Differences in Fruit and Vegetable Consumption Among Children Related to Serving Container Color

by

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ABSTRACT

Background: Children's fruit and vegetable consumption in the United States is lower than recommended. School lunch is an opportunity for students to be exposed to fruits and vegetables and potentially increase their daily intake. The purpose of this study is to examine the relationship between tray color and fruit and vegetable selection, consumption, and waste at lunch.

Methods: Study participants (n=1469) were elementary and middle school students who ate school lunch on the day of data collection. Photographs and weights (to nearest 2 g) were taken of fruits and vegetables on students' trays before and after lunch. Trained research assistants viewed photographs and sorted trays into variable categories: color of main tray, presence/absence of secondary fruit/vegetable container, and color of secondary fruit/vegetable container. Fruit and vegetable selection, consumption, and waste were calculated using tray weights. Negative binomial regression models adjusted for gender, grade level, race/ethnicity, free/reduced price lunch status, and within-school similarities were used to examine relationships between tray color and fruit and vegetable selection, consumption, and waste.

Results: Findings indicated that students with a light tray selected (IRR= 0.44), consumed (IRR=0.73) and wasted (IRR=0.81) less fruit and vegetables. Students without a secondary fruit/vegetable container selected (IRR=0.66) and consumed (IRR=0.49) less fruit and vegetables compared to those with a secondary container. Light or clear secondary fruit and vegetable containers were related to increased selection (IRR=2.06 light, 2.30 clear) and consumption (IRR=1.95 light, 2.78 clear) compared to dark

secondary containers, while light secondary containers were related to decreased waste (IRR= 0.57).

Conclusion: Tray color may influence fruit and vegetable selection, consumption, and waste among students eating school lunch. Further research is needed to determine if there is a cause and effect relationship. If so, adjusting container colors may be a practical intervention for schools hoping to increase fruit and vegetable intake among students.

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CHAPTER 1

INTRODUCTION

Low fruit and vegetable consumption is related to many negative health outcomes, including increased risk of cancer (Van Duijnhoven et al., 2009), cardiovascular diseases (Hung et al., 2004; La Vecchia et al., 1998), and stroke (Joshipura, 1999). Currently, however, the majority of children are not meeting the national recommendations for fruit and vegetable intake (Kim et al., 2014). More research is needed to understand how to promote fruit and vegetable consumption among young children so that they develop long-lasting positive eating habits.

School lunch is an environment where children can be exposed to a variety of fruits and vegetables that they may not have the opportunity to eat at home. Parents are unlikely to offer children foods that they themselves do not find palatable and many American adults fail to meet recommendations for fruit and vegetable intake (Skinner et al., 2002; U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). School cafeteria interventions to increase fruit and vegetable intake in children have utilized a variety of strategies, including incentives and prizes for fruit and vegetable consumption (Loewenstein et al., 2016; Morrill et al., 2016), increasing portion sizes of fruits and vegetables served (Fisher et al., 2003; Miller et al., 2015), adding extra fruit and vegetable options by way of a salad bar, (Adams et al., 2005, 2016; Andersen et al., 2015; Huynh et al., 2010), and changing the cafeteria environment to be more conducive to fruit and vegetable intake (or “smart” interventions) (J. F. W. Cohen et al., 2015; Hanks et al., 2013; Perry et al., 2004). Many of these methods have been shown to

be effective, but there are drawbacks as well, including increased costs of time and money to schools and staff. Anecdotally, increased time, labor, and menu item cost are major barriers to schools serving more fresh fruits and vegetables. However, little to no scientific study has been devoted to the amount of time and money schools spend on fruits and vegetables. Instead, much of the research on cost of fruits and vegetables has examined its impact on low-income families outside the school environment; these studies found that fruits and vegetables are more expensive relative to less nutrient-dense foods (Cassady et al., 2007; Drewnowski et al., 2004; Monsivais & Drewnowski, 2007). One study examined the cost of serving vegetables in school cafeterias, finding that vegetables cost from 11-22 cents per serving; however, researchers did not examine this cost relative to other menu items (Ishdorj et al., 2016). Therefore, the cost to schools of serving fruits and vegetables is a research gap that needs to be filled. In the meantime, exploring lower-cost methods of increasing fruit and vegetable consumption is likely warranted.

One strategy that has not been consistently researched in schools is changing the serving methods of fruits and vegetables. Something as simple as the container in which food is served can affect perception and intake of food. For example, research has shown that people will serve themselves more and eat larger portions of food when using a large plate compared to a small plate, even if they are not aware that they have done so (DiSantis et al., 2013; Wansink et al., 2006, 2014). Therefore, in theory, if students are provided with a larger plate they will select and eat larger portions of food. Promising research has also been done with plate, bowl, or cup color; the color of a container can

influence perceived sensory properties such as taste and even the amount of a food or beverage people consume (Genschow et al., 2012; Piqueras-Fiszman et al., 2012, 2013; Piqueras-Fiszman & Spence, 2012a; Reutner et al., 2015). However, very little previous research has been conducted on the potential impact of container color on amount of food consumed. In addition, no studies could be found that examined the effect of serving container characteristics other than size on children's eating behavior, particularly as it relates to fruit and vegetable intake. Lastly, strategies involving serving container color have yet to be studied in the school cafeteria environment. These gaps should be explored, as the serving container of fruits and vegetables could be a simple, cost-effective mechanism for increasing fruit and vegetable intake in children in school cafeterias.

The purpose of the present study is to examine whether the serving container has an impact on fruit and vegetable consumption of children in a school cafeteria setting. Analyses will examine main tray (dark vs. light) and secondary container colors (dark, light or clear) along with whether this serving container characteristic is related to fruit and vegetable selection, waste, and/or consumption in children eating school lunch. Based on previous research, it is hypothesized that fruit and vegetable consumption will likely not be related to container color. The only container color shown to affect food consumption in previous studies is red (Genschow et al., 2012; Reutner et al., 2015), whereas the trays used in this study were black or white.

Strengths and Weaknesses

As in every research design, the present study has strengths and weaknesses. Strengths include the fact that information was collected from a wide variety of schools and students in grades 1-8; thus, it is likely representative of the general population of students in Arizona elementary and middle schools. In addition, the plate waste data is of high quality, as specific students' trays were photographed before and after the lunch period and weights accurate to 2 g were obtained. This provides an accurate picture of individual students' mealtime behavior, which can be difficult to measure in a typical school setting. Lastly, information on students' grade, gender, and socioeconomic status along with within-school clustering effects were able to be controlled for in statistical models.

Weaknesses of the present study design include the fact that low fruit and vegetable selection and consumption by children in general often results in positively skewed selection and consumption data, requiring corrected models to account for this skewness. In addition, the schools which participated in the study were selected on a volunteer basis; therefore, there may be some differences between these schools and schools that did not participate. In addition, researchers were unable to collect data on other potential confounders such as students' color preferences or liking of fruits and vegetables. Lastly, as this study is a secondary data analysis, the information used is powered for the original outcome of differing fruit and vegetable intake when students are exposed to salad bars. Therefore, there is likely to be extra noise in the data which may cause difficulty in teasing apart the exact amount of difference made by various

containers. However, despite these weaknesses, this study also has the potential to provide results that may influence future research on the topic of children's food consumption and serving container color.

Definitions of Terms

- School lunch: a meal purchased and eaten at a school meeting the requirements for reimbursement stipulated by the National School Lunch Program
- Serving container: a tray, boat, or bowl from which fruits and vegetables are directly eaten
- Color contrast: distance between two colors on a color wheel
- Fruit/vegetable selection: Amount of fruits/vegetables that students take from the serving line
- Fruit/vegetable consumption: Amount of fruits/vegetables that students eat during lunch
- Fruit/vegetable waste: Amount of fruits/vegetables left after the lunch period ends

CHAPTER 2

REVIEW OF LITERATURE

Importance of Fruit/Vegetable (F/V) Consumption and Intake in Children

Health Benefits of F/V Consumption

The importance of fruit and vegetable consumption for good health is a widely accepted fact. Fruit and vegetable consumption provides essential nutrients for proper nutrition and has been linked to numerous positive health outcomes including decreased risk of stroke, cardiovascular disease, and colorectal cancer (Dauchet et al., 2006; Hung et al., 2004; Joshipura, 1999; La Vecchia et al., 1998). Building healthy habits of fruit and vegetable consumption can help set children up for success in life, and therefore is a priority for public health workers and clinicians (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015).

Consumption of F/V in Children and Youth

The majority of children do not meet recommended intakes of fruit and vegetables. A 2014 Center for Disease Control (CDC) report found that mean daily intake of fruits and vegetables (per 1,000 calories) was less than one cup per day for children ages 2-18 years. Average intake for older children was actually less than that of younger children, with 0.97 cups being the average intake for kids ages 2-5 and 0.6 cups the intake for ages 12-18. In addition, potatoes comprised 30% of vegetable intake, often in fried or chip form (Kim et al., 2014). While these estimates of fruit and vegetable intake are adequate for some young children, they are much lower than the recommended intake for older children, as suggested amounts of fruits and vegetables to consume increase as

children grow (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). For example, the recommendations for fruit and vegetable intake for an adolescent male are around 2 cups of fruit and 3 cups of vegetables per day (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). In addition, the Dietary Guidelines for Americans 2015-2020 recommend that all Americans consume a wide variety of fruits and vegetables, with limited intake of saturated fats. Thus, the finding that children consume a disproportionately large amount of potatoes relative to overall vegetable intake is concerning.

A recent nationwide survey of teenagers found that 60.8% of teenagers reported having eaten fruit or drunk 100% fruit juice one or more times per day in the week before the survey was administered. In regards to vegetables, 59.4% reported having eaten vegetables one or more times per day in the week before the survey was administered (Kann et al., 2018). These reports also demonstrate that as a whole, youth do not meet recommended fruit and vegetable intake.

The National School Lunch Program

The National School Lunch Program (NSLP) provides funding for nutritious foods to be served in schools across the United States. Schools receive reimbursement for meals that meet specific nutritional standards, allowing them to provide lunches for free or at reduced prices to students of lower socioeconomic status. This allows access to fruits and vegetables for many elementary, middle, and high school -aged children. With the recent passage of the Healthy, Hunger-Free Kids Act (HHFKA), school meals are required to meet additional nutritional requirements in order to be eligible for

reimbursement. In regards to fruit and vegetables, a meal will only be reimbursable if it contains a fruit or vegetable component. In addition, the requirement for the amount of fruit available to each child per week has increased, and a wide variety of vegetables from specific subgroups are required to be served (Nutrition Standards in the National School Lunch and School Breakfast Programs; Final Rule, 2012). The HHFKA also introduced nutrition standards regarding availability of snacks and other foods sold outside the umbrella of the NSLP and guidelines for school wellness policies (J. Cohen & Schwartz, 2020).

Recent academic publications detailing the effect of these new standards on school meals are promising. One study found that vegetable selection (what students take to eat) remained the same before and after the new standards were implemented, but fruit selection increased (J. F. W. Cohen et al., 2014). However, fruit consumption did not change and vegetable consumption increased after the new standards were implemented (J. F. W. Cohen et al., 2014). This evidence is supported by another study, which found that the percentage of students selecting fruit increased after implementation, and that the variety of fruits available was related to overall fruit selection (Schwartz et al., 2015). In addition, this study found that vegetable selection increased in the second year of the new standards and that plate waste did not increase significantly from what it was before the new standards took effect (Schwartz et al., 2015). A more recent article also supports the lack of change in plate waste before and after HHFKA standards were implemented, although it is likely that plate waste was high in the first place (J. Cohen & Schwartz, 2020). One study examining cost of vegetables served in schools found that vegetable

plate waste was 52-58%. Researchers also found that nutrient-dense and low energy-density vegetables were more expensive (Ishdorj et al., 2016).

Nutritional quality of school meals after the new standards were implemented has also been examined. One study found that nutritional quality of school meals selected by students increased following implementation of the new school meal standards (Johnson et al., 2016). Another study supported this finding, adding the detail that percent of calories from saturated fat and levels of sodium in foods selected decreased, while the amount of fiber increased. The amount of calcium in foods selected by students, however, also decreased (Bergman et al., 2014). The most recent study on this topic demonstrated that adoption of the standards set forth by the HHFKA has led to increased nutritional value of both breakfasts and lunches served in schools (Gearan & Fox, 2020). Overall, the literature regarding the new lunch standards has shown promising outcomes that support nutritional improvements to NSLP.

It remains to be seen, however, if the nutritional quality of meals served equates to the nutritional quality of meals eaten. Few studies have directly measured what foods students consume during lunch. One exception is a plate waste study conducted in Colorado elementary and middle schools measuring student food selection, consumption, waste, and energy and nutrient intake (Smith & Cunningham-Sabo, 2013). Researchers found that 56-59% of elementary students and 39-52% of middle school students selected fresh or canned fruit at lunch, with 45% of elementary students and 34% of middle school students selecting a vegetable. Elementary students wasted around 37% of fruit and 34% of vegetables they selected. Middle school students wasted 38% of canned fruits, 47% of

fresh fruits, and 31% of vegetables selected (Smith & Cunningham-Sabo, 2013). Fewer than half of both elementary and middle school students met the recommended per-meal nutrient intakes for iron and vitamins A and C based on what was consumed (Smith & Cunningham-Sabo, 2013). Another study in elementary school students discovered that younger elementary students wasted more food at lunch; specifically, students in kindergarten and Grade 1 wasted 43% of vegetables and 32% of fruits, while students in Grades 2 and 3 wasted 34% of vegetables and 23% of fruits and students in Grade 5 wasted 26% of vegetables and 22% of fruits. Of note, these statistics included fruit juice as part of the overall fruit category (Niaki et al., 2017). While plate waste estimates vary across these studies, they all contribute to a picture where high amounts of fruit and vegetable plate waste are common. This can have implications for both students and schools, as students are missing out on the nutritional benefits of increased fruit/vegetable intake and schools are paying for large amounts of wasted fruits and vegetables.

Determinants of F/V Intake in Children

Extensive research has been devoted to what influences intake of fruit and vegetables in children. Environmental, social, and personal factors have all been examined, and each area has provided unique insight into this topic.

Personal Preferences/Choice

In a longitudinal study of children's food preferences, the strongest predictors of the number of foods liked at age 8 was the number of foods liked at age 4 and their overall food neophobia score (Skinner et al., 2002). This may suggest that some aspects of food preference are innate and individual to the child. However, continued exposure to

a new food may also increase both liking for and consumption of that food in children of the same age group (5-8 years) (Gibson et al., 2003).

In adolescents, one major contributor to food choice was found to be taste and sensory properties; interviewed adolescents seemed to group foods into "tasty" and "not tasty" categories, with many fruits and vegetables belonging in the "not tasty" category (Arcan & Murray, 2012). However, respondents perceived conflict between their taste preferences and what they should be eating; they liked less healthy, "tastier" foods such as ice cream but were aware that fruits and vegetables were a healthier choice (Arcan & Murray, 2012). In another study, participants reported feeling "refreshed" and more able to focus after eating healthy foods (O'Dea, 2003 p. 498). They felt that their bodies functioned better and that they were psychologically rewarded after eating healthy foods. However, participants also stressed that less healthy foods were more convenient and often tasted better than healthy foods. In addition, parents and peers provided social reinforcement for unhealthy food choices (O'Dea, 2003). Thus, it remains to be seen how to tip the balance towards food that adolescents perceive as less tasty but more healthy.

Interpersonal Influences

Parents' eating habits and health behaviors can have a significant impact on children's eating patterns. In a study that compared a group of children with more healthy eating patterns to those with less healthy eating patterns, those who ate more frequently with friends and family were more likely to have healthier eating patterns (Husby et al., 2009). Thus, the extent to which eating is a social experience may influence nutritional value of foods consumed.

In another study, children whose parents did not implement healthy eating behaviors at home were less likely to eat vegetables often. Behaviors such as eating candy without asking, not eating family meals, eating takeout meals one or more times a week, and not cooking with a caregiver were all associated with lower vegetable intake (De Jong et al., 2015). Eating meals as a family was associated with higher intakes of fruit and vegetables, as well as other markers of diet quality such as more frequent breakfast intake and lower intake of soft drinks (Larson et al., 2007). The positive influence of family meals on nutritional intake is consistent with adolescent age groups as well as younger children (Neumark-Sztainer et al., 2003). Younger children often have little control over what foods are offered them to eat, and therefore what the parent selects is what the child must eat (Husby et al., 2009). Parents are unlikely to offer children foods that they themselves do not find palatable (Skinner et al., 2002), so children's food experiences are somewhat limited by what parents provide.

Availability and Competitive Foods

Simply having fruits and vegetables available is correlated with increased intake in adolescent populations (Neumark-Sztainer et al., 2003). Thus, the school food environment can either contribute to increasing intake of fruits and vegetables by making them readily accessible or contribute to decreased fruit and vegetable intake by making them unavailable. At lunch, students who participate in the NSLP are required to take a certain amount of fruits and vegetables. However, students who for example bring lunch from home do not have to meet this requirement. One aspect of the school food environment that interacts with fruit and vegetable availability is the availability of

competitive foods. The term “competitive foods” refers to food sold to students outside of National School Food Programs. In the 2004-2005 school year, researchers found competitive foods available in schools were often energy-dense with low nutritional value (Fox et al., 2009). Presence of competitive foods such as a la carte options in the school cafeteria and vending machines have been correlated with lower daily fruit and vegetable intake among middle schoolers (Kubik et al., 2003). In addition, consumption of competitive foods in adolescents was found to decrease consumption of the school lunch meal and decrease overall intake of nutrients such as calcium and vitamin A (Templeton et al., 2005). This is concerning, as plate waste at school lunch is high at baseline and replacing nutrient-dense foods with more calorically-dense foods could lead to inadequate nutritional intake, especially for children who are at nutritional risk (Smith & Cunningham-Sabo, 2013). From the perspective of school nutrition professionals, sale of competitive foods is related to decreased revenue from sale of reimbursable meals, leading to a slight decrease in overall revenue (Peterson, 2011). In order to combat these negative effects, the HHFKA introduced standards for the nutritional value of competitive foods referred to as Smart Snack requirements (Nutrition Standards in the National School Lunch and School Breakfast Programs; Final Rule, 2012). These changes initially impacted school food revenue, but overall schools recovered by the second year and participation in the NSLP increased compared to before standards were implemented (Cohen et al., 2016). Available literature regarding these changes on student intake is limited, but a study conducted in the Appalachian region found that students reported no change in their overall food consumption following introduction of smart

snack requirements (Mann et al., 2017). Further research is needed regarding the impact of competitive foods on students' lunchtime fruit and vegetable consumption.

Gaps in the Literature Related to F/V Intake

Much research has been devoted to the influence of the home environment on eating habits in children and adolescents. However, specific practice recommendations regarding what can be done to encourage children to make more healthy eating choices are often difficult to synthesize from previous research, given the many factors that compete for children's attention while they are selecting foods to eat. Directly changing children's perceptions of food or affecting the home environment of every child would be unrealistically costly and invasive. Thus, schools are a prime area in which potential interventions can be targeted.

School Interventions to Increase Fruit/Vegetable Intake

For many children, school lunch is an opportunity to be exposed to a wider variety of fruits and vegetables and more encouragement to eat them than they are likely to receive at home (Skinner et al., 2002). As such, many interventions hoping to increase fruit and vegetable intake among students have been conducted in schools.

Incentives

Using incentives, or, less often, a reward/punishment system to increase fruit and vegetable intake among children is a common intervention style in the available literature. Short-term success in increasing consumption of fruits and vegetables by use of prizes such as small toys, quarters, or rubber bracelets has been documented across several studies (List & Savikhin, 2012; Loewenstein et al., 2016; Morrill et al., 2016).

One study showed that effects of using incentives (in this case, small keychains, pens, wristbands, or toys) can be seen for up to two months after distribution of incentives stops, a finding which aligns with the tenets of operant conditioning (Loewenstein et al., 2016). Tangible prizes were shown to be more effective than verbal praise at increasing fruit and vegetable intake in elementary school students (Morrill et al., 2016). However, although most incentives in these studies are purposefully low-cost, using incentives as a long-term intervention is not feasible in most cases. In addition, most of these studies were conducted with elementary aged children; it is unclear whether the same methods are effective with middle or high school students.

"Smarter" Lunchrooms

Changing the lunchroom environment to be more friendly to fruit and vegetable consumption is another popular intervention. Schools have utilized such strategies as employing chefs to redesign menu items, reorganizing cafeteria serving lines so that fruits and vegetables are more readily accessible, adding promotional signs within schools to encourage student consumption of fruits and vegetables, packaging fruits and vegetables differently to make them more attractive, instructing cafeteria workers to verbally prompt students to take fruits and vegetables, role modeling fruit and vegetable consumption, and increasing variety of items served (J. F. W. Cohen et al., 2015; Hanks et al., 2013; Perry et al., 2004). Results from smart makeovers are generally promising; it is a positive sign that such simple strategies can increase fruit and vegetable intake. However, almost all studies examined employ multiple methods in their makeovers, and it is difficult to determine which strategies had the biggest effect or could be used alone.

For example, one study's "cafeteria makeover" moved the location of fruits and vegetables within the serving line, used clear packaging to make fruits and vegetables seem more attractive, changed signage to display pictures of fruits and vegetables, and instructed staff to give students verbal prompts (Hanks et al., 2013). This strategy was effective, as the number of students who ate at least half a serving of fruit increased by 18% and students who ate at least half a serving of vegetables increased by 25% from baseline; however, more research needs to be done to understand why and how these methods work (Hanks et al., 2013). In addition, comparison across studies is difficult because such different methods for the smart redesign are used, and implementation across schools may look very different. Hypothetically speaking, two schools may implement packaging changes for fruits and vegetables, but one could choose to display fruits and vegetables in a clear container so they are easier to see, while another could choose to serve them in plastic baggies so they are easier for students to "grab and go." Understanding what specifically works best in these instances could save cafeteria staff time, money, and effort.

Salad Bars

Adding a salad bar to the school cafeteria is an intervention touted by many nutrition professionals as an effective strategy to increase fresh fruit and vegetable intake among students. Scientific backing for these claims is limited, with only a few studies currently published on the topic. One study's results suggest that the variety of fruits and vegetables offered affects children's consumption of fruits and vegetables rather than the presence of a salad bar itself (Adams et al., 2005). In addition, the location of a salad bar

is significant; when a salad bar was placed inside the regular serving line, fruit and vegetable selection, intake, and waste increased significantly relative to when a salad bar was placed outside the serving line (Adams et al., 2016). Another study found that salad bars placed in a more visible location resulted in students' serving themselves more fruits and vegetables (Huynh et al., 2010). In addition, in the same study schools with more variety on the salad bar had students serve themselves larger amounts of fruit and vegetables (Huynh et al., 2010). From these studies, it is evident that the way fruits and vegetables are served is related to student selection and consumption.

Portion Sizes

Promising research has been done regarding increasing the portion size of fruits and vegetables served to children. This tactic has been tested both inside and outside schools (Kral et al., 2010; Mathias et al., 2012; Miller et al., 2015). In a study where children were given larger portion sizes of fruits and vegetables at dinner compared to their usual intake, only fruit intake was seen to increase significantly, although total energy intake for the meal did not increase (Kral et al., 2010). However, in a later study, both fruit and vegetable intake increased at a meal with larger portion sizes, although these effects were only present if children liked the foods served (Mathias et al., 2012). In a school cafeteria setting, increasing the portion size of fruits and vegetables also increased intake (Miller et al., 2015). However, there are limitations to simply increasing portion sizes. In the cafeteria study, some children chose to take no fruits or vegetables at all (Miller et al., 2015). Increasing portion sizes will do no good if fruit and vegetable items do not even make it onto students' trays. In addition, food service management

teams may be concerned about the increased food waste and increase in food and labor costs that may occur with increasing portion sizes.

General Limitations of School Interventions to Increase Fruit and Vegetable Intake

Interventions that use a reward system to encourage fruit and vegetable intake have a significant short-term effect but little to no data is available on their long-term effects or cost-effectiveness (List & Savikhin, 2012). Therefore, whether these interventions establish eating patterns that contribute to lifelong health or are sustainable for schools remains to be seen. Interventions encompassing environmental change are effective, but consumption of fruits and vegetables may decrease when students are in an environment that is not designed to be friendly to fruits and vegetables. Using a salad bar to increase variety of fruits and vegetables served can impact fruit and vegetable consumption of students, but this may not be a realistic method for all schools. Increasing the portion sizes of fruit and vegetable servings may also increase students' fruit and vegetable consumption, but there are concerns about food waste. Future research is needed to identify interventions that are specific, practical, and cost-effective.

Physical Characteristics of Food Containers and Eating Behavior

Many studies suggest that the way food is served influences eating behavior in individuals. Perhaps the most common effect found is that serving style influences perception of flavor and food's sensory properties. Serving style also influences the amount of food consumed in some cases, and is therefore a potential area in which to focus research on fruit and vegetable intake.

Color

Several studies have examined the effect of container color on food perception and intake with intriguing results. In a study with differently colored cups and a hot chocolate beverage, researchers found that participants indicated increased liking of the beverage in a red cup over a white cup and that the chocolate flavor was perceived as more pronounced in the red cup (Piqueras-Fiszman & Spence, 2012a). In another study, the flavor of popcorn was affected by the color of serving bowl; sweet popcorn was perceived as saltier and salty popcorn as sweeter when served in a colored bowl as opposed to a white bowl (Harrar et al., 2011). Another study found that color contrast can affect liking and perceived appetizing quality of desserts, as desserts that contrasted with the plate color were more appetizing to consumers (Piqueras-Fiszman et al., 2013). The color red has been found to reduce intake of soft drinks and snack foods when compared to blue and white cups and plates; the effect of the color red, however, may be modified by the perceived healthiness of the food being served (Genschow et al., 2012; Reutner et al., 2015). Therefore, consumers will eat less of a food served on a red plate regardless of the type of food. However, they will eat more of a healthier food served on a red plate compared to a less healthy food served on a red plate. For example, researchers found that participants eating from a red plate ate fewer grapes, chocolate pieces, white bread, and whole grain bread compared to when they were served on a white plate. However, participants ate comparatively more of the grapes and whole grain bread compared to chocolate pieces and white bread, likely due to perceived healthiness of these options (Genschow et al., 2012; Reutner et al., 2015). These findings have several intriguing

implications. The general concept that the serving container can influence perception and intake of a food may be applied in practice to make traditionally less appealing foods such as fruits and vegetables seem more appealing. Conversely, it would be relatively simple to make less healthy foods seem less appealing and therefore decrease intake. The fact that a characteristic as simple as the color of the serving container can affect food intake means that if specific color interactions can be found to affect food intake and perception, changing the serving container color may be an easy and cost-effective way to influence eating behavior. However, more research is needed to verify which color combinations produce these effects and whether contrast between the food and the plate is more important than the plate color itself. In addition, no studies have been conducted to determine if the effects of such visual stimuli have a long-term effect on eating behavior.

Size

The effect of serving container size on food intake has been well established in both children and adults. When given a larger serving plate or bowl, both children and adults serve themselves more food and consume more food than if they are given a smaller serving plate or bowl (DiSantis et al., 2013; Wansink et al., 2006, 2014; Wansink & Junyong, 2005). This effect was also observed with larger serving spoons as opposed to smaller serving spoons, with those given larger serving spoons serving themselves more food by weight than those given smaller serving spoons (Wansink et al., 2006). In addition, one study found that people ate more from a larger container even when they disliked the food they were eating; in this case, they were served stale popcorn (Wansink

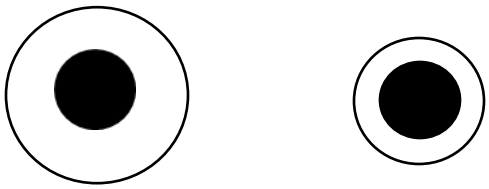
& Junyong, 2005). Therefore, changing the size of the serving container could be utilized as another simple intervention to increase intake of healthy foods or decrease intake of less healthy foods. However, there are also downsides to this method. Increased serving container size has been related to increased food waste in at least one study , and in a school cafeteria setting where the budget is always a concern, increased food waste may outweigh potential benefits of increasing food consumption (Wansink et al., 2014). In addition, only one of the studies reviewed examined fruit and vegetable intake (DiSantis et al., 2013).

The Delbouef Illusion

One explanation for the effect that larger plate size has on food intake is the Delbouef illusion. This illusion utilizes the optical effect that a small circle surrounded by a much larger circle appears smaller than the same small circle surrounded by an only slightly larger circle.

Figure 1

Delboeuf Illusion Illustration



Thus, someone serving themselves food on a large plate perceives that they are serving themselves the same or a smaller amount of food than on a smaller plate, when in reality they are actually serving themselves more than they would on the smaller plate. A few studies on this topic have tested the effects of color contrast and education on food

serving behavior where this illusion is present. Subjects were asked to match a reference serving of food with either a white plate on a white tablecloth or a white plate on a black tablecloth. Researchers found that color contrast (white on black) reduced overserving of food so that amounts more closely matched the reference (Van Ittersum & Wansink, 2012). In another study, participants who were given more time to examine the reference portion more closely matched its actual size, suggesting that attention may play a role in decreasing overserving of foods (Van Ittersum & Wansink, 2012). Educating participants about the Delbouef illusion before asking them to match a reference serving of food reduces overserving on large plates and underserving on small plates, but does not completely eliminate the effects of the illusion (Van Ittersum & Wansink, 2012). The last study examined behavior in a more naturalistic setting. Participants at a buffet served themselves pasta with either red or white sauce and were randomized to receive either a red or white plate. Researchers found that participants with high-color contrast conditions (white sauce on red plate and red sauce on white plate) served themselves significantly less pasta than those with low-color contrast conditions (white sauce on white plate and red sauce on red plate). No differences were observed between groups for color; those who received white sauce and white plates took the same amount as those who received red sauce and a red plate (Van Ittersum & Wansink, 2012).

These findings suggest that education, attention, and color contrast can moderate the effect of serving container size on self-serving of food. However, researchers only examined serving behavior, so what participants actually ate after serving themselves was not considered. In addition, most of these studies used a reference portion size. In a

school cafeteria, it is unlikely that students would be shown a reference portion size when self-serving food and may not even be allowed to serve themselves. Lastly, fruit and vegetable intake was not specifically examined in any of these studies, although a tomato-based soup and sauce were used in two of them (Van Ittersum & Wansink, 2012). More research should be done to determine what influence, if any, this illusion can have on fruit and vegetable consumption specifically and whether these results hold true in a naturalistic, less-controlled setting.

Shape

Literature regarding varying shapes of serving container is lacking, as most studies have focused on shape of foods instead of shape of serving containers (Olsen et al., 2012). One study compared circular, square, and triangular plates, and found no differences in food perception or intake (Piqueras-Fiszman et al., 2012). It is also unclear as to whether the Delbouef illusion generalizes to other shapes, such as rectangles or triangles. Therefore, more research is needed to verify that container shape does not influence food intake and identify the potential role of optical illusions in human eating behavior.

Weight

Research has recently found that the weight of a serving container may also influence food perception and intake. Participants were given two visually identical bowls of yogurt, with one having a hidden weight attached to the bottom. They were then asked to taste the yogurt and rate which one they felt would make them feel more full. Yogurt eaten from the heavier bowl was rated as significantly more satiating than yogurt

eaten from the lighter bowl. Thus, it is possible that heavier serving containers may influence expected satiety (Piqueras-Fiszman & Spence, 2012b).

Summary

In summary, color of a serving container can influence sensory perception of food and intake, with red plates/bowls and conditions of high color contrast perhaps leading to decreased food intake (Genschow et al., 2012; Piqueras-Fiszman et al., 2012, 2013; Piqueras-Fiszman & Spence, 2012a; Reutner et al., 2015; Van Ittersum & Wansink, 2012). Larger serving containers lead to increased serving sizes and therefore increased intake, which may occur because of the Delbouef illusion (Kral et al., 2010; Mathias et al., 2012; Wansink et al., 2006, 2014; Wansink & Junyong, 2005). This, however, may be offset by color contrast (Van Ittersum & Wansink, 2012). No previous research has found any significant effects of container shape on eating behavior (Piqueras-Fiszman et al., 2012; Van Ittersum & Wansink, 2012). Weight of a serving container, however, likely influences expected satiety, although the impact of weight on amounts of food eaten is not yet firmly established (Piqueras-Fiszman & Spence, 2012b).

Gaps in the Literature Related to Serving Containers and Fruit/Vegetable Intake

Few studies have been conducted in children regarding the influence of serving containers on intake besides those regarding size. Few of the studies reviewed examined vegetable intake, and whole fruit was only used in one study (Reutner et al., 2015). Types of food used in these studies were generally desserts, entrées, dairy, or grain items (DiSantis et al., 2013; Genschow et al., 2012; Harrar et al., 2011; Piqueras-Fiszman et al., 2012, 2013; Piqueras-Fiszman & Spence, 2012a, 2012b; Van Ittersum & Wansink, 2012;

Wansink et al., 2014, 2006; Wansink & Junyong, 2005). Considering the fact that increasing fruit and vegetable intake is a key focus of child nutrition, it is important that these studies be reexamined using fruit and vegetable items and children as the study population. No studies regarding container color have been conducted in schools. In addition, the shape of serving containers has received minimal focus, although limited present literature does not suggest that plate shape significantly affects food intake (Piqueras-Fiszman et al., 2012). The Delbouef illusion may apply to circular plates, but it is unknown if the same effects persist when using plates or serving containers of other shapes. Another key concern is that a major researcher in the field of serving styles and food intake, Brian Wansink, has recently been discredited and several of his papers have been retracted for poor data handling (none cited in this review). However, since a few of his papers have been called into question, rigorous replication studies are needed to confirm even non-retracted published findings. Future research is needed to fill the gaps regarding children's eating behavior and either support or refute the veracity of previous results.

CHAPTER 3

METHODS

Study Design and Sample

The present study is a secondary data analysis of baseline data derived from a randomized controlled trial examining the efficacy of salad bars on increasing fruit and vegetable intake in children (parent study). The original number of subjects was chosen in order to provide adequate power for the primary study outcomes. For this sub-study, a total of 1,469 lunch measurements were included.

The parent study included children attending Grades 1-12 in Arizona schools without salad bars at baseline. Children were invited to participate if they purchased a hot lunch from the school cafeteria and if they were randomly selected to be in the study sample on the day data was collected. Students were excluded if they brought lunch from home, were outside of the selected grades, or declined to participate. The sub-sample for the present study included only students in middle or elementary schools (Grades 1-8).

School administrators acted in loco parentis to provide informed consent for students to participate in the study, while students provided verbal assent. Participants were asked if researchers could take a picture of their lunch. If they agreed, the student was provided with a barcoded tray and instructed to select and pay for lunch as normal. Children were then directed to a table past the point of service where food was weighed and photographed. After children finished eating, their trays were collected, weighed, and photographed again. Children were given a small prize for participation. The study was approved by the Arizona State University Institutional Review Board.

Measures

Fruit and Vegetable Selection, Consumption, and Waste

The primary measures for this study are students' fruit and vegetable selection, consumption and waste. Photographs of the fruit/vegetables served cold or at room temperature on each student's tray before and after eating were taken by trained research assistants. Trays were placed on a digital scale so that weight of the tray (taken to the nearest 2 g) at each measurement point was visible in the photographs. Photographs of the student's full lunch were also taken before and after eating. Following data collection, additional trained research assistants viewed photographs and recorded fruit/vegetable weights along with tray types. Fruit/vegetable selection, consumption, and waste were calculated using the following method: selection was measured using the weight of fruit/vegetables taken before lunch, while waste was measured using the weight of fruit/vegetables left over after lunch. Consumption was calculated by subtracting the waste weight from the selection weight.

Tray/Container Types

Twenty different types of serving containers were offered in the participating schools, and some participants had up to four different containers on a single tray (see Table 1 for a comprehensive list of serving containers present on students' trays). Characteristics used in this analysis include the main tray color, presence of a secondary fruit/vegetable container, and color of the secondary container if present. Trained research assistants were responsible for viewing images and classifying trays into main

tray color (dark vs. light), presence or absence of secondary container, and secondary container color (dark, light, or clear) categories.

Table 1

Serving Containers by Color

Serving Container	Color	Secondary vs. Main Tray	Number of Trays with This Container
Black Circular Container with Lid	Dark	Main	16
Black Large 5-Compartment Tray	Dark	Main	835
Black Rectangular Portion Cup	Dark	Secondary	2
Black Square Portion Cup	Dark	Secondary	293
Clear Clamshell	Clear	Secondary	66
Clear Plastic Cup with Lid	Clear	Secondary	19
Clear Plastic Pre-Portioned Cup	Clear	Secondary	681
Clear Plastic Sandwich Container	Clear	Secondary	2
Large Clear Rectangular Clamshell	Clear	Secondary	45
Small Clear Clamshell Container	Clear	Secondary	33
Medium Circular Styrofoam Portion Cup	Light	Secondary	132
Small Styrofoam Pre-Portioned Cup	Light	Secondary	15
White Circular Bowl	Light	Secondary	178
White Large 5-Compartment Recycled Tray	Light	Main	280
White Large 5-Compartment Tray	Light	Main	2296
White Large Rectangular Boat	Light	Main	225
White Small Rectangular Boat	Light	Secondary	226
White Styrofoam Cup	Light	Secondary	4
Large Cardboard Rectangular Boat	Other	Main	17
Cardboard Hummus Tray	Other	Secondary	7

Student Sociodemographics

Information on participants' gender (male vs. female), grade level (elementary vs. middle school), race/ethnicity, and free/reduced lunch eligibility status was obtained from school records and built into the analysis to control for potential confounders.

Statistical Analysis

Descriptive statistics including student distribution by age, grade level, race/ethnicity, socioeconomic status, and gender were calculated; descriptives by grade level (elementary vs. middle school) were also examined. Differences in fruit and vegetable selection, consumption, and waste for three different predictors (main tray color, presence of secondary fruit/vegetable container, and secondary fruit/vegetable container color) were assessed. Given the skewed nature of the distributions of selection, consumption, and waste variables, the relationships between tray color and selection, consumption, and waste were examined using negative binomial regression models, adjusting for student sociodemographic factors and within-school similarity as a random effect. The same method was used to examine differences in selection, consumption, and waste where fruits and vegetables were served in a secondary container as well as selection, consumption, and waste related to color of secondary containers. In analyses examining secondary container color, adjustment for the main tray color was also included. Results for regression models are presented as incidence rate ratios. Analyses were performed using Stata statistical software package (version 15, College Station Texas, 2017).

CHAPTER 4

RESULTS

Descriptive Statistics

Overall the sample was diverse and balanced by gender, with 39% of participants non-White and 53% male. The middle school sample was more diverse, had a higher percentage of dark main trays, and had a higher proportion of students with secondary fruit/vegetable containers (Table 2). Fruit and vegetable selection and consumption differed for elementary vs. middle school students, with a mean of 119.7 g selected and 48.7 g consumed by elementary students compared to 138.1 g selected and 71.0 g consumed by middle school students. Fruit and vegetable waste per student had a mean of 71.1 g wasted by elementary and 67.1 g wasted by middle school participants. Across the entire sample, students selected a mean of 126.5 g, consumed 56.9 g, and wasted 69.6 g fruit/vegetables. For reference, 1 cup of fresh raspberries is around 123 g (Pennington & Spungen, 2010); therefore in raspberries students selected about 1 cup, consumed about 45%, and wasted the other 55%.

Main Tray Color

Regression models found a significant difference in fruit and vegetable selection, consumption, and waste for students with a dark-colored main tray compared to a light-colored main tray (Table 3). Those with a light tray on average selected 56% less fruits and vegetables (IRR=0.44; 95% CI: 0.37, 0.53); consumed 27% less fruits and vegetables (IRR= 0.73; 95% CI: 0.62, 0.87); and wasted 19% less fruits and vegetables (IRR=0.81; 95% CI: 0.68, 0.96) compared to those with a dark tray. A negative correlation between

grade level and fruit/vegetable selection (IRR=0.94; 95% CI: 0.93, 0.96) and waste (IRR= 0.92; 95% CI: 0.89, 0.94) was observed. A similar negative correlation was found for gender (selection IRR= 0.95, 95% CI: 0.90, 1.00; waste IRR= 0.91, 95% CI: 0.83, 0.99). Children who are Hispanic consumed (IRR= 0.82; 95% CI: 0.74, 0.90) and wasted (IRR= 0.71; 95% CI: 0.61, 0.83) less fruit and vegetables. In addition, students in the Black, Native American, and Asian race categories wasted less fruit and vegetables (IRR= 0.81, 95% CI: 0.68, 0.97; IRR= 0.73, CI: 0.59, 0.90; and IRR= 0.57, CI: 0.35, 0.93, respectively). Fruit and vegetable selection (IRR= 1.04; CI: 1.03, 1.06), consumption (IRR= 1.03; CI: 1.02, 1.04), and waste (IRR= 1.01; CI: 1.00, 1.03) also differed significantly by school.

Secondary Fruit/Vegetable Containers

Participants selected 34% less fruits and vegetables when the fruit/vegetables were served on the main tray without a secondary container (IRR= 0.66; 95% CI: 0.60, 0.72). It was also found that when fruits and vegetables were not served in a secondary container, students consumed less (IRR=0.49; 95% CI: 0.43, 0.56). No significant differences were observed in regards to waste and secondary container presence (Table 4). Male students selected (IRR=0.94, 95% CI: 0.90, 0.99) and wasted (IRR=0.92, 95% CI: 0.84, 1.00) less fruit/vegetables compared to female students. Selection (IRR=0.94; 95% CI: 0.93, 0.96) and waste (IRR=0.92, 95% CI: 0.89, 0.94) also varied significantly by grade. Students who are Hispanic selected (IRR=0.86; 95% CI: 0.77, 0.95) and wasted (IRR=0.74, 95% CI: 0.63, 0.86) less fruit and vegetables compared to the reference group (Table 4). Black and Native American students wasted less fruit and vegetables

(IRR=0.82, 95% CI: 0.69, 0.98; IRR=0.74, 95% CI: 0.60, 0.92, respectively). Students identified as Asian both consumed (IRR=0.56, 95% CI: 0.34, 0.93) and wasted (IRR=0.57, 95% CI: 0.35, 0.93) less fruit and vegetables. Fruit and vegetable selection (IRR= 1.04; 95% CI: 1.03, 1.05), consumption (IRR=1.03; 95% CI: 1.01, 1.04), and waste (IRR=1.01; 95% CI: 1.00, 1.03) varied significantly by school as well.

Secondary Fruit/Vegetable Container Color

In regards to color of secondary container, students selected 2.3 times more (95% CI: 1.32, 3.98) and consumed 2.78 times more (95% CI: 1.82, 4.24) fruits/vegetables when they were served in a clear container (Table 5). When served in a light container, students selected 2.06 times more (95% CI: 1.06, 4.02), consumed 1.95 times more (95% CI: 1.18, 3.24), and wasted 43% less (IRR=0.57, 95% CI: 0.34, 0.95) fruits and vegetables compared to those served in a dark container. Main tray color was a significant confounder for the secondary container color in analyses examining selection (IRR= 0.51, 95% CI: 0.30, 0.85). Gender was significantly related to fruit/vegetable selection when holding secondary container color constant (IRR= 0.93, 95% CI: 0.88, 0.99). Fruit and vegetable selection also differed significantly by school (IRR= 0.97, 95% CI: 0.95, 1.00). Grade level and waste were negatively related when controlling for secondary container color (IRR= 0.89; 95% CI: 0.85, 0.94). In addition, children identified as Native American consumed more (IRR= 1.32; 95% CI: 1.00, 1.72) and wasted less (IRR= 0.67; 95% CI: 0.47, 0.97) fruits and vegetables than the reference group.

Table 2

Participant demographics and key variables (n=1469)

	Elementary Students	Middle School Students	Total Students
Gender	% (n)	% (n)	% (n)
Male	53 (494)	54 (289)	53 (783)
Female	47 (437)	46 (249)	47 (686)
Race/Ethnicity			
White	69 (638)	41 (173)	60 (811)
Hispanic	12 (115)	37 (153)	20 (268)
Black	8 (74)	8 (34)	8 (108)
Other	5 (51)	4 (17)	5 (68)
Native American	4 (40)	8 (35)	5 (75)
Asian	1 (12)	1 (5)	1 (17)
Lunch Status			
Paid	18 (169)	19 (103)	19 (272)
Free/Reduced	82 (762)	81 (435)	81 (1197)
Grade			
1-5	63 (931)	*	63 (931)
6-8	**	37 (538)	37 (538)
Main Tray Color			
Dark	20 (186)	28 (148)	23 (334)
Light	80 (743)	69 (373)	77 (1116)
F/V Secondary Container			
Yes	28 (262)	47 (253)	35 (515)
No	72 (669)	53 (285)	65 (954)
Secondary Container Color			
Dark	44 (115)	3 (7)	24 (122)
Light	30 (79)	0 (0)	15 (79)
Clear	26 (69)	97 (246)	61 (315)
	Mean +/- SD (g)	Mean +/- SD (g)	Mean +/- SD (g)
Fruit/Vegetable Selection	119.7 +/- 62.3	138.1 +/- 93.6	126.5 +/- 75.8
Fruit/Vegetable Consumption	48.7 +/- 50.1	71.0 +/- 64.4	56.9 +/- 56.7
Fruit/Vegetable Waste	71.1 +/- 55.4	67.1 +/- 74.4	69.6 +/- 63.0

*Elementary sample included Grades 1-5. Percentage of students by grade is as follows: 1st grade— 10%; 2nd grade— 10%; 3rd grade— 15%; 4th grade— 14%; and 5th grade— 14%.
**Middle school sample included Grades 6-8. Percentage of students by grade is as follows: 6th grade—14%; 7th grade—13%; 8th grade—10%.

Table 3

*Negative binomial regression models examining association between main tray color and children's fruit and vegetable selection, consumption, and waste.****

	Selection			Consumption			Waste		
	Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)	
Main Tray Color									
Dark	Reference			Reference			Reference		
Light	0.44	0.37	0.53*	0.73	0.62	0.87*	0.81	0.68	0.96*
Grade	0.94	0.93	0.96*	1.01	0.98	1.04	0.92	0.89	0.94*
Gender	0.95	0.90	1.00*	0.98	0.89	1.08	0.91	0.83	0.99*
Race									
White	Reference			Reference			Reference		
Hispanic	0.82	0.74	0.90*	0.97	0.83	1.13	0.71	0.61	0.83*
Black	0.93	0.84	1.04	0.97	0.80	1.17	0.81	0.68	0.97*
Native American	0.91	0.80	1.03	1.12	0.90	1.40	0.73	0.59	0.90*
Asian	0.80	0.62	1.03	0.65	0.39	1.08	0.57	0.35	0.93*
Other	1.04	0.94	1.16	1.04	0.84	1.29	0.89	0.73	1.08
School	1.04	1.03	1.06*	1.03	1.02	1.04*	1.01	1.00	1.03*
Free/Reduced Price Lunch	0.99	0.90	1.09	1.07	0.92	1.25	0.90	0.78	1.03

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

** 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 gender, grade level, race/ethnicity, free/reduced price lunch status, and within-school similarities.

Table 4

*Negative binomial regression models examining association between presence of secondary fruit/vegetable container and children's fruit and vegetable selection, consumption, and waste.****

	Selection			Consumption			Waste		
	Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)	
Secondary Container									
Present	Reference			Reference			Reference		
Absent	0.66	0.60	0.72*	0.49	0.43	0.56*	1.05	0.93	1.19
Grade	0.94	0.93	0.96*	1.01	0.99	1.04	0.92	0.89	0.94*
Gender	1.94	0.90	0.99*	0.96	0.88	1.06	0.92	0.84	1.00*
Race									
White	Reference			Reference			Reference		
Hispanic	0.86	0.77	0.95*	0.88	0.76	1.03	0.74	0.63	0.86*
Black	0.95	0.86	1.06	0.96	0.80	1.16	0.82	0.69	0.98*
Native American	0.92	0.81	1.05	1.11	0.90	1.37	0.74	0.60	0.92*
Asian	0.82	0.63	1.06	0.56	0.34	0.93*	0.57	0.35	0.93*
Other	1.04	0.93	1.16	1.07	0.87	1.32	0.88	0.72	1.07
School	1.04	1.03	1.05*	1.03	1.01	1.04*	1.01	1.00	1.03*
Free/Reduced Price Lunch	0.98	0.90	1.08	0.99	0.85	1.16	0.91	0.80	1.04

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

**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 gender, grade level, race/ethnicity, free/reduced price lunch status, and within-school similarities.

Table 5

*Negative binomial regression models examining association between secondary fruit/vegetable container color and children's fruit and vegetable selection, consumption, and waste.****

	Selection			Consumption			Waste		
	Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)		Incidence Rate Ratio**	CI (95%)	
Secondary Container Color									
Dark	Reference			Reference			Reference		
Light	2.06	1.06	4.02*	1.95	1.18	3.24*	0.57	0.34	0.95*
Clear	2.30	1.32	3.98*	2.78	1.82	4.24*	1.04	0.75	1.43
Main Tray Color	0.51	0.30	0.85*	0.85	0.60	1.21	1.24	0.91	1.70
Grade	0.98	0.95	1.00	1.03	0.98	1.08	0.89	0.85	0.94*
Gender	0.93	0.88	0.99*	1.03	0.90	1.17	0.86	0.74	1.01
Race									
White	Reference			Reference			Reference		
Hispanic	0.94	0.84	1.05	0.91	0.72	1.13	1.01	0.79	1.31
Black	0.98	0.85	1.13	1.03	0.78	1.37	0.88	0.62	1.26
Native American	0.90	0.78	1.04	1.32	1.00	1.72*	0.67	0.47	0.97*
Asian	0.88	0.69	1.12	0.54	0.28	1.06	0.88	0.46	1.70
Other	1.14	0.96	1.34	0.95	0.65	1.39	0.98	0.65	1.49
School	0.97	0.95	1.00*	0.99	0.96	1.02	1.01	0.98	1.04
Free/Reduced Price Lunch	1.07	0.93	1.23	1.11	0.85	1.43	0.84	0.62	1.13

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

**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 main tray color, gender, grade level, race/ethnicity, free/reduce price lunch status, and within-school similarities.

CHAPTER 5

DISCUSSION

The purpose of this study is to examine the relationship between serving container color and students' fruit and vegetable selection, consumption, and waste. Major findings indicate that students were less likely to select, consume, and waste fruits and vegetables served on a light colored tray. In addition, students were more likely to select and consume fruits and vegetables served in a secondary container. In regards to color of the secondary container, students selected and consumed more fruits and vegetables when they were served in a light or clear container, and wasted less when they were served in a light container. If these findings are corroborated by future research, they may provide guidance to school food service operations on how best to serve fruits and vegetables in order to encourage students to select and consume larger amounts while wasting less.

The fact that student selection, consumption, and waste differed by main tray color is intriguing, as previous studies have only found differences in intake when serving containers were red (Genschow et al., 2012; Reutner et al., 2015). However, previous studies have found a difference in perception of a food's sensory attributes when it is served in a light vs. dark container (Piqueras-Fiszman et al., 2012, 2013). The present finding was that a darker tray color resulted in more selection and consumption of fruits and vegetables but also more waste compared to a light tray color. Perhaps a darker tray creates more visual color contrast, causing fruits and vegetables to be more appealing to students and increasing selection and consumption somewhat; however, this did not affect their consumption enough to completely offset the amount of waste students would

typically generate and therefore the excess selected fruit and vegetable was thrown away. Future research should compare light and dark main trays using the same types of fruit and vegetables to examine if this effect remains consistent under experimental conditions. If these findings are corroborated, darker trays may encourage students to select more fruits and vegetables and therefore could serve as a simple intervention for schools hoping to increase students' selection and consumption of fruits and vegetables at lunch.

The finding that students selected and consumed a greater quantity of fruits and vegetables when the fruits/vegetables were served in a secondary container differs from the more common result that people will eat larger amounts of food from larger containers (DiSantis et al., 2013; Van Ittersum & Wansink, 2012; Wansink et al., 2006, 2014; Wansink & Junyong, 2005). However, these studies often had subjects serve themselves (DiSantis et al., 2013; Van Ittersum & Wansink, 2012; Wansink et al., 2006, 2014). In the cafeteria setting, students may not have the option to plate their own food, so perhaps the effect of individuals eating larger amounts from larger containers is seen most often in a self-service setting. Future research could examine whether there is a difference in how much fruit and vegetables are consumed when students are allowed to self-select the amount on their plate. In addition, few studies have used fruits and vegetables when examining the idea that people will eat more from larger plates; other studies used foods such as ice cream, cereal, and pasta (Van Ittersum & Wansink, 2012; Wansink et al., 2006, 2014). Perhaps behavior is influenced differently when the food being consumed is perceived as healthy, as has been observed in a previous study of the effect of red plates on food consumption (Reutner et al., 2015). Future research should

first confirm if children do indeed consume more fruits and vegetables when they are served in a secondary container on a main lunch tray. If so, serving fruits and vegetables in this way may aid school food service operations in increasing fruit and vegetable selection and consumption.

Serving fruits and vegetables in a light or clear secondary container was associated with increased selection and consumption. In addition, students were less likely to waste fruits and vegetables served in a light container. No other studies were found that examined the specific impact of clear containers on food consumption. However, several previous studies regarding lunchroom interventions mention increasing the attractiveness of fruits and vegetables being served; one states that study schools increased the appeal of fruits and vegetables by putting them in little cups (J. F. W. Cohen et al., 2015; Hanks et al., 2013; Perry et al., 2004). It is possible that light-colored or clear containers make fruits and vegetables more visible and therefore more appealing to students. A significant relationship was found between main tray color and secondary container color in regards to selection; therefore, it is possible that various combinations of main tray colors and secondary container colors may yield differing results in regards to amount of fruit and vegetable selected. Future research may examine whether students select, consume, and waste different amounts when a dark tray and a light fruit/vegetable serving container are combined compared to a light tray and a dark serving container color or a light tray with a light serving container color.

While these findings are intriguing and may help direct future research in this area, several limitations of the present study should also be addressed. Firstly, this was

not a controlled experiment and therefore, causation cannot be presumed. In addition, this study only examined data from fruits and vegetables served cold or at room temperature, as the larger study from which the data were pulled focused primarily on fruits and vegetables suitable for service on salad bars. Therefore, different results may be observed with fruits and vegetables served hot. In addition, it was not possible to account for fruit or vegetables present in entrée dishes, which may have influenced students' consumption of fruits and vegetables served as sides with the meal. It is also possible that some fruits and vegetables were more likely to be served in certain types of containers, and these menu items may be innately more appealing to students. Students' existing fruit and vegetable preferences likely influence their consumption; unfortunately, the types of fruit and vegetables that individual students preferred were not able to be measured. Therefore, it is possible that the likeability of fruits and vegetables served is a hidden confounding variable.

Despite probable caveats to interpreting the results based on the above limitations, this study provides a new potential direction for research regarding children's fruit and vegetable consumption during lunch. The sample was diverse and included students from Grades 1-8, so these findings may apply to many different children and schools. In addition, results accurately reflect individual students' eating behavior as the same students' trays were weighed and photographed before and after lunch. In addition, although not all potential confounding factors were able to be controlled for in the data analysis models, researchers were able to control for gender, grade, race/ethnicity, socioeconomic status, and within-school clustering. Even after controlling for these

factors, significant effects were found. According to the study findings, serving fruits and vegetables in a light container on a dark-colored tray is related to an increased likelihood of fruit and vegetable selection and consumption and a decreased likelihood of fruit and vegetable waste in children. However, additional studies with more rigorous methodology and controlling for additional confounding variables such as students' fruit/vegetable preferences should be performed in order to establish the validity of these results under experimental conditions.

If these results hold true under experimental conditions, they may provide practical recommendations for schools hoping to increase students' fruit and vegetable intake. Simply using a dark tray instead of a light tray may lead to increased selection and consumption of fruits and vegetables; however, in the analysis this was also related to a larger amount of waste. It is possible that the benefits of increased selection and consumption outweigh the drawbacks of larger amounts of waste. One factor that has the potential to offset the negative effects of a dark tray is serving fruits and vegetables in a light-colored secondary container, as this was linked to both increased selection and consumption as well as decreased waste. While serving fruits and vegetables in secondary containers may lead to some additional incurred costs in materials and labor, there is potential for decreasing the amount of fruit and vegetables wasted, so this strategy may prove more cost effective when all factors are accounted for. In addition, the probable long-term health benefits to students of consuming larger portions of fruits and vegetables is likely worth the extra expense.

CHAPTER 6

CONCLUSION

This study provides unique insight into the relationship between serving containers and children's fruit and vegetable selection, consumption, and waste. These results suggest that students select, consume, and waste fewer fruits and vegetables when those fruits and vegetables are served on a light-colored tray, select and consume more when fruits and vegetables are served in a secondary container, and select and consume more when that secondary container is light or clear in color as opposed to dark. In the future, these findings may prove valuable to schools hoping to increase students' fruit and vegetable consumption and decrease waste. However, caution is warranted before making concrete recommendations due to potential confounding variables present in the data. Further studies should examine the effects of using light and dark trays and light, dark, and clear secondary containers with more rigorous methodology to determine if observed effects are consistent in a more controlled environment. Overall, more studies are needed to determine the best method for increasing fruit and vegetable consumption among children in schools.

REFERENCES

Adams, M. A., Bruening, M., Ohri-Vachaspati, P., & Hurley, J. C. (2016). Location of school lunch salad bars and fruit and vegetable consumption in middle schools: A cross-sectional plate waste study. *Journal of the Academy of Nutrition and Dietetics*, *116*(3), 407–416. https://doi.org/10.1016/j.jand.2015.10.011

Adams, M. A., Pelletier, R. L., Zive, M. M., & Sallis, J. F. (2005). Salad bars and fruit and vegetable consumption in elementary schools: A plate waste study. *Journal of the American Dietetic Association*, *105*(11), 1789–1792. https://doi.org/10.1016/j.jada.2005.08.013

Andersen, L., Myers, L., O'Malley, K., Mundorf, A. R., Harris, D. M., & Johnson, C. C. (2015). Adolescent student use of school-based salad bars. *Journal of School Health*, *85*(10), 722–727. https://doi.org/10.1111/josh.12302

Bergman, E. A., Englund, T., Taylor, K. W., Watkins, T., Schepman, S., & Rushing, K. (2014). School lunch before and after implementation of the Healthy Hunger-Free Kids Act. *The Journal of Child Nutrition & Management*, *38*(2), 1–12. https://doi.org/10.1016/j.jand.2014.06.195

Cassady, D., Jetter, K. M., & Culp, J. (2007). Is price a barrier to eating more fruits and vegetables for low-income families? *Journal of the American Dietetic Association*, *107*(11), 1909–1915. https://doi.org/10.1016/j.jada.2007.08.015

Cohen, J. F. W., Gorski, M. T., Hoffman, J. A., Rosenfeld, L., Chaffee, R., Smith, L., Catalano, P. J., & Rimm, E. B. (2016). Healthier standards for school meals and snacks: Impact on school food revenues and lunch participation rates. *American Journal of Preventive Medicine*, *51*(4), 485–492. https://doi.org/10.1016/j.amepre.2016.02.031

Cohen, J. F. W., Richardson, S. A., Cluggish, S. A., Parker, E., Catalano, P. J., & Rimm, E. B. (2015). Effects of choice architecture and chef-enhanced meals on the selection and consumption of healthier school foods a randomized clinical trial. *JAMA Pediatrics*, *169*(5), 431–437. https://doi.org/10.1001/jamapediatrics.2014.3805

Cohen, J. F. W., Richardson, S., Parker, E., Catalano, P. J., & Rimm, E. B. (2014). Impact of the new U.S. department of agriculture school meal standards on food selection, consumption, and waste. *American Journal of Preventive Medicine*, *46*(4), 388–394. https://doi.org/10.1016/j.amepre.2013.11.013

Cohen, J., & Schwartz, M. B. (2020). Documented success and future potential of the Healthy, Hunger-Free Kids Act. *Journal of the Academy of Nutrition and Dietetics*, *120*(3), 359–362. https://doi.org/10.1016/j.jand.2019.10.021

Dauchet, L., Amouyel, P., Hercberg, S., & Dallongeville, J. (2006, July). Fruit and vegetable consumption and risk of coronary heart disease: A meta-analysis of cohort studies 1. *J. Nutr*, *136*, 2588–2593. https://doi.org/10.1212/01.wnl.0000180600.09719.53

De Jong, E., Visscher, T. L. S., Hirasing, R. A., Seidell, J. C., & Renders, C. M. (2015). Home environmental determinants of children's fruit and vegetable consumption across different SES backgrounds. *Pediatric Obesity*, *10*(2), 134–140. https://doi.org/10.1111/ijpo.243

DiSantis, K. I., Birch, L. L., Davey, A., Serrano, E. L., Zhang, J., Bruton, Y., & Fisher, J. O. (2013). Plate size and children's appetite: Effects of larger dishware on self-served portions and intake. *Pediatrics*, *131*(5), e1451–e1458. https://doi.org/10.1542/peds.2012-2330

Drewnowski, A., Darmon, N., & Briend, A. (2004). Replacing fats and sweets with vegetables and fruits: A question of cost. *American Journal of Public Health*, *94*(9), 1555–1559. https://doi.org/10.2105/AJPH.94.9.1555

Fisher, J. O., Rolls, B. J., & Birch, L. L. (2003). Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. *American Journal of Clinical Nutrition*, *77*(5), 1164–1170. https://doi.org/10.1093/ajcn/77.5.1164

Genschow, O., Reutner, L., & Wänke, M. (2012). The color red reduces snack food and soft drink intake. *Appetite*, *58*(2), 699–702. https://doi.org/10.1016/j.appet.2011.12.023

Gibson, E. L., Cooke, L., Wardle, J., & Herrera, M. L. (2003). Modifying children's food preferences: the effects of exposure and reward on acceptance of an unfamiliar vegetable. *European Journal of Clinical Nutrition*, *57*(2), 341–348.

Hanks, A. S., Just, D. R., & Wansink, B. (2013). Smarter lunchrooms can address new school lunchroom guidelines and childhood obesity. *Journal of Pediatrics*, *162*(4), 867–869. https://doi.org/10.1016/j.jpeds.2012.12.031

Harrar, V., Piqueras-Fiszman, B., & Spence, C. (2011). There's more to taste in a coloured bowl. *Perception*, *40*(7), 880–882. https://doi.org/10.1068/p7040

Hung, H. C., Joshipura, K. J., Jiang, R., Hu, F. B., Hunter, D., Smith-Warner, S. A.,

Colditz, G. A., Rosner, B., Spiegelman, D., & Willett, W. C. (2004). Fruit and vegetable intake and risk of major chronic disease. *Journal of the National Cancer Institute*, *96*(21), 1577–1584. https://doi.org/10.1093/jnci/djh296

Husby, I., Heitmann, B. L., & O'Doherty Jensen, K. (2009). Meals and snacks from the child's perspective: The contribution of qualitative methods to the development of dietary interventions. *Public Health Nutrition*, *12*(6), 739–747. https://doi.org/10.1017/S1368980008003248

Huynh, L. M., Pirie, P., Klein, E. G., & Moore, R. (2010). Identifying associations between format and placement of school salad bars and fruit and vegetable selection. *The Journal of Child Nutrition and Management*, *39*(2). https://doi.org/10.1158/0008-5472.CAN-05-2502

Ishdorj, A., Capps, O., & Murano, P. S. (2016). Nutrient density and the cost of vegetables from elementary school lunches. *Advances in Nutrition*, *7*(1), 254S-260S. https://doi.org/10.3945/an.115.008698

Johnson, D. B., Podrabsky, M., Rocha, A., & Otten, J. J. (2016). Effect of the Healthy Hunger-Free Kids Act on the nutritional quality of meals selected by students and school lunch participation rates. *JAMA Pediatrics*, *170*(1), 1–6. https://doi.org/10.1001/jamapediatrics.2015.3918

Joshipura, K. J. (1999). Fruit and vegetable intake in relation to risk of ischemic stroke. *Jama*, *282*(13), 1233. https://doi.org/10.1001/jama.282.13.1233

Kann, L., McManus, T., Harris, W., & et al. (2018). Youth risk behavior surveillance-United States 2017. *MMWR Surveillance Summaries*, *67*(8), 1–479. https://doi.org/10.1144/jmpaleo2015-007

Kim, S. A., Moore, L. V, Galuska, D., Wright, A. P., Harris, D., Grummer-Strawn, L. M., Merlo, C. L., Nihiser, A. J., Rhodes, D. G., Division of Nutrition, P. A., Obesity, N. C. for C. D. P., & Health Promotion, C. D. C. (2014). Vital signs: fruit and vegetable intake among children - United States, 2003-2010. *MMWR Morb Mortal Wkly Rep*, *63*(31), 671–676. http://www.ncbi.nlm.nih.gov/pubmed/25102415

Kral, T. V. E., Kabay, A. C., Roe, L. S., & Rolls, B. J. (2010). Effects of doubling the portion size of fruit and vegetable side dishes on children's intake at a meal. *Obesity*, *18*(3), 521–527. https://doi.org/10.1038/oby.2009.243

Kubik, M. Y., Lytle, L. A., Hannan, P. J., Perry, C. L., & Story, M. (2003). The association between the school environment with dietary behaviors of young adolescents. *Research and Practice*, *93*(7), 1168–1173.

La Vecchia, C., Decarli, A., & Pagano, R. (1998). Vegetable consumption and risk of chronic disease. *Epidemiology*, *9*(2), 208–210. https://doi.org/9504293

Larson, N. I., Neumark-Sztainer, D., Hannan, P. J., & Story, M. (2007). Family meals during adolescence are associated with higher diet quality and healthful meal patterns during young adulthood. *Journal of the American Dietetic Association*, *107*(9), 1502–1510. https://doi.org/S0002-8223(07)01292-8 [pii]\n10.1016/j.jada.2007.06.012

List, J., & Savikhin, A. C. (2012). The behavioralist as dietician: Leveraging behavioral economics to improve child food choice and consumption. *Journal of Health Economics*, *39*, 135–146.

Loewenstein, G., Price, J., & Volpp, K. (2016). Habit formation in children: Evidence from incentives for healthy eating. *Journal of Health Economics*, *45*, 47–54. https://doi.org/10.1016/j.jhealeco.2015.11.004

Mann, G., Hosig, K., Zhang, A., Shen, S., & Serrano, E. (2017). Smart snacks in school legislation does not change self-reported snack food and beverage intake of middle school students in rural Appalachian region. *Journal of Nutrition Education and Behavior*, *49*(7), 599-604.e1. https://doi.org/10.1016/j.jneb.2017.05.338

Mathias, K. C., Rolls, B. J., Birch, L. L., Kral, T. V. E., Hanna, E. L., Davey, A., & Fisher, J. O. (2012). Serving larger portions of fruits and vegetables together at dinner promotes intake of both foods among young children. *Journal of the Academy of Nutrition and Dietetics*, *112*(2), 266–270. https://doi.org/10.1016/j.jada.2011.08.040

Miller, N., Reicks, M., Redden, J. P., Mann, T., Mykerezi, E., & Vickers, Z. (2015). Increasing portion sizes of fruits and vegetables in an elementary school lunch program can increase fruit and vegetable consumption. *Appetite*, *91*, 426–430. https://doi.org/10.1016/j.appet.2015.04.081

Monsivais, P., & Drewnowski, A. (2007). The rising cost of low-energy-density foods. *Journal of the American Dietetic Association*, *107*(12), 2071–2076. https://doi.org/10.1016/j.jada.2007.09.009

Morrill, B. A., Madden, G. J., Wengreen, H. J., Fargo, J. D., & Aguilar, S. S. (2016). A randomized controlled trial of the Food Dudes program: Tangible rewards are more effective than social rewards for increasing short- and long-term fruit and vegetable consumption. *Journal of the Academy of Nutrition and Dietetics*, *116*(4), 618–629. https://doi.org/10.1016/j.jand.2015.07.001

Neumark-Sztainer, D., Hannan, P. J., Story, M., Croll, J., & Perry, C. (2003). Family

meal patterns: Associations with sociodemographic characteristics and improved dietary intake among adolescents. *Journal of the American Dietetic Association*, *103*(3), 317–322. https://doi.org/10.1053/jada.2003.50048

Neumark-Sztainer, D., Wall, M., Perry, C., & Story, M. (2003). Correlates of fruit and vegetable intake among adolescents: Findings from Project EAT. *Preventive Medicine*, *37*(3), 198–208. https://doi.org/10.1016/S0091-7435(03)00114-2

Niaki, S. F., Moore, C. E., Chen, T. A., & Weber Cullen, K. (2017). Younger elementary school students waste more school lunch foods than older elementary school students. *Journal of the Academy of Nutrition and Dietetics*, *117*(1), 95–101. https://doi.org/10.1016/j.jand.2016.08.005

O'Dea, J. A. (2003). Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents. *Journal of the American Dietetic Association*, *103*(4), 497–501. https://doi.org/10.1053/jada.2003.50064

Olsen, A., Ritz, C., Kramer, L., & Møller, P. (2012). Serving styles of raw snack vegetables. What do children want? *Appetite*, *59*(2), 556–562. https://doi.org/10.1016/j.appet.2012.07.002

Pennington, J. A., & Spungen, J. (2010). *Bowes & Church's Food Values of Portions Commonly Used* (19th ed.). Lippincott Williams & Wilkins.

Perry, C. L., Bishop, D. B., Taylor, G. L., Davis, M., Story, M., Gray, C., Bishop, S. C., Mays, R. A. W., Lytle, L. A., & Harnack, L. (2004). A randomized school trial of environmental strategies to encourage fruit and vegetable consumption among children. *Health Education and Behavior*, *31*(1), 65–76. https://doi.org/10.1177/1090198103255530

Peterson, C. (2011). Competitive foods sales are associated with a negative effect on school finances. *Journal of the American Dietetic Association*, *111*(6), 851–857. https://doi.org/10.1016/j.jada.2011.03.021

Piqueras-Fiszman, B., Alcaide, J., Roura, E., & Spence, C. (2012). Is it the plate or is it the food? Assessing the influence of the color (black or white) and shape of the plate on the perception of the food placed on it. *Food Quality and Preference*, *24*(1), 205–208. https://doi.org/10.1016/j.foodqual.2011.08.011

Piqueras-Fiszman, B., Giboreau, A., & Spence, C. (2013). Assessing the influence of the color of the plate on the perception of a complex food in a restaurant setting. *Flavour*, *2*(1), 24. https://doi.org/10.1186/2044-7248-2-24

Piqueras-Fiszman, B., & Spence, C. (2012a). The influence of the color of the cup on consumers' perception of a hot beverage. *Journal of Sensory Studies*, *27*(5), 324–331. https://doi.org/10.1111/j.1745-459X.2012.00397.x

Piqueras-Fiszman, B., & Spence, C. (2012b). The weight of the container influences expected satiety, perceived density, and subsequent expected fullness. *Appetite*, *58*(2), 559–562. https://doi.org/10.1016/j.appet.2011.12.021

Reutner, L., Genschow, O., & Wänke, M. (2015). The adaptive eater: Perceived healthiness moderates the effect of the color red on consumption. *Food Quality and Preference*, *44*, 172–178. https://doi.org/10.1016/j.foodqual.2015.04.016

Schwartz, M. B., Henderson, K. E., Read, M., Danna, N., & Ickovics, J. R. (2015). New school meal regulations increase fruit consumption and do not increase total plate waste. *Childhood Obesity*, *11*(3), 242–247. https://doi.org/10.1089/chi.2015.0019

Skinner, J. D., Carruth, B. R., Bounds, W., & Ziegler, P. J. (2002). Children's food preferences: A longitudinal analysis. In *Journal of the American Dietetic Association* (Vol. 102, Issue 11, pp. 1638–1647). https://doi.org/10.1016/S0002-8223(02)90349-4

Smith, S. L., & Cunningham-Sabo, L. (2013). Food choice , plate waste and nutrient intake of elementary- and middle-school students participating in the US National School Lunch Program. *Public Health Nutrition*, *17*(6), 1255–1263. https://doi.org/10.1017/S1368980013001894

Templeton, S. B., Marlette, M. A., & Panemangalore, M. (2005). Competitive foods increase the intake of energy and decrease the intake of certain nutrients by adolescents consuming school lunch. *Journal of the American Dietetic Association*, *105*(2), 215–220. https://doi.org/10.1016/j.jada.2004.11.027

U.S. Department of Health and Human Services and U.S. Department of Agriculture. (2015). *2015-2020 Dietary Guidelines for Americans*. https://health.gov/our-work/food-and-nutrition/2015-2020-dietary-guidelines/

Nutrition Standards in the National School Lunch and School Breakfast Programs; Final Rule, 77 Federal Register 4088 (2012). https://doi.org/10.3168/jds.2016-11114

Van Duijnhoven, F. J. B., Bueno-De-Mesquita, H. B., Ferrari, P., Jenab, M., Boshuizen, H. C., Ros, M. M., Casagrande, C., Tjønneland, A., Olsen, A., Overvad, K., Thorlacius-Ussing, O., Clavel-Chapelon, F., Boutron-Ruault, M. C., Morois, S., Kaaks, R., Linseisen, J., Boeing, H., Nöthlings, U., Trichopoulou, A., … Riboli, E. (2009). Fruit, vegetables, and colorectal cancer risk: The european prospective investigation into cancer and nutrition. *American Journal of Clinical Nutrition*,

89(5), 1441–1452. https://doi.org/10.3945/ajcn.2008.27120

Van Ittersum, K., & Wansink, B. (2012). Plate size and color suggestibility: The Delboeuf illusion's bias on serving and eating behavior. *Journal of Consumer Research, 39*(2), 215–228. https://doi.org/10.1086/662615

Wansink, B., & Junyong, K. (2005). Bad popcorn in big buckets: Portion size can influence intake as much as taste. *Journal of Nutrition Education and Behavior, 37*, 242–245.

Wansink, B., van Ittersum, K., & Painter, J. E. (2006). Ice cream illusions: Bowls, spoons, and self-served portion sizes. *American Journal of Preventive Medicine, 31*(3), 240–243. https://doi.org/10.1016/j.amepre.2006.04.003

Wansink, B., Van Ittersum, K., & Payne, C. R. (2014). Larger bowl size increases the amount of cereal children request, consume, and waste. *Journal of Pediatrics, 164*(2), 323–326. https://doi.org/10.1016/j.jpeds.2013.09.036