Serving vegetables first: A strategy to increase vegetable consumption in elementary school cafeterias

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Chapter 1 : Introduction

The current pattern of consumption of vegetables in the United States is alarming given the evidence that vegetables are so beneficial to health (CDC, 2012; Guenther, Dodd, Reedy, & Krebs-Smith, 2006). Many studies have shown that food consumption patterns developed early in life continue through adulthood (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987; Cusatis et al., 2000; Kelder, Peny, Klepp, & Lytle, 1994; Mannino, Lee, Mitchell, Smiciklas-Wright, & Birch, 2004; Mennella & Beauchamp, 2002; Mennella, Jagnow, & Beauchamp, 2001; Skinner, Carruth, Bounds, Ziegler, & Reidy, 2002). Therefore, it is clear that increasing vegetable consumption in young children is key to increasing vegetable consumption throughout the population.

The current study aimed to increase vegetable consumption in elementary school children by means of serving vegetables before other meal components while students waited in line. In the past, two studies investigated very similar objectives (Harnack et al., 2012; Redden, Vickers, Reicks, Mann, & Mykerezi, 2013). Harnack et al. (2012) served various fruits and vegetables together before other meal components were available, while Redden et al. (2013) served carrots as students sat at the lunch table before retrieving the rest of their food. Results were mixed for vegetable consumption after an intervention in which vegetables or vegetables and fruits were served before other meal components. Numerous studies have investigated goals similar to the current research, but only two have used the current methodology. Several previous studies have shown that repeated taste exposure increases liking of foods (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Birch & Marlin, 1982; Kalat & Rozin, 1973; Pliner, 1982; Sullivan & Birch, 1990; Wardle, Herrera, Cooke, & Gibson, 2003b). Yet other studies have shown that increasing the portion size of a vegetable dish served first increases consumption of that vegetable (Mathias et al., 2011; Miller, N. E., 2013; Spill, Birch, Roe, & Rolls, 2010, 2011).

Chapter 2 : Literature Review

2.1 Relationship between vegetable consumption and health

It is widely accepted that consuming fruits and vegetables is associated with decreased risk for chronic diseases such as cardiovascular disease (CVD) and stroke (He, Nowson, Lucas, & MacGregor, 2007; Joshipura et al., 2001; Liu et al., 2001; Ness & Powles, 1997; Zhang et al., 2011), cancer (Bosetti et al., 2012; Key, 2011; Soerjomataram et al., 2010), and obesity (P. Miller, Moore, & Kral, 2011; Pérez-Escamilla et al., 2012; Vernarelli, Mitchell, Hartman, & Rolls, 2011). Diet-related CVD, stroke, and cancer are not prevalent in children. Childhood obesity, on the other hand, is on the rise (National Center for Health Statistics, 2012; Ogden, Carroll, Curtin, Lamb, & Flegal, 2010; Ogden, Carroll, Kit, & Flegal, 2012). Increased intake of vegetables may suppress hunger and result in decreased energy intake, and lower weight.

2.1.1 Obesity

The Centers for Disease Control (CDC) defines childhood obesity as a "body mass index (BMI) at or above the 95th percentile for children of the same age and sex" (CDC, 2011a)[1]. An adult is considered obese at a BMI of 30 or greater (National Center for Health Statistics, 2012). Secondary health problems may result from obesity in both children and adults including high blood pressure, high cholesterol, prediabetes, bone and joint issues, and increased risk of cancer (CDC, 2011a). Additionally, children who are

[1] CDC growth charts are developed according to data from national surveys and are updated infrequently resulting in greater than 5% of children at or above the 95th percentile. The most current growth charts were published in 2002 using data from 1963-1994 surveys (Kuczmarski et al., 2000).

overweight or obese are more likely to be overweight or obese as an adult (Biro & Wien, 2010; Serdula et al., 1993; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Creating healthy eating habits that include consumption of vegetables is much easier than trying to change unhealthy eating habits in the future[2] (Köster, 2009).

Using 2008 National Health and Nutrition Examination Survey (NHANES) data, Ogden et al. (2010) determined that 10.4% of 2-5 year olds and 19.6% of 6-11 year olds were obese according to the CDC definition. Another 11.2% and 15.9% were overweight, respectively. When looking specifically at Hispanic and Mexican-American children, these percentages are even more distressing. The increasing prevalence of overweight and obesity in children highlights the urgency of determining effective nutrition interventions (National Center for Health Statistics, 2012; Ogden et al., 2010, 2012). The CDC identifies multiple strategies including increasing fruit and vegetable consumption to reduce energy intake and subsequently childhood obesity (CDC, 2011b).

Increased intake of vegetables may suppress hunger and result in decreased energy intake. Vegetables are composed mostly of fiber, water, and vitamins and minerals that are necessary for human health. They are high nutrient-dense but low energy-dense. Consumption of fiber is known to increase satiety, which often decreases the amount of energy consumed at a meal (Howarth, Saltzman, & Roberts, 2001; Slavin, 2005). The type of dietary fiber found in fruits and vegetables also reduces absorption of fat and

[2] Köster explains that in order to change or break a habit, an error must occur in the intuitive system and then be recognized as such. Therefore, eating must break into the realm of conscious control, which is exceedingly difficult, though not impossible.

protein, further decreasing the number of calories available for energy and fat storage (Howarth et al., 2001). This is evidenced by the inverse association between fiber intake and body weight (Slavin, 2005). Water has zero calories, but takes up space in the stomach therefore increasing satiety and decreasing energy intake (Rolls, Bell, & Thorwart, 1999). Increased consumption of low energy dense foods has been shown to decrease energy intake (Flood & Rolls, 2008; Flood-Obbagy & Rolls, 2009; Roe, Meengs, & Rolls, 2012; Rolls et al., 1999; Rolls, Roe, & Meengs, 2004; Rolls, 2009). Lower energy intake and increased vegetable intake has been associated with lower BMI (Miller et al., 2011; Pérez-Escamilla et al., 2012; Vernarelli et al., 2011).

Vernarelli et al. (2011) conducted a study using NHANES data from 2001-2004 to determine if a lower energy dense diet was related to lower body weight status and higher vegetable intake in children. Twenty-four hour dietary intakes (organized by food group) and anthropometric measurements from children ages 2-8 years were the data points of interest. Dietary energy density was positively associated with body weight ($p = 0.002$). When children were divided by age group (2-3 years; 4-8 years), younger children's intake was not significantly related to their BMI, unlike the older children. Additionally, children with low energy dense diets consumed twice as many servings of fruits and vegetables as children with high energy dense diets. When removing juice and white potatoes from the analysis, the discrepancy between high and low energy dense groups was even more noticeable – the high energy dense group ate 90% fewer fruits and vegetables. Miller et al. (2011) also found that overweight and obese children consumed fewer fruits and vegetables than normal-weight children ($p = 0.02$).

An extensive review of the literature by Pérez-Escamilla et al. (2012) revealed that energy density was positively associated with adiposity in four out of the six longitudinal child studies examined. These associations carried through childhood and adolescence. In the same review, four of seven randomized, controlled trials found that adults who lowered the energy density of their diets experienced significantly greater weight loss than those who maintained energy density. One of the reviewed studies (Ello-Martin, Roe, Ledikwe, Beach, & Rolls, 2007) found that adults decreasing energy intake by increasing fruit and vegetables while decreasing fat experienced significantly more weight loss in one year than those that only reduced fat ($p < 0.01$).

2.2 Current consumption patterns

2.2.1 Overall vegetable consumption

Current data showing consumption patterns of fruit and vegetables are deplorable (CDC, 2012; Guenther et al., 2006) given the recommendations for optimal health (U.S. Department of Health and Human Services, 2010). In the 2011 National Youth Behavioral Risk Surveillance System survey, 6% of high school aged kids hadn't eaten any vegetables (including green salad, potatoes (excluding French fries, fried potatoes, and potato chips), and other vegetables) for at least seven days before the survey (CDC, 2012). This number was higher for males (7%) than females (5%). The numbers also varied greatly depending on ethnicity. Prevalence of not having eaten vegetables for greater than seven days was 10% in black youth, 8% in Hispanic youth, and 4% in white youth. Only 15% of kids met the recommendation of eating vegetables 3 or more times per day in the seven days leading up to the survey – meaning 85% did not.

2.2.2 Vegetable consumption at school

When school is in session, food at school contributes 35% of children's daily kilocalorie intake (Briefel, Wilson, & Gleason, 2009) and 44% of children's daily vegetable intake (Robinson-O'Brien, Burgess-Champoux, Haines, Hannan, & Neumark-Sztainer, 2010). The CDC reported in 2011 that fewer than 20% of elementary, middle, and high school students reported eating the recommended five servings of fruits and vegetables per day even though the schools are required to offer fruits and vegetables at every meal in order to receive government reimbursement (U.S. Department of Agriculture, 2013). A study conducted in Saint Paul, Minnesota found the same proportion – 80% of children in fourth through sixth grade did not consume the recommended five servings of fruits and vegetables (Robinson-O'Brien et al., 2010). The mean daily intake of vegetables was 1.5 servings – half of the recommended amount of vegetables in the 2005 Dietary Guidelines[3] (U.S. Department of Health and Human Services, 2005). At age nine, children ate only one serving of vegetables, while at age 12 children ate two servings of vegetables per day suggesting differences in consumption depending on age (Robinson-O'Brien et al., 2010).

[3] The 2010 dietary guidelines do not suggest a specific number of cups or servings in order to maintain a healthy diet, merely to fill half your plate with fruits and vegetables (U.S. Department of Health and Human Services, 2010).

2.3 Eating patterns developed in youth continue into adulthood

Familiarity influences consumption of foods, therefore family culture has a definite impact on food preferences later in life. Introduction of food flavors occurs even before birth. Flavors from the foods a mother consumes during pregnancy are transmitted to the fetus via the amniotic fluid and flavors continue to be transmitted to the infant postnatally through breast milk. Infants who were exposed pre- and postnatally (until two months after birth) preferred carrot flavor more after weaning than those who had not been exposed to carrot flavor (Mennella et al., 2001). A different study on formula-fed infants also showed preference for flavors similar to their infant formula four years after weaning (Mennella & Beauchamp, 2002). Children who were fed soy or protein hydrolysate formula as infants were more likely to prefer the flavor of the hydrolysate formula at age 4-5 than those who were fed milk formula.

It is logical to assume from the data above that eating behaviors developed very early in childhood continue for years afterward, and there is much evidence that supports this assumption (Lake, Mathers, Rugg-Gunn, & Adamson, 2006; Mannino et al., 2004; Nicklaus, Boggio, Chabanet, & Issanchou, 2004). In a longitudinal study following children from the age of 2-3 to the age of eight years, Skinner et al. (2002) found that foods introduced after age four tended to be disliked rather than liked indicating that those preferences developed before age four continued to be preferred four years later. Their results showed significant correlations between data collection points suggesting that the same foods were preferred over time. Vegetables composed 17 of the 24 most disliked foods included in the interviews indicating the need for earlier formation of vegetable eating habits. The same study reported mothers concluding that their child liked or didn't like a food after only two or three offerings, respectively. Evidence is inconclusive on the exact number of exposures needed for children's preferences to be affected, but it has been suggested that 5-10 exposures or more are needed for a child to become familiar enough with a food to be able to make a judgment about liking (Birch et al., 1987). This suggests perhaps mothers are prematurely making the decision of whether or not a child likes a food.

Although liking of specific foods does change over time, the general trend is that people who like and consume healthy foods continue to like and consume healthy foods throughout life. This can be seen in three different longitudinal studies (Cusatis et al., 2000; Kelder et al., 1994; Mannino et al., 2004). Kelder et al. (1994) utilized a design in which adolescents were asked to indicate their preference from 18 pairs of foods each year from seventh grade until twelfth grade. Those who chose the healthier option of the pair continued to choose the healthier option while those who chose the less healthy option continued to choose the less healthy option. That study did not record intake so it cannot be concluded that these preferences were reflected in the adolescents' consumption. Another study conducted in England, however, found that fruit and vegetable consumption increased significantly while intake of starchy foods and high sugar or fat foods decreased significantly between age 11 and 30 (Lake et al., 2006). That study also showed that change in preference and intake is not constant across all food groups. While the study conducted by Lake et al. (2006) found that vegetable intake increased from adolescence to adulthood, Nicklaus, Boggio, Chabanet, & Issanchou (2004) found that preference for vegetables did not change from age two to age 22.

Mannino et al.'s (2004) longitudinal study on girls' diets showed that although healthy eating patterns continued from early childhood through ages five, seven, and nine years, diet quality did decrease overall. For this reason, it is important for vegetable intakes to be even higher earlier in childhood so intake is still adequate after the decrease in diet quality occurs.

2.4 Determinants of vegetable consumption among children

Food choice is a complex behavior that is influenced by many internal and environmental factors. Factors that have been found to be the most correlated with fruit and vegetable intake are habit (Reinaerts, De Nooijer, Candel, & De Vries, 2007), preferences (Rasmussen et al., 2006; Resnicow et al., 1997), asking behaviors (Resnicow et al., 1997), exposure (Resnicow et al., 1997), and parental eating habits (Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002; Rasmussen et al., 2006; Wardle, Carnell, & Cooke, 2005). One 2006 review of ninety-eight papers also found determinants of fruit and vegetable consumption to be gender, age, socioeconomic status, and availability and accessibility of fruits vegetables at home (Rasmussen et al., 2006).

Gender and age appear to be relevant determinants of fruit and vegetable intake. Rasmussen et al.'s (2006) review of the literature found that 27 of 49 papers reviewed identified girls as having higher or more frequent intake of fruit and/or vegetables than boys. Increasing age was also associated with decreasing fruit and vegetable consumption in ten of 22 papers. Nine of the ten papers that showed an association utilized a food frequency questionnaire while six out of nine papers that did not find an association employed 24-hour recalls. This suggests that younger children do not eat a greater amount of fruits and vegetables than older children, but simply eat vegetables on more occasions.

Of 46 papers documenting socioeconomic status, 27 found a positive association between socioeconomic status and fruit and vegetable intake (Rasmussen et al., 2006). Eight of nine papers reporting home availability and accessibility showed a positive association between availability and accessibility and fruit and vegetable intake (Rasmussen et al., 2006).

Parental intake of fruits and or vegetables has a definite impact on a child's consumption of fruits and vegetables. Rasmussen et al. (2006) found a positive association between parental and child intake in eight out of nine papers examined. Wardle et al. (2005) and Fisher et al. (2002) also found that parental fruit and vegetable consumption was positively associated with child vegetable consumption.

2.5 Strategies to increase vegetable consumption

There have been many strategies identified to increase vegetable consumption in children and adults. Most relevant to the current research are portion size, repeated exposure, and behavioral economics.

2.5.1 Portion Size

Decreasing the portion size of an entrée has been seen to increase consumption of vegetables among children while increasing portion size of vegetable dishes has shown the same result.

Twenty-one children aged 3-5 years took part in a study in which the portion size of an entrée was manipulated and all other meal components remained constant (Savage, Fisher, Marini, & Birch, 2012). A decrease in intake of green beans ($p < 0.05$) and other meal components was seen as the portion size of the entrée increased. Additionally, total energy intake at the meal increased as entrée portion size increased.

In a study of 38 children ages 4-6 years, the portion size of a vegetable side dish was varied (Mathias et al., 2011). The test vegetable, cooked broccoli, was served in either 75 g (reference) or 150 g (double) portions. When the broccoli portion was doubled, children ate 37% more than when served the reference portion ($p < 0.01$). This effect was only seen in children who ate more than negligible amounts (> 10 g) of broccoli from the reference portion ($n = 17$).

In an effort to determine if the portion size of vegetables served as a first course had an effect on vegetable intake at a meal, Spill et al. (2010) served portions of 30, 60, and 90 grams of carrots before other meal components were offered. They found that the 60 and 90 gram portions led to a greater intake of carrots when compared to the 30 gram portion. Intake was the same whether children were served 60 grams or 90 grams of vegetables in the first course. A secondary vegetable (broccoli) was served as part of the main course and intake of broccoli was not influenced by carrot intake in the first course. Total meal vegetable intake increased as portion size increased ($p < 0.0001$), but total meal energy intake was not significantly affected by the amount of carrots served in the first course.

The same research team served a first course of tomato soup in portions of 67% (150 g), 100% (225 g), and 133% (300 g) of typical portion size consumed by 2-5 year olds (Spill et al., 2011). Cooked broccoli was served with the main course. Increasing portion size of tomato soup increased the overall vegetable intake at the meal significantly ($p < 0.0001$). Broccoli consumed during the main course was not significantly affected by the portion size of the vegetable soup course. When compared to no first course being served, total meal vegetable consumption increased by 490% and 580% with the 150 g and 300 g soup portions, respectively.

2.5.2 Repeated Exposure

Since the 'mere exposure hypothesis' was introduced in 1968 (Zajonc, 1968), the effect of repeated exposure to foods has been widely studied as demonstrated in the 'strategies to increase consumption' section. Pliner (1982) conducted an experiment to determine if 0, 5, 10, or 20 exposures to a previously unfamiliar tropical juice would produce an increase in liking of each juice. She found that more exposures resulted in a greater liking for the tropical juices. Repeated exposure might increase vegetable consumption for a variety of reasons including enhancing the ability to overcome neophobia, increasing taste preference, and forming new eating habits.

2.5.2.1 Overcoming neophobia

Food neophobia has been defined as the specific distrust of unfamiliar foods (Raudenbush & Frank, 1999) that is generally thought to be a mechanism to protect oneself from potentially harmful substances (Kalat & Rozin, 1973). Heath et al.'s (2011) review of the literature found that neophobia can be overcome by consuming the unfamiliar food. This taste exposure naturally results in visual exposure and both increase familiarity with previously unfamiliar foods. However, visual exposure alone does not influence taste preference (Birch et al., 1987). Exposure to unfamiliar foods is likely to increase liking of a variety of foods as children are more willing to try novel foods if they have learned that another novel or previously disliked food had become agreeable (Heath et al., 2011).

Neophobia does not affect the expected liking of familiar foods, but neophobic adults expected to like unfamiliar foods less than their neophilic counterparts though actual liking was not significantly different between neophobic and neophilic adults (Raudenbush & Frank, 1999). Neophobic adults also consumed 55% less of unfamiliar foods and were less willing to try foods again after an initial tasting. This is consistent with Wardle and colleagues' (2005) finding that food neophobia was negatively associated with fruit and vegetable intake in British children.

2.5.2.2 Food preference and intake

Food preference refers to the choice of one food item over others (Birch, 1999). Repeated exposure has been shown to increase children's preference for foods and influence the development of eating habits from an early age (Anzman-Frasca et al., 2012; Leann Lipps Birch & Marlin, 1982; Kalat & Rozin, 1973; Sullivan & Birch, 1990; Wardle et al., 2003b). The number of exposures required to increase preference for a food is not agreed upon and likely depends on the type of food (e.g. Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Birch & Marlin, 1982; Sullivan & Birch, 1990).

Many studies have been conducted to determine if repeated taste and/or visual exposure increases liking of novel or initially disliked foods. Infants aged 4-8 months (n = 45) with no previous experience with green beans or peaches were fed green beans or both green beans and peas for eight consecutive days (Forestell & Mennella, 2007). Liking of each was evaluated by facial expressions, refusal to continue feeding, and the mother's rating of her child's liking. Infants from both groups increased their intake of green beans an average of 300%, but intake of peaches did not increase nor did the number of distaste facial expressions decrease. Birch et al. (1987) determined that in two to five year old children, repeated taste exposure, but not visual exposure increased taste preference for seven novel foods. Younger children were more neophobic as evidenced by the high rate of refusal to try the novel food. In another study, liking and intake of originally disliked Nordic snack bars increased significantly when children were taste exposed to them nine times (Hausner, Hartvig, Reinbach, Wendin, & Bredie, 2012). Liking of an initially liked bar that was not repeatedly tasted decreased at the same time.

The same trend of increased exposure and liking can be seen for some vegetables. Anzman-Frasca et al. (2012) found that after eight exposures to an initially disliked vegetable, there was a significant increase in liking of that vegetable. Another research team found that liking of carrots, peas, and tomatoes increased after eight or nine tastings, but liking of red bell peppers did not increase even after ten tastings (Lakkakula et al., 2010). Yet another group found that parent-led exposure increased liking of a previously disliked vegetable in 65% of 3-7 year olds after 14 daily exposures ($p < 0.001$) (Wardle et al., 2003b).

It has also been found that mere exposure is more effective at increasing vegetable consumption than some other strategies such as flavor-nutrient learning or rewards (De Wild et al., 2013; Wardle et al., 2003b). De Wild and colleagues investigated the effects of flavor-nutrient learning and mere exposure in children aged 2-4 years ($n = 40$).

Results showed that intake increased regardless of energy density, indicating that mere exposure is a more powerful tool for increasing vegetable consumption than flavor-nutrient learning. Wardle et al. (2003b) presented sweet red peppers, which were found to be relatively novel and disliked, to 6-8 year old children 10 times in two weeks. It was found that both liking and intake increased significantly more for the mere exposure group than the group that was offered a reward for trying the peppers.

2.5.2.3 Formation of habit

In order to form a habit, control of actions needs to be shifted from internal control (conscious) to external control (without conscious control) (Ohtomo, 2013). In other words, actions that are habitual can be done automatically without consciously thinking about the action. Food preferences are not consciously or intentionally learned and therefore become habit as a result of an individual's experiences (Ohtomo, 2013). Reinaerts et al. (2007) found that habit was the most influential correlate of fruit and vegetable consumption when compared to availability, accessibility, exposure to fruits and vegetables, parental intake, and various psychosocial factors.

2.5.3 Behavioral Economics

"Behavioral economics combines the behavioral models of psychology with the decision models of economics to help highlight how biases in perception, memory, or thought processes may influence purchasing decisions" (Just & Wansink, 2009). In schools, behavioral economics is employed to strategically rearrange items that are already offered at school lunches to 'nudge' students to make healthier choices. Behavioral economics takes advantage of natural behaviors to increase the number of people selecting and consuming healthier foods. It focuses on making a healthier choice a more convenient choice (Downs, Loewenstein, & Wisdom, 2009). For example, placing fruits and vegetables at natural bottlenecks increases impulse buys of these foods instead of less healthy options (Just & Wansink, 2009). Another example would be displaying healthy sandwich options on the first pages of a menu and unhealthy options on the last pages (Downs et al., 2009). This is supported by findings that visibility of food increases desire of that food (Volkow et al., 2002). Increasing the convenience of healthy items may be all the change needed to increase consumption of healthier foods (Downs et al., 2009; Hanks, Just, Smith, & Wansink, 2012).

One study employing behavioral economics strategies simply converted one of the two lunch lines in a high school to a 'convenience line' filled with only healthier options already offered at the school (Hanks et al., 2012). This simple change increased healthy food purchases by 19% but also increased unhealthy food choices by 2%. Though purchasing of both healthy and unhealthy items increased, the consumption of these items stayed the same and decreased, respectively.

Another recent study found that giving junior high aged kids the choice between carrots or celery (94 of 103 chose carrots) resulted in 91% of kids eating their vegetable while only 69% of kids not given a choice ate their carrots (Just & Wansink, 2009). These results suggest that offering a choice while still requiring a vegetable may increase consumption of vegetables and decrease waste.

2.5.3.1 Serving a low energy-dense target food first

To date, most of the published research utilizing a design of serving a low energy-dense target food first focuses on decreasing energy intake at a meal rather than increasing consumption of the target food (Flood & Rolls, 2008; Flood-Obbagy & Rolls, 2009; Roe et al., 2012; Rolls et al., 1999; Rolls et al., 2004). However, decreased energy intake at a meal may be a result of increased satiety due to increased consumption of the low energy-dense target food.

Regardless of the form of a first course soup (pureed, chunky, or broth and vegetables served separately) total meal energy intake decreased when compared to no first course being served (Flood & Rolls, 2008). Increasing the amount of water in a first course soup has been shown to decrease total meal energy intake in women (Rolls et al., 1999). However, the same decrease in energy intake was not seen when the same amount of water was served in a glass at the meal. The results of both of these studies suggest that the energy density is the main reason for the decrease in intake.

Serving a large vegetable salad before the main course was also found to decrease overall energy intake by 11% and increase intake of salad by 23% when subjects were allowed to eat the salad and the main course ad libitum (Roe et al., 2012). When the consumption of a fixed amount of salad was compulsory, the amount of the main course consumed did not vary whether the salad was served before or alongside the main course. Though energy intake was higher for the meals with no salad and with ad libitum intake of salad than meals with fixed intake of salad, the hunger scores after the meal were the same in all treatments.

Another study on salads by Rolls et al. (2004) observed the difference in total meal intake when portion size and energy density of salads was varied. The researchers found that eating the low-energy dense salad decreased meal energy intake by 7% for the small portion (150 g) and 12% for the large portion (300 g) when compared to the condition when subjects did not receive a first-course salad.

A study conducted in a Head Start center in Minneapolis, Minnesota found that serving both fruits and vegetables before other components of a meal increased intake of fruit, but not vegetables (Harnack et al., 2012). The authors suggest that their use of canned vegetables may have contributed to low intake because canned vegetables often lack taste and texture appeal. Since both fruits and vegetables were served first at the same time, it is likely that children ate more fruits because of their innate preference for sweet foods (Birch, 1999). An effect on the consumption of vegetables may have been significant if only vegetables were served before the other meal components in the Head Start study.

Eating apple segments, applesauce, apple juice with added fiber, and commercial applesauce as a first course resulted in a reduction of meal energy intake when compared to eating no first course (Flood-Obbagy & Rolls, 2009). The largest difference was seen with the apple segments which reduced total meal energy intake by 187 +/-36 kcal to result in meal intake of 85 +/- 4%. Interestingly, this study demonstrated greater fullness ratings after eating apple segments than after any of the other treatments even though energy content, weight, energy density, fiber content, and ingestion rate were the same for all treatments except the control.

Increasing the portion size of a vegetable first course has also been shown to decrease energy intake while increasing vegetable consumption as described in the 'Portion size' section of this review (Spill et al., 2010, 2011). All of the studies described in this section show that serving a low energy-dense food before other meal components are available decreases the overall energy intake at the meal. In addition, some show that consumption of the low energy-dense food increases at the same time.

Chapter 3 : Objectives and Hypotheses

Objective: To determine if offering vegetables (broccoli or sweet peppers) before other meal components will increase the overall consumption of vegetables at school lunch.

Hypothesis 1: Serving broccoli or peppers first will increase the number of students eating broccoli or peppers.

Hypothesis 2: Serving broccoli or peppers first will increase the total amount of vegetables consumed.

Hypothesis 3: Providing broccoli or peppers first will result in decreased consumption of the secondary vegetable (cauliflower or cooked carrots) served at the meal and/or decreased consumption of the primary vegetable from the regular line.

Hypothesis 4: The effect of serving vegetables first will increase from the first day the intervention was implemented to the last day the intervention was implemented.

Hypothesis 5: Serving vegetables first will increase consumption of the primary vegetable even on days that vegetables are not served first.

Chapter 4 : Materials and Methods

4.1 Subjects

Subjects were children in grades kindergarten through fifth grade at a public, suburban elementary school in Richfield, Minnesota. The school participated in the U.S. Department of Agriculture's National School Lunch program (NSLP). Of the 829 students that attend the experimental school, 59% receive free or reduced price lunch. Approximately 64% of students were racial or ethnic minorities. Only students eating school-provided lunch were included in data collection (n = 486-575). All study procedures were approved by the University of Minnesota Institutional Review Board. Informed consent was waived due to the nature of the research.

4.2 Experimental Schedule

A within-subjects experimental design was used. All subjects received the same treatment on the same day. The effects of two primary vegetables were investigated: broccoli and sweet bell peppers. For each vegetable there was one control day, followed by three intervention days, then one follow-up day (Figure 4.1).

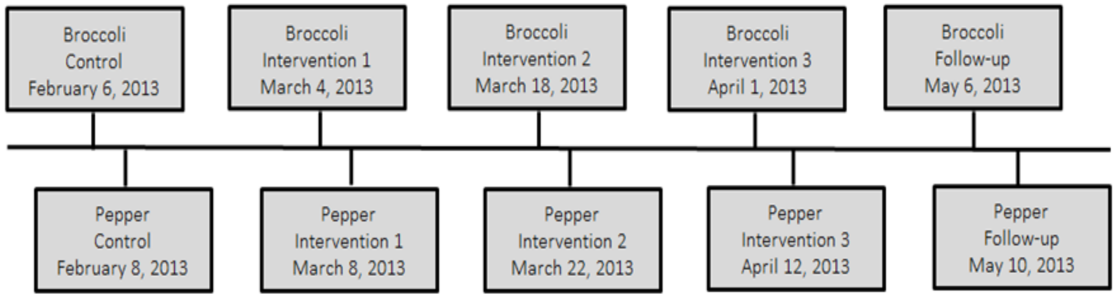

Figure 4.1: Experimental timeline.

The same menu was served on all broccoli days (Table 4.1) while a different menu was served on all pepper days (Table 4.2), though occasionally additional items were offered. Menus were previously decided by the supervisor of food services for the Richfield School District. Menu items were presented vegetables first, then fruit, then side and entrée. To meet USDA reimbursement standards, students not choosing at least three meal components, including a fruit or vegetable, were given a fruit or vegetable by a cafeteria employee before being seated at their lunch table U.S. Department of Agriculture, 2013).

Table 4.1: Experimental menu for broccoli days.

Milk (choose 1)	**Entrée (choose 1)**	**Hot side (choose 1)**	**Fruit (unlimited)**	**Vegetables (unlimited)**
Skim chocolate milk (236mL)	Teriyaki chicken	Vegetable fried rice	Fresh pear	Fresh broccoli
Skim white milk (236mL)	Entrée salad		Fruit cocktail	Fresh cauliflower
1% white milk (236mL)	Turkey & cheese sandwich			

Table 4.2: Experimental menu for pepper days.

Milk (choose 1)	Entrée (choose 1)	Hot side (choose 1)	Fruit (unlimited)	Vegetables (unlimited)
Skim chocolate milk (236mL)	Shrimp poppers	Macaroni and cheese	Orange slices	Fresh sweet peppers
Skim white milk (236mL)	Entrée salad		Applesauce	Cooked carrots
1% white milk (236mL)	Turkey & cheese sandwich			

4.2.1 Practice Day: January 30, 2013

To familiarize the students and the research team with procedures utilized during the study, a practice session employing intervention day procedures was conducted. As issues with the procedure arose, modifications were made to the original protocol to result in the methodology used on real data collection days.

4.2.2 Control and Follow-up Days

As typical at the school, students were allowed to serve themselves vegetables and fruit from a buffet-type line, while a cafeteria employee served the hot side and entrée. The primary (broccoli or peppers) and secondary (cauliflower or cooked carrots) vegetables were pre-portioned in four-oz. (120 mL) paper soufflé cups (Solo Cup Company, Urbana, IL) and four-oz. (120 mL) clear plastic portion containers (Dart Container Corporation, Mason MI), respectively. This procedure was used for all control and follow-up days.

4.2.3 Intervention Days: Vegetables First

In the intervention condition, all students were handed a portion of the primary vegetable in a two-oz. (60 mL) paper soufflé cup (Solo Cup Company, Urbana, IL) in the hallway prior to reaching the station where they entered their lunch numbers. On these days, there were two researchers handing children a 60 mL portion to eliminate the option of choosing whether or not to take a vegetable. On the occasion that a student refused to take a cup, they were encouraged to take a portion one more time and then allowed to pass empty-handed if they still refused. In order to reduce the number of cups abandoned in the milk crates, on the lunch line, and on the condiment tables, researchers were stationed at the lunch line and in the cafeteria to keep a watchful eye on students. As they picked up their trays, students were asked to put their small portion of vegetables on it and leave it there until they dumped their tray at the end of the period. Those entering the serving line without a 2-oz. portion or an empty cup were asked if they had their cups and if so, to put it on their tray. Once the students reached the lunch line, the procedure was the same as for the control days.

4.3 Vegetables

The experimental vegetables were chosen because broccoli was considered the most liked vegetable at the experimental school according to cafeteria employees. Peppers were chosen because results from repeated exposure studies have found mixed results for liking of peppers after 10-14 exposures (Lakkakula et al., 2010; Wardle et al., 2003b). Cauliflower and cooked carrots were chosen simply because they were already offered on the menu days of broccoli and peppers. Fresh broccoli, cauliflower, and peppers were purchased by researchers from H. Brooks & Company, Inc. (New Brighton, MN) cut into uniform pieces. Frozen carrot coins were purchased through the school district from its normal supplier (Lakeside Foods, Manitowoc, WI). Size of portions served on the lunch line was determined by the supervisor of food services for Richfield School District according to USDA guidelines (United States Department of Agriculture, 2013). For all vegetables, the number of pieces in each cup did not vary within one day, but depending on the weight per piece of vegetable, the number of pieces in a cup did change between days.[4] The volume of portion sizes stayed constant throughout the study, though the weight of a portion did vary depending on the weight per piece of vegetable (Table 4.3 and Table 4.4).

Table 4.3: Mean weight (g) per portion on broccoli days.

Portion size	Control	Intervention 1	Intervention 2	Intervention 3	Follow-up
Broccoli 60 mL	-	10	9	7	-
Broccoli 120mL	21*	22	19	19	26
Cauliflower 120 mL	40*	40*	32	36	51

*No weight recorded: value is the average of the days when the mean weight per portion was recorded

Table 4.4: Mean weight (g) per portion on pepper days.

Portion size	Control	Intervention 1	Intervention 2	Intervention 3	Follow-up
Pepper 60 mL	-	26	29	33	-
Pepper 120mL	17	49	70	72	52
Carrots 120mL	71*	71*	68	77	69

*No weight recorded: value is the average of the days when the mean weight per portion was recorded

[4]Although the vegetables were ordered from the supplier to follow size guidelines, weight of vegetables (particularly peppers) varied greatly due to the thickness of the flesh. Dimensions of peppers were changed on intervention day 2 to be twice as wide and half as tall to reduce the ease with which a cup could be tipped and its contents spilled on the floor.

The weight of one piece of vegetable was determined by finding the mean weight of ten cups and dividing by the number of pieces in a cup. Because carrot data were recorded as the number of fourths left in the cup, the weight of one fourth was found by dividing the mean weight of ten random cups by four.

On control and follow-up days, vegetables were displayed in pre-portioned cups in the order typical for the school. Each type of vegetable had its own tray from which students could elect to take as many cups as they would like (Figure 4.2). Serving trays were refilled as necessary.

Figure 4.2: Display of vegetables on pepper days.

On intervention days, vegetables were displayed on the line in the manner described above, with the addition of a tray in the hallway before the students reached the pin pad (Figure 4.3).

Figure 4.3: Vegetables first tray on pepper days.

4.4 Experimental Procedure

Students arrived at lunch in one of nine lunch periods. They were escorted through the entry hall to the pin pad by their teacher. On control and follow-up days, students proceeded through the hall and lunch line as per usual. On intervention days, they received a small portion of vegetables in the hallway well before the pin pad as described previously. This allowed most students a couple of minutes to eat their vegetables while waiting in line to enter their PIN numbers. Students then walked through the lunch line in their usual manner to receive the rest of their food and continued on to the cafeteria where they were seated with other students in the same class. Before each data collection day, researchers prepared a packet for each class containing unlined index cards with data collection numbers printed on them, a class list with names and lunch numbers, and a sheet of sticky labels with the unique PIN numbers of each student in the class (Figure 4.4).

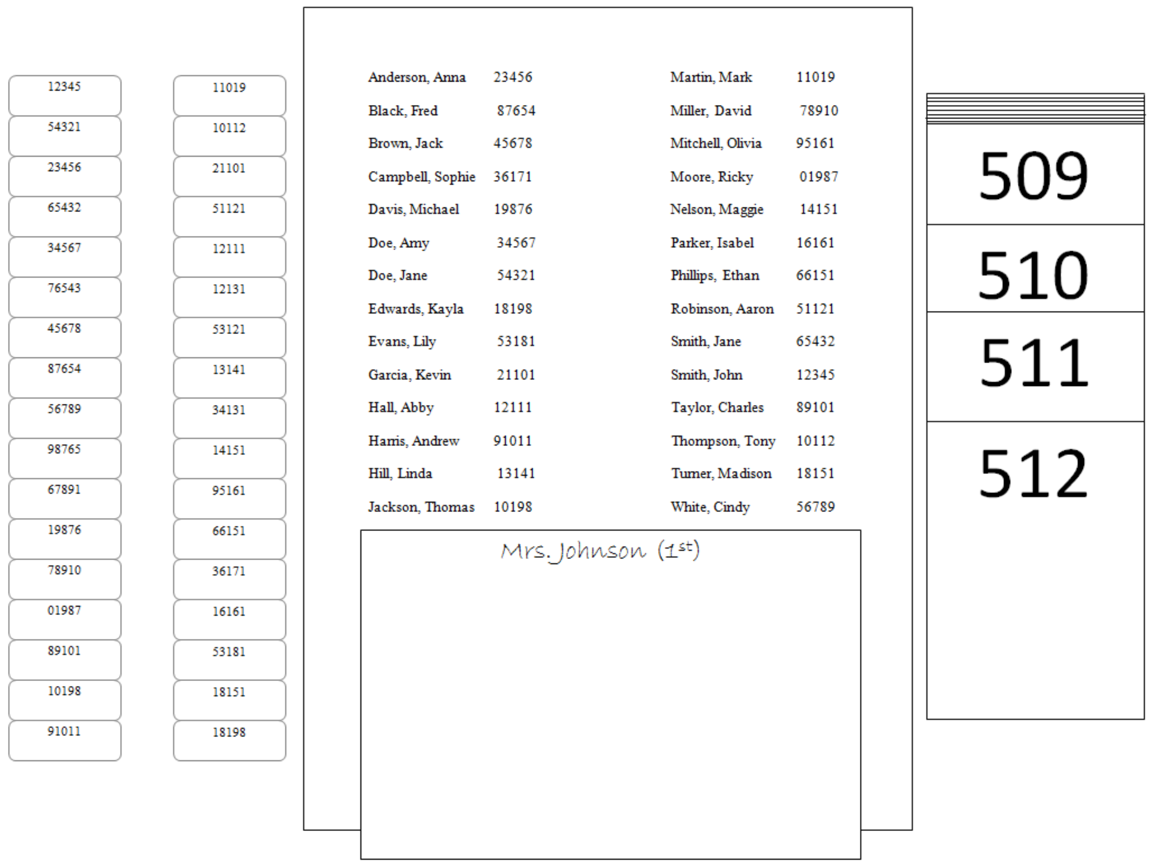

Figure 4.4: Example of class packet including stickers with unique student PIN numbers (left), a class list with student names and unique student PIN numbers (top center), and index cards with data collection numbers (right). Materials were packaged in an envelope with the grade and teacher's name (bottom center).

When students reached their class table, a trained investigator asked for their unique PIN number. The investigator then put the corresponding PIN number sticker on an index card with a data collection number (Figure 4.5). This student identification card was then placed next to the student's tray. If the student did not know his or her lunch number, the investigator asked for his or her last name and found him or her on the class list. The unique PIN number corresponding to his or her name was then placed on the student identification card and placed next to the student's lunch tray. In the event that the student was new to the school, the name and/or lunch number of the student was written on the class list and the identification card.

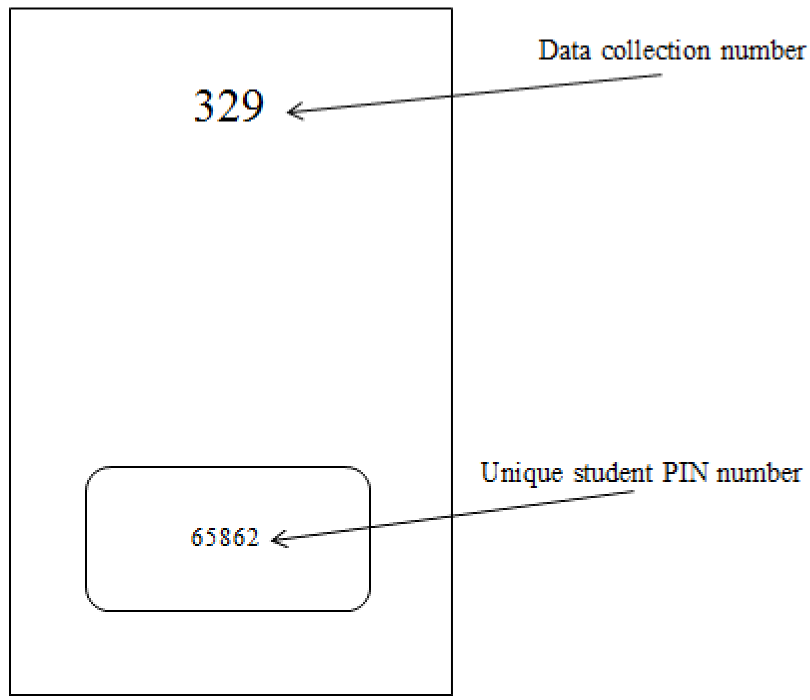

Figure 4.5: Example of student identification card. Unique student PIN numbers were added by investigators at the lunch table.

When there were five minutes left in the lunch period, a trained member of the research team visually assessed and recorded how much was left in each of the vegetable cups on data collection sheets. The data collector then retained the identification card and the student was released with the rest of his or her class by a cafeteria aide.

4.4.1 Data collection

Visual estimation has been shown to be highly correlated with actual weighed amounts of food (Williamson et al., 2003). Since weighing is time consuming and disruptive to students and to the flow of students exiting the cafeteria, visual estimation was used to determine the amount of vegetables left uneaten. When there were approximately five minutes left in the lunch period, a trained investigator visually assessed the number of pieces of vegetables remaining on each student's tray. In the case of cooked carrots, the number of fourths remaining of the original portion was recorded. For rapidity, the data collection number was used to record each student's data as opposed to their lunch numbers. If a student consumed all the vegetables on his or her tray, the investigator would write '0' on the data collection sheet next to the number corresponding to the student's data collection number (Figure 4.6). On the occasion that a piece of vegetable was partially eaten, it was rounded to the nearest whole number. Each student's subject identification card was retained after his or her datum was recorded.

Each intervention day the primary vegetables served that were dropped before the line were collected and weighed. The number of dropped cups was also counted on four out of six intervention days.

March 18, 2013:			Vegetable:	Broccoli and Cauliflower						
ID #	PIN #	2 oz.	4 oz. B	4 oz. C		ID #	PIN #	2 oz.	4 oz. B	4 oz. C
529						573				
530						574				
531		1				575				
532		2				576				
533		2				577				
534		1				578				
535		0	4			579				
536		0	0			580				
537						581				
538		1				582		0		
539		0				583		0	0	
540		0				584		2		
541		0				585		2		
542						586			4	
543						587		2	3	
544						588		0		
545						589		0		
546						590		2		
547						591		0		
548						592				
549						593		0		
550		2	2			594		2		
551		0				595		2		
552		2				596		0		
553		0				597		0		
554		0				598		2	3	
555						599		0		
556		2				600			3	
557		1				601		0		
558		2				602		2		
559		1				603		0		
560						604		2		
561		0				605				
562		2				606				
563		0				607				
564		2				608				
565		1				609				
566		0				610				
567						611				
568		2				612				
569						613		0		
570						614		0		
571						615		2		
572						616		1		

Figure 4.6: Example of data collection sheet. Columns from left: data collection number, unique student PIN number (used only if a student did not receive a data collection card), number of broccoli pieces remaining in 60 mL cup, number of broccoli pieces remaining in 120 mL cup, number of cauliflower pieces remaining in 120 mL cup.

4.5 Data analysis

4.5.1 Determining the weight consumed

The weight of vegetables consumed was determined by subtracting the number of pieces left in a given cup from the starting number of pieces in a full portion and multiplying by the mean weight of one piece of that vegetable. For example, if on a particular day there were 4 pieces of broccoli in a 120 mL cup and a student had 2 pieces of broccoli left in his 120 mL cup, the weight consumed would be calculated by 4 – 2 = 2 pieces consumed. Then, 2 pieces consumed x 5 g per piece = 10 g consumed. Since carrots were recorded as the number of fourths of a portion remaining in the cup, the weight consumed was calculated by multiplying the proportion of a serving left by the mean weight of a full serving.

The weight consumed per student exposed to the intervention was calculated by dividing the total amount of a specific vegetable consumed by the number of students eating the lunch provided by the school, whether they took vegetables or not.

4.5.2 Adjusting the data for vegetables dropped on the floor

Since there was a great number of portion cups and vegetable pieces dropped on the floor that appeared to be eaten when data were collected, the datum for each student was adjusted to account for this since it was impossible to know from whose cup the dropped vegetables came. As shown in Equation 4.1, data were adjusted for the vegetables and cups that were dropped in the hall, left in the milk crates, hidden on the condiment table, or otherwise discarded before reaching the lunch table. The number of cups picked up from these areas (P) was multiplied by the average weight per 60 mL portion to find the weight of full cups that were dropped. Then, that weight was subtracted from the total weight of vegetables picked up from the floor and other places (D) to find the remaining dropped weight. The remaining dropped weight was then divided by the total weight recorded as consumed from the 60 ml cups on that day (C) to give a fraction of vegetables that were recorded as eaten, but were discarded (not eaten) before they reached the lunch table. This fraction was subtracted from 1 to find the fraction that was actually eaten by all students. The fraction actually eaten was then multiplied by the recorded weight consumed by each student (S) and then used in the remaining analyses.

Equation 4.1: Equation used to adjust individual datum for vegetables dropped on the floor.

$$\left(1 - \left(\frac{D - (P \cdot E)}{C}\right)\right) \cdot S = A$$

D = weight of vegetables dropped on the floor, left in milk crates, hidden, etc.
P = number of cups recovered from floor, milk crates, hidden, etc.
E = mean weight of vegetables in 60 mL portion
C = total weight of vegetables consumed by all students from 60 mL portion
S = recorded weight consumed for a specific student
A = adjusted weight consumed for a specific student

4.5.3 Determining proportion eaten out of the total amount available

In order to determine the proportion consumed out of the total amount available per person, the adjusted weight consumed was divided by the total amount available per student. For example if a student ate 15 g of peppers from the 120 mL portion and the mean weight of a 120 mL portion on that day was 70 g, the proportion eaten from the regular line would be (15 g)/(70 g) = 0.21. If a different student ate 15 g of peppers from the 120 mL portion and 10 g of peppers from the 60 mL portion (mean weight per 60 mL portion was 30 g), the proportion eaten of primary vegetable eaten would be (15+10)/(70+30) = 0.25.

4.5.3 Statistical analysis

Quantitative statistical analysis was carried out using SAS version 9.3 (SAS Institute Inc., Cary, NC), unless otherwise noted. Since menus were different for each primary vegetable, data were analyzed separately for broccoli and pepper menus.

4.5.3.1 Creating datasets

Data were analyzed in three ways: mean weight eaten per person eating hot lunch (excluding those who ate school lunch only one time or less during the five study days), mean weight eaten per person taking the primary vegetable from either the vegetables first tray and/or the regular lunch line, and mean weight eaten per person who ate some of the primary vegetable. Separate data sets were created for each analysis. Students who attended only one day of testing for a particular vegetable were excluded from all analyses. Examples of SAS code used to create these datasets are shown below.

```
/*Creating subset for broccoli data excluding students only attending
lunch one time out of five*/
data BroccoliSubsetNoMissing;
set BroccoliSubset;
if HotLunch = 'x';
run;


proc freq data = BroccoliSubsetNoMissing noprint order = freq;
```

```
tables PIN / out = work.Broccolifreq;
run;

proc freq data = Broccolifreq;
tables COUNT;
run;

data Broccolicleaned;
 set BroccoliSubsetNoMissing;
 IF PIN NOT IN ('10774', '14847', '15862', '16023', '16698','17140',
'19724', '20001', '24434', '27606', '31357', '33419', '34110', '36450',
'39006', '39326', '39582', '43209', '45402', '46583', '49243', '53264',
'56919', '59029', '59461', '59926', '61839', '62620', '63603', '66155',
'67968', '67982', '70105', '70450', '75447', '75502', '79950', '80837',
'81916', '82061', '82468', '83038', '87506', '91111', '91829', '92572',
'93157', '93507', '95309', '95677', '99108');
run;

/*Creating dataset that includes only students who took a portion of
broccoli*/
data Broccolitakingprimary;
set Broccolicleaned;
if PrePrimaryLeft ^= '.' | PrimaryLeft ^= '.';
run;

/*Creating data set that includes only students who ate some amount of
broccoli*/
data Broccolinumbereatingprimary;
set Broccolicleaned;
if PrimaryWtConsumed ^= '0';
run;
```

4.5.3.2 Testing our hypotheses

To determine if consumption increased as a result of serving vegetables first, a mixed model analysis of variance was utilized. The three intervention days were combined and tested against the combined control and follow-up days. The dependent variables were the weight consumed of the primary vegetable and the proportion consumed of the total weight of the primary vegetable available including that served before other meal components and that served on the regular lunch line. The independent variables were PIN, grade, and date (method (control or intervention) was nested in date). The SAS code below was used to determine if consumption of the primary vegetable was greater on intervention days than on days without vegetables first.

```
proc mixed data = Peppercleaned method = reml covtest order = Data;
Class Grade Date PIN;
model PrimaryWtConsumed = Date Grade/ NOINT s;
repeated / type = un subject = PIN r;
contrast 'DateContrast'
Date -.5 .33333333 .33333333 .33333333 -.5;
Estimate 'Intervention-Control'
Date -.5 .33333333 .33333333 .33333333 -.5;
run;

proc mixed data = Peppercleaned method = reml covtest order=Data;
Class Grade Date PIN;
model PrimaryProportionEaten = Date Grade / NOINT s;
repeated / type = un subject = PIN r;
contrast 'DateContrast'
Date -.5 .33333333 .33333333 .33333333 -.5;
Estimate 'Intervention-Control'
Date -.5 .33333333 .33333333 .33333333 -.5;
run;
```

Separate proportions tests were calculated by hand to determine the significance of the number of people taking and eating the primary vegetable on the days with vegetables first compared to the days without vegetables first. Calculations are available in the appendix.

Analysis was further separated by the source of the vegetable (i.e. primary vegetable consumed from the regular line and secondary vegetable consumed). Analyzing the amount of primary vegetable and secondary vegetable consumed from the regular line in this way allowed us to determine if the intervention had any effect on the amount and type of vegetable selected from the regular lunch line.

```
proc mixed data=Peppercleaned method = reml covtest order=Data;
Class Grade Date PIN;
```

```
model LinePrimaryWtConsumed = Date Grade/ NOINT s;
repeated / type = un subject = PIN r;
contrast 'DateContrast'
Date -.5 .33333333 .33333333 .33333333 -.5;
Estimate 'Intervention-Control'
Date -.5 .33333333 .33333333 .33333333 -.5;
run;

proc mixed data=Peppercleaned method=reml covtest order=Data;
Class Grade Date PIN;
model SecondaryWtConsumed = Date Grade/ NOINT s;
repeated / type = un subject = PIN r;
contrast 'DateContrast'
Date -.5 .33333333 .33333333 .33333333 -.5;
Estimate 'Intervention-Control'
Date -.5 .33333333 .33333333 .33333333 -.5;
run;
```

A Wilcoxon t-test was used to determine if consumption of the primary vegetable was the same on the first intervention day compared to the last intervention day. The same procedure was used to compare intervention 1 versus intervention 2 and intervention 2 versus intervention 3.

```
data pepperint1andint3;
set Peppercleaned;
if Date = '08MAR13'd | Date = '12APR13'd;
run;

proc NPAR1WAY data = pepperint1andint3 Wilcoxon;
class Date;
var PrimaryWtConsumed;
run;
```

Weight of the primary vegetable consumed on the control and follow-up days were also analyzed in this way.

```
data peppercontvsfolup;
set Peppercleaned;
if Date = '08FEB13'd | Date = '10MAY13'd;
run;

proc NPAR1WAY data = peppercontvsfolup Wilcoxon;
class Date;
var PrimaryWtConsumed;
run;
```

Two proportions tests (calculated by hand) were used to see if the proportion of students taking and eating the primary vegetable were significantly different on the control versus the follow-up day.   Calculations are available in the appendix.

Chapter 5 : Results

5.1 Serving broccoli or peppers first increased the number of students eating broccoli or peppers.

The mean number of students taking broccoli increased from 79 on days without vegetables first to 409 on days with vegetables first – a 518% increase ($p < 0.0001$) (Table 5.1). The mean number of students eating broccoli also increased from 41 on days without vegetables first to 209 on days with vegetables first – a 510% increase ($p < 0.0001$).

Table 5.1: Number of students eating school lunch and numbers taking and eating broccoli from any source.

Condition	Number of students eating school lunch	Number of students taking broccoli	Number of students eating any amount of broccoli
Control	558	77	36
Intervention 1	486	347	203
Intervention 2	530	450	235
Intervention 3	529	429	188
Follow-up	529	80	45

A similar trend was seen for peppers where the mean number of students taking peppers increased from 45 on days without vegetables first to 346 on days with vegetables first -- a 769% increase ($p < 0.0001$) (Table 5.1). The mean number of students eating peppers increased from 34 on days without vegetables first to 139 on days with vegetables first – a 409% increase ($p < 0.0001$).

Table 5.2: Number of students eating school lunch and numbers taking and eating peppers from any source.

Condition	Number of students eating school lunch	Number of students taking peppers	Number of students eating any amount of peppers
Control	532	37	34
Intervention 1	500	356	168
Intervention 2	511	346	123
Intervention 3	575	336	125
Follow-up	534	53	33

5.2 Serving broccoli or peppers first increased the total weight of vegetables consumed at lunch.

Broccoli intervention days resulted in greater consumption of broccoli for both mean total adjusted weight ($p < 0.0001$) and mean adjusted proportion ($p < 0.0001$) (Table 5.3 and Figure 5.1).

Table 5.3: Mean adjusted consumption per person receiving school lunch on days when broccoli was served.

Condition	Mean total weight of broccoli consumed	SEM	Mean proportion consumed of total amount of broccoli available†	SEM
Control	0.8	0.16	0.04	0.007
Intervention 1	1.6	0.15	0.05	0.004
Intervention 2	3.2	0.24	0.11	0.008
Intervention 3	2.1	0.16	0.08	0.006
Follow-up	0.9	0.16	0.03	0.005
F-value*	93.17		147.93	
p-value*	<0.0001		<0.0001	

*contrasting control and follow-up vs. combined interventions
†includes broccoli from vegetables first tray and from the regular line

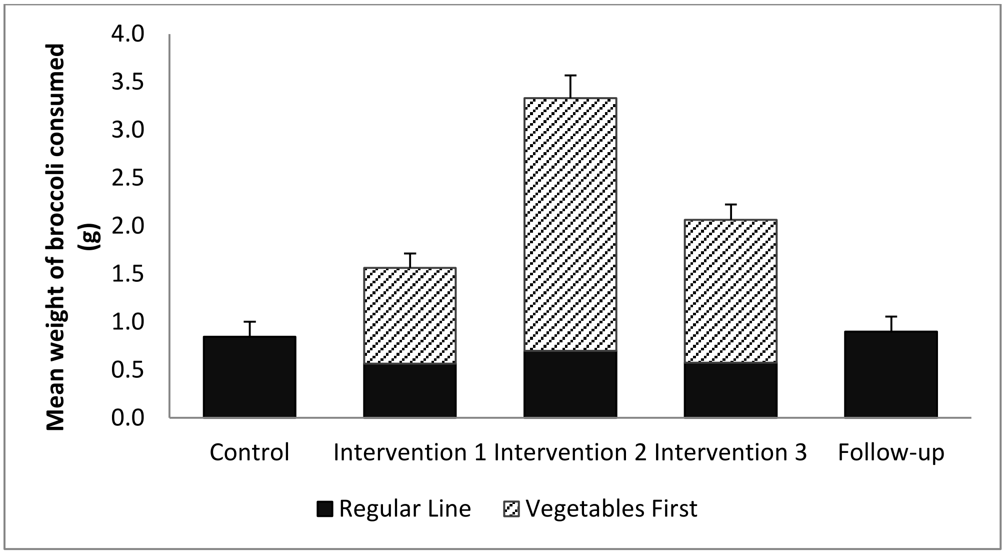

Figure 5.1: Mean weight of broccoli consumed from those cups served before other meal components and from the regular line as parts of the total.

Pepper intervention days resulted in greater consumption of peppers by weight (F = 65.05, p < 0.0001), but the proportion consumed of the total available was the same on days with and without peppers served first (F = 0.86, p < 0.35) (Table 5.4 and Figure 5.2).

Table 5.4: Mean adjusted consumption per person receiving school lunch on days when peppers were served.

Condition	Mean total weight of peppers consumed	SEM	Mean proportion consumed of total amount of peppers available†	SEM
Control	0.8	0.15	0.05	0.008
Intervention 1	3.2	0.48	0.04	0.007
Intervention 2	4.2	0.42	0.04	0.004
Intervention 3	4.9	0.21	0.05	0.005
Follow-up	2.1	0.41	0.04	0.008
F value*	65.05		0.86	
p value*	<0.0001		0.35	

*contrasting control and follow-up vs. combined interventions
†includes peppers from vegetables first tray and from the regular line

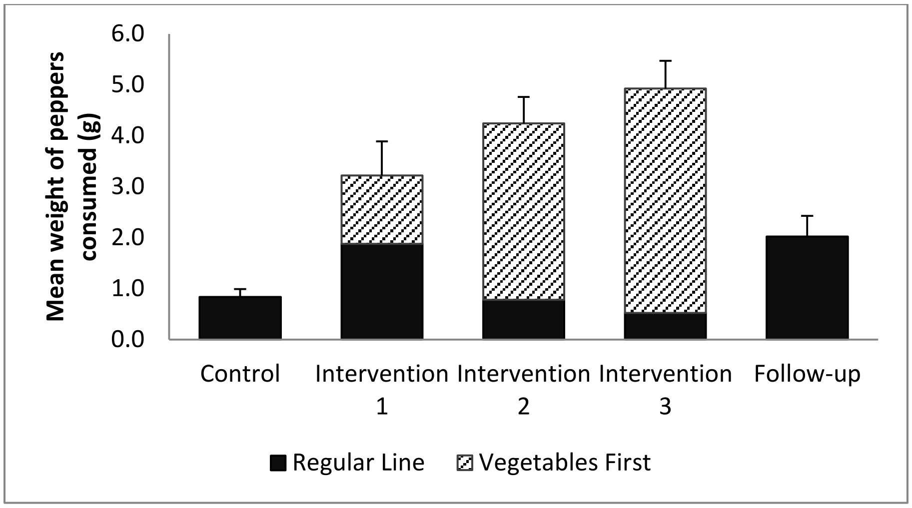

Figure 5.2: Mean weight of peppers consumed from those served before other meal components and from the regular line as parts of the total.

5.3 Providing vegetables first resulted in decreased consumption of cooked carrots, but not broccoli, peppers, or cauliflower from the regular lunch line.

Consumption of cauliflower (secondary vegetable on broccoli days) remained constant across all broccoli days (p = 0.75) (Table 5.5 and Figure 5.3).

Table 5.5: Break down of vegetable consumption on broccoli days. Mean weight consumed per student eating school lunch.

Condition	Broccoli (served first)	SEM	Broccoli (regular line)	SEM	Cauliflower	SEM
Control	--		0.8	0.2	0.6	0.2
Intervention 1	1.0	0.06	0.6	0.1	0.9	0.2
Intervention 2	2.6	0.2	0.7	0.1	0.6	0.2
Intervention 3	1.5	0.10	0.6	0.1	1.3	0.3
Follow-up	--		0.9	0.2	1.4	0.3
F value*			6.61		0.1	
p value*			0.01		0.75	

*contrasting control and follow-up vs. combined interventions

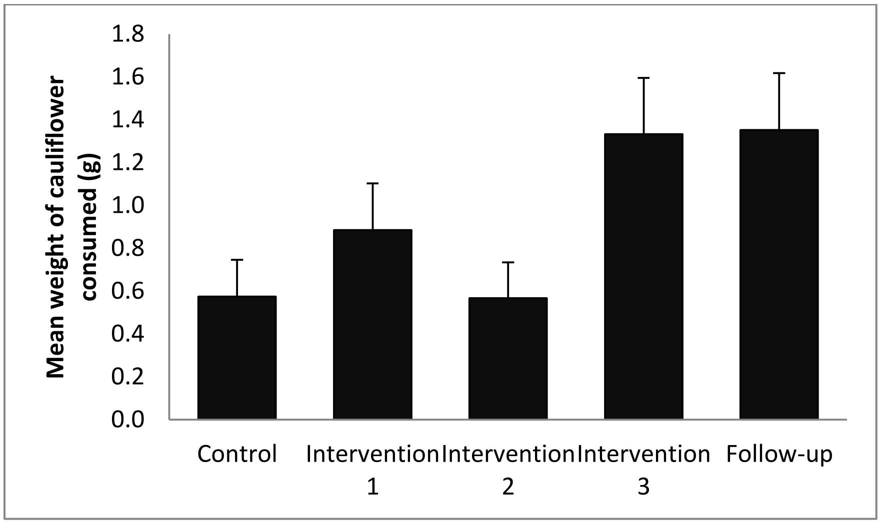

Figure 5.3: Mean weight of cauliflower consumed from the regular lunch line on each broccoli menu day.

Consumption of cooked carrots (secondary vegetable on pepper days) was higher on control and follow-up days than on intervention days ($p < 0.0001$) (Table 5.6 and Figure 5.4).

Table 5.6: Break down of vegetable consumption on pepper days. Mean weight consumed per student eating school lunch.

Condition	Peppers (served first)	SEM	Peppers (regular line)	SEM	Cooked carrots	SEM
Control	--	--	0.8	0.2	2.5	0.5
Intervention 1	1.3	0.09	1.9	0.4	1.4	0.4
Intervention 2	3.5	0.32	0.8	0.3	1.7	0.4
Intervention 3	4.4	0.39	0.5	0.2	0.8	0.3
Follow-up	--		2.0	0.4	3.0	0.6
F value*			3.2		15.4	
p value*			0.07		<0.0001	

*contrasting control and follow-up vs. combined interventions

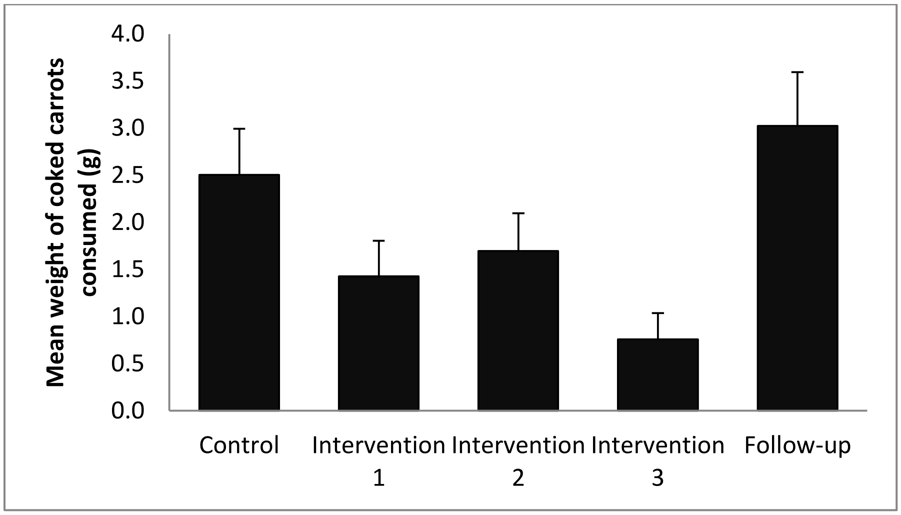

Figure 5.4: Mean weight of cooked carrots consumed from the regular lunch line on each pepper menu day.

5.4 The effect of serving peppers first but not broccoli, increased from the first day the intervention was implemented to the last day the intervention was implemented.

Consumption of broccoli was not different between intervention 1 and intervention 3 ($p = 0.21$) (Table 5.7 and Figure 5.5). Intervention 2 resulted in greater consumption than both intervention 1 and intervention 3 ($p < 0.0001$ and $p < 0.0001$, respectively).

Table 5.7: Mean adjusted weight of broccoli consumed per student eating hot lunch on broccoli intervention days. Means followed by the same letter are not significantly different ($p < 0.05$).

Condition	Broccoli consumed (g)	SEM
Intervention 1	1.6[a]	0.15
Intervention 2	3.2[b]	0.24
Intervention 3	2.1[a]	0.16

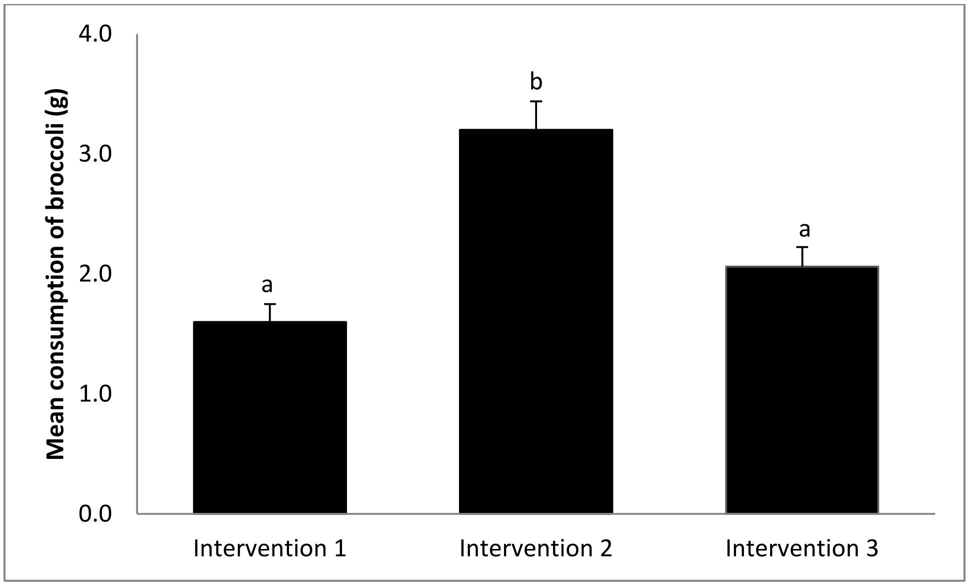

Figure 5.5: Mean adjusted weight of broccoli consumed from any source on the first and last day broccoli was served first. Means followed by the same letters are not significantly different ($p < 0.05$).

More peppers were consumed on the last intervention day than the first intervention day ($p = 0.01$) (Table 5.8 and Figure 5.6). Consumption on intervention 2 was not significantly different from either intervention 1 or intervention 3 ($p = 0.13$, $p = 0.13$, respectively). Results from the peppers suggest that as time went on, more peppers were eaten by the students.

Table 5.8: Mean adjusted weight of peppers consumed per student eating hot lunch on pepper intervention days. Means followed by the same letter are not significantly different ($p < 0.05$).

Condition	Mean adjusted weight consumed (g)	SEM
Intervention 1	3.2^{a}	0.48
Intervention 2	4.2^{ab}	0.42
Intervention 3	4.9^{b}	0.21

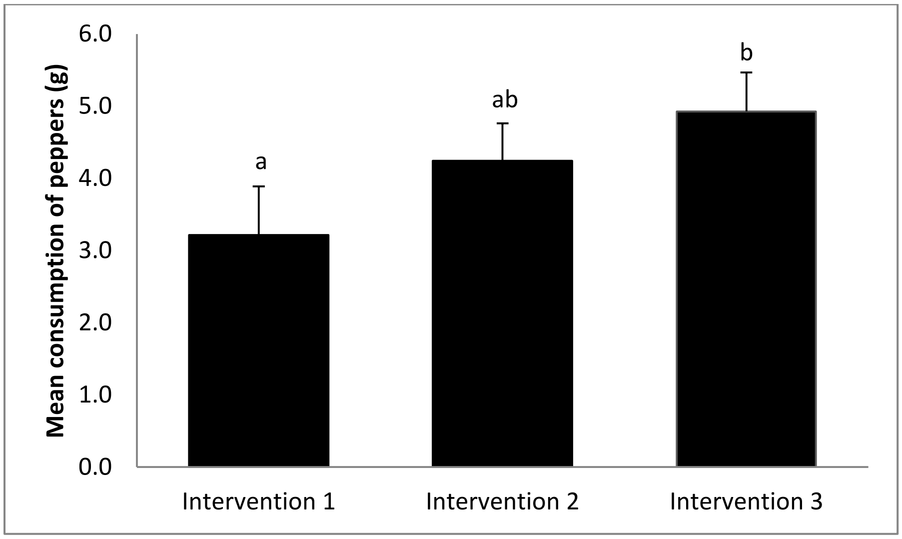

Figure 5.6: Mean adjusted weight of peppers consumed from any source on the first and last day peppers were served first. Means followed by the same letter do not significantly differ ($p < 0.05$).

5.5 Serving vegetables first did not increase consumption on days that vegetables were not served first.

Increased consumption did not continue after the intervention ceased to occur (Figure 5.7 and Figure 5.8).

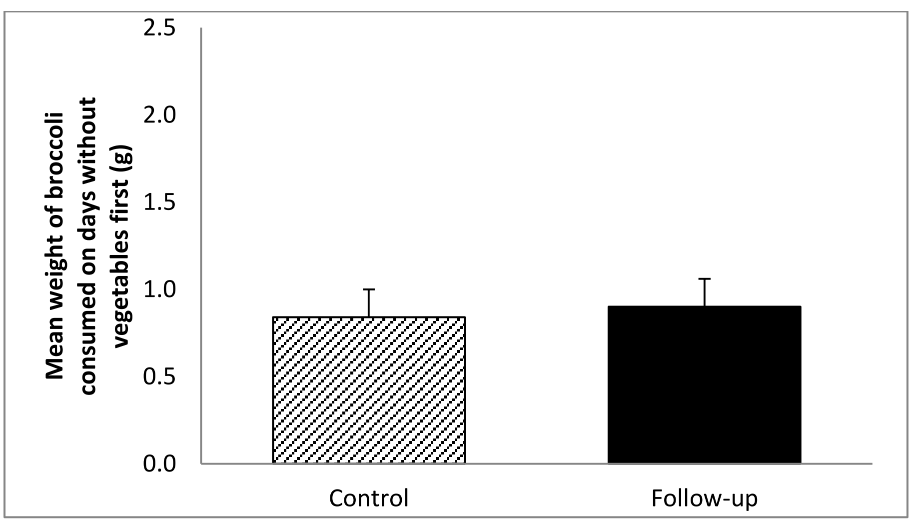

Figure 5.7: Mean weight of broccoli consumed on days without vegetables first.

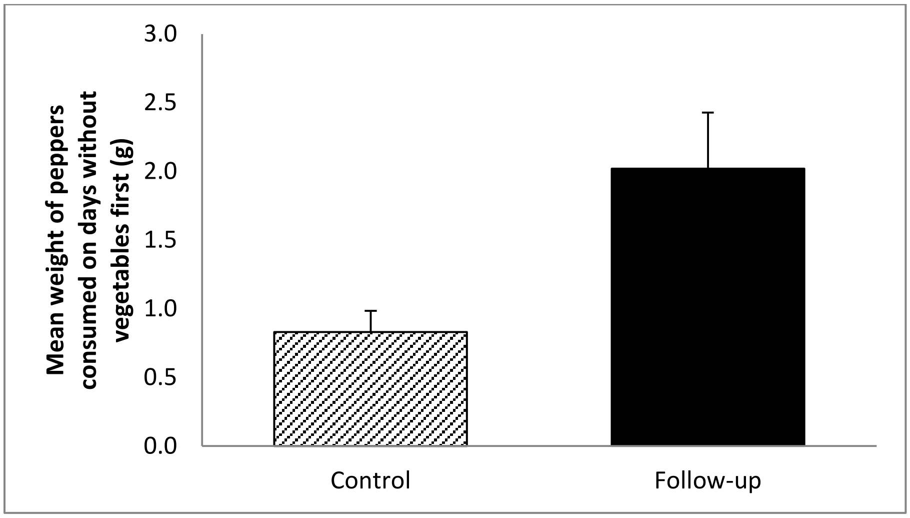

Figure 5.8: Mean weight of peppers consumed on days without vegetables first.

The proportion consumed was greater on the control and follow-up days than on intervention days for broccoli ($p < 0.0001$) (Table 5.3). Mean weight of broccoli consumed was not different from the control to the follow-up day ($p = 0.11$) (Table 5.3). Mean weight of peppers consumed was not different on the control versus follow-up day ($p = 0.49$) (Table 5.4). However, a greater proportion of students took peppers on the follow-up day than the control day ($p < 0.05$) (Table 5.2).

5.6 Other interesting findings

Mean weight of broccoli consumed per person who ***took*** broccoli from either or both sources was greater on control and follow-up days than on intervention days because on intervention days so many students ate only a small amount ($p < 0.0001$) (Table 5.9 and Figure 5.9).

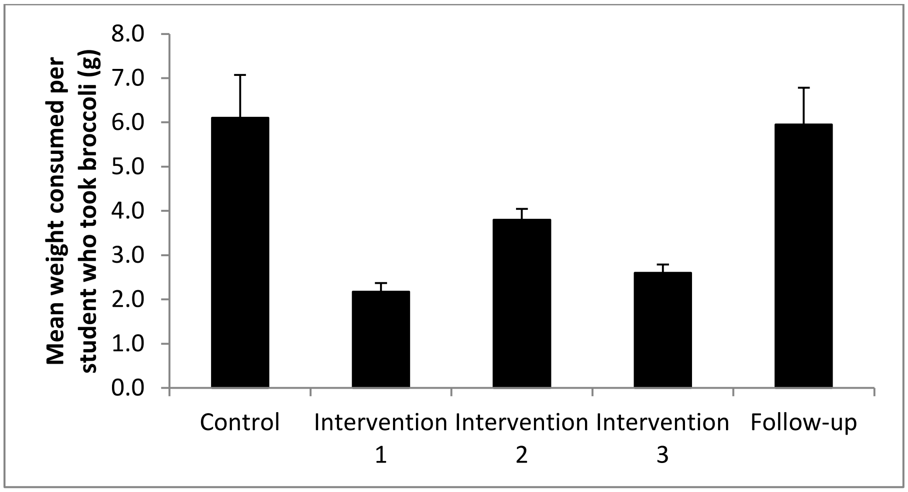

Figure 5.9: Mean weight of broccoli consumed per student who took broccoli from any source.

Mean weight of broccoli consumed per person who ***ate*** some amount of broccoli was greater on days without vegetables first than on intervention days ($p < 0.0001$) (Table 5.9 and Figure 5.9).

Table 5.9: Mean weight of broccoli consumed per person taking and eating broccoli.

	Mean weight consumed per person taking broccoli	**SEM**	**Mean weight consumed per person eating broccoli**	**SEM**
Control	6.1	1.0	13.1	1.3
Intervention 1	2.2	0.2	3.7	0.3
Intervention 2	3.8	0.3	7.7	0.3
Intervention 3	2.6	0.2	5.8	0.3
Follow-up	6.0	0.8	10.6	1.1
F value*	47.25		103.69	
p value*	<0.0001		<0.0001	

* contrasting control and follow-up vs. combined interventions

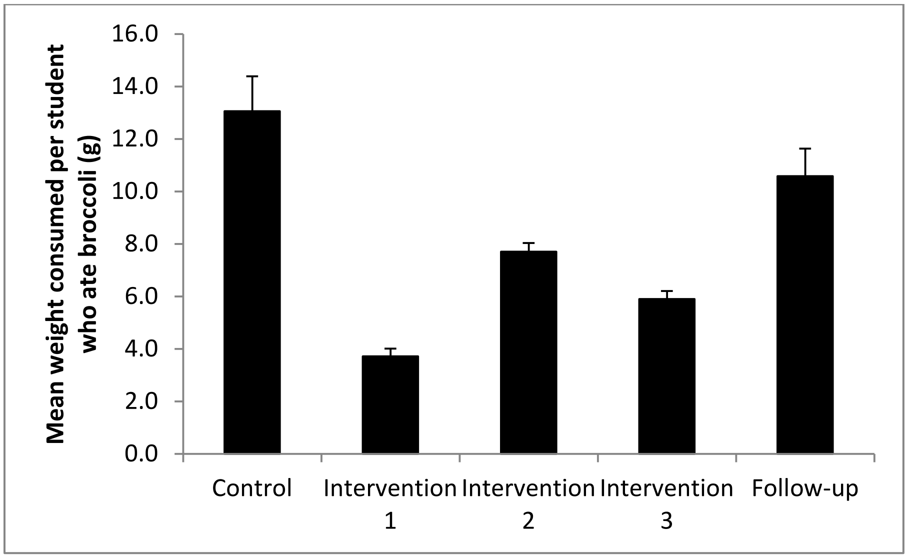

Figure 5.10: Mean weight of broccoli consumed per person who ate broccoli from any source.

Mean weight of peppers consumed per person who ***took*** a portion of peppers was greater on control and follow-up days than on intervention days ($p < 0.0001$) (Table 5.10 and Figure 5.11).

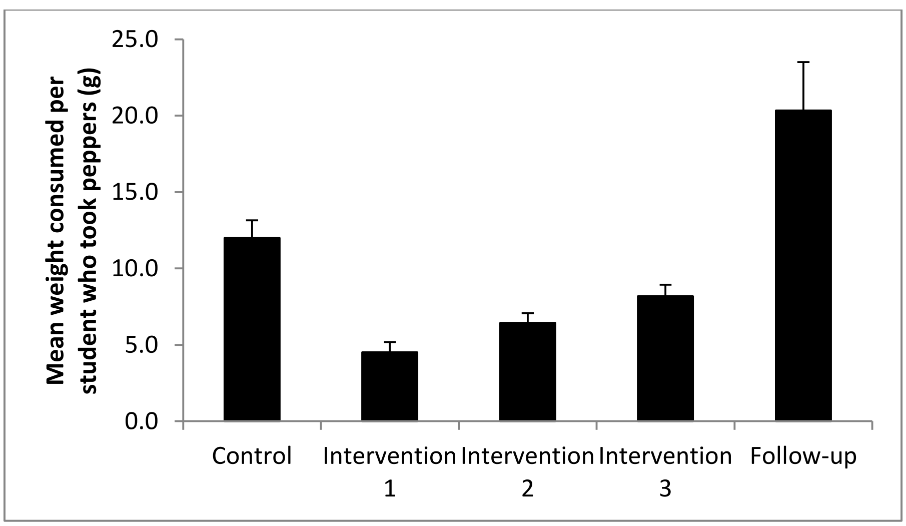

Figure 5.11: Mean weight of peppers consumed per person who took peppers from any source.

Table 5.10: Mean weight of peppers consumed per person taking and eating peppers.

	Mean weight consumed per person taking peppers	SEM	Mean weight consumed per person eating peppers	SEM
Control	12.0	1.1	13.1	1.1
Intervention 1	4.5	0.7	9.6	1.3
Intervention 2	6.5	0.6	17.6	1.6
Intervention 3	8.2	0.7	22.7	1.3
Follow-up	20.3	3.2	32.7	3.7
F value*	38.07		4.28	
p value*	<0.0001		0.04	

* contrasting control and follow-up vs. combined interventions

Per person who ***ate*** some amount of peppers from either source, the mean weight consumed was greater on control and follow-up days than on intervention days ($p = 0.04$). The mean proportion of peppers eaten per person eating some amount of peppers was greater on control and follow-up days than on intervention days ($p < 0.0001$) (Table 5.10 and Figure 5.12).

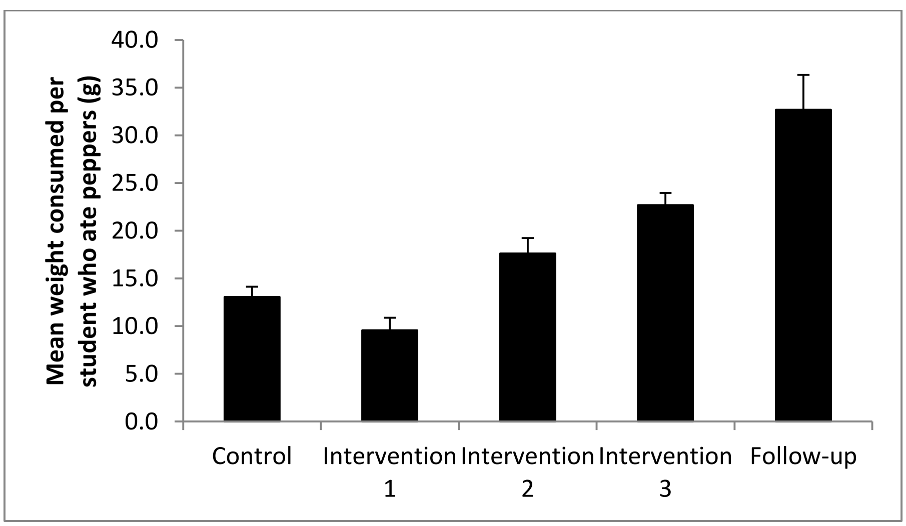

Figure 5.12: Mean weight of peppers consumed per person who ate peppers from any source.

For both broccoli and pepper days, mean weight of all vegetables consumed at school was greater on intervention days than on control and follow-up days ($p < 0.0001$ and $p = 0.007$, respectively).

Chapter 6 : Discussion

6.1 Discussion of results

When analyzing intake as a proportion of the amount of vegetables served, consumption of broccoli but not peppers was greater on intervention days than on control and follow-up days (Table 5.3 and Table 5.4). This discrepancy appears to arise because the weight of peppers served on the lunch line on intervention days was much larger than the amount served on the first control day masking the effects of the intervention. There was almost 3 times as much available on pepper intervention days compared to control days (93 g and 35 g, respectively). So while an average of 1.5 grams of peppers was eaten on control days and 4.1 grams of peppers were eaten on intervention days, the proportion eaten of the total amount available on each day was the same (4.3% and 4.4%, respectively). Increased portion size of vegetables has been shown to increase children's intake of those vegetables (Mathias et al., 2011; Spill et al., 2010, 2011). This may be the cause for the increased consumption of peppers on intervention days compared to control days.

The present intervention caused positive effects on the number of students taking and eating the two primary vegetables, but the mean weight eaten per person taking and the mean weight consumed per person eating the primary vegetable appear disappointing at first glance (Table 5.9 and Table 5.10). Taking a closer look however, it is not surprising that we saw lower consumption per person eating the primary vegetable on intervention days than on control and follow-up days (Figure 5.10 and Figure 5.12). The lower mean consumption per person eating the primary vegetable merely indicates that many students were taking a small taste, whereas on the control and follow-up days the people eating the primary vegetable already knew they liked it and so ate a greater amount. Previous research has shown that children tasting small portions (~4 g) of vegetables without requiring them to finish all their vegetables can increase their liking and subsequent intake of tasted vegetables (Anzman-Frasca et al., 2012). This has been shown with red bell peppers by Wardle et al. (2003b). Perhaps with continuous implementation of this strategy, children would learn to like and consume more vegetables.

There has been much research conducted in the past that suggests that serving vegetables first does not decrease the amount of vegetables eaten in the main course. Spill et al. (2011) reported that intake of broccoli was the same both when tomato soup was served first and when it wasn't. Another study by the same authors reported steady consumption of carrots from the main course even while the consumption of carrots in the first course did increase on days when carrots were served first compared to days when carrots were not served first (Spill et al., 2010). Results from the current study showed the same trend for broccoli, but not for peppers. Mean weight of peppers consumed from the regular line was marginally greater on control and follow-up days than on intervention days. This may be only because of the unusually high amount of peppers eaten on the follow-up day than on any other day.

We expected that consumption of the two vegetables would have increased from intervention 1 to intervention 3 since repeated taste exposure has been shown to increase liking (Anzman-Frasca et al., 2012; Hausner, Hartvig, et al., 2012; Hausner, Olsen, et al., 2012; Lakkakula et al., 2010; Pliner, 1982; Schindler et al., 2013). Increased liking is associated with increased consumption (De Wild et al., 2013; Lakkakula, Zanovec, Silverman, Murphy, & Tuuri, 2008; Olsen et al., 2012; Rasmussen et al., 2006; Wardle et al., 2003b; Zeinstra, Renes, Koelen, Kok, & Graaf, 2010). If something is more liked or more preferred, it will be chosen more frequently over other items (Birch, 1999). However, consumption only increased significantly from intervention 1 to intervention 3 for peppers, but not for broccoli as expected.

Serving vegetables first when no other well-liked competing foods are available is essential to the effectiveness of this intervention. Previous studies have shown that serving both fruit and vegetables first before other meal components increased intake of fruits, but not of vegetables (Harnack et al., 2012; Kral, Kabay, Roe, & Rolls, 2010). This is likely because serving both fruits and vegetables at the same time caused competition between fruits and vegetables. Kral et al. guessed this was because the children chose to eat more fruit, which is sweeter and more palatable, instead of increasing their intake of vegetables. Since high sugar and high fat foods are more liked, they are chosen over more healthy vegetables time and time again. Therefore, it is apparent that serving vegetables when other more palatable and/or less healthy options are not available will be more effective at increasing vegetable consumption than interventions where competing foods are available alongside vegetables.

There are a few factors that may have caused our intervention to result in increased consumption of the primary vegetable on intervention days compared to control and follow up days. For example, serving vegetables before other meal components allows the students to be eating when they normally wouldn't. If the students would have had more time to eat, the increase in consumption likely would have been even greater. The short amount of time that the students were allowed to get through the lunch line, sit down, and eat was only 20 minutes. This may have played a significant role in the amount of vegetables that they were able to consume. Giving the students vegetables before the regular lunch line is even more important because of these time constraints. It is likely that students would eat the more satiating and energy dense foods first when they get to the table and then start on the vegetables if they had time or weren't already full.

Different trends were seen in broccoli results and peppers results for some analyses (i.e. weight of cauliflower was the same on all days while weight of cooked carrots consumed was less on intervention days than control days, amount of broccoli consumed did not increase with each intervention while the amount of peppers consumed did increase from the first to the last intervention). These differences in results are likely due to the tastes, flavors, and physical characteristics of each. Peppers are sweeter and less bitter than broccoli. Sweet taste is well known to be innately liked while bitter is disliked (Birch, 1999; Nicklaus, Boggio, Chabanet, & Issanchou, 2004; Wardle, Cooke, et al., 2003a; Wardle, Herrera, et al., 2003b). Also at play may be the ease of chewing. Since broccoli is much harder to chew than peppers, it may take longer to eat, and therefore consumption would not increase as much. For this study, no initial liking data were collected, but according to the director of food service at the experimental school, broccoli was one of the most liked vegetables at the school. In samples with similar demographics to that of the current study, peppers were relatively disliked (Anzman-Frasca et al., 2012; Lakkakula et al., 2008; Wardle et al., 2003b). If we compare the number of students taking peppers compared to broccoli on the control days, peppers are not as well liked as broccoli (37 taking peppers versus 77 taking broccoli) (Table 5.1and Table 5.2). The probable difference in initial liking may explain why more students took broccoli than peppers (average across all broccoli days was 257 students taking broccoli and pepper days was 226 students taking peppers). Another possible explanation for the proportion of peppers consumed being insignificant while the proportion of broccoli consumed was significantly greater on intervention days compared to control days is the great variation in density of the two vegetables. Since the same volume of broccoli was much lighter, maybe the increase in weight consumed didn't appear to be as extreme.

6.2 Benefit of employing this technique in schools

Now that we have evidence that this technique does increase consumption of these two vegetables, it is necessary to decide if the benefits outweigh the costs of employing this technique. Providing the extra vegetables to serve before the regular lunch line cost $22-$122 (15-79% depending on the time of year and the type of vegetable served) more than providing only the vegetables on the regular line. Mean consumption of broccoli increased 150% on intervention days compared to control days although this only equals an increase from 4% to 10% of an average 120 mL (21 g) serving. On average, consumption of peppers increased 180% on intervention days compared to control days. Stated much less optimistically, consumption of peppers increased from 3% to 8% of an average 120 mL (52 g) serving. Although when stated this way, the results sound less than impressive, using this strategy would result in increased vegetable consumption five days a week at school so the compounding increase would definitely have an impact (an additional 1/3 of a serving) on weekly vegetable consumption. Therefore, it is worth the extra cost of implementing this strategy. Additionally, the vegetables served in this school were commodities and therefore would have come at a lower cost than what the investigators paid.

6.3 Strengths and limitations of this study

As with any study, there were many strengths of the current research. The study sample was from a low-income population, which has one of the lowest vegetable intakes and therefore has the most room for improvement (Drewnowski & Specter, 2004; Strauss & Pollack, 2001). The sample size was large and individuals were tracked throughout the study giving it a lot of power. Additionally, data were adjusted to account for the error caused by vegetables dropped and discarded before reaching the table. This assured that the results were still fairly accurate. The study was conducted in the children's usual eating environment with peers and familiar foods. Eating lunch in the presence of peers has been shown to have both positive and negative impacts on children's consumption of school lunch (Zandian et al., 2012). Socialization occurs that may encourage or discourage students eating vegetables.

The greatest limitation of the study was the impossibility of getting the 60 mL portions of vegetables into all students' hands and keeping them there until data were collected. However, by the end of the study, researchers were adept at encouraging students to put the cup on their trays and at retrieving dropped cups and vegetables. Also problematic was the great amount of missing data due to children being gone or going to recess early for various reasons. Occasionally cafeteria staff would serve items not listed on the menu so students may have changed their consumption on those days depending on the extra offerings.

Consistent weight of portions would have strengthened this study. The weight of a piece of pepper changed through the study because the long, thin pieces used at the outset easily tipped the cup over and fell out while students were holding them. In order to combat the extraordinary amount dropped on the floor because of the ease of the peppers flipping out of the cups onto the floor, the shape of the peppers was changed so they did not stick out much beyond the top of the cup. Despite this variability, the adjusted data did show a significant increase in consumption for both broccoli and peppers on intervention days compared to control days.

6.4 Conclusions and future research

Serving a small portion of vegetables before other meal components can be used as a strategy to increase consumption of broccoli and sweet peppers in elementary school students. This small portion resulted in many students trying the primary vegetable, which, when repeated, has been shown to increase liking of foods (Anzman-Frasca et al., 2012; Hausner, Hartvig, et al., 2012; Hausner, Olsen, et al., 2012; A. Lakkakula et al., 2010; Pliner, 1982; Schindler et al., 2013). Additional repetitions added to this study may cause additional increases in vegetable consumption. As discussed in the literature review section, repeated exposure to initially disliked or unfamiliar foods can increase liking, so students may choose to take vegetables from the regular line more often if the intervention was implemented for a longer period of time. A habit may also be formed if the intervention was implemented continuously.

More research needs to be done to confirm these findings. A similar study should be conducted in another school to determine if this technique would work in higher income schools and schools with different lunch time routines. Since our findings suggest that results differ depending on the type of vegetable being served, a variety of vegetables should be investigated. It would be interesting to record vegetable intake later in the day to determine if this intervention increased daily vegetable consumption or if the increase is washed out by a decrease in vegetable consumption later in the day. More work should be done to find the optimal portion size of vegetables served before the regular line that would maximize the amount eaten and minimize the amount uneaten. In order to find stronger results for the comparison of the follow-up to the control, a study should be carried out using the current methodology with more frequent interventions or an extended study period. A school that has a longer lunch period may be better suited for this study so that students do not have to rush or choose which components of their meal they should eat in the short amount of time allowed for lunch.

Some changes in methodology would be helpful to make results even stronger in future research on this topic. The teacher from each class should announce before lunch that each student is to take a cup of veggies from the tray before the regular line. This way, only one person would be needed in this area to monitor students taking cups. All the teachers should be asked to behave in the same manner. For example, investigators could request that all teachers remained unbiased since in the current study, some teachers would encourage students to eat their vegetables while others would make comments that they themselves wouldn't eat raw broccoli possibly influencing the students to refrain from eating the vegetable. It may be helpful to have fewer pieces in each cup, but for those pieces to be larger. That way it would be harder to spill the vegetables (particularly broccoli) because the pieces aren't perched precariously on top of each other.

Although the magnitude of the consumption increase was small, using this approach for all school meals would have a considerable impact on the weekly consumption of vegetables in elementary school kids and on building the habit of eating vegetables.

Chapter 7 : References

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Chapter 8 : Appendix

Proportion of people taking on control versus follow-up

Broccoli
Feb 6: 77/558 = 0.138
May 6: 80/529 = 0.151
One tailed test (Ha: p1<p2) z = 1.64 (if statistic is greater than 1.64 the difference is significant) (to calculate confidence interval subtract 1.64 * 0.619 interval goes to ∞)
(0.151 - 0.138)/ $\sqrt{}((0.138(1-0.138))/558\ +\ (0.151(1-0.151))/529)$
0.013 /$\sqrt{.0002 + 0.00024}$
0.013/ (0.619) = 0.61 ← not significant since the statistic is not greater than 1.64
Peppers
Feb 8: 37/532 = 0.0695
May10: 53/534 = 0.0993
One tailed test (Ha: p1<p2) z = 1.64
(0.0993 - 0.0695) /$\sqrt{}((0.0695(1-0.0695))/532\ +\ (0.0993(1-0.0993))/534)$
0.0298/$\sqrt{0.000267}$ = 1.8 since statistic is > 1.64 we should reject null (significant)

Proportion of people taking on control/follow-up versus interventions

Broccoli
One tailed test (Ha: p1<p2)
Controls: 79/544 = 0.145
Interventions: 409/515 = 0.794
(0.794 - 0.145)/ $\sqrt{}(\left(\frac{0.145(1-0.138)}{544}\right) + \left(\frac{0.794(1-0.794)}{515}\right))$
0.649/$\sqrt{0.00022 + 0.0003}$
0.649/$\sqrt{0.0005}$
0.649/0.022 = 29.5 ← p <<0.01 = significant

Peppers
Controls: 45/533 = 0.084
Interventions: 346/529 = 0.654
(0.654 – 0.084)/ $\sqrt{\left(\frac{0.084(1-0.084)}{533}\right) + (\frac{0.654(1-0.654)}{529})}$
0.57/$\sqrt{.000144 + .0004277}$
0.57$\sqrt{.0.000572}$
0.57/0.0239 = 23.84 ← p << 0.01 = significant

Proportion of people eating the primary vegetable on control/follow-up versus interventions

<u>Broccoli</u>
Controls: 41/544 = 0.075
Interventions: 209/515 = 0.406
(0.406 – 0.075)/ $\sqrt{\left(\left(\frac{0.075(1-0.075)}{544}\right)+\left(\frac{0.406(1-0.406)}{515}\right)\right)}$
0.331/$\sqrt{.0001275 + 0.000468}$
0.331/$\sqrt{0.0005957796}$
0.331/0.0244 = 13.565 ← p << 0.01 = significant

<u>Peppers</u>
Controls: 34/533 = 0.064
Interventions: 139/529 = 0.262
(0.262 – 0.064)/ $\sqrt{(\frac{0.064(1-0.064)}{533}}) + (\frac{0.262(1-0.262)}{529})$
0.198/$\sqrt{.00011 + 0.000366}$
0.198/$\sqrt{.000476}$
0.198/0.0218 = 9.08 ← p << 0.01 = significant