] Results from the 2019 Youth Risk Behavior Surveillance System (YRBSS) results from the CDC showed that 6.3% of high school students reported not eating any fruit or drinking fruit juice, which is up from 5.6% in 2017.[17] In this same survey, the percentage of high schoolers who reported not eating vegetables (other than fried potatoes) had risen from 7.2% in 2017 to 7.9% in 2019.[17]

One study analyzed NHANES data from 1999 to 2016, comparing diet quality scores among American youth ages 2-19 years old.[18] Study authors found that while diet quality had significantly improved over this time frame, a majority of children still had low-quality diets.[18] Another study which analyzed NHANES data found that fruit (but not vegetable) consumption decreased with age.[19] US high school students were surveyed in 2010 about their daily fruit and vegetable intake.[20] The questionnaire asked students how many times per day they ate fruits and vegetables.[20] Approximately one

third of the students reported consuming fruits and vegetables less than once per day (28.5% and 33.2%, respectively).[20] Black and Hispanic students had the greatest rate of reporting eating FV less than once per day.[20] In another study, US high school students were surveyed at around age sixteen and again at around age twenty about their FV intake, taste preferences, and fast-food consumption frequency.[21] Researchers found a positive correlation between liking FV at baseline and intake of FV at follow-up.[21] Researchers found a negative correlation between fast-food intake frequency at baseline and FV intake at follow-up.[21] This study suggested that students who, as teens, liked FV were more likely to consume FV as they get older. Conversely, teens who consumed more fast food were less likely to eat FV as young adults.[21]

Why Fruit and Vegetable Consumption is Important

Eating FVs as part of a healthy diet is recommended as a way to lower the risk of developing some of the most prevalent and costly diseases, including cancer, type II diabetes and cardiovascular disease.[4, 6, 7] Fruits and vegetables also contain essential vitamins and minerals and are a source of fiber, which have health benefits.[8]

Approximately 34.2 million people in the US had diabetes in 2018.[22] An estimated 23,000 of that were children and adolescents under the age of 20 years old with type 2 diabetes.[22] The incidence of type 2 diabetes in children and adolescents has significantly increased each year since 2003 across all races except non-Hispanic whites.[22] Direct and indirect costs of diagnosed diabetes in the US were around $327 billion in 2017.[23] People diagnosed with diabetes usually pay an estimated $9,600 per year in medical costs related to diabetes.[23] However, healthy eating patterns, which

include eating fruits and vegetables, have been linked to reduced risk of developing this disease.[4]

The prevalence of cardiovascular disease (CVD) in the US was 48% in 2013-16.[24] Direct and indirect costs of CVD in the US were estimated to be $351.2 billion.[24] These costs could reach $1.1 trillion by 2035.[24] Eating foods high in fiber, such as fruits and vegetables, is recommended to prevent CVD.[25]

The United States National Cancer Institute estimated that approximately 1.8 million Americans would be diagnosed with cancer in 2020, and there would be more than 600,000 cancer-related deaths in the US.[26] The estimated cost to the US for cancer care was $147.3 billion in 2017, an amount that is expected to increase as the prevalence of cancer grows and new treatments are needed.[27] However, there is strong evidence that eating a healthy diet can reduce cancer risk.[7]

Fruits and vegetables also contain vitamins, minerals and fiber, which have beneficial health effects.[8, 9] Vegetables are high in potassium, vitamins A, B_6, C, E and K, as well as folate, thiamin, niacin and choline.[4] Folate helps with red blood cell formation, and potassium helps keep blood pressure normal.[28] Fruits are high in vitamin C and fiber[4]. Vitamin C helps with the growth and repair of tissues in the body.[29] Fiber can help lower blood cholesterol levels and improve gastrointestinal tract health.[9, 29]

These are just a few reasons why fruit and vegetable consumption is important. Since millions of American children and teens eat school lunch for most of the year,[10] it is important and worthwhile to look at factors in this setting that might affect and improve fruit and vegetable (FV) intake, so that American children and adolescents can benefit from the numerous healthy aspects of fruits and vegetables.

Determinants of FV Intake in Children-Outside of School

Before children begin attending school, they form early taste preferences and eating habits at home.[30] Therefore, it is important to look at factors from the family and home environment that may impact what children prefer to eat when they go to school.

Genetics

Genetics effect taste and food consumption, and should be considered as one factor that influences fruit and vegetable consumption in children and adolescents. De Castro et al studied identical and fraternal twins and found that genetics may be associated with palatability of certain foods, as well as daily energy density intake.[31, 32] A 2006 study found strong evidence that food preferences can be inherited.[33] Specific genes that influence taste perception are being studied, too. The TAS2R38 gene has been linked to how intensely people experience the bitterness of a food.[34] Possessing the supertaster variant of the TAS2R38 gene may lead children to consume more sweet, energy-dense foods than children who are nontasters.[34] These studies further support the idea that a child's like or dislike of fruits and vegetables may be, in part, due to their genes.

Parental Modelling, Feeding Style and Feeding Practices

Children consume approximately two-thirds of their food at or from home, so it is possible that interactions between parents and their children shape food preferences and meal-time behaviors.[35, 36] Children who observe their parents eating fruits and vegetables are more likely to also eat them.[37] The HOME Plus randomized controlled trial found that parents who modelled eating fruits and vegetables reported that their children were

more likely to meet recommended FV serving amounts.[38] Mothers and daughters in particular have been observed to have very similar diets. Lee et al observed that when daughters reported consuming a high-fat diet, they and their mothers typically reported less consumption of fiber, vitamins and minerals that are commonly found in fruits and vegetables.[39]

Parental feeding style, which differs from parenting style, can also affect a child's relationship with food.[40] Three common categories of feeding styles include authoritarian, authoritative, and permissive. Parents with an authoritarian style are stricter about food consumption and permissive parents are considered to be lax and neglectful about food consumption, while authoritative parents create a harmonious, communicative eating environment.[40] Permissive feeding styles have been linked to lower fruit and vegetable consumption among preschool-aged children.[41]

Feeding practices are techniques that parents use to get their children to eat or not eat certain foods.[40] Inappropriate feeding practices include restriction of food, rewarding behavior with food and pressuring the child to eat. Bante et al found that while the use of inappropriate feeding practices may increase the intake of fruits and vegetables among preschool children, it decreases their preference for fruits and vegetables.[42] Parents who create a negative emotional atmosphere at mealtime by pressuring their children or complaining about them not eating certain foods are also shaping their children's food preferences.[43, 44] Galloway et al specifically studied how pressuring children to eat affected their intake and emotions towards vegetable soups.[44] They found that there was no difference in intake when pressure was or was not applied, but that children expressed negative feelings about the soups more often when under pressure to eat them.[44] These

feeding practices may accomplish the desired task of increasing FV intake at the time, but they do not help the child learn to self-regulate and build healthy long-term relationships with foods.

Cultural and Social Influences

Briefly, it is important to also keep in mind the cultural and social components of eating pattern development that occur outside of school. Consuming fast-food and eating outside of the home are a major part of the American culture, and in 2018, consumers' average yearly expenditures on food away from home accounted for 44% of total food spending.[45] It has been estimated that children ages 2-19 in the US consume one-third of their daily calories from foods prepared outside of the home.[46] For American teens and preteens, eating more fast food has been associated with less FV intake.[47] Watching television while eating, another aspect of American culture, has been found to decrease FV intake.[48] Eating meals as a family has been linked to healthier diets in children and adolescents.[49]

Food Neophobia and Exposure

Food neophobia, or the reluctance to eat new foods, is a common barrier to adequate FV intake in children.[50] Research has implied that having an initial aversion to foods is a survival measure.[51] This may be overcome by having positive experiences with foods. Birch et al examined the effects of repeated visual exposure to a food compared to repeated taste exposures in children.[52] They found that visual exposure alone did not seem to enhance acceptability of a food. However, repeated taste experiences did make the food more preferable to children.[52] Wardle et al measured children's likes and dislikes of certain vegetables and how this may change over time.

They tested if repeated taste exposure or being rewarded for consuming vegetables most impacted children's liking of the vegetable.[53] Study results found that exposure led to greater liking and intake of vegetables than the offer of a reward.[53] Maier et al studied the effects of repeated exposures to vegetables on 7-month old infants.[54] They had parents feed their infants a disliked vegetable puree along with a liked vegetable puree, eight times. By the eighth exposure, the intake of the initially disliked vegetable had increased at a rate of 17g/exposure.[54] Sixty-three percent of the infants were still responding well to the originally disliked vegetable nine months later, indicating that the repeated exposures had led to long-term acceptance of the vegetable.[54] This research implies that the more a child is exposed to a fruit or vegetable, the more likely they will be to consume and even like it. Therefore, repeated exposures to FV is important for children.

Fruit and Vegetable Availability/Accessibility at Home

One of the most evident determinants of fruit and vegetable intake among children and adolescents is availability and accessibility of FV in their home environment.[55] Availability refers to the presence of these food items in the home, while accessibility refers to the foods being prepared in a way that they can be readily eaten. Studies have found that children consume more fruits and vegetables when these foods are both available and accessible in the home.[37] Availability of fruits and vegetables has also been linked to parental feeding style. Homes with authoritative parents tend to have greater FV availability, while parents with an authoritarian feeding style tend to have fewer fruits and vegetables on hand.[56] Ding et al looked at the home and community food environments of children and adolescents from three major US cities to see if there

were associations between these environments and FV intake.[57] They found that home availability of fruits and vegetables was positively correlated to intake, and also that household income was positively associated with availability of fruits, vegetables and overall more healthful foods in the home.[57] These researchers did not find any connections between community environment and FV intake among the children and adolescents.[57]

The School Environment and Fruit and Vegetable Consumption

An estimated 56.4 million students are enrolled in elementary and secondary schools in the US[58]. While the number of school days varies by state, most operate for approximately 180 days, which is almost half of a year.[59] During the school year millions of kids and adolescents rely on school food service programs for lunch, breakfast and in some cases, snacks and supper.[10] In the US, many schools rely heavily on state and federal government funding, and are required to follow certain state and federal food-related policies in order to receive funding.[60] For example, the National School Lunch Program (NSLP), which had 94,542 schools and almost 29 million students (approximately 53.5% of enrolled students) participating in FY 2020, is a government assistance program that schools rely on.[10] This program, which began in 1946, reimburses schools that serve free or reduced-cost meals to eligible students, in the form of either cash or commodity foods.[60] In order to receive reimbursement, schools must serve meals that meet federal guidelines set by the Healthy, Hunger-Free Kids Act (HHFKA) of 2010.[60] HHFKA established reimbursement rates and meal pattern guidelines, which include increasing the variety of fruits and vegetables offered and reducing sodium and saturated fat in meals.[11] The meal pattern guidelines require schools

to make a fruit and two vegetable components available to students in quarter-cup to half-cup portions. It also stipulates that five vegetable subgroups must be served each week: dark green, red/orange, starchy, legume, and other. The other category includes vegetables such as cucumbers, celery and 100% vegetable juice. HHFKA has been linked to an improvement in the nutritional quality of lunches served under NSLP, which in turn means better nutrition for students from low-income homes in America.[61] It is important to consider these guidelines when looking at how fruit and vegetable consumption can be increased in schools, so that methods of doing so do not conflict with the policies schools have to follow and the limited funds they have available.

Strategies in School Cafeterias to Increase Fruit and Vegetable Intake

Nutrition Knowledge and Promotion

Patterson and colleagues examined the role that increasing FV promotion or education had on FV selection and knowledge in young elementary students.[62, 63] In one study, a registered dietitian provided second-graders with a series of nutrition classes.[62] They tested participants' nutrition knowledge before and after the program was implemented, and measured FV selection in the cafeteria during the time that classes were being offered. Test scores increased by 80% and FV selection increased 11% and remained elevated the month after the program concluded.[62] In their second study, a registered dietitian worked with the school to promote fruits and vegetables to students in kindergarten through second grade in a variety of ways for one day.[63] Promotion methods included announcements, signage and rewards for participating in the promotion.[63] Researchers measured FV selection the day of the promotion, as well as one month prior and one month after the promotion day. Fruit selection increased by

over 200% on the day of the promotion and remained higher than baseline by nearly 50% at the one-month follow up.[63] Vegetable selection increased by 360% and remained nearly 35% higher than baseline at one month.[63]

These studies demonstrated that FV promotion and education may help increase the selection of these foods.

Availability and Accessibility of FV in Schools

Improving availability and accessibility to FV as a strategy to increase consumption has been studied and is consistently associated with greater consumption of FV among children.[64] A Mississippi study looked at providing a variety of free fruits and vegetables to students at various times throughout the school year, making the FV more available.[65] They found that students reported liking the program and trying new fruits and vegetables, and that they associated the FV that they were eating with better health.[65] However, quantitative data on how much FV the students consumed throughout the experiment was not collected.[65]

Making fruits and vegetables more convenient to students could improve their accessibility. One of the primary reasons people purchase and consume fast-food is due to its convenience.[66] Researchers used the theory of present-biased preferences (current benefits or costs outweigh future benefits or costs) to attempt to increase FV selection and consumption in a high school cafeteria by making healthier food options more convenient to students.[66] After implementing a more convenient and "healthier" cafeteria service line, the research team found that while students did select more healthy foods than at baseline, they did not consume more healthy foods than at baseline.[66] Fewer less-healthy food options were consumed after the intervention, though.[66] The findings of this

study indicate that making healthy food options more convenient may be one way to increase selection of fruits and vegetables in the high school setting.

Policy

School-level policy may influence fruit and vegetable intake among students. In a study conducted in Minnesota schools in 2014, researchers examined the relationship between school policies that encourage healthy lifestyles and self-reported student anthropometrics and behaviors over a four-year period. They found that for each additional policy that a school had in place, students' reported FV consumption significantly increased, and sugary beverage intake decreased.[67] Policies included making healthy foods and drinks such as fruits, vegetables and 100% fruit juice more available and unhealthy items such as candy, soda and salty snacks less available.[67] This study suggests that policies set at the school level may be one way to increase student fruit and vegetable consumption, especially among older students.[67]

Time allotted to eat is also an aspect of accessibility.[68] Districts typically set the school day schedule in order to maximize time in the classroom. The Food and Nutrition staff who plan the lunch menu often do not have a say in how long students get to eat the food. Cohen et al studied plate waste and time to eat at four elementary and middle schools, and observed that when students had less than 20 minutes to eat, they were 44% less likely to select a fruit than students who had at least 25 minutes to eat.[69] Students with less than 20 minutes to eat also consumed less of their entree, milk and vegetable compared to students with at least 25 minutes to eat. The American Academy of Pediatrics recommends that children get at least 20 minutes to eat lunch, not including the time it takes to go through the serving line and wash hands.[69] More research on this

aspect of school lunch is needed to better understand how the length of school lunch affects the choices students make and the amount of food they consume. Students may not be able to eat whole fruits and vegetables in the time allotted, so serving FV in a manner that is more accessible may increase consumption.

Cut vs Whole Fruits and Vegetables

Previous research has examined whether or not slicing fruits and vegetables a certain way, or at all, impacts FV intake and waste at school lunch. However, this research is not exhaustive. Most of the research has been conducted with fruits such as apples and oranges and is limited to elementary and middle school students.[13, 15, 70]

Swanson et al looked at the effects of slicing apples and oranges on fruit selection and consumption in 2009.[13] Their subjects were 800 elementary students in one rural Kentucky school. They had two data collection days, where all students who ate school lunch those days were included in the study. Participant selection was not randomized. The school cafeteria staff reported that they normally served whole fruit at lunch, so serving sliced apples and oranges was novel for the students.

At data collection, researchers tagged lunch trays and took digital photographs of each plate after the student exited the serving line. Then, they took another photograph of each tray after lunch was over and matched it to the before picture. No tray weights were gathered. Waste was estimated using visual observation by two trained analysts. Estimates were averaged to determine how much was consumed on each tray.[13]

While selection of fruits was low, overall (22.6% of students took whole apples, 18.8% took sliced apples, 5.5% took whole oranges, 16.2% took sliced oranges), the results of this study indicated that students would be more likely to select sliced oranges

than whole oranges.[13] There was no significant difference in the selection of apples. When sliced fruit was offered, only half of the fruit was served. Therefore, when looking at consumption, whole fruits counted as two servings, and sliced fruit counted as one serving.

Researchers were able to analyze differences in selection and consumption between grades. Younger students were more likely to select sliced oranges than whole oranges.[13] They also consumed more of the orange when it was sliced than when it was whole.[13] Older students were more likely to select whole apples and consume at least one serving, or half an apple.

This study was conducted before the HHFKA was enacted, so meals did not necessarily have to include a fruit or vegetable in order to count as a reimbursable meal. The low selection of fruits before slicing was introduced could therefore be attributed to either it not being required, or the whole fruit being less desirable to students. The research team also concluded that while fruits were made available to students, a whole, unpeeled orange could not be considered accessible.[13] This study had limitations, including collecting data from only one school. Also, not obtaining tray weights before or after consumption limits the validity of this study.

Another study involving the comparison of sliced vegetables was conducted by Olsen et al. in 2012.[14] They looked at how appealing kids found various serving styles of vegetables, as well as which vegetables the children preferred the taste of. Study subjects were 138 children ages 9-12 from Copenhagen, Denmark.[14] The students were presented with pictures of a variety of fruits and vegetables that had been cut into different shapes and sizes and asked to use a visual analogue score to rank how well they liked each

serving style. The results indicated that large chunks were preferred over the small whole vegetables. Students liked slices and sticks equally, but students preferred FV cut into the shape of stars.[14]

Researchers concluded that kids want their vegetables to be cut, and if possible, into fun shapes and figures like stars.[14] However, they also recognized that once a vegetable is sliced up, there are added concerns over storage, shelf-life, product durability, labor and waste.[14] When taking all of this into account, researchers concluded that serving vegetables cut into slices or sticks would probably be easier to prepare, and still acceptable to kids.[14] Another important takeaway from this study is that size of the vegetable did not seem to matter to the children. Several "miniature" versions of vegetables have been marketed to kids, but this might not be necessary when getting a child to eat vegetables. Limitations of this study included peer influence, a narrow population sample, and the fact that students were rating their preferences for shapes and sizes based on visual representations, instead of having tangible items to hold and eat. The participants were all Caucasian and living in Denmark, so the results of this study cannot be globally extrapolated.

Another study on how pre-slicing fruit may impact children's selection and intake was published in 2013 by Wansink et al.[15] Researchers first interviewed 23 elementary and middle school students to narrow down the top two reasons why they avoided whole fruits at lunch. They found that most students considered whole fruits to be inconvenient to eat, especially if they had dental issues. Older students considered whole fruits to be too messy to eat in front of their peers. The researchers then conducted a pilot study with students from eight elementary schools in Wayne County, New York. They provided a

fruit slicer to these schools and told cafeteria staff to use it upon request. After slicers were added and used in schools, sales of fruit increased at all eight intervention sites. The researchers concluded that convenience could have a significant effect on behavior when it came to how fruits are served in schools.[15]

Authors then conducted a cluster randomized controlled trial with six middle schools (2150 students) in Wayne County, NY. In this county, 13-44% of the students qualified for either free or reduced lunch pricing.[15] Three schools were randomly chosen to implement fruit slicers for apples. Two of the intervention schools served a whole, segmented apple in cups, and the third intervention school served sliced apples on a tray and let students take as many as they wanted. Therefore, at the third school, researchers had no way of knowing what the "before" amount of apple was, but they could see how much was thrown away. Tray waste data was collected, and researchers visually assessed how much of the apple was wasted by either estimating how much apple was remaining from the whole fruit, or how many slices were remaining. The results of this study indicated that, after slicers were introduced at the schools, average daily apple sales went up by 71%.[15] The amount of apple wasted decreased, but not by a significant amount. The percentage of students who wasted half or more of their apple decreased significantly, though. The research team estimated that the percentage of students who ate more than half of their apple went up by 73% at the intervention schools.[15] However, it is not possible to tell if the missing fruit was actually eaten.

Strengths of this study include it taking place in a school cafeteria environment, as well as finding a potential solution to food waste. It also addresses practical reasons why students may avoid eating fruits and vegetables during school lunch. Limitations include

the potential that the sliced fruit was a novelty, which was addressed by collecting data on two occasions, and not weighing the whole apples before and after lunch. It is easy to see how many slices were consumed, but visually estimating how much apple was eaten is not the most objective way to gather data. This study was helpful in testing a simple way to potentially increase fruit selection and intake by elementary and middle school students.

Another study on the topic of sliced fruits and vegetables took place in Germany.[71] The schools included in the study took part in the European Union School Fruit Scheme (SFS), and were already receiving fresh, unprepared FV. Several schools were having students prep and distribute the FV to their peers, providing students with a learning opportunity, but also requiring time, preparation, storage space and equipment, which might not be feasible for all schools. Some schools were looking at moving to pre-cut, packaged FV. Before switching over to the ready-to-eat, packaged products, von Germeten and his team conducted a study to see if that was acceptable to students.[71] They recruited children between the ages of eight to ten years old from an elementary school. Students usually washed, sliced, prepared and served the fruits and vegetables that they received at morning break time. Both the intervention and control groups completed a questionnaire about their liking of different FV before the intervention began. Then, for 6 weeks, the intervention group received pre-sliced, individually packaged FV. After the intervention period, the research team asked students to complete another questionnaire about their liking of the FV they had been served.[71] Overall liking scores decreased significantly from baseline to post-intervention in the intervention group. Other questions captured students' feelings on having to put in the

effort to prepare and serve the whole FV, and the importance of equal serving sizes, a feature of the pre-cut FV. Responses indicated that most students enjoyed the preparation process they usually went through. The kids did indicate liking the perceived greater equality in portion sizes that pre-cut FV provided. They did not like the increase in waste from the packaging of the pre-sliced FV. Only 23% of the intervention group reported that they would like to have pre-sliced FV in the future.[71]

This study brings up several important points to consider when transitioning from whole fruits to sliced fruits in an elementary school setting. First, if students are used to fresh, whole, or fresh-cut FV, they may not accept industrially-prepared and packaged FV. Not all FV are available in pre-cut, packaged form, so variety of FV is limited. Pre-cut FV also come with more packaging, and therefore waste, than whole fruits and vegetables that are prepared onsite. Also, it appears that students may enjoy preparing foods for their classmates, which could solve the issue of the labor involved in providing fresh-cut FV in the US.

In 2016, Handforth and colleagues conducted a plate waste study in order to examine selection and consumption of FV at the elementary, middle and high school level.[72] They compared photographs taken after lunch trays with photos of standard pre-lunch servings, and visually estimated the consumption amount to the nearest 10%. Results were adjusted for by grade level, gender and school. They found that elementary and middle school students consumed less whole FV than high school students.[72] They also found that certain categories of FV were more selected and consumed, while others were wasted more frequently. Whole fruits and raw vegetable were selected, but also wasted more often. Canned fruits, fresh-cut fruits and juices were most selected and

consumed. Canned vegetables and dried fruits were least selected. The researchers recommended that elementary and middle schools remove whole fruits from their menus and replace them with fresh-cut fruits. They also recommended that a greater variety of FV be served across all grade levels to improve selection and consumption.[72]

In 2017, a study was conducted where several interventions were implemented at once.[70] Researchers recruited two elementary schools in Hennepin County, Minnesota to participate. Both schools had over 50% of student populations qualify for free or reduced lunch rates. Researchers implemented multiple strategies for increasing FV consumption, simultaneously, for a duration of twelve months. The interventions included using black trays and bowls for serving FV, slicing apples into wedges, adding attractive labels on the service line, installing menu boards with the menu of the day displayed, and placing the FV either at the beginning of the lunch line, or near the register.[70] Researchers collected data at each site at baseline, and after the new strategies were implemented. They measured they weight of the trays (in grams) before and after children ate their meals.

Apples were the only item to be sliced, However, researchers also implemented the new label strategy, the menu board strategy and the black tray/bowl strategy with apples. Therefore, while the results showed that apple selection did increase after the interventions were applied, it is impossible to tell if that was due to the slicing, or the other strategies.[70] Further research implementing only one strategy at a time would be helpful in determining which one actually had the most impact, and if all were necessary.

Most recently, in 2019 Ang and colleagues examined the effect of environmental factors present during school lunch on FV consumption among second and third graders.[73] They collected plate waste data from 14 elementary schools in New York City,

and visually estimated FV consumption. They examined the impact of ten school lunch environmental factors including when the lunch period occurred in relation to recess, if fruits were sliced or pre-cut, duration of school lunch, and number of FV options available to students on how much FV students consumed. Results were adjusted for individual- and school-level demographics. They concluded that slicing fruits could increase fruit consumption at school lunch.[73]

Summary

Most youth do not consume recommended amounts and the reasons why children may or may not consume FV are complex. Some research has been conducted to see if slicing FV has any impact on how much FV students select, consume, and waste, but more research should be done in this area, and on a wider range of age groups, to better understand whether or not this is an effective strategy to increase FV consumption and decrease FV waste.

CHAPTER 3

METHODS

Study Design

This was a secondary data cross-sectional analysis from the School Lunch Study, a larger cluster factorial randomized trial conducted to assess the effectiveness of salad bars and FV marketing on increasing FV consumption in Arizona elementary, middle and high schools.[16] The research team recruited a total of 37 schools in Arizona to participate in the study.[16] Researchers then randomly selected individual students (N=6804) to participate in the study by their school ID number prior to data collection. The team conducted data collections at each school three times during the school year. The students who were selected in the randomization process were then identified, assented, and given a barcoded lunch tray the same size and shape as the ones used in their school cafeteria. Student participants were instructed to select their lunch as usual, and then stop by a weigh station to have their lunch weighed and photographed before they ate anything. Then, participants were instructed to bring their tray and all trash to a designated tray depot once they had eaten all they wanted. Those who completed all data collection requirements were given a small incentive, which varied based on age-appropriateness. Principals at each school provided written informed consent. Students provided verbal assent. All study protocols were approved by the Arizona State University Institutional Review Board.

For this sub-study, baseline data from the School Lunch Study was pulled and examined. Seven pre-lunch trays and four post-lunch trays had to be eliminated due to weights not being coded (-777). Fifty trays had a negative weight difference greater than

2 grams, indicating an error in the weighing process. Thirty-six trays had a weight difference of -2 grams, which was within the margin of error, and the difference was changed to 0 grams. This study had a total of 2177 lunch measurements.

Measures

Whole vs cut fruits and vegetables. There were 42 varieties of fruits and vegetables served at baseline data collections for the School Lunch Study. Determining whether the items was considered cut or whole for the purposes of this study was done based on the amount of processing the item had gone through. For example, applesauce was considered cut, while cherry tomatoes were considered as being whole. Table 1 lists all of the FV served by cut or whole status. Some FV were served as a mix of cut and whole, and have been categorized as both. Once the FV was categorized, trays were coded as having "cut" FV present, "whole" FV present, "both", or "none". The post-lunch weight of the FV on the tray was deducted from the initial FV weight to determine the FV consumed. Mean weight differences for the "cut" trays and "whole" trays were then compared in adjusted negative binomial regression models. Trays with both whole and cut FV did not make up a significant portion of the sample, but did account for 15.7% of the trays (n=416).

Fruit and vegetable selection, consumption, and waste. FV selection, consumption and waste were the primary measures for this study. Trained research assistants took photographs and captured weights of trays after the student selected their lunch and exited the service line, and again, after the student had eaten what they wanted from the tray. The pre-lunch tray photographs showed the full lunch and its weight, and then the fruit and vegetables only, and their weight. The post-lunch photographs showed the

remainder of the full lunch, and its weight, and the remainder of the fruits and vegetables, and their weight. Post-lunch FV weights included rinds and peels. Since each tray barcode was scanned at pre-lunch and post-lunch, before and after photographs and weights could be linked together. Weight was measured with a digital scale to the nearest 2 grams. Photographs were taken with a digital camera that was mounted on a tripod above the tray and scale.

Covariates. Grade grouping is the primary covariate being used in this study. The groups include elementary students (grades 1-5), junior high students (grades 6-8) and high school students (grades 9-12). Student demographics such as gender, race/ethnicity, and free/reduced lunch status were also collected, and adjusted for in the analyses. Within-school similarities were adjusted for, as well.

Statistical Analysis

Trays were sorted by student ID number and tray ID number. Post-lunch fruit and vegetable weight (waste) was deducted from the pre-lunch fruit and vegetable weight (selection), and each tray ID was coded as having cut FV (1) or whole FV (0) present. The weight difference represents the amount of FV consumed. Chi-squared tests were used to compare cut, whole and overall FV selection by key variable. Two-sample T-tests were used to examine the mean amounts of FV selected, consumed and wasted (in grams) overall, and at each grade grouping (elementary, middle, high school). Adjusted negative binomial regression models were used to examine differences in FV selection, consumption, and waste by serving style (cut vs whole). Data were adjusted for sociodemographics and the clustering of students within schools. Statistical significance was set at $p<0.05$.

Table 1. Fruits and Vegetables Available by Serving Type

Fruit or Vegetable Name	Cut, Whole, Both
Apple crisps, packaged	Cut
Apple, sliced, packaged	Cut
Apple, whole	Whole
Applesauce, packaged	Cut
Apricots, frozen, pureed, packaged	Cut
Baby Carrots, packaged	Cut
Banana, whole	Whole
Bell peppers, sliced, bagged	Cut
Broccoli florets	Cut
Broccoli florets, celery sticks, baby carrots	Cut
Broccoli florets, cucumbers, sliced, and cherry tomatoes, whole	Both
Cantaloupe, sliced, bagged	Cut
Carrots, sticks	Cut
Cauliflower, florets	Cut
Celery, sticks, bagged	Cut
Cherry tomatoes, whole	Whole
Chickpeas	Cut
Clementine, whole	Whole
Coleslaw, cupped	Cut
Corn, cooked	Cut
Craisins, packaged	Cut
Cucumber, sliced	Cut
Fruit cup, frozen, pureed, packaged	Cut
Grapes, packaged	Whole
Honeydew melon and cantaloupe, cubed	Cut
Iceberg lettuce	Cut
Jalapenos, sliced	Cut
Lettuce, onion, tomato	Cut
Mandarin oranges, canned	Cut
Mixed fruit, diced, canned	Cut
Orange, halved	Cut
Orange, pieces	Cut
Orange, quartered	Cut
Orange, wedges	Cut
Orange, whole	Whole
Peaches, sliced, canned	Cut
Pear, diced, canned	Cut
Pear, sliced, canned	Cut
Pear, whole	Whole
Pickle slices, whole	Cut
Pineapple, cubed, fresh	Cut
Pineapple, diced, canned	Cut

Radishes, sliced, bagged	Cut
Raisins	Cut
Salsa, cupped	Cut
Side salad, iceberg	Cut
Side salad, mixed greens	Cut
Strawberries, whole	Whole
Strawberry, puree, frozen	Cut
Tomato, diced	Cut
Watermelon, cubed	Cut
Watermelon, sliced, bagged	Cut
Zucchini, sticks, bagged	Cut

CHAPTER 4

RESULTS

Descriptive Statistics

This sample was diverse with 79% of participants being non-white (Table 2). Approximately, 52% of the sample were male and 84% received free or reduced-price lunches. See Table 2 for additional demographic information.

Overall, a mean weight of 135.5 grams of cut FV were selected, as compared to a mean weight of 117.8 grams of whole FV selected (p=0.001). Chi-squared analyses also indicated significant differences among school grade groups and cut fruit selection: among the students who selected cut fruit, 43% were elementary students, 30% were middle school students, and 27% were high school students. At the elementary level, a significantly less mean weight of cut FV was taken (119.0g) than of whole FV taken (137.4g) (p=0.041). The mean weight of cut FV taken (155.3g, 140.0g) was significantly greater than the mean weight of whole FV taken (114.6g, 105.0g) at the middle and high school levels (p=<0.001 and p=<0.001, respectively). Overall, less whole FV were wasted (64.4g) than cut FV (77.6g) (p=0.010). Significantly less cut FV were wasted at the elementary level, while significantly more cut FV were wasted at the middle and high school levels. The amount of cut FV consumed at the middle school level was significantly greater than the amount of whole FV consumed by middle school students. There were no significant differences in consumption at the elementary and high school level.

Serving Style Differences: Cut vs Whole FVs

After adjusting for covariates, adjusted negative binomial regression models indicated a significant difference in overall selection and waste of cut FV compared to whole FV (Table 3). Cut FVs were significantly more likely to be selected (Incidence Rate Ratio[IRR]= 1.11, 95 %CI: 1.04, 1.18) than whole fruits and vegetables, but they were also more likely to be wasted (IRR=1.20, 95 %CI: 1.04, 1.39) than whole fruits and vegetables. When adjusted by grade, significant results were found for wasted FV (IRR=0.94, 95 %CI: 0.93, 0.96) and consumed FV (IRR=1.03, 95 %CI: 1.01, 1.05), but not for selection. There was a significantly greater likelihood of female students selecting (IRR=1.03, 95 %CI: 1.00,1.06) and wasting (IRR=1.15, 95 %CI: 1.07, 1.23) cut FV than males, when models were adjusted for gender. Hispanic students were 1.06 times more likely to select cut FV (95 %CI: 1.01, 1.11), and 1.27 times more likely to consume cut FV than whole FV (95 %CI: 1.13, 1.43). Native American students wasted less FV (IRR=0.74, 95 %CI: 0.60, 0.92), and consumed more FV (IRR=1.47, 95 %CI: 1.18, 1.84) when the fruit or vegetable was cut vs whole. When models were adjusted for within-school similarities, significant differences were found for selection (IRR=1.01, 95 %CI: 1.00, 1.01), consumption (IRR=1.01, 95 %CI: 1.01, 1.02) and waste (IRR=0.98, 95 %CI: 0.98, 0.99).

When examining possible interaction effects by school level (elementary vs other, middle school vs other, and high school vs other) for the selection, waste, and consumption of FVs, only two interactions were statistically significant (data not shown): middle school students had a significantly higher effect modification for the selection of cut FVs (IRR=1.18; p=0.006) as compared to other students; and, high school students

had a significantly lower effect modification for the selection of cut FVs (IRR=0.83; p=0.010) compared to other students. No other interactions by grade level were statistically significant.

Table 2. Participant demographics and cut vs whole FV selection (n=2177)

	Total	Whole	Cut	p-value
	% (n)	%(n)	% (n)	
Gender				
Male	52.2 (1160)	53.2 (91)	52.1 (1069)	0.773
Female	47.8 (1064)	46.8 (80)	47.9 (984)	
Race/Ethnicity				0.471
Hispanic	64.5 (1405)	58.7 (98)	65.0 (1307)	
White	21.2 (461)	25.2 (42)	20.8 (419)	
Black	6.4 (139)	6.0 (10)	6.4 (129)	
Other	4.5 (98)	5.4 (9)	4.4 (89)	
Native American	3.5 (76)	4.8 (8)	3.4 (68)	
Lunch Status				0.549
Free/Reduced	84.1 (1868)	82.5 (141)	84.2 (1727)	
Paid	15.9 (354)	17.5 (30)	15.8 (324)	
Grade level				<0.001*
Elementary	43.7 (972)	27.5 (47)	46.1 (925)	
Middle	31.8 (708)	40.9 (70)	31.1 (638)	
High	24.5 (544)	31.6 (54)	23.9 (490)	

*Indicates a statistically significant value at $p<0.05$ level.

Table 3. Mean weights (g) of FV selected, wasted and consumed (n=2177)

	Total	Whole	Cut	p-value
	Mean +/- SD (g)	Mean +/- SD (g)	Mean +/- SD (g)	
Fruit/Vegetable selected (total)	**133.9 ± 68.3**	**117.8 ± 62.8**	**135.3 ± 68.5**	**0.001***
Elementary	119.9 ± 60.4	137.4 ± 60.4	119.0± 60.3	0.041*
Middle	151.2 ± 74.4	114.6 ± 71.7	155.3 ± 73.6	<0.001*
High	136.6 ± 67.8	105.0 ± 47.8	140.0 ± 68.8	<0.001*
Fruit/Vegetable wasted (total)	**76.6 ± 65.0**	**64.4 ± 59.7**	**77.6 ±65.3**	**0.010***
Elementary	71.9 ± 54.7	89.4 ± 60.7	71.0 ± 54.3	0.025*
Middle School	84.0 ± 74.0	64.3 ± 53.4	86.1 ± 75.6	0.019*
High School	75.4 ± 68.6	42.7 ± 59.2	79.0 ± 68.6	<0.001*
Fruit/Vegetable consumed (total)	**57.5 ± 54.0**	**53.6 ± 44.9**	**57.9 ± 54.7**	**0.322**
Elementary	48.2 ± 50.4	48.2 ± 48.9	48.1 ± 50.5	0.993
Middle School	67.3 ± 56.7	50.4 ± 48.9	69.2 ± 57.3	0.008*
High School	61.5 ± 54.0	62.4 ± 34.1	61.4 ± 55.8	0.893

*Indicates a statistically significant value at $p<0.05$ level.

Table 4. Adjusted negative binomial regressions assessing the relationship between cut and whole fruits and vegetables and fruit and vegetable selection, waste, and consumption among elementary, middle, and high school students in Arizona (n=2177).***

	Selection		Waste		Consumption	
	Incidence Rate Ratio**	CI (95%)	Incidence Rate Ratio**	CI (95%)	Incidence Rate Ratio**	CI (95%)
FV Serving Style						
Whole	Reference		Reference		Reference	
Cut	1.11	1.04, 1.18*	1.20	1.04, 1.39*	1.04	0.89, 1.21
Grade	1.00	0.99, 1.01	0.94	0.93, 0.96*	1.03	1.01, 1.05*
Gender (female)	1.03	1.00, 1.06*	1.15	1.07, 1.23*	1.03	0.95, 1.11
Race/Ethnicity						
White	Reference		Reference		Reference	
Black	1.02	0.95, 1.10	0.90	0.77, 1.06	1.16	0.96, 1.40
Native American	1.08	0.98, 1.17	0.74	0.60, 0.92*	1.47	1.18, 1.84*
Other	0.98	0.90, 1.06	0.76	0.63, 0.93*	0.93	0.75, 1.15
Hispanic	1.06	1.01, 1.11*	1.04	0.95, 1.15	1.27	1.13, 1.43*
School	1.01	1.00, 1.01*	1.01	1.01, 1.02*	0.98	0.98, 0.99*
Free/Reduced Price Lunch	1.01	0.96, 1.07	1.00	0.89, 1.12	0.95	0.84, 1.09

*Indicates a statistically significant value at $p<0.05$ level.

** Incidence rate ratios reflect the likelihood of fruit/vegetable selection, consumption, and waste compared to the reference with all other variables held constant.

***Model adjusted for FV serving style, gender, grade level, race/ethnicity, free/reduced price lunch status, and within-school similarities

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the relationship between FV serving style and students' FV selection, waste, and consumption during school lunch. Significant findings from this study include that students are more likely to select and waste FV when they are cut compared to when FV are served whole. In this study, students selected and wasted a greater average weight of cut FV than whole FV. When broken down by grade group (elementary, middle, high school), a greater percentage of elementary students selected cut FV than middle and high school students did. A closer look at interactions between selection and consumption and grade group did not have significant findings, though. These findings can help guide future research and may help schools determine a more practical and cost-efficient way of serving FV to students, in order to increase consumption and decrease waste. School foodservice departments participating in NSLP are interested in finding better ways to increase FV consumption, since they are required by the USDA to serve FV. Knowing whether to cut or serve FV whole would be valuable information, and a relatively easy solution to implement.

The current study's finding that students were more likely to select cut FV than whole FV aligns with findings from previous research studies on cut vs whole FV in schools.[13, 15, 70] Selection of cut FV could have been higher due to several schools pre-plating trays with a cut FV, and providing whole FV as an option. Of all the FV options available during this study, only eight were considered whole (15%). Therefore, students could have selected more cut FV because that was available to them more often. Olsen and colleagues studied which size and shape of FV students visually preferred.[14] Future

research could investigate if there are differences in selection and consumption of the same FV served in a variety of shapes and sizes. Additionally, more research is needed to increase not only selection of FV, but also consumption.

The unadjusted finding that a greater percentage of elementary students selected cut FV than middle and high school students did does align with previous research findings that younger students prefer cut FV[13]; however, when examining the interactions, we actually found that middle school students selected significantly more FVs compared to other grades and there was significantly lower selection of cut FVs among high school students. Our analyses did not show other significant interactions between serving style selection, consumption, and waste and grade level. These findings demonstrate that it is important to examine data on FV selection and intake for all grade levels. Given the difference in selection by grade level, more research is needed to determine which serving style is most likely to be selected and consumed by different grade levels. Perhaps serving cut FV at high schools is not the most effective use of a cafeteria staff's time and funds, since they would need to either cut the FV themselves or pay extra for it to be pre-cut.

This study's findings differed from previous studies' findings. Only one previous study explicitly cited waste as a measure, and they found that fewer students wasted apples when they were sliced than when they were served whole.[15] Our study found a decrease in waste of cut FV only when adjusted for grade and race/ethnicity. Previous literature examining cut vs whole FV did not adjust for gender, race/ethnicity, free/reduced status or age like the present study did.[13-15, 70, 71] Previous studies found an increase in consumption of cut FV, while this study only found significant increases in

consumption when adjusted for grade, race/ethnicity and school.[13, 15, 70] Those studies also introduced sliced fruit as an intervention, so the increase in consumption could be due item novelty.[13, 15, 70] There are some new and interesting implications for how to increase FV consumption provided by this study. Given that so few studies have examined waste of FVs, more research is needed to replicate our findings.

Although this study provides some interesting data on cut vs whole FV selection, consumption and waste, there are some limitations to note. It was a secondary analysis of cross-sectional data using a convenience sample, so causality cannot be addressed and generalizability may be limited. There was a possibility for human error when using technology to collect digital images and weights of each tray before and after food was consumed. It is possible that students may have thrown away, given away or saved their FV before submitting their plates for post-lunch weighing, resulting in some measurement error of how much FV they actually ate. Weights were only collected on cold FV available to students, and hot FV were not considered. Selection, consumption and waste figures may have been significantly different if those items had been included, since they would have impacted the overall FV amount. Designating the fruits and vegetables as whole or cut in this study was not done using a validated method. Cut or whole designation was done based on the amount of processing the FV went through before being served. Few FV options available to students during this study were designated as whole. Therefore, the lower selection of whole FV could be attributed to the lower availability of them or an error in designation. While some trays did have both cut and whole FV on them, it was not a significant portion of the sample, so teasing out which serving style accounted for the most waste was not an issue.

Another limitation was the small sub-samples. While the initial study set out to gather data from the same number of elementary, middle and high school students, there were fewer high school students in the sample. This was due in part to non-compliance by participants, and also more of the high school students' trays being eliminated for having both cut and whole FV present. Future research is needed on high school students, since there is evidence that they are not eating recommended amounts of FV.[17] The results of this study also suggest that students of Native American and Other race/ethnicities were less likely to waste cut FV, but the sample sizes of each of these demographics was small (3.5% and 4.5%, respectively). More research is needed with a greater number of students from these sub-groups.

Finally, this study did not adjust for waste from non-edible portions of FV that were left on the tray such as rinds and peels. Waste may have been greater due to the inclusion of those things in the post-lunch weighing. Future research should either remove non-edible portions from the tray prior to collecting the post-lunch weight, or calculate the yield percentage of the fruit or vegetable, and use that as the post-lunch weight. Standardized yield percentages can be found in the USDA's *Food Buying Guide for Child Nutrition Programs*.[74]

It is important to note that with the passage of HHFKA, having at least one serving of fruits or vegetables on the tray became a requirement for schools to be able to get reimbursed for that meal; a serving is typically one half cup.[11] Schools may choose to serve the FV on every tray, or they may offer a selection of FV to students, allowing students to make a choice of which FV they want to eat.[11] Anecdotally, when cafeteria staff are trying to serve large numbers of students as quickly as possible, they may pre-

plate a fruit or vegetable of the day. Therefore, when examining FV selection, it is important to keep in mind that the student may not have made the selection of a cut or whole fruit. The portion of FV that students are being served is also not their decision. This could account for the high selection and high waste of cut FV in this study. Future research should control for this by ensuring each student selects the type and amount of FV that are placed on their tray.

There were strengths to this study compared to previous research on cut vs whole FV, as well. Weighing the FV on trays before and after lunch provided more objective data than visual estimations of waste would provide. There was a large variety of fruits and vegetables examined in this study, and not just apples and oranges. The sample was large and diverse, and a random selection of students were invited to participate, allowing for greater generalizability. Most plate waste studies focus on elementary or middle school students; this study includes grades 1-12, which allows for greater generalizability of findings. Participant blinding was also a strength of this study.

CHAPTER 6

CONCLUSION

FV consumption remains low among children; it's important to identify factors that promote the selection and consumption of FVs, while minimizing waste. Our findings indicated that while students were more likely to select cut fruits and vegetables during this study, they did not consume significantly more, and waste significantly less, cut FV than whole FV, as was hypothesized. The cross-sectional nature of this study limits its validity, so more controlled interventions should be done in the future to further examine the effects of FV serving style on FV selection, consumption and waste in schools. Cutting FV could be an inexpensive and practical solution for schools to increase FV selection and consumption, so further research on this topic is warranted.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

APPROVAL: MODIFICATION

Meredith Bruening
Nutrition
602/827-2266
Meg.Bruening@asu.edu

Dear Meredith Bruening:

On 3/10/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	Salad bars and students' fruit and vegetable consumption: A group-randomized trial with objective assessments
Investigator:	Meredith Bruening
IRB ID:	STUDY00005882
Funding:	Name: HHS-NIH: National Heart, Lung, & Blood Institute (NHLBI)
Grant Title:	None
Grant ID:	None
Documents Reviewed:	None

The IRB approved the modification.

When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Marc Adams
Amanda Jochimsen
Rebecca Ruditser
Madeleine De Brabant
Erika Sanchez-Gomez
Dahlia Stott
Carly Thunberg
Corey Ball
Emerson Armstrong
Karen Victor
Martha Ormeno Lopez
Madeline Badalamenti
Rachel Harmon
Haneen Mustafa
Timothy Richards
Michael Royer
Sanjana Kumar
Rafael Quijada Castillo
Zulema Marquez
Kenzie Wood
Abigail Burnell
Samantha Blonder
Christine Phillips
Tianna Baker
Daisy Cruz
Nora Hall
Merine James
Aleksander Gomez
Amber James
Marc Adams
Emilia Ferreyra
Carina Liddicoat
Punam Ohri-Vachaspati
Hannah Tuomisto-Bell
Dyanna Potter
Molly Jepson
Yaneli Camargo
Michael Todd
Elisa Rivera
Hannah Muise
Arriana Joy Cruz
Celeste Thalheimer
Joy Ren

Ashley Thorp
Raevyn Xavier
Alison Cantley
Brianna Mackey
Emily Keidel
Maria Christy
Renuka Vemuri
Kassandra Koester
Miranda Miller
Dakota Cooper
Tatam Kramer
Rosita Vera Perez
Tsung-Yen Yu
Chermiqua Tsosie
Amy Coulter
Corrie Whisner
Payton Gibson
Sydney Pisano
Carina Platte
Alexandra Lish
Courtney Villalpando
Brenda Hernandez
Madison Schmucker
Emily Foreman

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