A Conceptual Evaluation Framework for Measuring Fruit and Vegetable Consumption at School Lunch among Elementary Students Participating in the National School Lunch Program

Matthew M. Graziose

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ABSTRACT

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In the U.S., few children meet federal recommendations for fruit and vegetable consumption, putting them at increased risk for overweight, obesity and several non-communicable diseases. Interventions to increase fruit and vegetable consumption delivered within the school setting are advantageous in that they provide the opportunity to reach many youths in period of life during which key diet-related behaviors are formed that may track into adulthood. The National School Lunch Program (NSLP), a federal food assistance program that serves over 30 million meals daily in over 100,000 schools in the U.S., is one example of an intervention that may increase fruit and vegetable consumption among children. Recent regulatory changes to the program via the 2010 Healthy Hunger-Free Kids Act (HHFKA) require compliance with minimum daily and weekly minimums for fruit and vegetables offered to students at lunch to receive federal reimbursement, which has resulted in increased availability of fruits and vegetables. Although preliminary evaluations of the regulatory changes have documented small increases in consumption, there is interest in identifying other programs and policies to ensure that components are consumed. Yet there is little meta-evidence that critically examines aspects related to the design of school-based intervention studies assessing fruit and vegetable consumption. This dissertation describes a systematic mapping review of the literature and three empirical studies which inform the development of a conceptual evaluation framework for designing studies to measure fruit and vegetable consumption among elementary students in the U.S. within schools participating in the NSLP.

A systematic mapping review of the literature technique was used to identify studies conducted among elementary students in grades K-5th within schools in the United States in the period from 2004 to present with the primary outcome fruit and vegetable consumption at the lunch meal. A total of 61 records were included in the review, categorized as either methodological validation studies (n=10) or as studies of factors related to students’ consumption of fruits and vegetables (n=51). Validation studies were conducted with four types of dietary assessment methods within the school lunch setting, all
demonstrating moderate accuracy relative to the referent method: weighed plate waste, direct observation, digital photography and self-report instruments. In the studies examining factors related to fruit and vegetable consumption at school lunch, the frequency of methods was as follows: weighed plate waste method (n=21), direct observation (n=14), digital photography methodology (n=12), and self-report (n=4). Most studies utilized cross-sectional (n=15) or quasi-experimental designs (n=24). A socio-ecological framework was used to group 19 environmental factors examined in these studies into 5 clusters of factors: individual, item-specific, meal-specific, cafeteria environment and school-wide/policy. While many factors were explored across studies, relatively few studies accounted for multiple factors in their analyses, leaving room for potential confounding.

Three empirical studies were conducted within a larger, cross-sectional evaluation of FoodCorps, a national farm-to-school program that promotes fruit and vegetable consumption in school-aged children. First, this dissertation conducted a validation study to estimate the accuracy of a self-report questionnaire instrument relative to digital photography for measuring fruit and vegetable consumption in elementary students from 23 schools in a five-phase study. High agreement was observed between student reports of fruit and vegetable items on tray and items observed in digital photographs (match rate ranged from 77 to 88% depending on phase), as well as reports of amounts of fruit and vegetable items consumed (ranges from 67 to 83% depending on phase). There were no differences observed in accuracy of reporting between 2\textsuperscript{nd} and 3\textsuperscript{rd} grade students. It can therefore be concluded that a group-administered self-report instrument can be used to measure fruit and vegetable consumption in a school setting among 2\textsuperscript{nd} and 3\textsuperscript{rd} grade students, providing a potentially less costly instrument than existing objective methods.

Second, a descriptive study reports intra-class correlation estimates for fruit and vegetable outcomes, quantifying the variation in these outcomes attributable to the school-level that can be used in power calculation for future studies. Using 2,571 before- and after-meal digital photographs collected of students’ lunch trays across 40 days of data collection within 20 schools, the intra-class correlation coefficients (ICC) were estimated via multilevel regression models. The observed ICCs for all fruit and vegetable consumption outcomes ranged from 0.159 (vegetables on tray, continuous) to 0.472 (vegetables on tray, binary). Within each of food item category (fruit, vegetables, or fruit and vegetables combined), the highest ICC was observed for items on tray (binary). A multilevel linear model which
included as covariates the percent of students eligible for free/reduced price lunch and the percent of white students was shown to decrease the ICC for each fruit and vegetable outcome variable except fruit on tray (binary). The largest for decrease in ICC was for the outcome fruit and vegetables on tray (in cup equivalents), wherein the model reduced ICC from 0.268 to 0.018, a 93% decrease. The power calculations for cluster randomized controlled trial that can conducted using these ICCs will help to ensure that researchers have adequately powered their studies.

Third, select cafeteria environmental factors were examined in a cross-sectional study as they relate to students’ fruit and vegetable consumption at the lunch meal. Using the digital photographs of 2,571 lunch trays from the previous study, the association between fruit and vegetable consumption and several environmental factors was examined. The average consumption of fruit and vegetables was 0.35 cup equivalents (SD=0.31) and 0.24 cup equivalents (SD=0.29), respectively, among students who had them on their tray. When considering students who had a fruit or a vegetable or both on their tray (96% of the sample), the average was 0.45 cup equivalents (SD=0.40). Hierarchical linear models examined environmental variables and fruit and vegetable consumption outcomes: the number of fruit and vegetable items offered (range from 3 to 14 items) was positively associated with vegetable consumption (B=0.021; SE=0.006; P<0.001); noise (rate from 70 DbA to 84 DbA) was negatively associated with fruit consumption (B=-0.012; SE=0.004; P=0.003) and fruit and vegetable consumption (B=-0.017; SE=0.004; P<0.001); recess scheduled before lunch was positively associated with fruit consumption (relative to recess after lunch; B=0.100; SE=0.023; P<0.001) and fruit and vegetable consumption (B=0.096; SE=0.023; P<0.001). Despite cross-sectional evidence of an association, future research is necessary to systematically manipulate these variables to understand their impact.

The results from these three studies and the systematic mapping review are used to develop a conceptual evaluation framework that can be used by researchers to improve the quality and design of studies promoting fruit and vegetable consumption among elementary school-aged children in the U.S.
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DEDICATION

For Toni
CHAPTER 1: INTRODUCTION

1.1. OVERVIEW

In the U.S., few children meet federal recommendations for the daily consumption of fruits and vegetables (Krebs-Smith et al, 2010; Lorson et al, 2009; Guenther et al, 2006). This puts them at increased risk for obesity and chronic disease, both during childhood and later in life. The Health and Medicine Division of the National Academies of Science, Engineering and Medicine (formerly the Institute of Medicine [IOM]) suggests that schools are uniquely positioned to encourage youth to engage in healthy eating patterns, to reduce the prevalence of obesity and associated risk factors, and to mitigate health disparities (IOM, 2012). The potential benefits of interventions delivered via the school are well established, including an expanded reach and an educational setting where successful interventions can be institutionalized. Reaching children in early and middle childhood is important given that healthy eating and physical activity habits are established during this period of life and may track into adulthood (te Velde et al, 2007).

The National School Lunch Program (NSLP) provides an opportunity to increase fruit and vegetable consumption among children in participating schools. This program began in 1946 with the passage of the National School Lunch Act as a strategy to provide meals to students and promote health. Today, the NSLP provides meals to more than 30 million children every day in over 100,000 public and private schools in the U.S., and contributes up to one half of children’s daily calorie intake (Briefel et al, 2009). Recent regulatory changes in the form of nutrition standards have expanded the potential reach and impact of the program on students’ nutritional status. The 2010 Healthy Hunger-Free Kids Act (HHFKA) mandated changes to the nutritional quality of school lunch meals, including both weekly and daily requirements for nutrients and types of foods served, for schools to receive federal reimbursement. A more recent meal service option offered via the NSLP, the community eligibility provision, has extended the opportunity for communities to offer free meals to children in low-income neighborhoods to reduce the bureaucratic burden associated with the program and has greatly expanded its potential reach.

During the period since these policy changes have been implemented there has been an
expansion of the scientific literature attempting to understand the factors related to students’ eating behaviors at school lunch. This body of literature includes interventions designed to increase students’ consumption of school meals and/or items served during the school meal – these interventions may span across several different levels or determinants of school lunch consumption. There is the expectation that successful interventions could be implemented within schools participating in the NSLP to ensure fruits and vegetables are consumed. However, there is a limited evidence base of successful interventions and synthesis of factors or determinants related to fruit and vegetable consumption at school lunch. Previous systematic reviews have only focused on specific policy changes, such as the removal of competitive foods (Chriqui et al, 2014) or on “simple” or discrete modifications to the school cafeteria environment, such as adding a salad bar or reducing the price of items (Kessler, 2016). One additional systematic review only focused on single-component interventions designed to change the school food environment and thus did not consider nutrition education approaches (Driessen et al, 2014). A recent narrative review identified school-based programs and policies related to diet and obesity, but the authors did not employ a systematic search (Welker et al, 2016). There is little meta-evidence describing the research design, including diet assessment methodologies, sample size, and potential confounding variables related to successful interventions that increase children’s fruit and vegetable consumption at school lunch.

Notwithstanding the greater consistency between schools in meals served to students as mandated by the NSLP and the growing knowledge base of factors influencing consumption, researchers face a host of challenges in measuring consumption of fruits and vegetables at school lunch. First, there is a lack of validated, self-report methods that can be used in lieu of labor-intensive objective data collection methodologies for measuring fruit and vegetable consumption, particularly among younger students. Second, recruitment for studies examining consumption of school meals rely on a unit of recruitment at the school- or district-level (as opposed to the individual-level), creating a multilevel data structure that requires special considerations for the power calculation, sample size and data analyses. Third, there are a host of environmental factors that are not presently regulated by the NSLP or other federal policy which, if unobserved and unaccounted for, have the potential to moderate the effect of school-based interventions on primary outcomes of interest.

The objective of this dissertation was to develop a framework for researchers and practitioners
measuring elementary school students’ fruit and vegetable consumption at school lunch. This was accomplished through a systematic mapping review of the literature and three empirical studies with 2nd and 3rd grade students in public schools participating in the NSLP, defined here: 1) a validation study of a questionnaire measuring consumption of fruits and vegetables at school lunch, 2) a descriptive study of the intraclass correlation coefficients observed between schools in students’ consumption of fruits and vegetables at lunch, and 3) a cross-sectional study examining the relationship between school and cafeteria environmental factors, informed by a systematic mapping review of the literature, and consumption of fruits and vegetables at school lunch. The goal is to provide guidance for future researchers related to measurement of fruit and vegetable school lunch consumption, sample size calculations, and potential confounding school lunch environmental factors.

1.2. BACKGROUND

1.2.1. Recommendations for fruit and vegetable consumption in middle childhood

Proper nutrition is essential for optimal growth and development during childhood. The nutritional requirements associated with middle childhood – the period of life between 5 and 10 years old characterized by rapid physical growth and cognitive development – are substantial. In addition, childhood represents an important window of time to support the development of lifelong, health-promoting dietary behaviors. To continue to grow and function well in the adult world, children need to be provided with a set of skills that will enable them to eat healthfully in the absence of parental and institutional support. Encouraging appropriate eating behaviors, as well as positive attitudes toward food, can help children remain healthy and reduce their risk of non-communicable disease later in life.

Recommendations for a healthful diet have focused on improving the quality of the foods contained in the overall diet and have recently begun to emphasize healthful patterns, as opposed to individual nutrients (Mozaffarian & Ludwig, 2010). Several government agencies, expert groups, and normative organizations have developed recommendations for optimal dietary patterns in childhood, summarized below:
• The 2015-2020 *Dietary Guidelines for Americans* concludes that the healthiest dietary patterns are those that higher in vegetables, fruits, whole grains, low- or non-fat dairy, seafood, legumes, and nuts; moderate in alcohol (among adults); lower in red and processed meats; and low in sugar-sweetened foods and drinks and refined grains (United States Department of Agriculture [USDA], 2015).

• The Expert Committee of the American Academy of Pediatrics has identified several behaviors that contribute to energy balance in children: consuming fruits and vegetables, viewing television and other screen time, eating away from home, portion size, eating energy-dense foods, engaging in moderate to vigorous physical, consuming sugar-sweetened beverages, consuming breakfast, and eating family meals (Barlow et al, 2007).

• A 2005 consensus statement from the American Heart Association recommends for those aged 2 years and older to consume a diet rich in fruits and vegetables, whole grains, low-fat and nonfat dairy products, beans, fish, and lean meat (Gidding et al, 2005).

• The World Health Organization (WHO, 2004) offers practical advice for adults and children to maintain a healthy diet, which includes eating at least 400 g, or 5 portions, of fruits and vegetables per day.

• The American Institute for Cancer Research and the World Cancer Research Fund (2007) recommend eating at least five servings (at least 400 g or 14 oz) of a variety of non-starchy vegetables and of fruits every day for adults and children.

### 1.2.2. Scientific rationale for promoting fruit and vegetable consumption in childhood

The consumption of fruits and vegetables is central to dietary recommendations from expert groups, governments and normative organizations. The importance of fruit and vegetable consumption in middle childhood is underscored by the multiple, interrelated consequences for health, including nutrient status and obesity and chronic disease risk. In addition, there is longitudinal evidence suggesting that
dietary behaviors formed in childhood track into adulthood. Taken together, the evidence suggests that prevention of weight gain and chronic disease among children and adolescents should be mediated by the recommendation to consume more fruits and vegetables.

*Improved nutrient intakes.* American children do not meet recommended nutrient requirements. The Scientific Report of the 2015 Dietary Guidelines Advisory Committee (DGAC), which was the most recent systematic review of the average nutrient intakes of the American population, found that all Americans are under-consuming vitamin A, vitamin D, vitamin E, folate, vitamin C, calcium, and magnesium relative to the estimated average requirement (EAR) (USDA, 2015). For vitamin A, 15% of males and 24% of females age 9-13 were below the EAR, and the proportion of children below the EAR increases as they age (DGAC, 2015). Similarly, 17% and 23% of males and females aged 9-13 were below the EAR for vitamin C (ibid.). In addition, fewer than 3% of children 4-13y of age consumed an amount of dietary fiber above the adequate intake for their age (USDA, 2015). The mean intake of potassium among male and children 4-13y of age is 2108mg (32.2) and 1985mg (35.2), respectively, while the adequate intake level is 3800mg (ibid.). The 2015-2020 Dietary Guidelines for Americans include as a recommendation to increase fruit and vegetable consumption primarily because these foods act as a source of typically under-consumed vitamins (e.g., A, C, K), minerals (e.g., iron, magnesium, potassium) and nutrients (e.g., fiber) in the diet (USDA, 2015). Fruits and vegetables currently contribute, on average, over a third of daily potassium and nearly half of the dietary fiber of the diets of children age 4-13y of age (DGAC, 2015). Thus, more frequent consumption of fruits and vegetables could contribute to increasing the daily intakes of these shortfall nutrients among American children, although certain types of fruits and vegetables may be superior to others in terms of nutrient composition (Di Noia, 2015).

*Obesity prevention and treatment.* One in seven of the world’s citizens are obese, leading the World Health Organization (WHO) to characterize it as an “epidemic” (WHO, 2016). Obesity is caused by a calorie imbalance – too few calories expended and too many calories consumed – and it increases the risk of several non-communicable diseases (ibid.). Obesity is an independent risk factor for several chronic health conditions such as diabetes, heart disease and cancer (Barlow et al, 2007). As a result, obesity places a significant economic burden on the U.S., with costs projected to increase by $66 billion by the year 2030 if past trends continue (Wang et al, 2011). Of concern is the rate at which children are
affected. In the U.S., the prevalence of obesity (i.e., body mass index (BMI) ≥95th percentile age for sex) among children aged 2-19y has tripled in the period between 1976 and 2008, from 5.1% to 16.9% (Ogden et al, 2010). Presently 18.0% of children aged 6-11y are obese and 31.8% are overweight (Ogden et al, 2014). While the prevalence of childhood obesity is high, evidence also suggests there is a disparity in rates of obesity among racial and ethnic subgroups in the U.S. Among children aged 2-19y, African Americans and Hispanics are more likely to experience obesity (ibid.). Furthermore, evidence from longitudinal studies suggests that overweight and obese children are likely to remain overweight and obese into adulthood (Goldhaber-Fiebart, 2013; Guo et al, 2002), providing rationale for prevention and treatment in the early years of life. Intervention in childhood is likely to have cost-savings in adulthood in the form of averted medical spending and quality-adjusted life-years gains (Graziose et al, 2016).

Increased fruit and vegetable consumption is hypothesized to lower overall calorie intake and thus decrease risk for obesity among children. The mechanism for this effect is via the energy density pathway (Ledoux et al, 2011): fruits and vegetables are low energy-density foods due to a high fiber and water content, making absolute calories per gram of food low. Lower energy density foods are associated with a greater sense of satiety and reduced daily consumption of energy (Rolls et al, 2006). A systematic review by Perez-Escamilla et al (2012) concluded that consuming a diet that is relatively low in energy density improves weight loss and weight maintenance among both children and adults. Using 2001-2004 National Health and Nutrition Examination Survey (NHANES) data, Vernarelli et al (2011) showed that a greater energy density of the diet was positively associated with body weight status in U.S. children aged 2-8y. However, in a cross-sectional study of children in school settings, intake of calories in the form of fruits and vegetables as part of the school lunch meal was associated with fewer calories from other parts of the school lunch meal (e.g., non-fruit or non-vegetable energy), but had no effect on overall energy intake and thus did not support the reduced energy intake hypothesis (Bontrager-Yoder et al, 2014).

A limited body of evidence suggests that fruit and vegetable consumption is inversely related to body mass index (BMI) among children: a 2010 systematic review for the USDA Nutrition Evidence Library concluded that there “a limited body of evidence from longitudinal studies suggests that greater intake of fruits and/or vegetables may protect against increased adiposity in children and adolescents.” A subsequent systematic review by Ledoux et al (2011) identified one experimental study of fruit and
vegetable consumption and body weight, which did not have the expected inverse effect, and four longitudinal studies of fruit and vegetable consumption and body weight among children, of which only one study observed the expected inverse association. Yet there are several more recent longitudinal studies that were not included in this systematic review. For example, Bayer et al (2014) found no significant relationships between fruit and vegetable consumption and BMI among a cohort of children during the transition from age 6-10y, but noted that fruit and vegetable consumption may act by displacing energy from the consumption of high-fat and high-sugar foods. Data from Project EAT (Eating and Activity in Teens and Young Adults), a 10y longitudinal study of children 15-25y of age, show that higher diet quality was associated with lower weight gain and less increase in BMI over the 10y period (Cutler et al, 2012).

**Chronic disease prevention.** Several studies have found that consumption of fruits and vegetables is associated with reduced risk of chronic disease, independent of weight status. In adults, inverse associations have been reported between fruit and vegetable consumption and risk for diabetes mellitus, hypertension and cancer. The World Cancer Research Fund (2007), in a systematic review of the evidence, concludes that there is probable evidence suggesting that consumption of non-starchy vegetables protects against cancers of the mouth, pharynx, and larynx, and those of the esophagus and stomach among adults. Similar findings have been reported in children and adolescents; a diet high in fruits and vegetables can lower the risk of diabetes mellitus, coronary heart disease, hypertension and cancer. For example, Moore et al (2012) found in a longitudinal study of girls aged 9-10y, those who consumed more than 2 daily servings of dairy and more than 3 servings of fruits and vegetables had a 36% lower risk (95 % CI: 0.43, 0.97) of elevated blood pressure after 10 years of follow-up. A similar finding was reported in a study of nearly 800 adolescents living in Brazil by Damanceno et al (2011), wherein lower systolic and diastolic blood pressure was associated with consumption of fruit twice daily as compared to less frequent consumption (p<0.001). In a study of Australian adolescents aged 12-18y, McNaughton et al (2008) found that consumption of a diet rich in fruit, salad, cereals, and fish was associated with a decreased diastolic blood pressure, after adjustment for age, sex, and physical activity. Qureshi et al (2009), using data from 1999-2002 NHANES, found that blood levels of C-reactive protein, an inflammatory biomarker, were lowest among children who consumed more grains, vegetables and
Dairy.

*Dietary behaviors track into adulthood.* Several longitudinal studies support the conclusion that dietary behaviors, and fruit and vegetable consumption in particular, track from the early and middle childhood period, through adolescence, and into adulthood. (In this regard, tracking refers to stability in behaviors over multiple observation points.) The Cardiovascular Risk in Young Finns Study, which was a longitudinal study that followed Finnish children and adolescents for 21 years, used a factor analysis to identify eating patterns from a baseline set of 24-hour recalls conducted among children. The authors found that after follow-up, over a third of participants followed the same eating pattern, and correlations between 24-hour recalls were 0.32-0.38, depending on the eating pattern (Mikkila et al, 2005). Similarly, the Framingham Children’s Study followed children for 6 years beginning at 3y and found high correlations between the intakes of nutrients such as fat, cholesterol, calcium and potassium across all ages, ranging from 0.3 to 0.6 (Singer et al, 1995). Te Velde et al (2007) found that fruit and vegetable consumption patterns tracked between the ages of 12 and 36 years of age among participants in the Amsterdam Growth and Health Longitudinal Study (AGAHLS), with correlations for fruit consumption at 0.33 and vegetable consumption at 0.27. Kelder et al (1994) examined participants in the Minnesota Heart Health Program beginning at 6th grade for a period of 7 years and found that food choice behaviors, as measured by a dietary checklist, tracked over the course of the study. These longitudinal studies offer unique implications for early life intervention to promote healthy dietary patterns in childhood, given the likelihood that they will remain relatively stable throughout the life course. They suggest that intervention in the early years of life, if successful toward the goal of increasing fruit and vegetable consumption, may instill a habitual behavior that continues into adulthood. Yet caution is warranted because few studies have tracked intervention effects long enough to determine if behavior changes are indeed sustained, and a few studies, such as the one by Hoffman et al (2011), showed that there were no longer any differences in fruit and vegetable consumption in the intervention and control groups one year after an intervention among elementary students.

1.2.3. Evidence of inadequate fruit and vegetable consumption among children in the U.S.

Despite the importance of proper nutrition for present and future health and wellbeing, few
children in the U.S. are eating in accordance with federal recommendations. The 2015-2020 Dietary Guidelines for Americans recommends that, for example, a child who is at the 1,800-daily calorie level consume 2.5 cups of vegetables and 1.5 cups of fruit per day (DGAC, 2015). Yet recent examinations of the diets of American children have shown that less than 1 in 10 meet the U.S. Department of Agriculture (USDA) recommendations for consumption of both fruit and vegetables (Krebs-Smith et al, 2010; Guenther et al, 2006; Lorson et al, 2009). Again, the Scientific Report of the 2015 Dietary Guidelines Advisory Committee, which was the most recent systematic review of food and nutrient intakes of the American population, found that few children are consuming enough fruits and vegetables (DGAC, 2015). On average, children 4-8 years of age are consuming 0.8 cup equivalents of vegetables and 1.2 cup equivalents of fruit. Among children 9-13 years of age, the mean consumption of vegetables and fruit, respectively, is 1.0 and 1.1 cup equivalents (ibid.).

There is also evidence suggesting that as children age, consumption of fruits and vegetables decreases. The Scientific Report of the 2015 Dietary Guidelines Advisory Committee found that children aged 14-18y are, on average, consuming less than 43% of the recommended amounts of vegetables and less than 50% of the recommended fruits. Rasmussen et al (2006) conducted a systematic review of research on determinants of children’s fruit and vegetable consumption and found that age was examined in 22 research articles, with 10 of these observing an inverse association and 9 observing no effect. Lytle et al (2000) found that fruit and vegetable consumption decreased substantially between 3rd and 8th grades. Vegetable consumption is lowest among boys aged 9 to 13 years and girls aged 14 to 18 years, with only 1% consuming the recommended 2 to 2.5 cups per day. The large decreases in fruit and vegetable consumption associated with the transition from childhood to adolescence suggest that efforts to increase consumption are best targeted toward early and middle childhood to prevent the decline that is associated with age.

Further, according to the 2015-2020 Dietary Guidelines for Americans, consumption of fruits and vegetables should be stratified by certain subgroups (e.g., leafy green, red/orange, etc.) to support dietary variation and meet nutrient requirements. However, only 0.2% of school-aged children met the recommendations for dark-green vegetables and 1.2% for orange vegetables (DGAC, 2015). In addition, the leading source of total fruit for most children was 100% fruit juice (Wang et al, 2008) and the average
intake of white potatoes is 1.0 serving per day, which is of concern given that the way children usually consume these items are in highly processed forms, such as French fries or chips. Programs that are designed to increase fruit and vegetable consumption should therefore target the under-consumed subgroups, including dark-green and orange vegetables, and decrease the proportion of fruits and vegetables consumed as juice and potatoes. The recommendation from the 2015-2020 Dietary Guidelines for Americans to stratify fruit and vegetable consumption according to subtypes is used to inform guidelines for service of school meals to students according to the National School Lunch Program (further described in the forthcoming sections).

There is also concern about disparities in the consumption of fruit and vegetables evident across racial/ethnic groups and economic status (Di Noia & Byrd-Bredbenner, 2014). Mexican American children (2-18y) are less likely than non-Hispanic whites to meet recommendations for fruit consumption (OR: 0.66; 95% CI: 0.54, 0.81). Using the most recent NHANES data from 2011-2012, Haughton et al (2016) found that 0.5% of non-Hispanic black children consumed >5 fruits and vegetables per day, compared to 1.8% of white, 6.0% of Hispanic, and 10% of Asian children (P=0.04). Children who reside in households <130% of the federal poverty level are also markedly less likely to meet both fruit and vegetable consumption recommendations (Lorson et al, 2009). Given the low proportion of children meeting current recommendations for fruit and vegetable consumption and the important health benefits they provide, in addition to the documented disparity across socioeconomic groups, there is a need to develop programs and create supportive environments that encourage increased consumption among all U.S. children.

1.2.4. School-based strategies to promote fruit and vegetable consumption in childhood

School-based interventions to promote healthy dietary patterns among children are growing increasingly common in the U.S. Although they are now frequently discussed and implemented, they are not new; as early as 1922, a Department of Interior publication, “Diet for the School Child,” provides a rationale for the importance of encouraging proper dietary patterns among schoolchildren and discusses several strategies that can be used, including providing plenty of time for meals, encouraging consistency in meal times, and teaching children to like new, healthy foods.

Today, expert groups espouse the use of the school as a setting for public health interventions
designed to improve dietary behaviors. It is the Position of the American Dietetic Association, the School Nutrition Association, and the Society for Nutrition Education that schools provide coordinated school health policies and programs to improve the nutritional status, health and academic performance among children in the U.S. (Briggs et al, 2010). A 2012 report by the Institute of Medicine (IOM), *Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation*, identifies schools as a priority setting for interventions to promote healthy dietary patterns for several reasons. First, children spend most their time in schools and they offer an opportunity to reach many children at once, potentially mitigating health disparities across communities. Second, children and adolescents may consume up to half of their daily calories in school, and thus changes to the quality of the meals offered here might have a large influence on overall diet (Briefel et al, 2009). Third, the school food environment acts as a signal to children, as well as their parents, about what constitutes a healthful and normative diet (Wechsler et al, 2000).

However, using schools as a setting to increase fruit and vegetable consumption among children is not without its challenges, given that schools are often faced with competing demands for their time and resources. Recently, schools have faced increasing pressure to improve academic performance among their students. Concurrently, there has been an expansion of the public health literature describing schools as the setting of interventions for improving health and wellbeing. Administrators, teachers, and school stakeholders may view the increasing emphasis on public health goals as a distraction to the goal of improving academic achievement (Berezowitz et al, 2015). For schools to continue to be successful in the goals of improving academic achievement and diet and public health simultaneously, future research should examine potential synergies in interventions delivered in the school setting (Berezowitz et al, 2015; Basch, 2011).

Despite these challenges, schools offer an opportunity to target several determinants of eating behaviors, across multiple layers of influence. Strategies to promote fruit and vegetable consumption among children in schools may act on one or more determinants of eating behaviors, spanning individual, social and environmental domains (Contento, 2016). While there is a growing literature examining factors that influence children’s consumption of fruits and vegetables, a majority of studies have focused on individual sociodemographic characteristics, such as race, ethnicity or participation in federal income assistance programs. In schools, many individual factors (such as race and ethnicity) are fixed and thus
not amenable to intervention, making alternative approaches, such as promoting nutrition education curricula, promoting wellness policies, restructuring the choice environment (e.g., behavioral economics approaches), and promoting healthy-eating design and architecture of the school lunch cafeteria more important avenues for intervention (Price and Just, 2013; Huang et al, 2013; Frerichs et al, 2015).

School-based behavioral interventions focused on children have been modestly effective in increasing overall daily fruit and vegetable consumption, although the components included in these interventions are highly varied, including classroom based motivational and educational strategies, fruit and vegetable distribution schemes, and school social marketing programs. The systematic review by Knai et al (2006) found that of 15 studies focusing on children, 10 studies produced significant increases in daily fruit and vegetable consumption, ranging from 1/3 to 1 cup. In a more recent review focusing on studies published from 2005-2011, Thompson & Ravia (2011) found that the average change in fruit and vegetable consumption in the intervention groups was +0.39 servings/day above control conditions. A comprehensive meta-analysis was conducted by Evans et al (2012), which included 21 studies conducted with children aged 5 to 12 years of age between 1985 to 2009. The authors found an average increase in consumption of fruit and vegetable 0.25 portions daily (95% CI: 0.06, 0.43 portions) among students participating in an intervention that included nutrition education, communications, food provision, and/or social marketing components. Although the authors cautioned that many studies included in the meta-analysis had a weaker study design that did not utilize randomization, they concluded that multicomponent programs (e.g., those with both environmental and education strategies combined) tended to result in larger increases in fruit and vegetable consumption. An additional systematic review focused on nutrition education approaches, though not specific to fruit and vegetable consumption outcomes or elementary students in school-settings, found that the following factors were associated with greater efficacy in interventions: longer duration of the intervention, having few focused objectives, appropriate use of theories, fidelity in interventions, and support from policy makers and management for the environmental interventions (Murimi et al, 2017).

There are other potential aspects of the design of interventions which potentially contribute to increased effectiveness in promoting fruit and vegetable consumption and related outcomes of interest among schoolchildren. In a systematic review and meta-analysis, Diep et al (2014) found that theory-
based interventions may be overall slightly more efficacious than those that are not theory-based. Although fruit and vegetable consumption is the most studied outcome of school-based interventions, there is also the potential for school-based interventions to have synergistic effects with other outcomes. For example, changes to the school food environment may also contribute to positive academic achievement outcomes among students. An intervention study by Golley et al (2010) found that a multi-component program with changes to the school food service and dining room atmosphere resulted in an increase in levels of alertness (e.g. concentration and engagement) among students in the hour after lunch. This finding echoes a broader body of literature that, although observational, suggests a link between diet and academic achievement (Haapala et al, 2016; Basch, 2011).

1.2.5. The U.S. National School Lunch Program (NSLP)

The NSLP is a food assistance program which aims to increase access to food among children that, because of its reach, may be one of the largest determinants of dietary quality among children in the U.S. In 2015, over 30 million school lunches were served via the NSLP on an average day. The purpose of the NSLP, as summarized in the 1946 enabling legislation, is “to safeguard the health and well-being of the Nation’s children and to encourage the domestic consumption of nutritious agricultural commodities and other food” (National School Lunch Act, P.L. 79-396, Stat. 281 [June 4, 1946]: §2). Today, the program provides free lunch to any child in a participating school whose families earn an income that is less than 130% of the national poverty level and reduced price lunch for students who families earn between 130-185% of the national poverty level. (In 2015, the U.S. Census Bureau set the federal poverty level at $24,257 for a family of four).

Although estimates vary, the 2005 School Nutrition and Dietary Assessment (SNDA) study, using 24-hour recalls from a nationally representative sample of students, found school lunches provide up to 47% of the daily calories to the diet of participating and up to 63% of the total fruits and vegetables (Briefel et al, 2009). The proportion of calories and fruit and vegetables consumed at school is higher among low-income students and students from families that are struggling with food insecurity (ibid.). Furthermore, there is evidence that suggests participating in the program protects against food insufficiency. Huang et al (2015), in a nationally representative sample of families, showed that for
households with children participating in the NSLP the food insufficiency rate (term used as defined by study the study authors) was consistent between January and May, but increased in the summer months (June and July) during which no school lunch meals were offered.

School lunches are required to meet certain nutrition standards, namely that they provide one-third of the daily calories, protein, vitamin A, vitamin C, calcium and iron needed by students. The 2010 School Nutrition Dietary Assessment Study found that, on average, 76% of elementary schools served lunches that met the standards for these target nutrients (Fox and Condon, 2012). An additional 16% of schools fell within 10% of the requirements of these nutrients. Almost all schools served school lunch meals that met requirements for protein and calcium and more than 80% met the standards for vitamin A and vitamin C (ibid.).

The Healthy Hunger Free Kids Act of 2010 (HHFKKA) was the most recent reauthorization of the NSLP, which has updated the nutrition standards for the program to align with the dietary patterns recommended by the 2010 Dietary Guidelines for Americans. These regulations were designed to ensure that meals served to students adhere to both nutrient and food group standards. All school lunch meals served to children in grades K-12 via the NSLP meet the following requirements to receive federal reimbursement:

- Offer between 0.75 to 1 cup of vegetables and 0.5 to 1 cup of fruits (children may choose only one or both components to be in compliance).
- Meet weekly requirements for vegetable subtypes, as defined in the 2010 Dietary Guidelines for Americans, including (1) dark green; (2) red/orange; (3) beans/peas (legumes); (4) starchy; (5) other
- All grains served to students must be whole grain rich (at least 50% whole grain)
- Provide 1 cup of milk as either fat-free (flavored or unflavored) or 1% low-fat (unflavored)
- There are additional nutrient based requirements for lunch meals, which vary based on grade, including for calories, sodium, saturated fats and trans fats.

The NSLP is increasingly recognized as an important public health intervention for our nation’s children. The updated nutrition standards have worked to increase the availability of fruits and vegetables offered during lunch in schools across the country and reduce waste (Cullen & Dave, 2016). An analysis
of the 2014 School Health Policies and Practices Survey found that most schools offered two or more vegetables (79.4%) and two or more fruits (78.0%) each day for lunch and nearly one third of schools offered self-serve salad bars during lunch (Merlo et al, 2015). Johnson et al (2016) conducted a longitudinal study in 3 middle schools and 3 high schools in a large, urban US school district in Washington state to examine the nutritional quality of student school lunch food selections before and after implementation of the updated nutrition standards. Using school food production records obtained from school food service directors, the authors found that students chose healthier foods after the implementation of the nutrition standards, from mean adequacy ratio [the mean percent daily value of protein, vitamin C, vitamin A, calcium, fiber and iron per 1000 kcal] of 58.7 (range 49.6 to 63.1) to 75.6 (range 68.7 to 81.8). The authors also found that energy density of the meals selected decreased, and found a negligible effect on overall participation. Terry-McElrath et al (2015) examined longitudinal changes in middle and high schools during 2011-2013 because of the NSLP lunch standards using data from the Youth, Education and Society study. The authors found that fruit and vegetable availability increased significantly at the high school-level (+10% of schools had a daily fruit and vegetable offered from 2011-2013) and the availability of French fries decreased at the middle school-level (+15% of schools had no French fries from 2011-2013). Three studies examined fruit and vegetable consumption on the individual student-level and found that changes to the NSLP were not associated with increased plate waste (Schwartz et al, 2015; Cullen et al, 2015; Cohen et al, 2014). In Chapter 2 of this dissertation, I review these the findings of these studies and others related to the primary outcome fruit and vegetable consumption at school lunch.

However, the evidence is mixed regarding the extent to which participants of the NSLP have a better diet quality than non-participants. Hanson and Olson (2013) observed a higher total vegetable Healthy Eating Index (HEI) score among students participating in in both breakfast and lunch programs than nonparticipants using NHANES dietary recall data (2003–2008) for children aged 6–17 y. Using a sample of 6th grade students from Minnesota, Robinson-O’Brien (2010) found that school meals provided 64% and 51% to boys and girls total daily consumption of fruits and vegetables, respectively. Gleason and Suitor (2003) found that eating a school lunch was associated with a greater intake of a host of vitamins and minerals (for example, vitamin A, vitamin B6, vitamin B12, thiamin, riboflavin, folate, calcium,
magnesium, phosphorus, iron, and zinc) and protein and fat, but a lower intake of added sugars, using data from the 1994–96 Continuing Survey of Food Intakes by Individuals (CSFII). The Third School Nutrition Dietary Assessment Study, a nationally representative study of children in public schools in the U.S., found that the diets of elementary school students participating in the NSLP were not of a higher nutrient quality as compared to the diets of non-participants (Fox et al, 2010). Importantly, none of these studies were conducted in schools implementing the updated food-based guidelines for school meals described in the 2010 Healthy Hunger Free Kids Act.

Several studies have compared the nutritional quality of lunches brought from home and those offered through the NSLP. Home lunch is frequently found to be less healthy than school lunch both in terms of nutrient composition and in meeting food-based dietary recommendations consistent with the 2015 Dietary Guidelines for Americans (Farris et al, 2015, Caruso et al; 2015). Au et al (2015), using 24-hour recall data obtained from students in 43 schools in California, showed that 4th and 5th grade students who participated in the NSLP had greater HEI scores than students who brought lunch from home. Although these studies were conducted prior to changes in the NSLP, it is impossible to draw conclusions about the difference in dietary quality from home lunch as compared to lunches served via the NSLP because none of these studies examined consumption (they only examined the nutritional content of lunch served or brought from home).

Similarly, there is mixed evidence of an association between participation in the NSLP and body weight among children, with two large-scale studies finding that NSLP participation was associated with increased likelihood of obesity (Capogrossi and You, 2016, Millimet et al, 2010), two finding null associations (Paxton et al, 2012; Gleason and Dodd, 2009), and one finding that NSLP participation was associated with decreased likelihood of obesity (Gunderson et al, 2010). Using data from the ECLS-K, a nationally representative longitudinal study of children beginning in the 1998-1999 to the 2006-2007, Capogrossi and You (2016) found mixed evidence for participation in the NSLP across the ages from 1st to 8th grade. A study by Millimet et al (2010), which also used ECLS-K data, found that there was a slight positive association between participation in the NSLP and childhood obesity. Paxton et al (2012) found that participation in the NSLP was not significantly related to BMI among 4th grade students from Georgia. Using the Third SNDA, Gleason and Dodd (2009) showed the participation in the NSLP had no
effect on child BMI. In a study by Gunderson et al (2012), using data from the 2001-2004 NHANES collected from children age 6-17, participation in the NSLP was associated with a reduction in obesity by 3.2 percentage points. There are justifications for this mixed evidence base, which include misspecification of the exposure variable (e.g. difficulty in determining NSLP participation on a given day) and different populations under study. Importantly, participation in the NSLP is not the same as measuring consumption of the school lunch meal, given that students may choose to eat only certain parts of the meal or none. Further, all studies relating participation in the NSLP and body weight were conducted before the updated meal pattern requirements, which preclude conclusions about the healthfulness of the new standards. An additional study by Terry-McElrath (2015) which was conducted post-HHFKA using self-reported data from food service administrators, found that having fruits or vegetables available wherever foods were sold was significantly associated with lower odds of overweight/obesity among high school students, although this did not consider individual student participation in the NSLP. Although there are positive trends toward greater availability of healthful foods, higher dietary quality, and lower rates of overweight and obesity among students who participate in the school lunch program associated with the HHFKA, more research is needed to objectively measure consumption at school lunch meals (as opposed to merely participation) and link these to nutrition and health outcomes.

1.2.6. Challenges to measuring fruit and vegetable consumption during school lunch

Researchers and evaluators conducting studies with the primary outcome of students’ consumption of fruits and/or vegetables provided via the NSLP are faced with a host of methodological design decisions. This dissertation will explore three issues unique to school-based studies measuring fruit and vegetable consumption among elementary-aged students from schools participating in the NSLP: the use of self-report dietary assessment methodologies; statistical considerations for the design and evaluation of cluster-randomized designs; and the potential confounding of primary outcomes via school cafeteria environmental factors that are presently not regulated by the NSLP. Briefly, I elaborate on several challenges to measuring fruit and vegetable consumption at school lunch.

The 2010 reauthorization of the NSLP specified the daily and weekly minimum requirements for
fruit and vegetables offered to students via school lunch. Although there is presumed to be greater consistency in the nutritional content and types of foods offered to students via the NSLP, there are limited empirical data describing compliance to the new meal pattern requirements in the time since the passage of the 2010 Healthy Hunger Free Kids Act. Using data from the 2012-2013 school year, the external evaluation firm Westat estimates that about 76% of school food authorities were then certified to receive the additional 6-cent-per-meal reimbursement, which is allocated to schools that meet the updated nutrition requirements (May et al, 2014). Among school food authorities serving grades K-5, 76.2% reported increasing the servings of fruits and vegetables offered to students since the passage of the HHFKA. Among all school food authorities, a majority reported serving fresh, whole vegetables (53.2%), and fresh, pre-cut vegetables (51.0%) more often. Most school food authorities found it easy to work vegetable subgroups (dark green, red/orange, beans/peas, starchy and other) into menus (all over 52.4% responding positively). However, there are few empirical data examining compliance with the menu requirements on an individual student-level, which is necessary to understand the level of consistency in meals offered to students across schools.

Relatedly, although the federal rulemaking for the HHFKA specified minimum quantities of fruits and vegetables to be served at lunch, there are limited definitions of what constitutes a fruit or a vegetable for the purposes of the NSLP (76 CFR 2493). For example, the rule specifies that fruits can be served as fresh, 100% juice, frozen without sugar, dried, or canned in fruit juice, water, or light syrup. For vegetables, the only requirement is that schools offer, over the course of one week, at lunch at least ½ cup equivalent of each of the following vegetable subgroups: dark green, orange, and legumes (dry beans). Beyond this, the rule does not provide specific definitions for foods or preparations that meet these requirements, leaving individual food service directors to define these for their own purposes. Although there are strengths to this approach in terms of greater autonomy and fewer regulatory hurdles, this creates a challenge for evaluators in comparing across different schools. There is the potential that schools categorize and define fruits and vegetables differently, or even impose stricter standards, such as not serving white potatoes or 100% juice. The lack of more specific policy definitions for fruits and vegetables leaves researchers and evaluators to create their own definition for their study, which at times leads to problems in the design and analysis of data in the context of evaluation studies (Graziose & Ang,
This creates problems for researchers seeking to compare results across studies, but may also introduce confounding effects within individual studies when fruit and vegetable options are not balanced across schools.

The field of nutrition is divided over the use of self-report dietary assessment methodologies (Subar et al, 2015; Dhurandhar et al, 2015). Most agree that self-reported diet assessments are not specific enough to examine individual calorie or nutrient intakes, but instead should be useful for comparing groups on consumption of foods. Therefore, most work examining consumption of fruits and vegetables during school lunch has utilized objective methods, such as weighed plate waste, digital photography or direct observation. Previous research has shown that these methods are expensive and require highly-trained research staff to implement well. For example, Kenney et al (2015) showed that in an afterschool setting, the weighed plate waste method cost on average $0.95/observation, while both digital photography and direct observations cost $0.62/observation. While there are no empirical data on the cost of self-report methods as compared to these objective methods, questionnaires are hypothesized to be lower in cost because of the opportunity to collect many observations in short time and the low cost of the raw materials. In addition, a growing body of research has highlighted methodological factors that may improve the accuracy of self-report methods among children (Sharman et al, 2015). Yet existing research examining the validity of self-report methods has not explored the accuracy of using such instruments among younger children (<3rd grade). Despite the continuing debate over the use of self-report methods, there is a need to improve the validity of self-report instruments that can be used in lieu of labor-intensive objective methods such that they can be used to compare groups in the intakes of fruit and vegetables.

As consumption of fruits and vegetables at school lunch is more commonly studied, and statistical analysis methods become more advanced, the field is converging on appropriate statistical analysis that can increase reliability and reproducibility of results. One issue that has garnered attention is the special data analysis methods required for evaluating cluster-randomized control trials (George et al, 2016). Given that in such designs the unit of requirement is at the cluster-level (e.g., schools), participants who are recruited from the same school are not independent, and may enroll in the study with greater similarity than individuals selected at random (Gray et al, 2015). Delgado-Noguera (2011) conducted a
systematic review of 19 school-based interventions among primary school children and found that most studies did not account for clustering effect. When the analyses were corrected to reflect the clustered nature of the data, the authors concluded that there was insufficient statistical power to detect an intervention effect within most studies. While the growing attention to cluster-randomized designs is not unique to nutrition education research, previous school-based nutrition education intervention studies have been retracted owing to inappropriate statistical analyses, including a large intervention trial called LA Sprouts (Gatto et al, 2015). Acknowledgment of the effect of clustering via specific statistical analysis methods is important, but of equal or greater importance is identifying the factors that contribute to clustering so that they can be accounted for early in the design of school-based studies examining fruit and vegetable consumption.

There is also a growing evidence base examining environmental factors that may influence students’ consumption of fruit and vegetables at school lunch. These factors may have multiple implications in the context of evaluation research. These factors may contribute to confounding effects across different schools, although this issue has not been critically evaluated or fully explored in the current literature. The factors that have been examined include: the order of recess relative to lunch, the time allocated to eating lunch and aspects of the items or meals served to students. The majority of these studies have examined these environmental factors in isolation (Gorman et al., 2007); therefore, there is little understanding of the potential interactions among these factors or an identification of the most salient factors. Improving our understanding of these environmental factors is important because, as previous obesity-prevention research has shown, differential exposure to these environmental factors in the context of a cluster-randomized controlled trial can moderate the effect of an intervention on primary outcomes of interest. For example, within the context of previous behavioral nutrition and physical activity cluster-randomized trials among adults and children, access to parks (Grazioso et al, 2015), walkability of the neighborhoods (Kerr et al, 2010; Grazioso et al, 2015) and access to food retail outlets such as supermarkets or mobile fruit vendors (Fiechtner et al, 2016; Feathers et al, 2015) were identified as environmental factors that could moderate the effect of an intervention on primary intervention outcomes. Although these studies are exploratory, they suggest that effect modifiers, if not measured and controlled for early in the design of the intervention could potentially contribute to a form of selection bias, whereby
groups are systematically different in baseline characteristics that are theoretically related to the outcome (Higgans & Green, 2011). Therefore, in the school lunch context, there is a need for additional research to identify and categorize potential effect modifiers to prevent confounding and bias in future cluster randomized controlled trials.

1.3. RATIONALE

There is a documented shortfall in fruit and vegetable consumption among children in the United States, as well as a recent expansion of the scientific literature examining school-based interventions to improve fruit and vegetable consumption during school lunch. There has, however, been little critical assessment of the literature examining children’s fruit and vegetable consumption at school lunch in terms of diet assessment methodology, sample size/selection, and research design. This dissertation is structured to fill three key research gaps and inform future interventions for promoting fruit and vegetable consumption during the school lunch meal.

1.4. PURPOSE

The purpose of this dissertation is to develop an evaluation framework for measuring consumption of fruits and vegetables among elementary students from schools participating in the NSLP. Three empirical studies measuring fruit and vegetable consumption will be presented, in addition to a purposeful systematic mapping review of the literature, to inform the development of a conceptual evaluation framework for cluster-randomized studies measuring fruit and vegetable consumption among elementary students in schools participating in the NSLP. It is believed that a conceptual evaluation framework would be of use during the design phase of future cluster-randomized controlled trials aimed at increasing fruit and vegetable consumption.
1.5. RESEARCH QUESTIONS

**Research Question 1:** What is the validity of a group-administered, self-report instrument to measure 2nd and 3rd grade students’ consumption of fruits and vegetables at school lunch?

**Research Question 2:** What are the observed intra-class correlation coefficients of 2nd and 3rd grade students’ consumption of fruits and vegetables at school lunch?

**Research Question 3:** What is the association between the following environmental factors and 2nd and 3rd grade students’ consumption of fruits and vegetables at school lunch: recess before lunch, time allocated for eating lunch, number of fruit and vegetable items offered, presence of a self-serve salad bar, and the cafeteria noise level?

1.6. STUDY CONTEXT

The main study from which the empirical data for this dissertation is derived is an evaluation of the FoodCorps, Inc. (hereafter, FoodCorps) program. FoodCorps is a multi-component, holistic farm to school program based in the United States. FoodCorps uses a public service model in which AmeriCorps service members receive a living stipend and spend one year working within a school system and the wider community (Ellis et al, 2013). FoodCorps’ goal is to ensure that children know what healthy food is, care where it comes from, and have access to it every day. To meet this goal, FoodCorps identifies a lead partner (state host site) that works to coordinate efforts in each state. Within each state, community organizations (service sites) such as local non-profit organizations, university extension programs, or schools/school districts support and oversee the work of one or more service members. In 2014-2015, FoodCorps had over 180 service members working in over 140 communities and more than 400 schools in 17 states across the country.

In August 2014, the Laurie M. Tisch Center for Food, Education & Policy (hereafter, Tisch Food Center) within the Department of Health and Behavior Studies, Program in Nutrition of Teachers College Columbia University responded to a request for proposals from FoodCorps. The purpose of this call for proposals was to identify an external evaluator to assess FoodCorps impact related to several key
outcomes of the program. Specifically, FoodCorps sought proposals to: (1) revise an existing farm to school-focused school food environment assessment and implementation rubric (the Landscape Assessment Tool); and (2) assess the influence our school-based programming (from classes to school-wide environmental changes) has on children’s consumption of healthy foods during school meals. The Tisch Food Center was awarded the contract after a competitive review of proposals; this dissertation will use empirical data describing 2nd and 3rd grade students’ consumption of school lunch meal components collected during this evaluation. This evaluation is fully detailed and described in Koch et al (2017). The Institutional Review Boards of Teachers College Columbia University, the New York City Department of Education, the District of Columbia Department of Education and Newark Public Schools provided ethical approval for this study.

1.7. SIGNIFICANCE

Broadly, this dissertation is focused on informing future school-based interventions for improving fruit and vegetable consumption among students in public elementary schools participating in the NSLP. This dissertation will have implications for researchers and practitioners interested in evaluating the effects of future programs designed to increase fruit and vegetable consumption in a school lunch context. Researchers who are evaluating such interventions are often faced with considerable constraints on sample sizes, dietary assessment methodologies, and research designs in the process of scientific inquiry. The systematic mapping review, presented in Chapter 2, will serve as a resource for researchers interested in learning more about the research designs, diet assessment methodologies and sample sizes from previous school-based research examining students’ fruit and vegetable consumption.

Understanding the strengths and limitations of dietary assessment methodologies is imperative for the evaluation of school-based programs designed to improve fruit and vegetable consumption, and the use of accurate, self-report methods would contribute to considerable cost-savings in lieu of labor intensive observational methods. The development and validation of a self-report questionnaire instrument for use among 2nd and 3rd grade students, as described in Chapter 3, provides a novel instrument for researchers and practitioners who seek to evaluate their interventions with self-report
instruments instead of costly objective methods such as digital photography or direct observations.

The reliance on cluster-randomized designs for evaluating school-based interventions to improve fruit and vegetable consumption at school lunch may result in severely underpowered trials, given the high degree of clustering that is potentially present in outcomes of interest between schools. Estimates of the observed clustering in fruit and vegetable consumption between schools would allow researchers to perform *a priori* power calculations that appropriately justify the necessary sample sizes. The intra-class correlation coefficients, presented in Chapter 4, for several indicators of fruit and vegetable consumption during the school lunch meal can be used by researchers who are conducting power calculations to decide on the appropriate sample sizes for future multi-state evaluation studies.

There is growing, albeit at times mixed, evidence describing environmental factors that may influence students’ consumption of foods during lunch, which, when unobserved and unaccounted for in research designs, may contribute to confounding or moderating effects on primary outcomes of interest. Because several of these factors are currently not regulated by the NSLP and/or other relevant federal policies, they may vary across schools. The cross-sectional associations between environmental factors and students’ consumption of fruits and vegetables, presented in Chapter 5, will help generate hypotheses for understanding potential confounding variables in future cluster-randomized controlled trials that are designed to alter environmental factors to increase fruit and vegetable consumption. Furthermore, the identification of factors related to consumption may provide rationale for future interventions or regulations.

### 1.8. SCOPE AND DELIMITATIONS

This dissertation will take the form of three research articles, each examining a separate research question informed by a systematic mapping review of the literature designed to identify priority areas of future research and to strengthen the design of studies examining consumption of fruits and vegetables at school lunch among elementary students. As aforementioned, the schools participating in this study are recruited from the larger sample of FoodCorps schools. Given that these schools already participating in the FoodCorps program, a multi-state farm to school program, it is perhaps likely that these schools are
different from the population of U.S. elementary schools in that they have already significant interest in farm-to-school related programming and have external capacity and technical support to implement such programming. In addition, all the schools in this study participated in the NSLP at the time of data collection and thus the foods served during lunch must meet several nutritional requirements to meet eligibility criteria for federal reimbursement. Therefore, these studies are conducted within the assumption that the foods served to students as part of school lunch align with guidelines from the NSLP.

1.9. DEFINITION OF TERMS

ENVIRONMENT: Everything outside the person, in contrast with individual or personal variables (Story et al, 2008).

INTRACLASS CORRELATION COEFFICIENT: The proportion of total variation that belongs to the group, wherein the group refers to clusters of individuals (e.g., schools, hospitals, classrooms, neighborhoods) (Snijders & Bosker, 2012).

FOODCORPS: FoodCorps is a multi-component, holistic farm to school program based in the United States. FoodCorps uses a public service model in which service members receive a living stipend and spend one year working within a school system and the wider community (Ellis et al, 2013).

FOODCORPS SERVICE MEMBERS: Service members are hired through the AmeriCorps national service program and lead FoodCorps program activities in schools across the U.S.

NATIONAL SCHOOL LUNCH PROGRAM (NSLP): The National School Lunch Program is a federal meal assistance program, authorized through the National School Lunch Act of 1946, which provides low or no cost meals to students in schools who qualify based on income.

OFFER VS. SERVE PROVISION: This concept applies to the National School Lunch Program, and allows students to decline some of the components of the reimbursable school lunch meal. Students may decline some of the school lunch meal components (e.g. fruit, vegetables, grains, protein or milk), but they must select at least one fruit or one vegetable in order for the lunch to qualify as reimbursable. The offer versus serves provision is described within the federal register at 7 CFR 210.10.

SOUND PRESSURE LEVEL: The sound pressure level is used to describe the pressure of a
sound relative to an internationally agreed reference value (20 μPa or the believed threshold of human hearing). The decibel scale is a logarithmic scale designed to reflect the changes in sound level pressure relative to this reference value and such that changes in the scale reflect a subjective response to the sound. The decibel scale can be weighted to reflect the different frequencies at which sound pressure can occur where every 10-dB increase in noise is subjectively perceived as a doubling in loudness. Db(A) is one such weighting scheme whereby sounds occurring at 1000Hz are the referent. Given that sound often fluctuates over time, it can be averaged over a given time (Leq) (Basner et al, 2014).

**SOUND LEVEL METER:** An instrumented use to measure sound pressure levels (Types 0 [laboratory reference standard] through 3 [field noise survey applications]) (Berglund et al, 1999).

### 1.10. LIST OF ABBREVIATIONS

- **CS** = Cross sectional
- **C-RCT** = Cluster-randomized controlled trial
- **DGAC** = Dietary Guidelines Advisory Committee
- **EAR** = Estimate average requirement
- **FVRQ** = Fruit and Vegetable Recall Questionnaire
- **HHFKA** = Healthy Hunger-Free Kids Act of 2010
- **ICC** = Intraclass correlation coefficient
- **IRR** = Interrater reliability
- **NSLP** = National School Lunch Program
- **NR** = Not reported
- **N/A** = Not applicable
- **OVS** = Offer versus serve provision
- **QE** = Quasi experimental
CHAPTER 2: SYSTEMATIC MAPPING REVIEW OF STUDIES ASSESSING ELEMENTARY STUDENTS CONSUMPTION OF FRUITS AND VEGETABLES AT SCHOOL LUNCH

2.1 METHODS

Overview of the systematic mapping review

A systematic mapping review, as defined by Grant and Booth (2009), is designed to map and categorize all existing literature on a topic to identify areas for further primary research and/or to commission future targeted systematic reviews. A systematic mapping review, when presented in an explicit and transparent way, is an ideal method for answering policy- and practice-related research questions. They are dissimilar from traditional systematic reviews or meta-analyses in that they do not employ a formal appraisal of the quality of included studies and that they may use an existing theoretical framework to categorize studies in a way meaningful for a field of practice. Examples of previous systematic mapping reviews include the study by Osei-Kwasi et al (2016), in which the authors mapped the range of factors influencing the dietary behaviors of minority groups living in Europe, and the study by O’Cathain et al (2013), in which the authors conducted a systematic search to identify how qualitative research was used to understand certain aspects of randomized-controlled trials.

This aim of this systematic mapping review was to identify existing literature that quantitatively measured the consumption of fruits and vegetables during the school lunch meal among elementary school students residing in the U.S. All designs were considered for inclusion in the aim of identifying and mapping the extent of research in this context. For this review, studies focusing on students above 5th grade were excluded, given that these students may have the ability to leave cafeterias in accordance with open campus policies and have more autonomy in decision making for foods because they have greater access to a la carte foods, vending machines and other foods that potentially compete with the NSLP (Fox and Condon, 2012). In addition, given the extensive policy changes that have dictated the nutrient and food group content of school lunch, the search was limited to articles describing work since 2004, to align with the passage of the last two child nutrition reauthorization laws, the Child Nutrition and Women, Infants and Children Reauthorization Act of 2004 and the subsequent Healthy, Hunger-Free Kids
Act of 2010. Studies published in 2004 were considered for this review even if they reported on interventions conducted prior to 2004 to capture any schools that may have implemented menu changes early to comply with the forthcoming federal regulations and/or used as a comparator for the effects of the implemented changes.

The PICO-C framework was used to guide the mapping review: the study Population (elementary students in grades K-5th within schools in the United States), Intervention (all intervention types were considered and described in this review), Comparator (comparisons may include pre vs. post, control vs. intervention and/or exposed vs. unexposed groups), Outcome (fruit and vegetable consumption at the school lunch meal), and Context (the lunch setting among schools participating in the NSLP).

Search strategy

Searches were conducted within PubMed, ProQuest, Embase, ERIC and PsycINFO databases to identify records describing studies of the consumption of school lunch meal components in the United States. Searches were performed in January 2017 using the following terms: school and lunch and diet or consumption or intake or nutrition and elementary. (The full search strategy is included in Appendix A). In addition, hand searches of the references lists were performed of previously identified reviews (Chriqui et al, 2014; Kessler, 2016; Driessen et al, 2014; Welker et al, 2016) and all records that received a full-text review in this study.

Study screening and eligibility

Studies that satisfied the following criteria were eligible for inclusion: (i) conducted within schools in the United States; (ii) examined elementary school students (those enrolled in grades 1st through 5th); (iii) published in English between 2004-present and (iv) examined quantitatively the consumption of fruit and/or vegetables during the school lunch meal on a specific day (e.g. not a food frequency questionnaire). Studies that only examined as the primary outcome the purchase or selection of school lunch meal components or participation in the NSLP were excluded. Conference abstracts or records from the gray literature were considered for this review.
**Abstraction of studies**

Identified records were exported into EndNote, version X5 (Thomson Reuters, Philadelphia, PA, 2011) and duplicates were removed. The lead investigator (MMG) reviewed the titles and abstracts of all records. After removing records that did not meet the inclusion criteria, the full text of the remaining articles was reviewed against the eligibility criteria.

**Data extraction**

The following data was extracted from each article: setting, study design, sample size (students and schools), the intra-cluster correlation coefficient observed in outcomes of interest, type of dietary assessment methodology used, the factor or intervention examined, school lunch menus on days of data collection, data analysis methods, results, limitations, conclusions and funding source. All supplementary data and referenced publications from the same study were considered. Given that the aim of this review was to map the existing literature, there was no formal appraisal of the quality of included studies.

### 2.2 RESULTS

**Search overview**

The search strategy and flow is described in Figure 2.1. A total of 3,859 records were identified from the database searches. Of these records, 3,535 were retained for screening after duplicates were removed. Through screening, 3,351 records were excluded based on title and the abstracts of 184 records were reviewed. After excluding 94 based on the abstract, the full texts of the remaining 90 records were reviewed for eligibility. An additional 9 records were identified from the hand searches of recent reviews and articles considered for this review. Records that did not meet inclusion criteria (n=38) were then excluded, leaving a total of 61 records for review. During the search, records were categorized as either methodological validation studies (n=10) or as studies of factors related to students’ consumption of fruits and vegetables (n=51) and are reviewed separately in the forthcoming sections.

**Figure 2.1. Flow diagram for systematic mapping review of studies examining consumption of**
school lunch meal components among elementary students, 2004-2016

Records identified in database searches
- Proquest (n = 2,120)
- Embase (n = 1,675)
- PsychINFO (n = 369)
- PubMed (n = 151)
- ERIC (n = 407)

Records after duplicates removed (n = 3,535)

Title screened (n = 3,535)
Excluded on the basis of title (n = 3,351)

Abstract screened (n = 184)
Excluded on the basis of abstract (n = 94)

Included from hand-search (n = 9)

Full text review for eligibility (n = 99)

Excluded (n = 38)
- Non-F/V consumption (n = 18)
- Measures daily or weekly F/V consumption (n = 11)
- Review (n = 3)
- Aggregate school-level (n = 3)
- Non-U.S. context (n = 2)
- Duplicate (n = 1)

Included in review (n = 61)
2.2.1. Methods to measure fruit and vegetable consumption at school lunch

Several methods have been validated for measuring fruit and vegetable consumption during school lunch among elementary-age students (Table 2.1). While there are important technical differences in the implementation of each method, these can be broadly categorized into methods relying on: digital photography, direct observation, weighing, and self-report (e.g., 24-hour recalls and questionnaires).

Digital photography

Digital photography appears reliable and valid for use in measuring fruits and vegetables at school lunch. Generally, the digital photography method involves the use of a digital camera to take photographs of students’ lunch trays prior to eating and again after finishing the meal; by visually comparing the two photographs, researchers can reasonably assess what has been eaten. Swanson (2008) showed that the digital photography method was reliable among two independent raters for assessing all items consumed at school lunch among a sample of K to 5th grade students in one Kentucky school (92% agreement). While the indicators of reliability for fruit and vegetables items alone were not disaggregated from the remainder of the school lunch components offered to students, Swanson (2008) notes that 29% of apples and 24% of oranges had gone missing in the “after-meal” photographs, suggesting that students had traded or discard these meal components during the meal or are taking them out of the cafeteria for consumption later. Taylor et al (2014) conducted a validation study of the digital photography method against weighted plate waste (discussed below) and again found the method reliable (96% agreement) and accurate (correlations >0.90 as compared to criterion). Taylor et al (2014) also demonstrated that digital photography plus direct observation results in an improvement over digital photography alone, presumably in identifying the location of missing items that have been traded, discarded, or saved for later. Hanks et al (2014) examined the use of digital photographs relative to weighed plate waste, finding the method was reliable among two independent raters (r=0.53) and valid relative to weighed plated waste [correlations for fruit (r=0.55-0.87) and vegetables (r=0.72-0.90)].

Weighed plate waste
The weighed plate waste method relies on the use of a scale to weigh the quantity of foods served at the beginning of the meal and the leftovers foods at the end of the meal to determine what each student has eaten. There are important variations in the use of this method in order to save time or labor. One variation involves averaging the weights of a select number of trays or portions of food at the beginning of the meal that are likely representative of all those served (generally, 5 to 10 samples) during a meal service and then weighing all students remaining portions after the meal. Alternatively, researchers may employ an aggregate plate waste method, whereby all students’ leftover foods are combined into one bin and weighed together; the total waste can then be divided by the number of students in the cafeteria to determine an average consumption weight. Weighed plate waste is used a criterion method in the validation studies conducted by Hanks et al (2013) and Taylor et al (2014) showing moderate relative accuracy with both the direct observation and digital photography methods.

Direct observation

Direct observation is a method that has been widely used in the study of the consumption of school lunch meal components. Hanks et al (2014) described the use of a “waste method” in which observers visually denote the amount of food remaining on the school lunch tray immediately prior to it being discarded. The researchers have compared the use of a “quarter waste method”, in which remaining food is rated in increments ranging from 0, 0.25, 0.5, 0.75 to 1, to the “half waste method”, in which remaining food is rated in increments ranging from none, some, or all a food item is wasted. Both methods showed good reliability (r=0.90 and r=0.83 for quarter and half waste, respectively), however, the validity as compared to weighed plate waste was considerably higher for the quarter waste [Fruit (r=0.74-0.91), Vegetables (r=0.76-0.88)] than the half-waste method [Fruit (r=0.53 – 0.91), Vegetables (r=0.72-0.93)]. Direct observations are also used as the criterion method in the studies by Paxton et al (2011) and Baxter et al (2015) (described below).

Self-report methods

Self-report questionnaire methods have been validated for use in measuring school lunch consumption among children in three studies. Wallen et al (2011) validated an adapted version of the Day
in the Life Questionnaire among 4th grade students in Colorado relative to weighed plate waste. The percent agreement for items on tray was 87% for fruit and 88% for vegetables, and the percent agreement for the amount eaten was 58% for fruit and 47% for vegetables. Paxton et al (2011) validated the School Lunch Recall Questionnaire among 3rd to 5th grade students relative to direct observation. Although the accuracy was not disaggregated for fruit and vegetable items separately, the percent agreement for all items was 84%, with total inaccuracy in servings on average 0.63 (0.05). Economos et al (2008), in a study of 75 students in Massachusetts, validated a fruit and vegetable questionnaire relative to direct observation. The questionnaire was reliable in test-retest (percent agreement ranging from 93-96%) and valid for identifying specific fruits and vegetables consumed (ranging from 61-78% agreement).

Self-report 24-hour recalls have also been used among elementary school-aged children to measuring fruit and vegetable consumption at school lunch. Harrington et al (2009) used data from an ongoing cluster-randomized controlled design (“Hi5+”) to assess differential self-reporting in 24 hour recalls as a function of group assignment using direct observations as the referent method. Using a sample of 396 fourth grade students completed a 24-hour recall and were observed by trained researchers, Harrington et al (2009) found no differences in total reported fruit and vegetable consumption by intervention arm. Overall, percent agreement was 54.4% fruit consumption and 40.4% for vegetable consumption. The authors noted several factors that were related to reporting accuracy, including higher BMI, increased fruit availability at lunch, and free/reduced price lunch eligibility for reporting fruits and availability of vegetables for reporting vegetables. Baxter et al (2009) conducted a series of studies examining 24-hour recall retention interval, the time since eating and reporting, accuracy as compared to direct observation. Fourth grade children were randomized to different retention interval conditions: prior 24 hours [24 hours immediately preceding the interview]; previous day [midnight to midnight of the day before the interview]) crossed with three interview times (morning; afternoon; evening). Across all conditions, the correspondence rate (match between observed energy consumed and reported energy consumed) for the lunch meal was highest when the retention interval was the shortest and when recalls were conducted in the afternoon directly after the lunch meal. Using a similar protocol and data from the same set of studies, Baxter et al (2010) compared whether the act of
observing students influenced their reported school lunch consumption. The authors observed no effect of observation status on reported number of items or calories consumed during the meal (p>0.083), leading to the conclusion that school-meal observations did not influence children’s 24-hour dietary recalls. The study by Baxter et al (2015) used a similar protocol to analyze the effect of prompts on children’s reporting accuracy in 24-hour recalls relative to direct observations with four types of prompt [forward (distant-to-recent), meal-name (breakfast, etc.), open (no instructions), and reverse (recent-to-distant)] crossed with two types of retention intervals (long or short). The agreement rate was higher when the retention interval was short (replicating the finding from Baxter et al [2009]). There was no effect of type of prompt on accuracy for short reporting intervals, but, for the long reporting interval, there was significant effect of reverse order prompts on children’s recall accuracy leading to increased accuracy when reverse order prompts were used.

Table 2.1. Summary of methodological validation studies for the measurement of fruits and vegetables at school lunch included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Method(s)</th>
<th>Criterion</th>
<th>Results -- Reliability</th>
<th>Results -- Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economos et al., 2008</td>
<td>75 students NR NR MA</td>
<td>Fruit and Vegetable Questionnaire</td>
<td>Direct observation</td>
<td>Test-retest of the questionnaire for specific fruit and vegetable items ranged from 93-96%</td>
<td>Validity of the questionnaire for specific fruit and vegetable items ranged from 61-78% agreement</td>
</tr>
<tr>
<td>Swanson, 2008</td>
<td>859 trays 1st - 5th grades 1 school KY</td>
<td>Digital photography</td>
<td>---</td>
<td>92% agreement between two independent raters for all items</td>
<td>--</td>
</tr>
<tr>
<td>Taylor et al., 2014</td>
<td>276 trays K - 6th grades 2 schools VT</td>
<td>Digital photography alone, Digital photography with direct observation</td>
<td>Weighed plate waste</td>
<td>96% agreement between two independent raters for all items using digital photography alone</td>
<td>Correlation with plate waste: Digital photography alone: Fruits (0.95) Vegetables (0.91) Digital photography with direct observation: Fruits (0.97) Vegetables (0.95)</td>
</tr>
</tbody>
</table>
| Hanks et al., 2014 | 197 trays K - 5th grades 1 school | Direct observation, Digital photography | Weighed plate waste | Correlation among two raters: Quarter waste (0.90), Half waste (0.83), | Correlation with plate waste: Half-waste: Fruit (0.53 – 0.91), Vegetables (0.72-
2.2.2. Factors related to consumption of fruits and vegetables at school lunch

**Research design, sample size and diet assessment methodology**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Sample Size</th>
<th>Grade(s)</th>
<th>Schools</th>
<th>Methodology</th>
<th>Waste Measurement</th>
<th>Correspondence and Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wallen et al., 2011</td>
<td>125 students</td>
<td>4th grade</td>
<td>2 schools</td>
<td>Colorado Day in the Life Questionnaire - Weighed plate waste</td>
<td>---</td>
<td>Items on Tray: Match rate 87% for fruit, 88% for vegetables</td>
</tr>
<tr>
<td>Paxton et al., 2011</td>
<td>37 sets</td>
<td>3rd - 5th grades</td>
<td>1 school</td>
<td>School Lunch Recall Questionnaire - Direct observation</td>
<td>---</td>
<td>For all items: Match rate 84%, Intrusion 10%, Omission 6%</td>
</tr>
<tr>
<td>Harrington et al., 2009</td>
<td>396 students</td>
<td>4th grade</td>
<td>33 schools</td>
<td>24 hour recall - Direct observation</td>
<td>---</td>
<td>Portion consumed: Fruit 54.4% agreement, Vegetables 40.4% agreement</td>
</tr>
<tr>
<td>Baxter et al., 2009</td>
<td>293 students</td>
<td>4th grade</td>
<td>17 schools</td>
<td>24 hour recall - Direct observation</td>
<td>---</td>
<td>Correspondence rates were higher for prior-24-hour recalls in the afternoon than previous-day recalls in the afternoon and evening (p &lt;0.0018)</td>
</tr>
<tr>
<td>Baxter et al., 2009</td>
<td>555 students</td>
<td>4th grade</td>
<td>17 schools</td>
<td>24 hour recall</td>
<td>---</td>
<td>Number of meal components (3.7[1.9] vs. 3.8[1.9]) and number of kilocalories (574 [341] vs. 583 [360]) reported consumed not differ between students observed and unobserved</td>
</tr>
<tr>
<td>Baxter et al., 2015</td>
<td>480 students</td>
<td>4th grade</td>
<td>10 schools</td>
<td>24 hour recall - Direct observation</td>
<td>---</td>
<td>Energy correspondence rate was higher among with a short retention interval as compared to long (P&lt;0.001). For those with a short retention interval, there was no difference in the type of prompt used.</td>
</tr>
</tbody>
</table>

**Abbreviations:** NR = not reported
Fifty-one studies that directly measured students’ fruit and/or vegetable consumption at school lunch were included in this review, which are summarized in Table 2.2 through Table 2.6. Of these, 24 studies used a quasi-experimental design, 15 used a cross-sectional design, 10 used a cluster-randomized controlled design, and 2 used a prospective cohort design. Studies varied in their sample sizes of schools and students, ranging from 1 school to 42 schools and from 42 student observations to 19,762 student observations. Few of these studies reported an a priori power calculation. Studies were conducted the following states: AL (n=1), CA (n=3), CO (n=1), CT (n=1), KY (n=1), MA (n=3), MI (n=1), MN (n=5), MS (n=1), NY (n=2), OR (n=1), PA (n=4), TX (n=7), UT (n=6), WA (n=4), WI (n=4) or the following regions: Northeast (n=3), Midwest (n=1), or Southeast (n=1).

Studies also varied in their use of dietary assessment methodologies for quantifying students fruit and vegetable consumption at school lunch: 21 studies used a weighed plate waste method, 14 studies used direct observation, 12 studies used a digital photography methodology, and 4 studies utilized a self-report methodology (including 24-hour recalls, food records or questionnaires). Studies that used the weighed plate waste protocol frequently measured a representative sample of trays (modal number of trays measured = 5) at the beginning of the meal to serve as an estimate of potion sizes of fruits and vegetables served. Studies that used direct observation most frequently used the quarter-waste method (Hanks et al, 2013), in which consumption was estimated in increments of 0, 25%, 50%, 75% or 100%.

There were several important variations in the dietary assessment protocols used, including in the amount of days of observation, the analysis method and the outcome of interest. On average, studies collected fruit and vegetable consumption at school lunch on 23 days total across the entire study, with 5 days being the modal duration of data collection. Studies also varied in the outcome of interest obtained from the dietary assessment protocol, which included: fruit and/or vegetable item selected (binary), portion on tray (in cups, g, or servings), fruit and vegetable consumption (in cups, kcal, g, servings or percent of total served). Furthermore, there were important differences in how these outcomes were calculated: among all students sampled or, for consumption variables, among only those who selected them or had them on their tray.

Environmental factors related to the consumption of fruits and vegetables at school lunch
The studies of factors related to students’ consumption of fruit and vegetables are organized according to a socio-ecological framework (Story et al, 2008; Contento et al, 2016): intrapersonal factors, item-specific factors, meal-specific factors, cafeteria environment factors, classroom or school-wide factors and NSLP policy-related factors (Figure 2.2).

Figure 2.2. Socioecological framework of environmental influences on elementary students’
Intrapersonal factors

Few intrapersonal factors have been examined as they relate to consumption of fruits and vegetables at school lunch.
vegetables, potentially due to the difficulty of obtaining potentially sensitive information (e.g. sociodemographic variables, participation in federal assistance programs, etc.) from children of this age group (Table 2.2). Age has been examined as factor influencing consumption of fruit and vegetables at school lunch in five studies (Capps et al, 2016; Bontrager-Yoder et al, 2015; Niaki et al, 2016; Smith & Cunningham-Sabo, 2013; Handforth et al, 2016). All five studies found that consumption of fruit and vegetables increases as students’ age, specifically between students in K to 5th grade (Capps et al, 2016; Niaki et al, 2016), 3rd to 5th grade (Bontrager-Yoder et al, 2015), 1st to 5th grade (Smith & Cunningham-Sabo, 2013) and 1st to 12th grade (Handforth et al, 2016).

Three studies examined how consumption of school lunch relates to the overall diet quality of individuals (Au et al, 2016, Bontrager Yoder et al, 2014; Bergman et al, 2016), although there were differences in how dietary quality was operationalized. Bontrager-Yoder et al (2014) showed, in a cross-sectional study of 3rd through 5th graders from 8 schools in Wisconsin, that greater consumption of fruit and vegetables at school lunch was not associated with a decreased calorie consumption over the whole meal, suggesting that consumption of fruit and vegetables does not reduce the energy density of the meal, but merely replaces calories from other, potentially less-nutrient dense, sources. Another cross-sectional study conducted by Au et al (2016) among 4th and 5th grade students from 42 California schools showed that consumption of lunch offered via the NSLP, as opposed to lunch from home, was associated with a greater score on the Healthy Eating Index measured via a 24-hour recall, but was not related to any differences in fruit and vegetable subscales on the HEI subscales. Using a similar design, Bergman et al (2016) found that HEI scores were significantly higher among lunches from NSLP than lunches from home; although this study observed no differences in the fruit subscale (0-5 points), lunches offered via the had an average score of 1.9 (2.0) as compared to the score of lunches from home of 1.2 (1.9) (P<0.05) on the vegetable subscale (0-5 points).

Table 2.2. Summary of studies examining individual factors related to consumption of fruits and vegetables at school lunch among K through 5th grade students in schools participating in the NSLP included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Type</th>
<th>Method Total days collected</th>
<th>Independent variable(s)</th>
<th>Dependent variable(s)</th>
<th>Main result(s)</th>
<th>Menu Reported? FV Definition</th>
<th>Cluster</th>
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<td></td>
</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Study Design</td>
<td>Data Collection</td>
<td>Study Details</td>
<td>Outcome Measures</td>
<td>Overall</td>
<td>Notes</td>
<td></td>
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<td>-----------------</td>
<td>---------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Au et al (2016)</td>
<td>3,219 students</td>
<td>42 schools</td>
<td>Cross-sectional</td>
<td>4th - 5th grade</td>
<td>CA</td>
<td>24-hr recall, 1 day</td>
<td>Lunch from home vs. lunch from school</td>
<td>HEI scores: fruit and vegetable subscores (1-5 score)</td>
</tr>
<tr>
<td>Bergman et al (2016)</td>
<td>834 students</td>
<td>4 schools</td>
<td>Cross-sectional</td>
<td>2nd – 5th grade</td>
<td>WA</td>
<td>Digital photography, 20 days</td>
<td>Lunch from home vs. lunch from school</td>
<td>HEI scores: fruit and vegetable subscores (1-5 score)</td>
</tr>
<tr>
<td>Bontrager-Yoder et al (2015)</td>
<td>7,117 trays</td>
<td>11 schools</td>
<td>Cross-sectional</td>
<td>3rd – 5th grade</td>
<td>WI</td>
<td>Digital photography, 44 days</td>
<td>Various school level and menu factors: FV consumption (cups)</td>
<td>Total lunch energy (kcal) and FV (kcal)</td>
</tr>
<tr>
<td>Bontrager-Yoder et al (2014)</td>
<td>845 students</td>
<td>8 schools</td>
<td>Cross-sectional</td>
<td>3rd – 5th grade</td>
<td>WI</td>
<td>Digital photography, 32 days</td>
<td>FV energy density and total energy</td>
<td>There was no effect of years of participation in farm-to-school programming on FV consumption</td>
</tr>
<tr>
<td>Handforth et al (2016)</td>
<td>693 students</td>
<td>4 schools</td>
<td>Cross-sectional</td>
<td>1st – 2nd grade</td>
<td>PA</td>
<td>Digital photography; 15 days</td>
<td>Grade level differences</td>
<td>Fruit selection (%) Vegetable selection (%) Fruit consumption (%) Vegetable consumption (%)</td>
</tr>
<tr>
<td>Niaki et al (2016)</td>
<td>567 students</td>
<td>8 schools</td>
<td>Direct observation; 40 days</td>
<td>K – 5th grade</td>
<td>TX</td>
<td>Fruit consumption (cups) Vegetable consumption (cups)</td>
<td>Total vegetable consumption increased between K-1st [0.17 cups (0.04)], 2nd-3rd [0.21 cups (0.04)], and 4th-5th [0.28 cups (0.04)] grades</td>
<td>No; potatoes and juice are included</td>
</tr>
<tr>
<td>Smith &amp; Cunningham-Sabo (2014)</td>
<td>899 students</td>
<td>5 schools</td>
<td>Cross-sectional</td>
<td>1st – 5th grade</td>
<td>CO</td>
<td>Digital photography; 25 days</td>
<td>Grade, gender</td>
<td>Fruit selection (%) Vegetable selection (%) Fruit consumption (%) Vegetable consumption (%)</td>
</tr>
</tbody>
</table>

**Abbreviations:** FV = fruits and vegetables, C-RCT = cluster randomized-controlled trial; QE = quasi-experimental design; CS = cross-sectional design, NR = not reported, N/A = not applicable

**Item-specific factors**
Studies examining item-specific factors are summarized in Table 2.3. Two studies examined the effect of pre-slicing fruits on students’ consumption (Swanson et al, 2009, Wansink et al, 2013); both observed positive effects this practice on students’ consumption of the sliced items. Swanson et al (2009) demonstrated that there was no difference in the overall consumption of sliced apples, but sliced oranges were more likely to be consumed (2.3% vs. 10.2%), particularly among the younger students (Grades K and 1) from one school in Kentucky. In the study described in Wansink (2013), the authors demonstrated that the percentage of students consuming more than one half an apple increased when the fruit was sliced rather than whole (40.0% vs. 71.0%; P=0.02).

Miller et al (2015) found that increasing the portion size of fruit and vegetables at lunch resulted in greater consumption among students who selected these components. Specifically, increasing the portions of carrots, applesauce and orange slices by about 50% resulted in increased consumption of these items (apple sauce +42g; oranges +16g; and carrots +13g) relative to days where normal sized portions were served (normal sized portions were on average 55g for carrots, 67g for oranges, and 115g for applesauce).

Serving vegetables as the first part of the meal, prior to receiving any other item, as a means to increase consumption has been the subject of two studies (Redden et al, 2015; Elsbernd et al, 2009). The study by Elsbernd et al (2009) was a pilot to test the effect of serving red peppers while students waited for their lunch (before they received any other items); the authors observed greater consumption of peppers by weight (mean 4.1g per each child eating school lunch) compared to days when peppers were not served first (mean 1.4g). In an article describing two studies, Redden et al (2015) replicated the effect for carrots and broccoli, which resulted in significantly greater consumption of carrots on the day when it was served first as compared to one control day (12.7 g vs. 2.4 g; p<0.0001) and significantly greater consumption of broccoli on the three days it was served first compared to one control day (Day one 3.99g; Day two 4.06g; and Day three 2.10g vs. Control 0.84 g; p<0.0001).

The study by Wansink et al (2012) tested the effect of using an attractive name (“X-ray Vision Carrots”), a simple name (“The Food of the Day”) or no name (control) on the consumption of vegetable items on the menu. Children ate more carrots when they were attractively named (11.3g [16.3g]) than when simply named (4.7g [6.7g]; p=0.02) or when unnamed (6.8g [8.7g]; p=0.06).
Table 2.3. Summary of studies examining item-specific factors related to consumption of fruits and vegetables at school lunch among K through 5th grade students in schools participating in the NSLP included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Type</th>
<th>Method Total days collected</th>
<th>Independent variable(s)</th>
<th>Dependent variable(s)</th>
<th>Main result(s)</th>
<th>Menu reported? FV Definition</th>
<th>Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capps et al (2016)</td>
<td>431 trays 3 schools K – 5th grade TX</td>
<td>CS</td>
<td>Weighed plate waste, 9 days</td>
<td>Vegetable consumption by grade and item</td>
<td>Vegetable consumption (%) Vegetable waste (%) Among selecting students</td>
<td>Vegetable consumption ranged from 10% to 83% Vegetable waste ranged from 17% to 90% Vegetable consumption increased among increase grade levels (K – 5th)</td>
<td>No Potatoes included</td>
<td>No</td>
</tr>
<tr>
<td>Miller et al (2015)</td>
<td>680, 663 and 684 students 1 school K – 5th grade MN</td>
<td>QE</td>
<td>Weighed plate waste; 5 days</td>
<td>Portion size of F/V Fruit consumption (g) Vegetable consumption (g) Among selecting students</td>
<td>On intervention compared to control days, students consumption of apple sauce (+42g), oranges (+16g) and carrots (+13g) increased per students taking these items</td>
<td>Yes; all items are reported</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Swanson et al (2009)</td>
<td>491 and 288 students 1 school K – 4th grade KY</td>
<td>QE</td>
<td>Digital photography; 2 days</td>
<td>Sliced vs. whole apples and oranges Consuming &gt; 1 half a fruit serving (%) Among all students</td>
<td>Apple consumption NS No difference in consumption of apples Sliced oranges more likely to be consumed (2.3% vs. 10.2%)</td>
<td>Yes; all menu options are provided</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Wansink et al (2013)</td>
<td>334 students 6 schools NR NY</td>
<td>C-RCT</td>
<td>Direct observations; 18 days</td>
<td>Sliced vs. whole apples Consuming &gt; 1 half an apple (%) Among all students</td>
<td>More students in school with apple slices consumed &gt; 1 half an apple (71% vs. 40%, p=0.02)</td>
<td>Yes; target is apple</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Wansink et al (2012)</td>
<td>147 students 5 schools NR NY</td>
<td>QE</td>
<td>Direct observations; 15 days</td>
<td>Use of attractive names for carrots Vegetable consumption (%) Among all students</td>
<td>Children ate more of their carrots when attractively named (65.9%) than when simply named (32.0%) or when unnamed (35.1%) [p&lt;0.01]</td>
<td>Yes; carrot is target</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: FV = fruits and vegetables, C-RCT = cluster randomized-controlled trial; QE = quasi-experimental design; CS = cross-sectional design, NR = not reported, N/A = not applicable

Meal-specific factors
Studies examining meal-specific factors are summarized in Table 2.4. Two studies examined the types and sizes of dishware used during the school lunch meal service. Reicks et al (2012) found that by placing photographs of carrots or green beans in one compartment of the school lunch tray, there was a significant increase in the amount of green beans (from 1.2g to 2.8g; P<0.001) and carrots (from 3.6g to 10.0g; P<0.001) consumed per student who selected these items relative to a control day where no photographs were used. DiSantis et al (2013) tested the effect of the size of the dishware used to eat in a school lunch meal service setting whereby students self-served entrées and sides. Children self-served 15.7 kcal (SE = 6.3 kcal) more fruit when using adult-size rather than child-size dishware (P <0.05), but there was no effect observed on children’s self-served vegetable portions. Although self-served portions were larger, DaSantis et al (2013) did not observe any significant differences in total energy consumed across dishware size conditions.

Three studies examined factors related to the preparation and service of the meal. Ishdorj et al (2015) describe the most frequently consumed items among sample of K through 5th grade students from 3 school in Texas: as a percentage of amount served, the most popular vegetables were starchy vegetables (mashed potatoes with gravy, oven baked French fries, tater tots, and potato wedges), both pre- and post-implementation of the new HHFKA standards. Ishdorj et al (2015) also examined the change in consumption of vegetables when they are paired with different entrees. For example, the authors found that broccoli florets served with a hot dog on a bun were among the five highest consumed entrée and vegetable combinations (as a percentage of total weight served). Using the same data, Capps et al (2015) found that vegetable consumption (as a percent of proportion served ranges from 10% to 83%), with potatoes the most consumed. Similarly, Bontrager-Yoder et al (2015) fruit and vegetable consumption at school lunch among 3rd through 5th graders at 8 schools is Wisconsin, finding that fruits and vegetables were not wasted at different rates (P>0.05).

Table 2.4. Summary of studies examining meal-specific factors related to consumption of fruits and vegetables at school lunch among K through 5th grade students in schools participating in the NSLP included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Type</th>
<th>Method Total days collected</th>
<th>Independent variable(s)</th>
<th>Dependent variable(s)</th>
<th>Main result(s)</th>
<th>Menu reported? FV Definition</th>
<th>Cluster</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>Study Authors</th>
<th>N/A</th>
<th>Setting</th>
<th>Design</th>
<th>Sample Size</th>
<th>Measures</th>
<th>Results</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>DiSantis et al (2013)</td>
<td>42</td>
<td>1 school 1st grade PA</td>
<td>C-RCT</td>
<td>Weighed plate waste; 8 days</td>
<td>Plate size (child versus adult size) Self-served portion of fruit (kcal) Self-served portion of vegetables (kcal) Total energy intake (kcal)</td>
<td>Among all students Children served themselves 15.7 kcal (SE = 6.3 kcal) more of the fruit when using adult-size than child-size dishware (t = 2.50, P &lt;0.05). Dishware size had no effect on children’s self-served vegetable portions or total energy intake (P&gt;0.05).</td>
<td>Yes; mixed vegetable and applesauce N/A</td>
</tr>
<tr>
<td>Elsbernd et al (2016)</td>
<td>500-575 students 1 school K - 5th grade MN</td>
<td>QE</td>
<td>Direct observation; 5 days</td>
<td>Serving vegetables first vs. serving them on the lunch line</td>
<td>Vegetable selection (%) Vegetable consumption (dichotomous) Vegetable consumption (g)</td>
<td>Among all students and among eating students Pepper intervention days resulted in greater consumption of peppers by weight (mean = 4.1 g per each child eating school lunch) compared to days when peppers were not served first (mean =1.4 g).</td>
<td>Yes; F/V items are peppers and carrots N/A</td>
</tr>
<tr>
<td>Ishdorj et al (2015)</td>
<td>8430 students 3 schools K – 5th grade TX</td>
<td>CS</td>
<td>Weighed plate waste; 30 days</td>
<td>F/V pairing with entrees</td>
<td>FV consumption (%)</td>
<td>Chicken nuggets and green beans represented the most highly consumed pairing.</td>
<td>Yes; F/V are reported No</td>
</tr>
<tr>
<td>Redden et al (2015)</td>
<td>680 and 755 students 1 school K – 5th grade MN</td>
<td>QE</td>
<td>Weighed plate waste; 7 days</td>
<td>Serving vegetables first (Study 1 carrots; Study 2 broccoli)</td>
<td>Vegetable selection (%) Vegetable consumption (g)</td>
<td>Among all students Students consumed more carrots when served first in isolation versus control (12.7 g vs. 2.4 g; p&lt;0.0001). Students consumed more broccoli on the first (3.99 g), second (4.06g) and third (2.10g) intervention day than control days (0.84 g; p&lt;0.0001; and 0.90 g, p&lt;0.0001).</td>
<td>Yes; target items are broccoli and carrots N/A</td>
</tr>
<tr>
<td>Reicks et al (2012)</td>
<td>666 and 647 students 1 school K – 5th grade MN</td>
<td>QE</td>
<td>Weighed plate waste; 2 days</td>
<td>Photographs in vegetable compartment of lunch tray</td>
<td>Vegetable selection (%) Vegetable consumption (g)</td>
<td>Among all The amount of green beans (from 1.2g to 2.8g; P&lt;0.001) and carrots (from 3.6g to 10.0g;</td>
<td>Yes, target items are green beans and carrots N/A</td>
</tr>
</tbody>
</table>
design; CS = cross-sectional design, NR = not reported, N/A = not applicable

Cafeteria environment factors

Studies examining cafeteria environment factors are summarized in Table 2.5. Four studies examined the effect of multi-component cafeteria environmental interventions (Williamson et al, 2013; Perry et al, 2004; Cohen et al, 2014; Zellner & Cobuzzi, 2017). Williamson et al (2013) combines the samples from two separate cluster-randomized controlled trials, LA Health and Wise Mind, for 2nd to 6th graders and 4th to 6th graders, over 26 and 18 months, respectively, in which the interventions were cafeteria modification programs, which included modification of the recipes for school meals to include healthier items and alterations to the portion sizes served to students such that they were age-appropriate and in accordance with NSLP guidelines. The authors report the outcomes in terms of the HEI score, which is not disaggregated according to subscales; there were no differences observed in the cafeteria modification arm relative to control after 18 months in overall HEI score. However, after 28 months, the cafeteria modification arm in the LA Health had higher mean HEI change score relative to control (3.9 (1.7) vs. -6.2 (2.3); P<0.05), although the mean HEI scores at follow-up are not reported individually (ibid.). In a cluster-randomized controlled trial, Cohen et al (2014) examined the effect of chef-enhanced meals and/or choice architecture in the school lunch meals. This study was conducted among students in 3-8th grade from 14 schools in one low-income school district in Massachusetts with follow-ups at 4 months and 7 months. After long-term exposure of 7 months, the authors found that students in the schools with chef-enhanced meals consumed more fruit than control schools (+0.17 cups; 95% CI: 0.03-0.30 cups), but there were no differences observed in the choice architecture intervention or combined intervention groups. Relative to control schools, the amount of vegetables consumed increased in schools with chef-enhanced meals (+0.16 cups; 95% CI, 0.09-0.22 cups/d), in schools with chef-enhanced meals and choice architecture combined (+0.13 cups; 95% CI, 0.05-0.19 cups/d), but not in schools with choice architecture alone. The Cafeteria Power Plus program is a cluster-randomized controlled trial, described
in Perry et al (2004), which includes changes to the social environment (including role modeling and encouragement) and physical environment (improved quality of fruit and vegetables offered and posters) of the cafeteria. The study, conducted among 1st through 3rd grade students from 26 schools in Minnesota, found that there were no differences among students’ total servings of fruit and vegetables (P=0.33), but higher consumption of non-potato fruit and vegetable items in the intervention relative to control (1.06 servings vs. 0.92; P=0.03). Zellner & Cobuzzi (2017) tested the effect of the Eatiquette program, which was a multicomponent intervention in the cafeteria that included the use of non-disposable cutlery and family-style eating arrangements among 3rd and 4th graders from 2 schools in PA. In the intervention school relative to the control school, consumption of target vegetables including sweet potato and cauliflower increased from the beginning of the year to the end of the year (37.5% to 50% and 31% to 69%, respectively, as a percentage of total portion).

Four studies examined the order of recess relative to the lunch meal as it relates to consumption of fruit and vegetable components (Bergman et al., 2016; Fenton et al., 2015; Price & Just, 2013; Hunsberger et al., 2014), and of these, three found significant increases in consumption when recess was scheduled before lunch, although none of these studies used a randomized design. Fenton et al (2015) found that recess before lunch was associated with a 0.349 (0.074) cup increase in fruit and vegetables consumption among 4th and 5th grade students relative to the recess after lunch (P<0.001) after adjusting for ethnicity, sex, spoken language, and whether school lunch items were eaten. Price and Just (2013), among a sample of 1st through 6th graders, found that schools that shifted recess before lunch experienced a 0.157 serving increase in fruit and vegetable consumption (a 54% increase relative to the baseline rates at these schools). Bergman et al (2016) found that recess before lunch (RBL) increased consumption of all meal components (RBL: 72.8% ± 18.2% versus RAL: 59.9% ± 21.5%; p<0.0001; these data are for consumption of the whole meal as the data were not disaggregated by item type). Hunsberger et al (2014), among a sample of K through 2nd graders, found no significant differences in the consumption of fruit and vegetables across recess order conditions.

Two studies examined the effect of the amount of time allocated to students for eating lunch on the consumption of meal components (Cohen et al., 2016; Bergman et al., 2004). Cohen et al (2016) demonstrated among 3rd to 8th grade students from 8 schools in Massachusetts that the amount of time
allocated for lunch, >25 minutes vs. 20-24 minutes vs. <20 minutes, respectively, was related to consumption of entrees (77.2% vs. 70.3% vs. 64.4%), vegetables (46.6% vs. 42.9% vs. 34.8%) and milk (72.6% vs. 70.3% vs. 62.3%), but not fruit. In a study of 3rd though 5th grade students from two schools, Bergman et al (2004) observed an increased consumption in all NSLP meal components when lunches lasted for 30 minutes as compared to when they lasted for 20 minutes (72.8% [18.2%] vs. 56.5% [22.1%]; p<0.0001). Importantly, as with recess comparisons, time for lunch was not randomly assigned to schools and thus subject to confounding via unobserved variables.

Three studies examined the use of incentives in the cafeteria to encourage the consumption of fruits and vegetables, one at the group-level (Chinchanachkai et al, 2015) and two at the individual level (Just & Price, 2013; Hendy et al, 2005). By offering incentives (such as gift cards, free bowling passes, and recognition plaques) when group-level targets for daily fruit or vegetable consumption were met, Chinchanachkai et al (2015) observed no significant differences in consumption of fruit and a significant increase in vegetable consumption (from 0.52 ounces to 0.78 ounces) over the course of a ten-day intervention for K through 5th grade students in one school. Just & Price (2013) used a cluster-randomized design to test the effect of six different incentive conditions (receive a lottery ticket for a prize immediately, receive a quarter immediately, receive a lottery ticket for a prize in two weeks, receive a quarter in two weeks, receive a nickel immediately, no incentive) delivered to individual students among 15 schools from 2 districts in Utah. Students in schools within all active incentive conditions increased consumption of one serving of fruits or vegetables relative to baseline; the smallest increase was observed in the nickel condition (+15.4%) and the largest increase was observed in the quarter condition (+38.5%). In the “Kids Choice” program described in Hendy et al (2005), a cluster-randomized design was used to assign 14 classrooms of 1st to 4th grade students to a token-reinforcement intervention or control. Students in the token-reinforcement condition received a hole punch into their nametags which could later be traded in for small prizes if they consumed at least 1/8 cup of fruit or vegetables. Children in the token-reinforcement group increased consumption of fruit across all phases of the intervention, while only increase consumption of vegetables only during the first phase of the intervention.

One study examined the use of verbal prompts by food service workers in the cafeteria on students’ consumption of fruit. Using a cluster-randomized design within two schools, Schwartz et al
demonstrated that the use of the prompt, "Would you like fruit or juice?", increased consumption of whole fruit across two days of the intervention, relative to a control condition (Day 1: OR = 3.5, 95% CI 2.0–6.2 and Day 2: OR = 2.3, 95% CI = 1.3 – 4.2).

Using a 2-year longitudinal design, Cullen et al (2004) observed changes in consumption of school lunch meal components associated with changes in access to a la carte competitive food offerings. The authors used a natural experimental design during the transition of a cohort students to a new school with a la carte offerings between 4th and 5th grade and utilized a cohort of students transitioning between 5th and 6th grade as a control for secular trends (who had continual access to a la carte offerings). Students in cohort 1 decreased consumption of fruits by 33% and regular vegetables by 42% (P < 0.001 for all), while students in cohort 2 decreased consumption of regular vegetables by 10% (P < 0.05) but had no change in fruit consumption.

One study examined the effect of a salad bar on 1st through 5th grade students’ consumption of fruits and vegetables from 4 schools in California. Adams et al (2005) found no significant differences in the consumption of overall fruit and vegetables between schools with or without a salad bar (47 ± 60g vs. 43 ±58 g, respectively).

One conference abstract describes protocol to examine the cafeteria noise level and its effect on students’ plate waste and consumption (Byker et al, 2014). The authors describe null findings with respect to plate waste or consumption between two schools defined as high-noise and low-noise, however there was little actual variability observed in the objectively measured noise levels (Personal communication, E. Serrano, January 25th, 2016).

Table 2.4. Summary of studies examining cafeteria environment factors related to consumption of fruits and vegetables at school lunch among K through 5th grade students in schools participating in the NSLP included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Type</th>
<th>Method</th>
<th>Total days collected</th>
<th>Independent variable(s)</th>
<th>Dependent variable(s)</th>
<th>Main result(s)</th>
<th>Menu reported? FV Definition</th>
<th>Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams et al</td>
<td>288 students 4 schools 1st - 5th grade CA</td>
<td>CS</td>
<td>Weighed plate waste, 4 days</td>
<td>Presence of salad bars vs. no salad bar</td>
<td>FV portion (g) FV consumed (g) FV consumed (%)</td>
<td>All outcomes NS</td>
<td>Yes No potatoes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Number of Students</td>
<td>Schools</td>
<td>Study Design</td>
<td>Intervention</td>
<td>Outcome Measures</td>
<td>Results</td>
<td></td>
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<tr>
<td>Bergman et al (2004)</td>
<td>1119 (School 1) and 889 (School 2) students</td>
<td>2 schools</td>
<td>CS</td>
<td>Weighed plate waste, 10 days</td>
<td>Recess before lunch vs. after lunch</td>
<td>Total lunch consumption (g and %)</td>
<td>Students with recess before lunch consumed more (410.9g ± 103.2g (72.8% ± 18.2%)) than students with recess after lunch [330.7g ± 121.8g (59.9% ± 21.5%)], p&lt;0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bergman et al (2004)</td>
<td>1119 (School 1) and 758 (School 2) students</td>
<td>2 schools</td>
<td>CS</td>
<td>Weighed plate waste, 20 days</td>
<td>Length of lunch period (20 vs. 30 minutes)</td>
<td>Total lunch consumption (g and %)</td>
<td>Students with a 30 minute lunch period consumed more (410.9g ± 103.2g (72.8% ± 18.2%)) than students with 20 minutes [338.3g ± 132.9g (56.5% ± 22.1%)], p&lt;0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chincha et al (2015)</td>
<td>424 students</td>
<td>1 school</td>
<td>QE</td>
<td>Weighed plate waste, 10 days</td>
<td>Group level incentives to encourage FV consumption (baseline vs. intervention vs. follow-up)</td>
<td>Vegetable consumption (oz) Fruit consumption (oz) FV consumption (oz)</td>
<td>Fruit NS Vegetable consumption was significantly different across the study periods: 0.52 ounces to 0.78 ounces to 0.40 ounces (p&lt;0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohen et al (2016)</td>
<td>1,001 students</td>
<td>8 schools</td>
<td>Cohort</td>
<td>Weighed plate waste, 48 days</td>
<td>Length of lunch period (20 min vs. 20-24min vs. &gt;25min)</td>
<td>Fruit selection (%) Vegetable selection (%) Fruit consumption (%) Vegetable consumption (%)</td>
<td>Among selecting students</td>
<td>Vegetable selection NS Length of lunch period (20 min vs. 20-24min vs. &gt;25min) was related to fruit selection (44.4% vs. 46.9% vs. 57.3%, P&lt;0.001) Fruit consumption NS Length of lunch period (20 min vs. 20-24min vs. &gt;25min) was related to vegetable consumption (46.6% vs. 42.9% vs. 34.8%, P&lt;0.04)</td>
<td></td>
</tr>
<tr>
<td>Cohen et al (2014)</td>
<td>2,628 students</td>
<td>14 schools</td>
<td>C-RCT</td>
<td>Weighed plate waste; 84 days</td>
<td>Choice architecture and chef-enhanced meals intervention (3 months)</td>
<td>Fruit selection (%) Vegetable selection (%) Fruit consumption</td>
<td>Short term (3 months): NS Long term (7 months): Fruits consumed in the chef schools were</td>
<td>NR</td>
<td>Yes</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Design</td>
<td>Methods</td>
<td>Outcomes</td>
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<tr>
<td>Cullen et al (2004)</td>
<td>852 students 5 schools 4th – 5th grade TX</td>
<td>Cohort</td>
<td>Food records; 25 days</td>
<td>Vegetable consumption (cups) greater than control schools (0.17 cups; 95%CI, 0.03-0.30 cups/d), but the smart café had no effect (~0.00 cups; 95%CI, ~0.13 to 0.11 cups/d). Vegetables consumed increased by (0.16 cups; 95% CI, 0.09-0.22 cups/d) in chef schools and by (0.13 cups; 95% CI, 0.05-0.19 cups/d) in smart café group</td>
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<tr>
<td>Fenton et al (2015)</td>
<td>2,167 students 31 schools 4th and 5th grade CA</td>
<td>CS 24-hr recall; 1 day</td>
<td>Timing of recess (before or after eating)</td>
<td>Fruit and vegetable consumption (cups) Servings of fruits and regular vegetables decreased 33% and 42%, respectively (P &lt; 0.001). Control group: consumption of regular vegetables (P &lt; 0.05) decreased by 10%, No; Potatoes included</td>
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<tr>
<td>Hendy et al (2005)</td>
<td>188 students 1 school 1st, 2nd and 4th grades PA</td>
<td>CRC T Direct observation; 24 days</td>
<td>Token reinforcement</td>
<td>Number of meals where &gt;1/8 cup of FV was consumed</td>
<td>There was a significant effect of the intervention on FV consumption across all grades (P&gt;0.001) Yes; F/V items are reported in full</td>
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<tr>
<td>Hunsberger et al (2014)</td>
<td>261 students 1 school K – 2nd grade OR</td>
<td>CS Weighed plate waste; 5 days</td>
<td>Timing of recess (before or after eating)</td>
<td>Fruit and vegetable consumption (%) Fruit and vegetable consumption NS</td>
<td>Yes; F/V items are reported in full (includes potatoes)</td>
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<tr>
<td>Just &amp; Price (2013)</td>
<td>47,414 student-day observations 15 schools Grade NR UT</td>
<td>C-RCT Direct observation; 10 days</td>
<td>Incentives of varying types</td>
<td>Fruit and vegetable consumption (cups) Providing an incentive raised the percent of children eating at least one serving of F/V by No; excludes potatoes, corn, and fruit juices</td>
<td>Yes</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Design</td>
<td>Observational Method</td>
<td>Timing of Recess</td>
<td>Timing of Consumption</td>
<td>Timing of Consumption</td>
<td>Recess before Lunch</td>
<td>Fruit and Vegetable Consumption</td>
<td>Students in Intervention School</td>
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<tr>
<td>Price &amp; Just (2013)</td>
<td>2,477 students in 7 schools</td>
<td>UT</td>
<td>QE</td>
<td>Direct Observation: ~98 days</td>
<td>Timing of Recess (before or after eating)</td>
<td>Fruit and Vegetable Consumption (servings)</td>
<td>Ate at least one serving (%)</td>
<td>Recess before lunch was associated with a 0.157 serving increase in fruit and vegetable consumption</td>
<td>No; does not count potatoes or juice</td>
</tr>
<tr>
<td>Schwart z et al (2007)</td>
<td>NR in 2 schools in New England</td>
<td>C-RCT</td>
<td>Direct Observations: 4 days</td>
<td>Verbal prompt to take fruit on two days</td>
<td>Fruit Selection (%)</td>
<td>Fruit Consumption (%)</td>
<td>Students in the intervention school were more likely to eat fruit (Day 1: OR = 3.5, CI 2.0–6.2; Day 2: OR = 2.3, CI = 1.3–4.2). The likelihood of drinking juice was similar on Day 1 (OR = 1.1, CI 0.6–2.5) but not Day 2 (OR = 2.9, CI 1.5–5.5).</td>
<td>Yes; all items are reported</td>
<td>N/A</td>
</tr>
<tr>
<td>Serrano et al (2014)</td>
<td>273 trays in 2 schools Pre-K - K</td>
<td>NR</td>
<td>QE</td>
<td>Weighed plate waste; 10 days</td>
<td>Noise</td>
<td>Fruit Consumption</td>
<td>Students in the intervention school were not significantly different from the control school in terms of fruit and vegetable consumption.</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Abbreviations:** FV = fruits and vegetables, C-RCT = cluster randomized-controlled trial; QE = quasi-experimental design; CS = cross-sectional design, NR = not reported, N/A = not applicable

**Classroom or school wide environment factors**

Studies examining classroom, school-wide and policy-related factors are summarized in Table 2.6. In the study by Bontrager-Yoder et al (2015) that examined fruit and vegetable consumption at school lunch among 3rd through 5th graders at 8 schools in Wisconsin, there was no relationship observed between years of participation in a Farm to School program (from 0 to 5 years) and students’ consumption of fruit and vegetables.

Struempler et al (2014) examined the impact of a 17-session classroom-based curriculum intervention, Body Quest: Food of the Warrior, on 3rd grade students’ fruit and vegetable consumption. The authors used the What’s For Lunch Checklist, a self-report checklist of foods served during lunch, to evaluate the effect of the program. Students in the treatment group consumed significantly higher fruits (P<0.001) and vegetables (P<0.001) than the control condition after controlling for baseline consumption.
Alaimo et al (2015) evaluated the effect of the Project FIT program, a community and social marketing intervention that included nutrition education, taste tests and posters, brochures and banners, on students’ consumption of fruits and vegetables. Students in the intervention schools were 2.16 times more likely to consume fruits (95% CI: 1.01, 4.62), although there were no differences observed in consumption of vegetables.

Two studies examined the effect of the Food Dudes program on students’ consumption of fruit and vegetables at school lunch (Wengreen et al, 2013; Morrill et al, 2015). The Food Dudes intervention, which includes videos, teachers reading letters and small rewards for tasting fruits and vegetables, has been widely used in Europe and includes intervention through several phases. In Phase 1, target fruit and vegetable items are provided in the cafeteria as part of the school lunch meal and incentives are introduced in Phase 2, alongside educational videos and other FoodDudes promotional materials. In the pilot study by Wengreen et al (2013) conducted in 1st through 5th grade students from 1 school in Utah, students’ consumption of fruit and vegetables increased significantly during the Phase I, the provision of target fruit and vegetable items (P<.001 for both fruit and vegetables). Students’ consumption of fruit and vegetables increased in Phase 2 relative to the baseline, in which students consumed, on average, 0.28 cups of fruit and 0.22 cups of vegetables (P<0.001 for both). In an expanded version of the FoodDudes program conducted among 1st through 5th grade students from 6 schools, Morrill et al (2015) compared two incentives types, social rewards (e.g., praise) and tangible rewards (e.g., prizes). Baseline consumption of fruits and vegetables were: 0.35 cups (prize group), 0.47 cups (praise group) and 0.38 (control group). During Phase I, combined fruit and vegetable consumption increased by 0.21 cups (control vs. praise), 0.32 cups (control vs. prize), and 0.11 cups (praise vs. prize). During phase 2, fruit and vegetable consumption increased by 0.12 cups (control vs. praise and control vs. prize).

Hoffman et al (2011) describe the effects of a 2.5 year school wide intervention, which included daily loud speaker announcements, an instructional DVD, daily stickers contingent on a bite of fruit or vegetable, and take-home activity books, on students’ consumption of fruit and vegetables. This cluster-randomized trial targeted K through 1st grade students from 4 schools in northeastern U.S. and used weighed plate waste to evaluate students’ consumption of fruit and vegetables at school lunch. After one
year, the experimental group consumed 22g more fruit (95% CI: 14-30 g, p<0.00001) and 7g more vegetables (95% CI: 3 to 10g, p <.005). After year 2, the experimental group consumed 15g more fruit (95% CI: 6 to 23 g, p <.0005), but there was no significant difference in consumption of vegetables. After year 3, the experimental group consumed an additional 3g of vegetables (95% CI: -0.2 to 6.7 g, p<0.05), but there was no significant difference in consumption of fruit. The follow-up data-collection which occurred one year following the end of the intervention, described in Hoffman et al (2011), showed that there were no longer any differences in fruit and vegetable consumption between groups.

Jones et al (2014) describes a gamification approach to increasing fruit and vegetable consumption among 1st through 5th grade students from in one school Utah. Fruit or vegetable consumption (randomly selected on each day) was targeted for improvement each day among all students, and students were notified of the target food (fruit or vegetable) daily before lunch and were instructed that their goal was to eat “a little more” than normal. Students consumed an average of 62 g of fruit and 42 g of vegetables at baseline, which was increased to 86 g of fruit (p<0.01) and 56 g of vegetables (p <0.05) when the game targeted each item, respectively.

Parmer et al (2009) described the effect of nutrition education and gardening (alone or combined) on students’ fruit and vegetable consumption relative to control group. Within one school in the Southeastern U.S., 6 second grade classes received either nutrition education, nutrition education plus gardening or no active intervention, although this was not randomized. There were no significant changes in fruit consumption among any intervention arm. For vegetable consumption, the nutrition education alone group did not change consumption, while the nutrition education plus gardening group increased consumption from 0.70 (0.40) to 1.0 (0.0) servings (P<0.01). The control group decreased from 0.83 (0.3) to 0.50 (0.05) servings (P<0.001).

**National School Lunch Program policy-related factors**

Four studies examined the use of active choice in the selection of school lunch meal components and its effect on students’ consumption of fruit and vegetables (Hakim et al, 2013; Price & Just, 2013; Goggans et al, 2011). In one school in the Midwest, Hakim et al (2013) conducted a quasi-experimental design in which students had to choose the type of fruit or vegetable to include in their lunch. On days
when fruits were the forced active choice (e.g., students were forced to choose a fruit item on this day), consumption increased from 48.26% (44.9%) at baseline to 62.23% (43.46%) at follow-up (P<0.01) and on days when vegetables were the forced active choice consumption increased from 18.61% (33.84%) at baseline to 34.2% (42.1%) at follow-up (P<0.01). On the other hand, Price and Just (2013) used an observational, pre-post design, to test the effect of default options provided as part of the NSLP reimbursable meals. The authors describe data from two separate studies that examine the effect of defaults between 15 schools from two districts with different policies about defaults and within 3 schools before and after implementation of a default policy. In the between-district comparison, there was no significant difference in the percent of students consuming a serving of fruit or vegetable (from 35% to 33%). However, in the pre-post comparison within the same school, there was slight increase in the percent of students eating at least one serving of fruit or vegetable (from 20% to 28%; P<0.001). In the study described by Goggans et al (2011), students from two schools in which service differed (one utilized the offer versus serve provision while the other utilized a serve only approach) were compared in consumption of fruit and vegetables. Fourth and fifth grade students from the school utilizing the offer versus serve provision consumed more of all the fruit and vegetable items served on the days of data collection (except for French fries), although no formal statistical comparisons were made.

Eight studies examined students’ consumption of fruit and vegetables as associated with implementation of new NSLP standards in accordance with the recent 2010 HHFKA (Smith & Cunningham-Sabo, 2013; Cullen et al; 2014; Cohen et al, 2014; Ishdorj et al, 2015; Amin et al, 2015; Smith et al, 2016; Cullen et al, 2015; Bontrager-Yoder et al, 2015). In a descriptive study of 1st through 5th grade students 5 schools from Colorado, Smith & Cunningham-Sabo (2014) found that about than one in ten meals served to elementary school students met the NSLP standards for calories. The authors also report descriptive statistics regarding the average consumption of fresh fruits (63% of portion served) and vegetables (66.4% of portion served) among elementary school students. This study was conducted in 2010, the first year of the implementation of the new standards. Cullen et al (2014) examined improvements in students’ consumption of fruit and vegetables associated with the new NSLP standards using a cluster-randomized design (the authors conducted the study in the year before the meal standards were finalized and thus mandated). Students within 8 elementary schools (4 intervention and 4
control) were measured using direct observation. The authors found that intervention students consumed significantly more vegetables than control students (0.14 cups vs. 0.10 cups; P<0.05), but no difference in total fruit. Control students also consumed significantly more juice (0.23 cups vs. 0.18 cups; P<0.05) than intervention students. In four schools from Massachusetts, Cohen et al, 2014 conducted a pre-post study to compare schools before and after implementation of the new NSLP standards. The authors used weighed plate waste and found that vegetable consumption increased by 16.2% or 0.18 cups (P<0.0001) but that there was no change in fruit consumption. Ishdorj et al (2016) examined changes in vegetable consumption among K through 5th graders in 3 schools from Texas and found that vegetable consumption (as a percentage of portion served) decreased slightly, although significantly, after implementation of the standards (48% vs. 42%; P<0.05). Amin et al (2015) also examined changes in consumption associated with the new NSLP standards within 3rd to 5th grade students from 2 schools. The authors found that more children did not consume any fruit and vegetables after implementation of the offer vs. serve provision (4% vs. 12%, p<0.001) and that consumed 0.06 fewer cups of fruit and vegetable (p<0.01), among all students regardless of whether they had a fruit or vegetable on their tray. Smith et al (2016) examined the effect of the NSLP recommendations on 2nd to 5th grade students' consumption of meal components from four schools participating in the HealthierUS School Challenge. Using a before- and after-meal digital photography method and a conversion to HEI scores, the authors observed an increase in the HEI scores of meals consumed, including an increase in total fruit and whole fruit subscales, although no difference was noted in the vegetable subscale. Cullen et al (2015) observed changes in consumption of fruit and vegetables among students from 8 schools in Texas before and after implementation of the NSLP standards. Compared with 2011, students in 2013 who selected the food groups consumed significantly greater amounts of total fruit and 100% fruit juice (p<0.001) and red-orange vegetables (p<0.01), but significantly lower amounts of other vegetables (p<0.05 for all).

Bontrager-Yoder et al (2015) observed no significant difference in the wastage of fruits and vegetables (in volumetric measures) after implementation of the Health Hunger-Free Kids Act.

Table 2.6. Summary of studies examining classroom, school-wide and/or policy factors related to consumption of fruits and vegetables at school lunch among K through 5th grade students in
schools participating in the NSLP included in this systematic mapping review, 2004-2016

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Sample (students, schools, grade, location)</th>
<th>Type</th>
<th>Method</th>
<th>Total days collected</th>
<th>Independently variable(s)</th>
<th>Dependent variable(s)</th>
<th>Main result(s)</th>
<th>Menu reported?</th>
<th>FV Definition</th>
<th>Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaimo et al (2015)</td>
<td>410 students 4 schools 3&lt;sup&gt;rd&lt;/sup&gt; - 5&lt;sup&gt;th&lt;/sup&gt; grade MI</td>
<td>QE</td>
<td>Digital photography, 12 days</td>
<td>Nutrition education intervention vs. control</td>
<td>Fruit consumed (servings) Vegetable consumed (servings)</td>
<td>Among all students</td>
<td>Intervention students more likely to consume fruits (OR 2.16; 95% CI: 1.01, 4.62) Vegetables NS</td>
<td>NR</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Amin et al (2015)</td>
<td>498 (pre) and 944 (post) 2 schools 3&lt;sup&gt;rd&lt;/sup&gt; - 5&lt;sup&gt;th&lt;/sup&gt; grade Northeast</td>
<td>QE</td>
<td>Digital photography, 21 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>FV portion (cups) FV consumed (cups)</td>
<td>Among all students and selecting students</td>
<td>Among all students and among selecting students, respectively: FV selected increased (29% and 11.0%; P&lt;0.001) and FV consumed decreased (-11.8% and -13.5%; P&lt;0.01)</td>
<td>NR</td>
<td>No</td>
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<tr>
<td>Bontrager-Yoder et al (2014)</td>
<td>1,117 students 9 schools 3&lt;sup&gt;rd&lt;/sup&gt; – 5&lt;sup&gt;th&lt;/sup&gt; grade WI</td>
<td>QE</td>
<td>Digital photography, 36 days</td>
<td>Participation in a F2S program (yrs)</td>
<td>FV consumption (cups)</td>
<td>FV consumption increased with increased age (r=0.022; P=0.02) Prior years of participation in farm-to-school (0-5) was not associated with FV consumption</td>
<td>Yes</td>
<td>Yes; Potatoes and juice excluded</td>
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<tr>
<td>Cohen et al (2014)</td>
<td>1,030 students 4 schools 3&lt;sup&gt;rd&lt;/sup&gt; – 8&lt;sup&gt;th&lt;/sup&gt; grade MA</td>
<td>QE</td>
<td>Weighed plate waste; 16 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>Fruit selection (%) Vegetable selection (%) Fruit consumption (%) Vegetable consumption (%)</td>
<td>Among selecting students</td>
<td>Vegetable selection NS Following NSLP-implementation, students were more 23% likely to selected fruit (P&lt;0.0001). Fruit consumption NS Following NSLP-implementation, students consumed 0.18 more cups of vegetable (P&lt;0.0001).</td>
<td>Yes; potatoes are included</td>
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<tr>
<td>Cullen et al (2015)</td>
<td>472 and 573 students</td>
<td>QE</td>
<td>Direct observation;</td>
<td>NSLP implementation</td>
<td>Fruit consumption (cups)</td>
<td>Compared with pre-</td>
<td></td>
<td>No; NR</td>
<td>No</td>
<td></td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Setting</td>
<td>Methodology</td>
<td>Baseline</td>
<td>Intervention</td>
<td>Outcome Measures</td>
<td>Findings</td>
<td>Notes</td>
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<tr>
<td>Cullen et al, 2014</td>
<td>1149 students</td>
<td>8 schools</td>
<td>C-RCT</td>
<td>Direct observation; 8 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>Fruit consumption (cups) Vegetable consumption (cups)</td>
<td>Elementary students with NSLP implementation consumed significantly more vegetables than control students (0.14 cups vs 0.10 cups; P&lt;0.05). Control students consumed significantly more juice (0.23 cups vs 0.18 cups; P&lt;0.05)</td>
<td>No; NR</td>
<td></td>
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<tr>
<td>Goggans et al, 2011</td>
<td>649 students</td>
<td>2 schools</td>
<td>CS</td>
<td>Weighed plate waste; 5 days</td>
<td>Serve only versus offer vs. serve provision</td>
<td>Fruit consumption (%) Vegetable consumption (%)</td>
<td>Students in the school with the OVS consumed more of the F/V served (67.85% ±11.74 vs. 48.01%±19.98; p&lt;0.01)</td>
<td>Yes; F/V items are reported in full</td>
<td>N/A</td>
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<tr>
<td>Hakim &amp; Meissen, 2013</td>
<td>586 students</td>
<td>1 school</td>
<td>QE</td>
<td>Direct observation and weighed plate waste; 20 days</td>
<td>Active choice for F/V items</td>
<td>Fruit consumption (%) Vegetable consumption (%)</td>
<td>Direct observation: Fruit: 48.26% (44.9% baseline) to 62.23% (43.46%) follow-up (P&lt;0.01) and Vegetables: 18.61% (33.84%) to</td>
<td>Yes; F/V items are reported in full</td>
<td>N/A</td>
<td></td>
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<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Intervention Details</td>
<td>Outcome Measures</td>
<td>Results</td>
<td>F/V Reporting</td>
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<tr>
<td>Hoffman et al (2011)</td>
<td>297 baseline and 166 follow-up 4 schools K – 1st grade Northeast</td>
<td>C-RCT</td>
<td>Weighed plate waste; 12 days</td>
<td>School-Based Fruit and Vegetable Promotion Program (F&amp;VPP)</td>
<td>Fruit consumption (g) Vegetable consumption (g) Among selecting students</td>
<td>Year 1: the experimental group 22g more fruit (p&lt;0.00001) and 7g more vegetables (p&lt;0.005) Year 2: the experimental group consumed 15g more fruit (p&lt;0.0005) and NS vegetables Year 3: the experimental group consumed 3g more vegetables (p&lt;0.05), Fruit NS Follow-up: vegetables NS, Fruit NS</td>
<td>Yes; F/V are reported</td>
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<tr>
<td>Ishodorj et al (2016)</td>
<td>8430 students 3 schools K – 5th grade TX</td>
<td>QE</td>
<td>Weighed plate waste; 30 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>Vegetable consumption (%) Among all students Vegetable consumption (as a percentage of portion) decreased after implementation of the standards: 48% vs. 42% (p&lt;0.05)</td>
<td></td>
<td>Yes; F/V are reported No</td>
<td></td>
<td></td>
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<tr>
<td>Just &amp; Price (2013)</td>
<td>10,208 and 19,672 observations 15 and 3 schools Grade NR UT</td>
<td>QE</td>
<td>Direct observation; 10 and ~19 days</td>
<td>Default options</td>
<td>Ate at least one serving of F/V (%) Among all students</td>
<td>Study 1: No difference in the percent of children eating a serving of F/V (35% v. 33% of children; NS) Study 2: The default option increased the percent of children eating a serving of F/V (20% to 28%; p&lt;0.001)</td>
<td>No Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jones et al (2014)</td>
<td>251 students 1 school 1st – 5th grade UT</td>
<td>QE</td>
<td>Weighed plate waste; 29 days</td>
<td>FIT game; a gamification approach to increasing F/V consumption</td>
<td>Fruit consumption (g) Vegetable consumption (g) Among selecting students</td>
<td>When the FIT Game targeted fruit, students consumed an average of 86 g of fruit (p&lt;0.01). When the FIT Game</td>
<td>No N/A</td>
<td></td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Design</td>
<td>Intervention/Method</td>
<td>Measure 1</td>
<td>Measure 2</td>
<td>Measure 3</td>
<td>Measure 4</td>
<td>Measure 5</td>
<td>Findings</td>
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<tr>
<td>Morrill et al (2016)</td>
<td>2257 students</td>
<td>C-RCT</td>
<td>Digital photography; ~96 days</td>
<td>Food Dudes program</td>
<td>Fruit and vegetable consumption (cups)</td>
<td>During Phase 1: F/V consumption increased by 0.21 cups (control vs. praise), 0.32 cups (control vs. prize), and 0.11 cups (praise vs. prize). During Phase 2: F/V consumption increased by 0.12 cups (control vs. praise and control vs. prize).</td>
<td>Yes; target F/V are reported in full</td>
<td>No</td>
<td>targeted vegetables, students consumed an average of 56 g of vegetables (p &lt; 0.05)</td>
<td></td>
</tr>
<tr>
<td>Parmer et al (2009)</td>
<td>115 students</td>
<td>QE</td>
<td>Direct observation; 2 days</td>
<td>Nutrition education and/or gardening</td>
<td>Vegetable consumption (servings)</td>
<td>Nutrition education: NS Gardening: 0.83 (0.3) to 0.50 (0.05) servings (P&lt;0.001) Nutrition education plus gardening: 0.70 (0.40) to 1.0 (0.0) servings (P&lt;0.01)</td>
<td>No</td>
<td>N/A</td>
<td></td>
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<tr>
<td>Perry et al (2004)</td>
<td>1,668 at baseline</td>
<td>C-RCT</td>
<td>Direct observation; NR</td>
<td>Cafeteria Power Plus intervention</td>
<td>Fruit and vegetable consumption (servings)</td>
<td>All F/V: 1.30 servings (intervention) 1.21 servings (control); NS F/V non potatoes, non-juice: 0.64 servings (intervention) vs. (0.50 control); p=0.02</td>
<td>No; analysis conducted with and without potatoes and juice</td>
<td>Ye</td>
<td></td>
<td></td>
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<tr>
<td>Schwartz et al (2015)</td>
<td>1,370 students</td>
<td>QE</td>
<td>Weighed plate waste; 36 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>Fruit selection (%) Vegetable selection (%)</td>
<td>Fruit NS Vegetable consumption did not change significantly the first year of the new standards, but did increase significantly</td>
<td>No</td>
<td>Ye</td>
<td></td>
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</tr>
<tr>
<td>Study</td>
<td>Sample Size</td>
<td>Setting</td>
<td>Data Collection Method</td>
<td>Interventions</td>
<td>Outcomes</td>
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<tr>
<td>Smith et al, (2016)</td>
<td>1,033 lunches</td>
<td>4 schools</td>
<td>Digital photography; 60 days</td>
<td>NSLP implementation vs. pre-implementation</td>
<td>Fruit HEI score for selected and consumed food (1-5) Total Vegetables consumed increased from 2.16 (0.10) to 3.22 (0.10) (p &lt; 0.05) Whole Fruit consumed increased from 2.35 (0.11) to 3.43 (0.10) (p &lt; 0.05)</td>
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<tr>
<td>Struempler et al (2014)</td>
<td>2,477 students</td>
<td>60 schools</td>
<td>Self-report; 5 days</td>
<td>Body Question nutrition education curriculum</td>
<td>Weekly fruit and vegetable consumption (servings) Students in the treatment group significantly increased consumption for both fruits (P&lt;.01) and vegetables (P&lt;.001) from pre- to post-intervention.</td>
<td></td>
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<tr>
<td>Wengreen et al (2013)</td>
<td>253 students</td>
<td>1 school</td>
<td>Digital photography; 16 days</td>
<td>Food Dudes intervention (incentives)</td>
<td>Fruit and vegetable consumption (cups) Among all students Default Vs. Phase 1: Consumption of F/V increased significantly following FV Provision (P&lt;.001 for both). Naturalistic vs. Phase 2: Consumption increased and was on average 0.28 cups of fruit and 0.22 cups of vegetables (P&lt;.001 for both).</td>
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<td></td>
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<tr>
<td>Zellner &amp; Cobuzzi (2017)</td>
<td>~110 students</td>
<td>2 schools</td>
<td>Direct observations; 24 days</td>
<td>Family-style dining intervention</td>
<td>Vegetable consumed (%) Consumption of target vegetables (cauliflower and sweet potato) increased from pre- to post intervention (31% to 69% and 37.5% to 50%). Yes; target F/V items are described</td>
<td></td>
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</table>
2.3. DISCUSSION

In light of the growing interest in understanding influences on children’s dietary behavior, this mapping review with a systematic search strategy aimed to identify studies assessing fruit and vegetable consumption at lunch among elementary students from schools participating in the NSLP within the U.S. between 2004 and present. This review identified a total of 61 such studies, with 10 of these being methodological validation studies wherein two or more methods were compared and 51 of these being studies that examined the influence of one or more environmental factors on students’ consumption of fruits and vegetables. The evidence from this review is useful for policymakers, practitioners and researchers who are interested in measuring and/or understanding factors influence fruit and vegetable intake as a strategy to improve overall dietary quality and health among elementary school-aged children. The evidence from this review was incorporated into a framework for categorizing and understanding these influences to inform future research and evaluation in elementary school settings.

The methodological validation studies identified in this review were generally considered to be valid and reliable for measuring fruit and vegetable consumption at school lunch. Broadly, four categories of methods have been validated for use in elementary school settings: weighed plate waste, direct observation digital photography and self-report methods. In general, validation studies have utilized the weighed plate waste and direct observation methodologies as the criterion method for relative comparisons of other methods. One study compared a digital photography method plus direct observation and a weighed plate waste method (Taylor et al, 2015), finding high accuracy for fruit and vegetable consumption (r≥0.95), suggesting these two methodologies are concordant. The study by Baxter et al (2010) showed that observations of students during the lunch period did not alter their consumption or reporting accuracy, suggesting that observations are not inherently biasing the study outcomes. Reliability of methods was strong, including the digital photography method, which showed up to 92% agreement between raters in the study by Swanson et al (2008) and 96% agreement between raters in the study by
In general, the self-report methods appear to be valid, although not nearly as accurate as the objective measures identified in the systematic mapping review. In comparing the 24-hour recall method to direct observations, Baxter et al and Harrington et al (2008) found relatively low agreement. Importantly, the study by Harrington et al (2008) showed that there were no differences in the accuracy of a self-report method across groups participating in an intervention study, suggesting that social desirability bias is not inherent to self-report methods in elementary school settings. Two shorter questionnaires, the School Lunch Recall Questionnaire (Paxton et al, 2011) and the Fruit and Vegetable Questionnaire (Economos et al, 2008), showed moderate accuracy relative to the direct observation method, suggesting that improvements can be made to self-report methodologies to improve accuracy, such as shortening the retention interval and asking about only one meal. To further improve the accuracy of self-report methods, researchers should design validation studies to systematically vary the factors that are likely to influence accuracy, such as age, meal type, and administration protocol for the self-report method.

These validation studies provide evidence for researchers in their choice of methods in future research. Generally, all four methods (weighed plate waste, direct observation, digital photography, and self-report methods) appear accurate and reliable for use among elementary school-aged students and could be chosen based on the needs of the proposed study. However, there are important caveats given the nature of the samples under study. First, several of these studies lumped students of diverse grades, (for examples, see Taylor et al., (2015), Hanks et al., (2014) and Swanson et al., (2008)). Thus, little is known regarding the accuracy of the measurement methods specifically for different age groups. Second, these studies focused exclusively on understanding validity and/or reliability, with little attention given to the feasibility of implementing the method in diverse settings. One study conducted in an after-school setting (Kenney et al., 2015), and thus ineligible for inclusion in this review, examined the costs of implementing the weighed plate waste, direct observation and digital photography methods. The authors found that direct observation and digital photography were similar in cost (both about $0.62/observation), and that the weighed plate waste method was more expensive (about $0.95/observation) (ibid.). Future research should examine the costs and feasibility of implementing the methods, so that
researchers can better understand the implications for using each method and choose the method that best fits the school environment.

This review extracted 19 environmental factors that had been the subject of 51 previous studies which were grouped into 5 clusters informed by a socio-ecological framework. These clusters include: individual, item-specific, meal-specific, cafeteria environment and school-wide environmental factors. In general, there was limited high-quality evidence across studies to make a definition conclusion about factors included in the framework. There were several factors that appeared with consistent associations across multiple studies (>2 studies) in their relationship with fruit and vegetable consumption at school lunch: four studies identified increases in consumption of fruit and vegetables as students aged; two studies supported slicing fruits; two studies supported serving vegetables first, three studies supported multi-component modifications to the school cafeteria environment; three studies supported the order of recesses before lunch; two studies supported increasing the amount of time allocated to school lunch; three studies supported the use of incentives; five studies supported the use of school-wide marketing and/or nutrition education curricula; four studies support the use of active choice; and eight studies support the newly revised NSLP nutrition standards. However, few of these studies examined more than one factor at a time or controlled to relevant confounding factors identified in the framework. Thus, despite the existence of consistent evidence for several factors identified in the framework, future research should employ stronger research designs to systematically isolate these factors from other, potentially confounding factors and to determine if they are robust to other influences occurring simultaneously.

The research design of studies examining factors related to consumption of fruits and vegetables at school lunch also varied significantly. Most studies included in this review did not utilize cluster randomized controlled designs and also recruited a small sample of schools. A broader line of research has shown that there are unique considerations to multi-level research designs, wherein the unit of recruitment is not the individual (Murray et al, 2015). When researchers recruit individuals from groups, such as schools, the observations are no longer independent; the clustered nature of individuals within groups necessitates a statistical approach to account for the clustering. While many studies employed a correction for clustering, some studies did not; a recent systematic review showed that after correcting for
clustering, many studies become underpowered, and thus unlikely to detect an intervention effect (Delgado-Noguera et al, 2011). Similarly, studies often grouped students from diverse grades into one sample. This is problematic because four of the studies included in this review demonstrated differences in consumption of fruits and vegetables by grade, with older students consuming more fruits and vegetables.

Additionally, there were inconsistencies in the definition of fruits and vegetables applied across studies. Of the studies included in this review, 7 explicitly stated that they excluded potatoes from the analysis, whereas the rest either did not report their definition or included them. While 100% fruit juice and white potatoes are considered fruits and vegetables, respectively, by the NSLP, many researchers chose to exclude these from their quantifications of fruit and vegetable consumption or else did not specify the definition employed. While the exclusion of potatoes and 100% juice is acceptable from a public health model wherein these items are already highly consumed and less-nutrient dense, this creates problems for data analysis if not considered a priori in the design of the experiment (Graziose & Ang, 2016). This is especially true given that different fruit and vegetables are consumed at different rates and that their consumption may also be influenced by other items on the menu, such as the entrée (Ishdorj et al, 2015). A key reporting requirement for future research includes the full menu of fruit and vegetable items assessed during the experiment, so that researchers can understand the definition employed and facilitate comparisons across studies.

There are several limitations to this systematic mapping review that should be considered. First, only one investigator performed the search and data extraction. A future iteration of this systematic mapping review should employ multiple investigators and analysts to ensure that interpretations of the research and conclusions are reliable. Second, the systematic mapping review, by design, did not include an appraisal of research quality, which therefore prevented a categorization of the strength of the evidence. Given that most the studies included in the review did not utilize a cluster-randomized design, it may have been pre-emptory to employ a quality appraisal; there is a clear need for stronger research designs in this field of work. Third, the systematic mapping review used strict inclusion criteria to narrow the population of studies to those conducted in the U.S. during the period from 2004 to present. It is likely that additional evidence can be collated from studies conducted outside the U.S. and before this time,
although the intent of the review was to identify those that are potentially consistent with the updated NSLP nutritional standards and to understand factors that are potentially synergistic or constraining within the context of this program.

There are important implications for future research and practice. Researchers can utilize the categorization of environmental factors in this study to commission future systematic reviews or conduct research using gold-standard research designs (i.e., cluster-randomized controlled trials) that focus on one or more of the factors identified here. This systematic mapping review also has identified several issues that could be considered a priori in the research design, such as the sample size of schools and students, dietary assessment method used, the number of days of school lunch observation, and the definition of fruit and vegetables employed. Practitioners and policymakers who are interested in promoting fruit and vegetable consumption at school lunch can utilize the framework generated in this review. While much of the evidence is derived from cross-sectional studies, there are several factors that appear robust in their association with fruit and vegetable consumption across multiple studies in this review. Although future research is needed on all factors in this review, several may be amenable to intervention immediately within school lunch settings with potential positive effects on school lunch consumption: including the order of recess relative to lunch, the time allocated to eat lunch; slicing of fruits; serving vegetables first; the use of incentives; and the use of social marketing and/or nutrition education curricula.
CHAPTER 3: VALIDATION OF A GROUP-ADMINISTERED, PAPER-AND-PENCIL QUESTIONNAIRE TO MEASURE 2ND AND 3RD GRADE STUDENTS FRUIT AND VEGETABLE CONSUMPTION AT SCHOOL LUNCH

3.1 INTRODUCTION

Despite the well-established health benefits of following a dietary pattern rich in fruits and vegetables, few American children (2-19y) meet federal recommendations for their daily consumption (Krebs-Smith et al, 2010; Lorson et al, 2009). Poor dietary behaviors put children at increased risk for overweight, obesity and several associated non-communicable diseases. Given that dietary behaviors are established early in life, and track into adulthood (Kelder et al, 1994; te Velde et al, 2007), there is growing interest in early life interventions to support the consumption of fruits and vegetables and encourage positive attitudes toward them.

Schools are frequently the setting of such interventions because they offer the opportunity to reach many youth (IOM, 2012). The foods served through school meal programs, such as the National School Lunch Program (NSLP), offer an opportunity for improving dietary patterns among children. The Healthy Hunger Free Kids Act (HHFKA) has prompted schools providing federal-reimbursable meals to conform to guidelines on the amounts of fruits and vegetables served at school lunch. For example, students in grades K through 5 are to be offered at least ½ cup of fruit per day and ½ cup of vegetables per day, although, in accordance with the offer versus serve provision, they are only required to take either a fruit or vegetable component to meet the requirements of a federally reimbursable meal. The prior regulations stipulated that only 0.5 cups of fruit and/or vegetables combined be offered. This update has made the foods offered at lunch meals more consistent both between schools and between students, given that schools must serve both a fruit and a vegetable on every day.

Notwithstanding the greater consistency in meals offered between schools, evaluating the effectiveness of school-based programs to promote healthy eating remains a challenge. Parents are frequently tasked with reporting their children’s diet, yet they are unable to report on what their children ate in the school setting (Livingstone and Robson, 2000). Several methods have been used in the school lunch setting to overcome this challenge. For example, direct observations, weighed-plate waste, and
digital photographs of school lunch trays are widely used methods, although they are labor-intensive and require highly-trained research staff (Kenney et al, 2015), which may not be appropriate for large-scale epidemiological studies.

Dietary assessment methods relying on self-report appear useful in the school setting, however, there is concern about the reporting error inherent in self-reported dietary data (Subar et al, 2016). Self-reporting methods require several concurrent and linked cognitive processes that span how information is attended to, perceived, organized, retained, retrieved, and formulated into a response (Baranowski & Domel, 1994). Given their stage of cognitive development, children of a very young age (under 8 years) are not considered to be accurate and reliable reporters of dietary intake, especially across longer retention periods (Livingstone and Robson, 2000; Baranowski & Domel, 1994).

Despite this general assumption, there is a growing body of evidence examining the use of self-report methods among children that has produced several insights into how, and under which conditions, children accurately report their dietary intake. A string of research examining the use of the 24-hour recall (either administered orally or written) have identified factors that can be modified to produce greater accuracy in children’s’ recalls (Sharman et al, 2015). For example, several modifiable factors associated with interviewer-assessed recall of diet may reduce the inaccuracy rate among children, such as minimizing the retention interval between consumption and reporting, using meal-specific prompts, and using prompts regarding hedonic preferences. Thus, despite calls for the use of more objective measurement methods to measure diet (Dhurandhar et al, 2015), there is a need to continue to optimize self-report methods for use among young children.

To date, there are only a few existing group-administered, paper-and-pencil questionnaire instruments to measure consumption of fruits and vegetables at school lunch among lower elementary school students, which are advantageous in that they can be used in lieu of costly objective measurement methods. In addition, by administering the instrument in a group setting such as a classroom, it allows several students to complete the instrument at the same time as compared students completing them individually, potentially resulting in a greater number of observations collected in the same time. One previously validated instrument -- the School Lunch Recall Questionnaire (Paxton et al, 2011) -- is employed immediately following school lunch to minimize the memory retention period and includes items
regarding children’s preference of items served, both of which have been shown to improve accuracy (Baxter et al., 2002; Baxter et al., 2015). A previous validation study found that this instrument has modest accuracy in quantifying the consumption of school lunch meal components as compared to direct observations among 3rd to 5th graders in a summer school setting. However, little is known about the accuracy of this instrument specific for fruits and vegetables and for use among a younger population of students. There is a growing interest in intervening within the early years of life, given that repeated exposure, social modelling and sensory experiences during this time have unique implications for acceptance of and preference for fruit and vegetables (Mennella, 2006). The paucity of self-report instruments for measuring fruit and vegetable consumption at school lunch may be an impediment to researchers who are looking to evaluate the effect of interventions during this critical time. Thus, the objective of this study was to validate a group-administered paper-and-pencil questionnaire for assessing fruit and vegetable consumption during school lunch among 2nd grade within urban elementary schools participating in the NSLP.

### 3.2 METHODS

**Overview**

This validation study was conducted in 5 Phases. The questionnaire was modified prior to each phase, based on qualitative (e.g. research staff perceptions of what worked well and what didn’t) and quantitative results, with the goal of obtaining a level of validity consistent with or greater than that of previous literature (using the study by Paxton et al [2011] as the criterion). All data for this validation study were collected between May 2015 and June 2016.

**Participants**

In Phases 1 through 4, participants were 2nd grade students from three New York City public elementary schools. These schools were a convenience sample chosen based on their proximity to research staff, prior working relationships with the research center, and current participation in the NSLP. All second grade students present on the day of data collection were eligible to participate, unless parents
opted to have their children not participate, and provided written assent in the classroom prior to data collection. School information obtained from rosters and the New York City Department of Education are displayed in Table 3.1. All three schools followed a similar lunch service procedure, including the use of stand-alone salad bar that is offered after the point-of-purchase and is not counted as part of the federally reimbursable meal. Menu items served on the days of data collection were similar across schools, with only one vegetable item and 1 to 3 fruit items served.

In Phase 5, participants were 2nd and 3rd grade students from 20 schools participating in the FoodCorps program. These schools were selected to participate in a study to assess the relationship between the school environment and students’ fruit and vegetable consumption, but were included in this validation study to examine the validity of the questionnaire across different sociodemographic and school lunch service contexts. The 20 FoodCorps schools were selected to display a range of food environments supportive of healthy eating, based on the school’s score on the Healthy Schools Progress Report, an instrument developed for the parent study (the full development of the instrument is described in Koch et al, 2017). School information obtained from rosters and the 2013-14 National Center for Education Statistics Common Core of Data are displayed in Table 3.1, including free/reduced price lunch eligibility and ethnicity. The school food service procedure was different in each school, but all schools adhered to the NSLP nutritional requirements for this age group. Given that salad bars were not used in a similar fashion across all these schools included in this Phase, the Questionnaire asked about each fruit and vegetable item separately and did not use the “salad bar” section of the questionnaire (further described below).

Procedure

The data collection process was similar across all phases of the validation study. The research staff included up to 8 graduate-level students in nutrition and/or adult volunteers who participated in a 1-hr training on the day of data collection. Before lunch, research staff visited 2nd and 3rd grade classrooms and students were each given a unique identifying code, written on both a wristband and sticker (attached to the student’s back), which was used to match digital photos and questionnaires. All students were briefed on the study protocol and assented to participating in this study (unless their parent had opted
them out of the study via a letter sent home prior to the day of data collection). No individual sociodemographic information was collected during this study.

Digital photographs

A digital photography protocol as the criterion method for this validation study, adapted from Swanson et al (2008) and Taylor et al (2014). Prior to students arriving in the cafeteria, research staff set up photo stations and participated in a 1-hour training on the data collection protocol. Four digital cameras (Cyber-shot DSC-W800, Sony Corp., USA) were attached to a 13-inch tripod affixed at a 60-degree angle on a folding table in the cafeteria. The table with cameras was placed directly after the serving line to capture before-meal photos. As the students left the lunch line in the cafeteria, the sticker was removed from the back of the student and placed on the lunch tray. Lunch trays were placed in a marked area on the table and the photographer conducted a visual inspection of the tray to assure all foods, as well as the sticker with the code number, were fully visible before taking the photo. The table was moved nearer to the tray disposal area once all students had exited the line to capture post-meal photos; each photo was taken once the student completed their meal, but before discarding their tray. To capture fruits and vegetables brought from home, one member of the research staff circulated the lunchroom with a camera to obtain photos at the lunch table. (Due to staff and logistical constraints, foods from home were not assessed during Phases 1 and 3. Furthermore, across all Phases, the amounts consumed of foods from home were not verifiable given that foods were often packed away in lunch boxes and not consistently present in both before- and after-meal photographs).

Fruit and Vegetable Recall Questionnaire (FVRQ)

The Fruit and Vegetable Recall Questionnaire (FVRQ), a group-administered paper-and-pencil questionnaire, was adapted from the School Lunch Recall Questionnaire (described in Paxton et al, 2011). The first version of the FVRQ was developed by five members of the research staff who are experts in nutrition assessment and was designed to assess the fruit and vegetable items consumed during the lunch period from any source (the school lunch, the salad bar, and home). For up to 4 fruit items and 4 vegetable items served via the NSLP on the day of administration, the FVRQ asks students:
(1) Did you have [insert menu item] on your tray? “Yes” or “No” (2) How much of [insert menu item] did you eat? (3) How much did you like [insert menu item]? (4) Would you eat [insert menu item] next time at school lunch? “Yes,” “Maybe,” “No.” For salad bar, the FVRQ asked students: (1) Did you have any food from the salad bar on your tray? “Yes” or “No” (2) How much of the salad did you eat? (3) How much did you like the salad? (4) Would you eat the salad next time at school lunch? Fruits and vegetables brought from home were captured by the FVRQ through 4 additional questions: (1) Did you bring any fruit from home? “Yes” or “No” (2) How much of the fruit from home did you eat? (3) Did you bring any vegetables from home? “Yes” or “No” (4) How much of the vegetables from home did you eat? The response options for the items assessing amounts consumed were modified across each Phase of this validation study. In this study, the “How much did you like it?” and “would you eat it again?” questions served as the preference and intention items, respectively.

Following a standardized protocol, research staff administered the FVRQ in all 2nd and 3rd grade classrooms directly following lunch or recess (not more than 30 minutes following the meal). Students used the unique code from the wristband to identify themselves on the questionnaire. Staff administering the questionnaire guided students through each question, and had the students fill in the food options served for lunch on that day.

Data analysis

Digital photos were exported onto a desktop computer, renamed, and matched using the unique code number from sticker affixed to the tray visible in the photograph. In Phases 1-4, one member of the research staff reviewed each photo for food items present and, by comparing the before-meal and after-meal photos, amounts consumed using a four- or five-point Likert-analog scale, consistent with that of the questionnaire used on the day of data collection. Every tenth photo, as well as any photo in which there were uncertainties (i.e. missing or occluded food items), was reviewed by a team of three researchers who came to a consensus on the coding scheme for that photo. All reviewers were blinded to the students’ response options on the questionnaire. In Phase 5, photos were reviewed by a team of 6 members of the research staff for items present and amounts consumed using a 0% to 100% scale in 10% increments. Similarly, a majority consensus process was used for any photos in which there were
uncertainties. Inter-rater reliability was assessed throughout the coding process; percent agreement for items on tray averaged 99.5% amounts consumed averaged 82.9%. To match the questionnaire responses, this scale was collapsed such that 0% = none, 10-40% = a little, 50-90% = half to most, and 100% = all.

Student’s questionnaire responses and before- and/or after-meal lunch tray photographs were matched using the unique identification code to create “sets”. To answer the research question regarding the accuracy of the questionnaire relative to digital photographs, all analyses were conducted by item, and not by individual student. For the questionnaire item assessing items on tray, all sets for which a questionnaire with a before-meal photo could be matched were included (cases with only an after-meal photo were excluded). For the questionnaire item assessing items amount eaten, sets in which the questionnaire could be matched with a both a before- and after-meal photograph were included.

A match-intrusion-omission protocol was used to categorize the accuracy of the FVRQ as compared to the digital photographs (Baranowski et al, 2002; Paxton et al, 2011). If the photograph and the FVRQ agreed on the presence of a menu item on the tray, then it was deemed a “match”. If the photo showed an item present on the tray, but it was not reported on the FVRQ, it was called an “omission.” If the photograph did not show an item present on the tray but it was reported on the FVRQ it was called an “intrusion”. The total number of matches, omissions, and intrusions were tallied for each item category (fruit, vegetable, salad, home vegetable, home fruit) present.

A similar protocol was used to establish accuracy for amount eaten of each fruit or vegetable item. An item was a “match” if the questionnaire response and coder estimation from photographs agreed on the amount consumed. An item was deemed as an “overestimation” if the questionnaire response was higher than what was estimated via the digital photograph and an item was an “underestimation” if the questionnaire response was lower than what was estimated via the digital photograph.

Additional secondary analyses were conducted using data collected during Phase 5 to determine if there were any differences in reporting accuracy in amounts eaten by the service type, given that there was a mix of items from standardized (e.g. NSLP school lunch line service) and non-standardized (e.g. self-served from the salad bar to meet NSLP criteria) portions. A cup-equivalent amount eaten for each fruit and vegetable item was calculated: amounts eaten from the questionnaire were coded in 0, 0.15,
0.30 and 0.5 cup equivalents and amounts eaten from the digital photograph were calculated as the portion served on tray (in cup equivalents) judged via visual estimation multiplied by the amount eaten (between 0 and 100%, in 10% increments). This assumes that a standard portion size for fruit and vegetable options at school lunch based on the NSLP requirements for K-5th grade students: 1 NSLP serving of fruit or vegetables is ~0.5 cups. Amount consumed for self-served items were judged relative to the portion visible in the before-meal photograph; however, given that administration of the survey in the “real world” would not necessary allow for an estimate of the amount self-served, a similar assumption was used in coding the questionnaire responses (i.e., 0, 0.15, 0.30 and 0.5 cup equivalents). To determine if there are differences in the estimates obtained for these two service types, the intra-class correlation coefficient and Pearson correlation coefficient were calculated as indicators of accuracy comparing the amounts eaten from the questionnaire and the digital photographs. Correlation coefficients were classified as excellent (>0.81), good (0.61–0.80), moderate (0.41–0.60), or poor (<0.40).

Reporting accuracy for items on tray and amounts eaten were conducted separately for each of the 5 Phases in this study. Additionally, given that Phase 5 included both 2nd and 3rd grade students, an additional secondary analysis was performed to determine if there were any differences in reporting accuracy by grade, through a chi-square analysis. To understand the degree of convergence of the items on questionnaire, inter-item correlations were calculated between the amount eaten, preference and intention items using Pearson correlation coefficients. All data analyses were performed using SPSS version 23.

3.3 RESULTS

Sample

The sample of schools is described in Table 3.1. In Phase 1, questionnaires were collected from 46 students and photographs of 42 students’ lunch trays, of which n=1 were post-only and were excluded from further analysis. A total of 41 questionnaires could be matched with a before meal photo and 36 cases could be matched with both a before-and after-meal photo. In Phase 2, questionnaires were collected from 135 students and photos collected of 112 students lunch trays, of which 50 after-meal
photos were excluded because there was no before-meal photo. The 62 questionnaires could be matched with a before-meal photo; of these, 50 cases had both a before- and after-meal photo. In Phase 3, photos of 80 students lunch trays were collected. Of these, n=2 were post-only and were excluded from further analysis. Questionnaires were collected from 96 students, of which n=71 could be matched with a before-meal photo. For n=60 cases questionnaires were matched to a before- and after-meal photo. In Phase 4, photos of 66 students lunch trays were collected. Of these, n=2 were post-only and were excluded from further analysis. Questionnaires were collected from 69 students, of which n=63 could be matched with a before-meal photo and, of these, n=44 cases could be matched with both a before- and after-meal photo. In Phase 5, questionnaires were collected from a total of 1,323 students, of which n=976 could be matched to a matched set of before and after-meal photographs.

Table 3.1. School characteristics and lunch menu options for five phases of the validity study of the Fruit and Vegetable Recall Questionnaire as compared to digital photographs among 2nd and 3rd grade students in 23 public elementary schools in the U.S., 2015-2016

<table>
<thead>
<tr>
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<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
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<tbody>
<tr>
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<td>School Y *</td>
<td>School Y *</td>
<td>School Z *</td>
<td>Schools C-V †</td>
</tr>
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<td>2nd grade</td>
<td>2nd grade</td>
<td>2nd grade</td>
<td>2nd and 3rd grade</td>
</tr>
<tr>
<td>Male (%)</td>
<td>53.5%</td>
<td>49.1%</td>
<td>49.1%</td>
<td>49.5%</td>
<td>51.4%</td>
</tr>
<tr>
<td>Free/reduced</td>
<td>100.0%</td>
<td>89.4%</td>
<td>89.4%</td>
<td>49.8%</td>
<td>74.6%</td>
</tr>
<tr>
<td>price lunch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eligible (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black (%)</td>
<td>30.1%</td>
<td>0.7%</td>
<td>0.7%</td>
<td>13.2%</td>
<td>40.1%</td>
</tr>
<tr>
<td>Hispanic (%)</td>
<td>61.6%</td>
<td>96.5%</td>
<td>96.5%</td>
<td>42.2%</td>
<td>22.1%</td>
</tr>
<tr>
<td>White (%)</td>
<td>3.8%</td>
<td>2.4%</td>
<td>2.4%</td>
<td>37.9%</td>
<td>29.4%</td>
</tr>
<tr>
<td>English</td>
<td>12.4%</td>
<td>29.3%</td>
<td>29.3%</td>
<td>9.8%</td>
<td>--</td>
</tr>
<tr>
<td>language learners (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable(s)</td>
<td>Broccoli</td>
<td>Broccoli</td>
<td>Cucumbers</td>
<td>French fries</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Fruit(s)</td>
<td>Peach cup (Sunrise Growers®)</td>
<td>Peach cup (Sunrise Growers®)</td>
<td>Strawberry fruit cup (Sunrise Growers), Apple</td>
<td>Apple, banana, orange</td>
<td>Banana, pear</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For a complete list of menu items, please see Table 4.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Salad bar items

<table>
<thead>
<tr>
<th></th>
<th>Lettuce, peppers, cucumbers, carrots</th>
<th>Lettuce, peppers, cucumbers, carrots</th>
<th>Lettuce, cucumbers, carrots, broccoli</th>
<th>Lettuce, cucumbers, tomatoes, spinach</th>
<th>Carrots, lettuce, tomatoes, cucumber, peppers</th>
</tr>
</thead>
</table>

* School characteristics were obtained from New York City Department of Education for the 2015-16 school year.

† School characteristics were obtained from the National Center for Education Statistics Common Core of Data for the 2013-14 school year and means are presented for each indicator.

### Modifications to the FVRQ

Throughout the development of the FVRQ, modifications were made to the instrument based on research staff qualitative reports to improve accuracy. These changes are described in Table 3.2 and include changes to the page orientation, the font size, and response options for amount eaten, preference and salad bar items. In later Phases (4 and 5), visuals were also included on the questionnaire (e.g., icons to orient the student to each question and smiley faces to reinforce response options) and a short training activity before administering the questionnaire to orient students to the types of questions included on questionnaire.

<table>
<thead>
<tr>
<th>Instrument characteristics</th>
<th>Phase 1</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phases 4 – 5 *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>Landscape</td>
<td>Landscape</td>
<td>Landscape</td>
<td>Portrait</td>
<td>Portrait</td>
</tr>
<tr>
<td>Font size</td>
<td>12pt</td>
<td>12pt</td>
<td>12pt</td>
<td>14pt</td>
<td>14pt</td>
</tr>
<tr>
<td>Training activity</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>3 pages (1 “on tray,” 2 “amount eaten”)</td>
<td>2 pages (1 “on tray,” 1 “amount eaten”)</td>
</tr>
<tr>
<td>Fruit and vegetable options</td>
<td>Options are prefilled</td>
<td>Students write in option 5 times</td>
<td>Students write in option 1 time</td>
<td>Students write in option 1 time</td>
<td>Students write in option 1 time</td>
</tr>
<tr>
<td>Amount eaten response options</td>
<td>6 amount eaten response options: • I didn’t eat any • I tasted it • I ate a little bit • I ate half • I ate most • I ate all</td>
<td>6 amount eaten response options: • I didn’t eat any • I tasted it • I ate a little bit • I ate half • I ate most • I ate all</td>
<td>4 amount eaten response options: • None • A little • Most • All</td>
<td>4 amount eaten response options: • None • A little • Most • All</td>
<td>4 amount eaten response options: • None • A little • Most • All</td>
</tr>
</tbody>
</table>

Table 3.2. Modifications to the Fruit and Vegetable Recall Questionnaire during validation study
<table>
<thead>
<tr>
<th>Salad bar response options</th>
<th>Preference response options: • I didn’t eat any • I loved it • I liked it • I didn’t like it</th>
<th>Preference response options: • I didn’t eat any • I loved it • I liked it • I didn’t like it</th>
<th>Preference response options: • I didn’t eat any • I loved it • I liked it • I didn’t like it</th>
<th>Preference question response options: • I didn’t eat any • I didn’t like it • It was okay • I liked it Includes smiley faces following words</th>
<th>Preference question response options: • I didn’t eat any • I didn’t like it • It was okay • I liked it Includes smiley faces following words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference response options</td>
<td>Intention response options: • No • Maybe • Yes</td>
<td>Intention response options: • No • Maybe • Yes</td>
<td>Intention response options: • No • Maybe • Yes</td>
<td>Intention response options: • No • Maybe • Yes</td>
<td>Intention response options: • No • Maybe • Yes</td>
</tr>
<tr>
<td>Icons to orient students on the page (i.e., teachers call out the name of the symbol to aid students to find the place on the page)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes; 1 icon is used for each fruit and vegetable item</td>
<td>Yes; 1 icon is used for each fruit and vegetable item</td>
</tr>
</tbody>
</table>

* The same version of the instrument was used in both Phase 4 and Phase 5

**Accuracy of the FVRQ for items on tray**

The match, omission and intrusion rates for items on the tray across the five phases of the validity study are described in Table 3.3. From Phase 1 to Phase 4, the overall match rate for items present on the tray increased, from 77.4% to 81.9% to 90.6% to 91.9%. Across all days, the overall intrusion rate was greater than the omission rate. In Phase 1 the lowest match rate was observed for salad bar items and the highest match was observed for fruit. In Phase 2, the lowest match rate was observed for items from the salad bar and the highest match rate was observed for vegetables from home. In Phase 3, the lowest match rate was observed for items from the salad bar and the highest match rate was observed for...
vegetables. In Phase 4, the lowest match rate was observed for vegetables from home and the highest match was observed for vegetables. In Phase 5, across the sample of 20 schools, the match rates for both fruit and vegetables exceeded 88.3%, which was slightly lower than the previous phase. Although there were few occurrences of fruits and vegetable items from home, the reporting accuracy for these items were similarly high (92.3% for home vegetables and 85.3% for home fruit).

Table 3.3. Reporting accuracy for food items on tray in a 5 phase validation comparing sets of digital photographs and Fruit and Vegetable Recall Questionnaires among 2nd and 3rd grade students in 23 public elementary schools, 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Total items</th>
<th>Occurrences</th>
<th>Matches</th>
<th>Omissions</th>
<th>Intrusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>items</td>
<td>%</td>
<td>items</td>
<td>%</td>
</tr>
<tr>
<td>PHASE 1 (n=41 students)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>32</td>
<td>24</td>
<td>75.0</td>
<td>25</td>
<td>78.1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>42</td>
<td>7</td>
<td>16.7</td>
<td>36</td>
<td>85.7</td>
</tr>
<tr>
<td>Salad</td>
<td>41</td>
<td>8</td>
<td>19.5</td>
<td>33</td>
<td>71.7</td>
</tr>
<tr>
<td>All items</td>
<td>115</td>
<td>39</td>
<td>33.9</td>
<td>94</td>
<td>81.7</td>
</tr>
<tr>
<td>PHASE 2 (n=62 students)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>124</td>
<td>60</td>
<td>48.4</td>
<td>104</td>
<td>83.9</td>
</tr>
<tr>
<td>Vegetables</td>
<td>62</td>
<td>48</td>
<td>77.4</td>
<td>53</td>
<td>85.5</td>
</tr>
<tr>
<td>Salad</td>
<td>62</td>
<td>9</td>
<td>14.5</td>
<td>46</td>
<td>74.2</td>
</tr>
<tr>
<td>Home veggies</td>
<td>62</td>
<td>0</td>
<td>0.0</td>
<td>55</td>
<td>88.7</td>
</tr>
<tr>
<td>Home fruit</td>
<td>61</td>
<td>0</td>
<td>0.0</td>
<td>52</td>
<td>85.2</td>
</tr>
<tr>
<td>All items</td>
<td>248</td>
<td>117</td>
<td>47.7</td>
<td>203</td>
<td>81.9</td>
</tr>
<tr>
<td>PHASE 3 (n=71 students)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>212</td>
<td>69</td>
<td>32.5</td>
<td>191</td>
<td>90.1</td>
</tr>
<tr>
<td>Vegetables</td>
<td>70</td>
<td>70</td>
<td>100.0</td>
<td>68</td>
<td>97.1</td>
</tr>
<tr>
<td>Salad</td>
<td>70</td>
<td>12</td>
<td>17.1</td>
<td>60</td>
<td>85.7</td>
</tr>
<tr>
<td>All items</td>
<td>352</td>
<td>151</td>
<td>42.9</td>
<td>319</td>
<td>90.6</td>
</tr>
<tr>
<td>PHASE 4 (n=63 students)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>125</td>
<td>31</td>
<td>24.8</td>
<td>116</td>
<td>92.3</td>
</tr>
<tr>
<td>Vegetables</td>
<td>62</td>
<td>13</td>
<td>22.2</td>
<td>58</td>
<td>93.5</td>
</tr>
<tr>
<td>Salad</td>
<td>60</td>
<td>15</td>
<td>23.8</td>
<td>55</td>
<td>91.7</td>
</tr>
<tr>
<td>Home veggies</td>
<td>55</td>
<td>6</td>
<td>10.9</td>
<td>49</td>
<td>89.1</td>
</tr>
<tr>
<td>Home fruit</td>
<td>54</td>
<td>13</td>
<td>24.1</td>
<td>49</td>
<td>90.7</td>
</tr>
<tr>
<td>All items</td>
<td>356</td>
<td>78</td>
<td>21.9</td>
<td>327</td>
<td>91.9</td>
</tr>
<tr>
<td>PHASE 5 (n=976 students)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>1,909</td>
<td>836</td>
<td>43.8</td>
<td>1,686</td>
<td>88.3</td>
</tr>
</tbody>
</table>
Vegetables 2,213 783 35.4 1,974 89.2 71 3.2 168 7.6
Home veggies 918 60 6.5 847 92.3 0 0.0 71 7.7
Home fruit 934 8 0.1 797 85.3 6 0.6 131 14.0
All items 4,122 1,687 40.9 3,660 88.8 117 2.9 345 8.4

Occurrence: This is a food item that was observed in photograph
Match: This is a food item that was observed in photograph and reported on the questionnaire.
Omission: This is a food item that was observed in photograph but was not reported on the questionnaire.
Intrusion: This is a food item that was not observed in photograph but was reported on the questionnaire.

### Accuracy of the FVRQ for amounts consumed

The match, overestimation and underestimation rate for amount consumed across the five phases of the validity study are described in Table 3.4. Exact match refers to students who reported on the FVRQ the same amount eaten as was judged from the digital photographs. Generally, rates of overestimation were higher than underestimation for all items. The exact match rate was lower in Phase 1 than it was in Phases 2, 3 and 4. The exact match rates in Phase 4 were above 81.2% for all fruit and vegetable items. In Phase 5, across all 20 FoodCorps schools, the match rates for the amount consumed of fruits was 73.4% and the amounts consumed for vegetables was 78.1%, which were both lower than in the previous phase.

### Table 3.4. Reporting accuracy for amounts eaten of food items in a 5 phase validation study comparing sets of digital photographs and Fruit and Vegetable Recall Questionnaires among 2nd and 3rd grade students in 23 public elementary schools, 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Total items</th>
<th>Occurrences</th>
<th>Exact match</th>
<th>Overestimation of amount eaten</th>
<th>Underestimation of amount eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>items</td>
<td>%</td>
<td>items</td>
<td>items</td>
</tr>
<tr>
<td><strong>PHASE 1 (n=36 students)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>36</td>
<td>10</td>
<td>27.8</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Vegetables</td>
<td>35</td>
<td>3</td>
<td>8.6</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td>Salad</td>
<td>36</td>
<td>6</td>
<td>16.7</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>All items</td>
<td>107</td>
<td>19</td>
<td>17.8</td>
<td>73</td>
<td>30</td>
</tr>
<tr>
<td><strong>PHASE 2 (n=50 students)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td>82</td>
<td>20</td>
<td>24.4</td>
<td>53</td>
<td>24</td>
</tr>
<tr>
<td>Vegetables</td>
<td>50</td>
<td>4</td>
<td>8.0</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Salad</td>
<td>49</td>
<td>2</td>
<td>4.1</td>
<td>36</td>
<td>13</td>
</tr>
<tr>
<td>All items</td>
<td>181</td>
<td>26</td>
<td>14.4</td>
<td>121</td>
<td>53</td>
</tr>
</tbody>
</table>
Using data from Phase 5, in which both 2\textsuperscript{nd} and 3\textsuperscript{rd} grade students participated, there were no immediate differences in the match rate for fruit or vegetable items on tray for 2\textsuperscript{nd} (fruit match=85.7%;
vegetable match=88.6%) versus 3\textsuperscript{rd} grade (fruit match=88.9%; vegetable match=85.6%) students (Table 3.5. and Table 3.6.). The chi-square values for items on tray among 2\textsuperscript{nd} versus 3\textsuperscript{rd} graders were 4.719 (p=0.094) for fruit and 4.223 (p=0.121) for vegetables. There were also no apparent differences in the match rates for amounts eaten for 2\textsuperscript{nd} (fruit match=69.2%; vegetable match=74.0%) versus 3\textsuperscript{rd} grade (fruit match=72.8%; vegetable match=75.9%) students. Chi-square values for items consumed among 2\textsuperscript{nd} versus 3\textsuperscript{rd} graders were 7.648 (p=0.265) for fruit and 5.274 (p=0.509) for vegetables. As in previous Phases, intrusion rates were higher when reporting items on tray and overestimation rates were higher when reporting amounts eaten of fruit and vegetable items, but there were no apparent differences by grade in the rates of either.

Table 3.5. Results comparing 2\textsuperscript{nd} vs. 3\textsuperscript{rd} grade students in accuracy of fruit and vegetables on tray
in the Fruit and Vegetable Recall Questionnaire as compared to digital photographs among students in 20 public elementary schools, 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Total Items</th>
<th>Occurrences</th>
<th>Match</th>
<th>Omission</th>
<th>Intrusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Items</td>
<td>%</td>
<td>Items</td>
<td>%</td>
<td>Items</td>
</tr>
<tr>
<td>2nd Grade - Fruit</td>
<td>868</td>
<td>373</td>
<td>43.0</td>
<td>744</td>
<td>29</td>
</tr>
<tr>
<td>3rd Grade - Fruit</td>
<td>586</td>
<td>273</td>
<td>46.6</td>
<td>521</td>
<td>10</td>
</tr>
<tr>
<td>2nd Grade - Vegetables</td>
<td>952</td>
<td>359</td>
<td>37.7</td>
<td>843</td>
<td>31</td>
</tr>
<tr>
<td>3rd Grade - Vegetables</td>
<td>717</td>
<td>312</td>
<td>43.5</td>
<td>616</td>
<td>37</td>
</tr>
</tbody>
</table>

**Match:** This is a food item that was observed in photograph and reported on the questionnaire.

**Omission:** This is a food item that was observed in photograph but was not reported on the questionnaire.

**Intrusion:** This is a food item that was not observed in photograph but was reported on the questionnaire.

Table 3.6. Results comparing 2nd vs. 3rd grade students in accuracy of fruit and vegetables amounts eaten in the Fruit and Vegetable Recall Questionnaire as compared to digital photographs among students in 20 public elementary schools, 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Total Items</th>
<th>Occurrences</th>
<th>Match</th>
<th>Overestimation</th>
<th>Underestimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Items</td>
<td>%</td>
<td>Items</td>
<td>%</td>
<td>Items</td>
</tr>
<tr>
<td>2nd Grade - Fruit</td>
<td>819</td>
<td>242</td>
<td>29.5</td>
<td>567</td>
<td>219</td>
</tr>
<tr>
<td>3rd Grade - Fruit</td>
<td>540</td>
<td>169</td>
<td>31.3</td>
<td>393</td>
<td>120</td>
</tr>
<tr>
<td>2nd Grade - Vegetables</td>
<td>947</td>
<td>235</td>
<td>24.8</td>
<td>701</td>
<td>183</td>
</tr>
<tr>
<td>3rd Grade - Vegetables</td>
<td>702</td>
<td>189</td>
<td>26.9</td>
<td>533</td>
<td>118</td>
</tr>
</tbody>
</table>

**Occurrence:** This is a food item that was observed eaten in photograph.

**Match:** This is a food item that was observed eaten in photograph and reported eaten on the questionnaire.

**Overestimation:** This is a food item that was reported on the questionnaire to be consumed in an amount greater than what was observed in the photograph.

**Underestimation:** This is a food item that was reported on the questionnaire to be consumed in an amount less than what was observed in the photograph.

**Self-serve versus standardized portion estimations**

When a portion size was used to estimate amounts consumed in Phase 5 by service type (standardized vs. self-serve), there were no differences in the estimates of cup equivalents consumed by service type (Table 3.7.). There was good agreement (ICC > 0.61) across both fruit and vegetable items from both sources (standardized and self-serve sources), although there were fewer items obtained from self-serve sources. For fruit, the estimates of amounts eaten of items in standardized portions had good
agreement between methods (ICC=0.605) and the estimates of amounts eaten of items in self-serve 
portions also had good agreement between methods (ICC=0.611). For vegetables, the estimates of 
amounts eaten of items in standardized portions had good agreement between methods (ICC=0.635) and 
the estimates of amounts eaten of items in self-serve portions also had good agreement between 
methods (ICC=0.649). The Pearson correlation coefficient for all items types and service types was above 
0.64. This portion size quantification was useful regardless of the source of item.

Table 3.7. Comparison amounts eaten of standard and self-serve portions of fruit and vegetable 
between questionnaires and digital photographs of 972 school lunch trays observed among 2nd 
and 3rd grade students from 20 schools

<table>
<thead>
<tr>
<th></th>
<th>Amount Eaten (cup equivalents) *</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Items</td>
<td>ICC</td>
<td>Pearson r</td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Standardized†</td>
<td>1490</td>
<td>0.605</td>
<td>0.642</td>
</tr>
<tr>
<td>• Self-Serve†</td>
<td>320</td>
<td>0.611</td>
<td>0.740</td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Standardized†</td>
<td>1662</td>
<td>0.635</td>
<td>0.652</td>
</tr>
<tr>
<td>• Self-Serve†</td>
<td>526</td>
<td>0.649</td>
<td>0.764</td>
</tr>
</tbody>
</table>

*Amounts eaten from the questionnaire were coded in 0, 0.15, 0.30 and 0.5 cup equivalents; Amounts 
eaten from the digital photograph were calculated as the portion served on tray (in cup equivalents) 
judged via visual estimation multiplied by the amount eaten (between 0 and 100%, in 10% increments) 
† Standardized portions were served via the lunch line by adult paraprofessionals or food service workers 
using measurement utensils. In contrast, self-serve portions were those taken by students at a salad bar 
on their own volition and direction without a mechanism to ensure that portions were consistent.

Inter-item correlations

Inter-item Pearson correlations were conducted to assess the item structure and construct validity 
(Table 3.8). There were high inter-item correlations on student responses to the amount eaten, 
preference and intention items for both fruit and vegetable items. The correlation between amount eaten 
and preference was high for fruit (r=0.893) and vegetables (r=0.912). The correlations between 
preference and intention was 0.503 for fruit and 0.574 for vegetables and the correlations between 
intention and amount eaten was 0.484 for fruit and 0.555 for vegetables.

Table 3.8. Inter-item correlations for responses from 2nd and 3rd grade students on the Fruit and
**Vegetable Recall Questionnaire**

<table>
<thead>
<tr>
<th></th>
<th>Amount Eaten</th>
<th>Preference</th>
<th>Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pearson r</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fruit (n=1,810 items)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Amount Eaten</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>• Preference</td>
<td>0.893 **</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>• Intention</td>
<td>0.484 **</td>
<td>0.503 **</td>
<td>1</td>
</tr>
<tr>
<td><strong>Vegetables (n=2,188 items)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Amount Eaten</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>• Preference</td>
<td>0.912 **</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>• Intention</td>
<td>0.555 **</td>
<td>0.574 **</td>
<td>1</td>
</tr>
</tbody>
</table>

**P<0.001**

Amount eaten response options: None (0), A little (1), Most (2), All (3)
Preference response options: I didn’t eat any (0), I didn’t like it (1), It was okay (2), I liked it (3)
Intention response options: No (0), Maybe (1), Yes (2)

### 3.4. DISCUSSION

This validation study suggests that the Fruit and Vegetable Recall Questionnaire meets the needs for a simple and accurate evaluation instrument for use in schools participating in the NSLP. Across five phases of the validation study conducted among 2nd and 3rd grade students from 23 schools, in which the Questionnaire was systematically modified to improve accuracy, we observed high match rates for fruit and vegetable items on tray and amounts consumed: The instrument, in its final form, is feasible and efficient to implement, low-cost, and valid for capturing children’s fruit and vegetable intake at school lunch.

Overall, the match rate observed throughout each phase of our validation study rivals that observed during validation studies of similar instruments. For example, the validation study of the School Lunch Recall Questionnaire (Paxton et al, 2011) found an overall match rate of 84% for all items served at school lunch. Although the match rate observed in the final phase of this study was higher, there are three important differences. First, direct observations of school lunch intake were used as the reference method in the original validation study, whereas digital photography was used in the present study. A previous validation study found the digital photography method accurate relative to weighed plate waste, with only a slight improvement in accuracy when digital photography method is combined with direct
observations. Second, the study sample in the original validation of the School Lunch Recall included 3rd through 5th grade students, which contrasts with the sample of 2nd and 3rd grade students in this study. This was purposeful to create an instrument that was valid with younger students as they were the focus of the main FoodCorps evaluation study. Third, the original validation study reported the match rate for all items served at school lunch (entrée, beverage, sides) and used a subjective statistical weighting technique to place more importance on errors in reporting the main entrée relative to sides or drinks. This study intentionally focused only on fruits and vegetables, which is a focus for evaluating farm to school programs. For these three reasons, the results of this study are not directly comparable to those of Paxton et al (2011).

Another validation study has explored the accuracy of the Day in the Life Questionnaire for use in elementary school-age children. Wallen et al (2011) compared the questionnaire to weighed plate waste in school cafeterias among 4th and 5th graders and observed match rates of 87% and 88% for fruit and vegetables, respectively. Regarding amount eaten, the Day in The Life Questionnaire had low agreement with the plate waste measure for fruits (58%) and vegetables (47%) using the same four-point scale as used in the FVRQ. As above, there are important differences in the research design which makes our studies not directly comparable, including the use of a different referent method (weighed plate waste) and different study population.

The FVRQ is accurate to measure students’ intakes of fruits and vegetables at school lunch as compared to digital photography given the high match rates for fruits and vegetable items observed in this validation study. To our knowledge this is the first questionnaire to directly assess fruit and vegetable items and bought from home. Although this study did not able to assess the accuracy of the Questionnaire for measuring amounts consumed of fruits and vegetables from home, this portion of the questionnaire can be used to determine if any items have been brought, given the match rates observed in earlier phases of the study. Because so few fruit and vegetable items were brought from home in the final phase of this study, it is useful to have an accurate measure to assess this outcome. Similarly, this study demonstrated that there were no apparent differences in the reporting accuracy when items were served in self-served or standardized portions. This is useful given that within the current NSLP guidelines, there is no requirement for how fruit and vegetable items ought to be served other than they
are both offered to students and that they at least meet the portion size requirements defined for each (3/4 cup for vegetables and ½ for fruit). Children can self-serve as much or as little as they want, especially when schools utilize a self-serve salad bar. Thus, given this study did not demonstrate any major differences when estimating the amounts consumed in cup equivalent amounts according to self-serve or standardized portions, it is likely that the FVRQ instrument can be used across diverse school lunch service settings.

Additionally, this one of the first studies to examine self-report methods for measuring fruit and vegetable consumption at school lunch among children as young as 2nd grade. There are two previous studies that have examined self-report methods for school lunch which had been conducted among 3rd grade students (Paxton et al, 2011) and 4th grade students (Wallen et al, 2011). Previous researchers have questioned the abilities of young children to accurately report their consumption given their stage of cognitive development. Several aspects of this Questionnaire were modified to help guide students through the process and to improve accuracy. For example, the number of times students were to write in the name of the fruit or vegetable item was reduced from four to only one, which decreased the amount of time taken for each question. Pictures were also added in multiple places on the questionnaire to help orient students, including shapes to identify each fruit and vegetable item and smiley faces for the question regarding preference for fruit and vegetable items. While there is certainly still room for improvement, the results of this validation study provide support for the accuracy of using this self-report method with children of this age.

The questionnaire also can be used to assess theory-based psychosocial constructs related to fruit and vegetable consumption among elementary students. This study observed that student responses on preference and intention items were significantly and positively correlated with their responses on consumption of fruit and vegetable items, which demonstrates a form of construct validity (Chatterji & Lin, 2016). A previous systematic review concludes that preference for fruits and vegetables as well as behavioral intention to consume fruit and vegetable items are associated with consumption of these foods in children (Rasmussen et al, 2011). Preference and behavioral intention are constructs of existing behavioral theories and have supporting evidence for their role as mediating variables in behavioral nutrition education interventions (Contento, 2016; Townsend & Kaiser, 2005). Using Pearson correlation
coefficient cut-offs consistent with previous research (Gray et al., 2016), the correlations observed in this study between preference and consumption were classified as excellent (>0.81) and those observed for preference and intention were classified as moderate (0.41–0.60). Thus, the questionnaire appears valid for measuring these constructs, given the inter-item correlations in directions consistent with existing behavioral theories.

Most studies examining fruit and vegetable consumption at school lunch have employed objective measures, such as weighed plate waste, digital photography, or direct observations. Self-report methods are hypothesized to be of lower cost than objective methods for measuring fruit and vegetable consumption at school lunch. The group-administered questionnaire method utilized for the FVRQ allows many observations to be collected in a short time frame (all administrations of the FVRQ were <30 minutes in length). By way of comparison, the study by Kenney et al. (2015) assessed the costs associated with weighed plate waste, direct observation and digital photography, observing costs of $0.92, $0.62 and $0.62 per observation, respectively. While this study did not empirically measure the costs of administering this questionnaire, it is possible that the cost of this method is equal or less than the cost of the methods examined in Kenney et al. (2015) due to the need for fewer raw materials (i.e., only the paper needed for printing the questionnaires) and the shorter time for administration.

There are several limitations to this study. The first is in the chosen sample of schools. In the first 4 Phases of the validation study, the participating schools may only be representative of similar urban elementary schools with a majority of students who qualify for free/reduced price lunch and/or a racial/ethnic minority. In the last Phase of the validation study, the participating schools were more diverse in race, ethnicity and income levels, but were part of a larger evaluation of the FoodCorps program, and thus are likely generalizable to schools interested in or currently participating in a national farm-to-school program. Although, importantly, using this sample, the study demonstrated there were no differences in reporting accuracy for amounts consumed by service type (whether schools utilized standardized portions or allowed students to self-serve). Second, while this validation study affirms that accuracy of the instrument to measure fruit and vegetable consumption among 2nd and 3rd grade students, it does not empirically measure the sensitivity of the instrument to detect change. Wallen et al. (2011) tested the sensitivity of the DILQ-Co instrument by comparing students’ responses from schools
participating or not in the FFVP, which provides an additional serving of fruits and vegetables in schools. Future research should examine the sensitivity of the FVRQ instrument prior to use within a program evaluation.

This validation study has important implications for researchers measuring fruit and vegetable consumption at school lunch. This study suggests that use of this paper-and-pencil questionnaire is acceptable in lieu of the resource-intensive digital photography method and can be used in diverse school lunch service settings, such as those that employ a self-serve salad bar. In addition, this study demonstrates that student responses on questionnaire for fruit and vegetable consumption are associated with constructs such as preference and intention in a degree and direction consistent with existing theory. Therefore, the FVRQ provides researchers with a low-cost instrument, applicable in diverse school lunch service settings, which is accurate relative to the digital photography method.
CHAPTER 4: INTRACLASS CORRELATION COEFFICIENTS OF 2\textsuperscript{ND} AND 3\textsuperscript{RD} GRADE STUDENTS
CONSUMPTION OF FRUITS AND VEGETABLES AT SCHOOL LUNCH

4.1. INTRODUCTION

Randomized controlled trials are considered the gold standard for evaluating the relative effectiveness of a treatment or intervention. In individually-randomized controlled trials, the interventions are implemented at the individual-level, for example, as a medication, supplement, or diet delivered to an individual. However, some interventions may be best implemented at the group-level, where the unit of implementation is dependent on groupings of individuals, such as an intervention delivered by teachers to students in classrooms or a salad bar placed within a cafeteria and available to all students. In such instances, a cluster-randomized design, a type of randomized controlled trial, may be used to allocate clusters, or groups of individuals, to a treatment or intervention and all members of the cluster receive the intervention. Clusters may be hospitals, schools, clinics or neighborhoods.

Cluster-randomized trials require special considerations for the research design and analysis of data. The primary challenge that arises from the use of cluster-randomized trials is the potential for clustering among individuals, wherein individuals within a group are more similar than those between groups (George et al, 2016). This similarity leads to an increase in the standard error of the treatment effect because individuals have not been randomly selected from the general population and observations are therefore not independent, an assumption required for most statistical tests. The greater level of similarly observed among individuals within groups effectively reduces the sample size of the trial, creating a reduction in the power to detect a treatment effect (increase the chance of a Type II error). Failure to account for clustering and the use of inappropriate statistical methods to account for potential school level clustering effects has been identified in previous trials (George et al, 2016; Delgado-Noguera et al, 2011).

Investigators planning to conduct a cluster-randomized trial will therefore have an improved design if they have an estimate of variation within each study group compared to variation across the entire sample, given the potential effect this has on the power of the study. The intra-class correlation coefficient (ICC) is an indicator of the degree of clustering within groups of individuals which, when known
during the design of a study, can be used to justify an appropriate sample size that accounts for the clustering effects (Resnicow et al, 2010). Moreover, prior knowledge of the covariates that are related to ICC can help to reduce the effect that within school clustering has on the analysis when included within models examining the outcome of interest (Murray and Blitstein, 2003).

School-based studies often rely on cluster-randomized designs, given the logistical constraints associated with randomly assigning individual students to treatment. However, schools are not immune from the potential clustering effects in outcome variables of interest; high levels of clustering have been identified among students in schools for several outcomes including academic achievement (Hedges and Hedberg, 2007), smoking (Resnicow, 2010), physical activity (Murray, 2006) and obesity (Richmond & Subramanian, 2008). There is a growing evidence base suggesting that adjustment for school and neighborhood contextual factors may reduce clustering effects observed in behaviors between schools (Sellstrom & Bremerg, 2006; Gray et al, 2015; Graziose et al, 2016), which can be used a priori in the design of such studies.

Several studies have examined school-level clustering effects on children’s total daily consumption of fruit and vegetables. Murray et al (2001) observed an ICC of 0.03 for fruit and vegetable consumption as measured by a six item scale derived from the BRFSS among a sample of 7th grade students participating in the TEENS study. In a study of Danish 11-year old children across 59 schools, Krolner et al (2009) estimate an ICC of 0.06 for vegetable consumption and an ICC of 0.02 for fruit consumption as measured via one day’s 24-hour recall. The ICCs were further reduced when accounting for as covariates the school availability of fruits, vegetables and unhealthy competitive foods and students’ gender. Rovner et al (2011) compared the fit of two models examining fruit and vegetable consumption among 6th to 8th graders from 152 schools and found that adjustment for access to vending machines and school-level poverty reduced the between-school variation. The study by Gray et al (2015) reports the ICCs in food-frequency type questionnaire items assessing fruit and vegetables consumption at school lunch, with estimates of 0.017 and 0.020 for fruit consumption and vegetable consumption at school lunch, respectively, which increased slightly with the adjustment for school-level covariates such as free/reduced price lunch and ethnicity. The increase in ICC is potentially due to misspecification in the model, and thus an indication that covariates are not contributing to additional reductions in the between-
However, there are few reports of the degree of clustering observed between schools in students' consumption of fruits and vegetables specifically at the lunch meal. Adams et al (2005; 2015) estimate that the ICC of students’ consumption of fruit and vegetable items to be 0.03 among first through fifth grade students from four elementary schools in California measured via weighed plate waste. Hoffman et al (2010) estimated an ICC of 0.09 for consumption of fruit and 0.11 for consumption of vegetables among K through 1st grade students from 4 schools in the Northeastern U.S. measured via plate waste. However, the samples under study in Adams et al (2005) and Hoffman et al (2010) are small and relatively homogenous and thus the clustering observed in these samples may not be representative of those across different states and across school with varying levels of poverty. Both estimates were obtained within a small sample of schools (4 each), which limits the generalizability of these findings. Moreover, in the time since these studies were published, policy changes to the NSLP have resulted in greater standardization in the nutritional content of meals offered to students in schools participating in the NSLP; therefore, no ICC estimates exist for the time following the implementation of stricter school lunch nutrition standards.

Furthermore, there is a range of outcome indicators reported in school-based interventions designed to increase fruit and vegetable consumption at school lunch. Previous studies have assessed: the proportion of students selecting a fruit and/or vegetable; the amount of fruit and/or vegetable eaten among only students selecting these items; or the amount of fruit and/or vegetable eaten among all students in the school. This study is agnostic with respect to the most appropriate outcome indicator for use in an evaluation, but instead presents ICC estimates for all the outcomes observed in the literature to inform the power calculations and design of interventions for one or more of these outcomes.

The objective of this study is to provide estimates of the ICC of 2nd and 3rd grade students consumption of fruits and vegetables and items on tray from 20 schools across 8 states in the U.S. participating in a national farm to school program and to examine changes in the ICC after adjusting for observable school-level covariates. The reporting framework for ICCs as developed in Campbell et al (2004) was followed, which includes: 1) a description of the dataset and outcomes of interest, 2) information on the software and method of calculation of the ICC, and 3) an estimate of the precision of
the ICC via a confidence interval.

4.2 METHODS

**Study Design**

This is a cross-sectional study conducted within 20 elementary schools participating in the FoodCorps program during the 2015-16 school year. Briefly, FoodCorps is a national service organization that places service members in schools to conduct farm-to-school activities such as nutrition education and experiential learning opportunities with the goal of increasing students' consumption of fruits and vegetables.

**School selection**

In consultation with FoodCorps evaluation staff, a sample of schools was selected to be representative of the population of all FoodCorps schools. A stratified sampling methodology was used in which the stratification is based on the use of a prospective propensity score matching technique (Tipton, 2013; Tipton, 2013) and, simultaneously, a power calculation to determine an adequate sample size; these methods are further described in the subsequent sections.

**Stratification technique**

To select a sample representative of the inference population, a stratified sampling methodology was used in which the stratification is based on the use of a prospective propensity score matching technique (Tipton, 2013; Tipton, 2013). The strata are defined using observable covariates believed to explain the treatment effect, which was informed by previous work within 20 New York City public elementary schools (Gray et al., 2015) and existing literature: locale (city, suburb, town, or rural), total school enrollment, percent minority students, percent of students eligible for free and reduced price lunch. These data were obtained from the National Center for Educational Statistics for the 2013-14 school year.

An additional covariate used for the stratification technique was the Healthy School Progress Report, an instrument used to measure the frequency and intensity of farm-to-school activities occurring
within a school which are theorized to influence consumption of fruits and vegetables among children. The full development and validation of the instrument is described in Koch et al., 2017. Briefly, the Healthy School Progress Report collects general school information, assesses activities across FoodCorps’ four areas of service (Hands-on Learning – Knowledge, Hands-on Learning – Engagement, Healthy School Meals and Schoolwide Culture of Health), and has two additional sections on Staying Power (the degree to which activities are institutionalized) and Policy (classroom, school, local, and state policies that support healthy eating). The Hands On Learning – Knowledge, Hands-on Learning – Engagement, Healthy School Meals and Schoolwide Culture of Health sections are each scored on a 0-25 scale with a higher score representing farm-to-school activities more frequently and intensely implemented (the Staying Power and Policy sections are not scored). During the 2015-2016 school year, FoodCorps service members were asked to complete the Healthy School Progress Report for each school in which they serve. In November of 2015, FoodCorps service members completed the Healthy School Progress Report for 313 schools. FoodCorps schools with 2nd or 3rd grade students (n=144) served as the inference population for the parent study. The school’s score on the Healthy Schools Progress Report (from 0-100) was used within our stratified sample selection. The final sample was to be 8 schools from the highest quintile of scores, 4 from the middle, and 8 from the lowest (the middle two quintiles were excluded from participating).

**Power calculation**

An a priori power analysis was conducted for the parent study evaluating the effectiveness of the FoodCorps programming with fruit and vegetable consumption at school lunch as the primary outcome using Optimal Design Software Version 3.01. Given that schools are the cluster or sampling unit from which students are recruited, the evaluation of the intervention effect will therefore require the use of a hierarchical model. The following estimates were used for the power calculation: the minimum detectable effect size (MDES); the intra-class correlation (ICC); and the number of schools (m) and number of students within each school. Assuming moderate ICCs for consumption of fruit (0.069) and vegetables (0.154) [obtained from a previous study of 14 elementary schools in New York City], a sample of 100 students from 20 schools was deemed appropriate to attain 80% power to detect an effect size of 0.37 for
fruit and 0.48 for vegetables. For comparison, Sharps and Robinson (2015) reported a 0.37 effect size in a trial of elementary school students investigating the effect of perceived norms/behavioral modeling wherein the intervention group consumed 57.72g (SD=39.02g) of vegetable relative to the control which consumed 29.00g (SD=31.80g), a difference of about 29g.

Participants

The participant flow for this study is described in Figure 4.1. A total of 26 schools were invited to participate in the current study and 6 declined to participate. When a school declined to participate, another school with similar demographics was invited until a final sample of 20 schools was achieved. All second and third students in these schools were eligible to participate in this study; based on school rosters, there were a total of 2,424 second and third students enrolled in these schools during the 2015-16 school year. Due to logistical constraints, research staff visited up to 6 classrooms in each school on each day of data collection. In schools were there were more than six second and third grade classrooms (n=7), 6 classrooms were randomly selected to participate on the first day of data collection and the remaining classrooms were purposeful sampled on the second day. (In one school, there was one remaining classroom that was not sampled over the course of the two days.)

Prior to data collection, parents received a consent form, which allowed them to opt their child out of the study; across both days, 38 students parents’ opted them out of the study. Students present on the days of data collection whose parents did not choose to opt them out of the study and who provided written assent were included in this study. Missing data was the result of student absenteeism from the classroom during the assent and/or absenteeism from the cafeteria during the data collection. All data were collected anonymously and without any individual sociodemographic information such as gender, age, race, or ethnicity.

Figure 4.1. Flow diagram for school and student recruitment in a study using digital photography to examine fruit and vegetable consumption among 2\textsuperscript{nd} and 3\textsuperscript{rd} grade students from 20 schools participating in the National School Lunch Program and the FoodCorps farm-to-school program
* The “Progress Report” is a school environmental assessment tool designed to measure the degree to which the environment is supportive of consuming fruits and vegetables (scored from 0-100) which was the subject of the main study, an evaluation of the FoodCorps farm to school program, during which the digital photography data were collected.
Fruit and vegetable consumption at school lunch

Consumption of meal components during lunch was assessed on two consecutive days among second and third grade students from each school using a digital photography method using a protocol informed by previous authors (Taylor et al., 2014; Swanson et al., 2008; Bontrager-Yoder et al., 2014). The dates of data collection were chosen in consultation with school staff, but no consideration was given to the lunch menu for that day prior to data collection. For consistency, one of two senior members of the research staff was present at each of the schools to oversee data collection.

Research staff set up photography stations in the cafeteria before the lunch period. Up to four digital cameras (Cyber-shot DSC-W800, Sony Corp., USA) attached to a tripod affixed at a 60-degree angle on folding tables were used to collect photographs. A station with three cameras on tripods was placed directly following the serving line to capture pre-photos. Students’ school lunch trays were placed in a marked area on the table to take the photos. The photographer conducted a visual inspection of the tray to assure all foods, as well as the label with the unique code, were fully visible before taking the photo, and used a marker and/or rubber band to denote the contents consumed from opaque food containers (such as bags of chips, milk containers, etc.). The photo station was moved near the tray disposal area once all students had exited the line to capture post-meal photos. This protocol was adapted for one school in which meals were served family-style by students at individual tables by using digital cameras at tables without the tripod. To capture fruits and vegetables selected from stand-alone salad bars in the cafeteria, research staff stood directly next to the salad bar and/or circulated the lunchroom with a camera to collect photos at the lunch table of these items.

Digital photographs of student’s lunch trays were imported to a computer and renamed using the unique code number from the sticker on the tray to facilitate side-by-side comparison of photos. Six coders (trained, undergraduate-level students in nutrition) first visually assessed the portion sizes of food items available on the lunch tray in the pre-photo, which was supplemented by portion size information obtained on the day of data collection from food service directors and cafeteria staff, school menus and/or nutrition facts panel labeling, and uneaten reference images of meal components and packaging. The USDA Standard Reference Nutrient Database was used for consistency in estimations of standard portion sizes (in cup equivalents) for fruits and vegetables. Coders conducted a side-by-side comparison
of pre- and post-meal photographs to determine amount consumed, assuming that amounts that had disappeared from the photos were consumed. Coders rated amount consumed in 10% increments (e.g. 0%, 10%, 20%, etc.), and items or packaging completely missing from the photographs were treated as missing data. The portion size on the tray in the pre-photo was multiplied by the percentage consumed to determine the absolute amount consumed. Outcome measures were portions of foods served and consumption of school meal components (in cup equivalents), categorized according to the NSLP meal components definitions for fruits (including juice) and vegetables (excluding white potatoes). The full list of items included as fruits and vegetables in this study is in Table 4.1.

Table 4.1. Frequency of fruits and vegetable items offered across 40 days of observation of 2nd and 3rd grade school lunch trays from 20 schools participating in the FoodCorps farm to school program in the United States, 2015-16

<table>
<thead>
<tr>
<th>Fruit Type</th>
<th>Description of subtypes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>whole, sliced, applesauce</td>
<td>24</td>
</tr>
<tr>
<td>Juice (100%)</td>
<td>apple, orange, grape, fruit punch</td>
<td>23</td>
</tr>
<tr>
<td>Orange</td>
<td>whole, sliced</td>
<td>17</td>
</tr>
<tr>
<td>Banana</td>
<td>whole</td>
<td>10</td>
</tr>
<tr>
<td>Peaches</td>
<td>whole, sliced, canned</td>
<td>6</td>
</tr>
<tr>
<td>Dried fruit</td>
<td>raisins, crasins</td>
<td>5</td>
</tr>
<tr>
<td>Mixed fruit salad</td>
<td>canned, fresh</td>
<td>5</td>
</tr>
<tr>
<td>Pears</td>
<td>whole, sliced, canned</td>
<td>4</td>
</tr>
<tr>
<td>Pineapple</td>
<td>canned</td>
<td>4</td>
</tr>
<tr>
<td>Watermelon</td>
<td>wedge</td>
<td>4</td>
</tr>
<tr>
<td>Strawberries</td>
<td>sliced, canned</td>
<td>2</td>
</tr>
<tr>
<td>Kiwi</td>
<td>sliced</td>
<td>2</td>
</tr>
<tr>
<td>Grapes</td>
<td>whole</td>
<td>2</td>
</tr>
<tr>
<td>Mixed berries</td>
<td>strawberries &amp; blueberries</td>
<td>1</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>sliced</td>
<td>1</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>sliced</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetable Type</th>
<th>Description of subtypes</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce, raw</td>
<td>romaine, spinach, iceberg</td>
<td>25</td>
</tr>
<tr>
<td>Carrots</td>
<td>baby, sliced, cooked</td>
<td>23</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>cherry, sliced, tomato sauce</td>
<td>19</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>sliced</td>
<td>15</td>
</tr>
<tr>
<td>Celery</td>
<td>strips</td>
<td>14</td>
</tr>
<tr>
<td>Broccoli</td>
<td>raw, cooked</td>
<td>12</td>
</tr>
<tr>
<td>Beans</td>
<td>kidney, chickpeas, hummus</td>
<td>11</td>
</tr>
<tr>
<td>Corn</td>
<td>corn</td>
<td>9</td>
</tr>
<tr>
<td>Peppers</td>
<td>sliced</td>
<td>7</td>
</tr>
<tr>
<td>Radishes</td>
<td>whole, sliced</td>
<td>6</td>
</tr>
<tr>
<td>Green beans</td>
<td>cooked</td>
<td>6</td>
</tr>
<tr>
<td>Pickles</td>
<td>sliced</td>
<td>4</td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>fries, mashed</td>
<td>3</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>sliced</td>
<td>2</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>raw</td>
<td>2</td>
</tr>
<tr>
<td>Mixed veggies</td>
<td>peas &amp; carrots</td>
<td>3</td>
</tr>
<tr>
<td>Spinach</td>
<td>cooked</td>
<td>2</td>
</tr>
<tr>
<td>Coleslaw</td>
<td>prepared</td>
<td>2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>cooked</td>
<td>1</td>
</tr>
<tr>
<td>Collard greens</td>
<td>cooked</td>
<td>1</td>
</tr>
<tr>
<td>Pea pods</td>
<td>raw</td>
<td>1</td>
</tr>
<tr>
<td>Onions</td>
<td>sliced</td>
<td>1</td>
</tr>
<tr>
<td>Eggplant</td>
<td>roasted</td>
<td>1</td>
</tr>
<tr>
<td>Juice (100%)</td>
<td>vegetable</td>
<td>1</td>
</tr>
<tr>
<td>Sunflower</td>
<td>roasted</td>
<td>1</td>
</tr>
</tbody>
</table>
Inter-rater reliability (IRR) was assessed prior to and during data analysis (Table 4.2). First, each coder participated in a 3-hour training and coded 12 photos and IRR was assessed by overlapping with the lead author, reaching a match rate of 100% for identifying items present on the tray and 92% for amount eaten in adjacent categories across all food categories. Throughout coding, photographs from each day of data collection were assigned to one coder, in a counter balanced order, and IRR was assessed by having two coders and the lead author overlap on 5 photos from each day of data collection (200 photos total). IRR was calculated as percent agreement between raters for the same school and averaged across schools. The average IRR for the entire sample was a 99.5% exact match rate for identifying items present on the tray and a 82.9% exact match (and 95.8% adjacent match rate) for amounts eaten across all food categories. In addition, any questions on photographs were reviewed by a quorum of at least 3 other coders and the lead author, and a majority consensus was reached.

Table 4.2. Percent agreement between 6 independent coders of digital photographs of 2nd and 3rd grade students’ lunch trays from 20 schools in the United States, 2015-16

<table>
<thead>
<tr>
<th>School</th>
<th>Food on Tray</th>
<th>Amount Eaten – Exact</th>
<th>Amount Eaten – Adjacent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
<td>100.0</td>
<td>77.1</td>
<td>92.0</td>
</tr>
<tr>
<td>C</td>
<td>97.3</td>
<td>78.8</td>
<td>92.8</td>
</tr>
<tr>
<td>D</td>
<td>100.0</td>
<td>85.3</td>
<td>94.5</td>
</tr>
<tr>
<td>E</td>
<td>98.8</td>
<td>77.0</td>
<td>95.5</td>
</tr>
<tr>
<td>F</td>
<td>100.0</td>
<td>89.5</td>
<td>99.0</td>
</tr>
<tr>
<td>G</td>
<td>100.0</td>
<td>89.5</td>
<td>97.3</td>
</tr>
<tr>
<td>H</td>
<td>99.5</td>
<td>86.5</td>
<td>94.8</td>
</tr>
<tr>
<td>I</td>
<td>100.0</td>
<td>91.0</td>
<td>97.3</td>
</tr>
<tr>
<td>J</td>
<td>100.0</td>
<td>93.3</td>
<td>98.0</td>
</tr>
<tr>
<td>K</td>
<td>100.0</td>
<td>69.8</td>
<td>92.0</td>
</tr>
<tr>
<td>L</td>
<td>100.0</td>
<td>84.5</td>
<td>93.0</td>
</tr>
<tr>
<td>M</td>
<td>97.5</td>
<td>83.0</td>
<td>96.5</td>
</tr>
<tr>
<td>N</td>
<td>100.0</td>
<td>69.8</td>
<td>90.5</td>
</tr>
<tr>
<td>O</td>
<td>100.0</td>
<td>93.8</td>
<td>99.3</td>
</tr>
<tr>
<td>P</td>
<td>99.0</td>
<td>74.5</td>
<td>90.8</td>
</tr>
<tr>
<td>Q</td>
<td>98.5</td>
<td>78.3</td>
<td>96.5</td>
</tr>
<tr>
<td>R</td>
<td>100.0</td>
<td>70.0</td>
<td>95.5</td>
</tr>
</tbody>
</table>
Table 1. Summary Statistics

<table>
<thead>
<tr>
<th></th>
<th>S</th>
<th>T</th>
<th>U</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100.0</td>
<td>99.3</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>80.3</td>
<td>90.5</td>
<td>100.0</td>
<td>79.0</td>
</tr>
<tr>
<td>Mean</td>
<td>99.5</td>
<td>82.9</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* Protocol for calculating IRR was adapted from Baglio et al (2004). Exact matches for amount eaten refer to direct agreement between two raters on a scale from 0 – 100% (in ten percent increments). Adjacent matches for amount eaten refer to agreement within an adjacent category between two raters on a scale from 0 – 100% (in ten percent increments).

School-level demographic variables

School level covariates for use in this study were collected via two sources: the National Center for Education Statistics and on-site observational data collected during the study. The National Center for Education Statistics Common Core of Data 2013-14 provided school-level information regarding the ethnic makeup of the student body (percent White, Black, Hispanic, Asian, other). In addition, the percentage of free/reduced price students was collected from each school for the 2015-16 school year based on conversations with school administrators.

School-level environmental factors

School-level environmental factors believed to explain between-school variation were used for this study. All school-level factors were collected by direct observation of study staff during data collection when fruit and vegetable consumption was measured. A standard observation form was used which assessed: the number of fruit and vegetable items served, the types of items served, the time allocated for lunch, the time of day, and whether recess was scheduled before lunch. The number of fruit and vegetable items offered to students during the lunch period which was assessed on the day of data collection. Research staff denoted all fruit and vegetable items offered via the school lunch service line and via the salad bar on an observational sheet. The final variable is a count of all fruit and vegetable items offered to students. The presence of a school lunch salad bar was also denoted by research staff using a standardized observational sheet. A salad bar was operationalized as any apparatus for the service of fruit and or vegetable items that allows students to self-select both the types and portions these items. (This is as opposed to fruit and vegetable items served to students on the lunch line where portions are standardized). All salad bars were counted regardless of whether they were placed before or after the
point of purchase and regardless of if the items were counted toward the federally reimbursable school meal. Salad bars were also included if they were stand-alone or if they connected to the hot lunch meal service line. The school’s score on the Healthy School Progress Report was also used in this study. The FoodCorps Healthy School Progress Report was based on a score of 1–100. The Hands On Learning – Knowledge, Hands-on Learning – Engagement, Healthy School Meals and Schoolwide Culture of Health sections are each scored on a 0-25 scale with a higher score representing farm-to-school activities more frequently and intensely implemented.

Data analysis

For each outcome of interest, descriptive statistics are calculated for each school participating in the study. Given that the indicators of fruit and/or vegetable portion on tray and amount consumed were skewed right (there were a large portion of students that did not have fruit or vegetable on their tray or did not eat them), a square-root transformation was performed to normalize the distribution.

Four models were fitted for each outcome. The first model was an empty model, without any covariates, and was used to calculate the ICC with the following formula (Snijders & Bosker, 2013):

$$\frac{\tau^2}{\sigma^2 + \tau^2}$$

Where, \(\tau^2\) is the variance observed between schools and \(\sigma^2\) is the variance observed within schools.

Three subsequent models were fitted using school-level covariates. Model 1 was a demographic only model which included covariates obtained from the Common Core of Data and included the percent of students in the school eligible for free/reduced price lunch, the percent of white students. Model 2 included school-level environmental data collected through on-site observations and included, in addition to the demographic variables (% white and % free/reduced price eligible), whether a salad bar was available to students (binary), the number of fruit and vegetable items offered during the school lunch meal. Model 3 included all the covariates from Model 2 with the addition of the school’s score on the Healthy Schools Progress Report Hands-On Learning - Knowledge section (0-25). Covariates chosen for these models were informed by prior literature and through iterative model fitting. Covariates were each evaluated individually for model fit and then combined in a full model if their inclusion contributed to
explaining between-school variation. Additional covariates that did not account for significant between-
school variation include: male (%), black (%), Hispanic (%), Asian (%), time of eating (early morning, mid-
morning or afternoon), length of lunch period (min) offering potatoes, offering juice, time allocated for
eating lunch, time of day for lunch, recess order relative to eating, and the overall score on the Healthy
School Progress Report and three sub-sections (Hands-On Learning – Engagement, Healthy School
Meals, and Schoolwide Culture of Health). The change in ICC was the primary indicator of model fit. To
calculate the change in ICC, the following formula was used (ICC for Model 1 or 2 – ICC for the Empty
Model/ ICC for the Empty Model). In addition, a 95% confidence interval was calculated for each ICC
estimate to provide an upper and lower bound for the estimate. All data analyses were performed using R
Software (R Core Team, 2013).

4.3 RESULTS

The twenty schools participating in this evaluation, recruited from the sample of FoodCorps
schools in the U.S., display average sociodemographic roughly equivalent to the population of elementary
schools (Grades K to 5) in the U.S. eligible for Title I funding. Using Common Core of Data 2013-14, the
population of elementary schools in the U.S. eligible for Title I funding (n=42,492) has an average of 451
(SD=229) students, 63% (SD=26%) of whom are eligible for free/reduced price lunch, 48% (SD=35%) of
whom are white, 17% (SD=26%) of whom are Black, and 27% (SD=31%) of whom are Hispanic. This
sample of FoodCorps schools, on average, has a lower proportion of white students (29%) and a higher
percent of Black students (40%) and free/reduced price lunch eligible students (77%).

A total of 2,571 before- and after-meal digital photographs were collected of students’ lunch trays
across 40 days of data collection within 20 schools. This represented an average of 121 observations per
school included in the study, and ranged from 48 to 227. Descriptive statistics for the student-day lunch
tray observations (n=2571) are presented in Table 4.3. These observations were obtained from 2nd and
3rd graders at a roughly equivalent rate (52.9% vs. 41.4%, respectively; 5.7% of the sample was
indistinguishable by grade owing to mixed classrooms). These observations were also collected equally
across both days of data collection at each school (49.0% and 51.0%). Additionally, a majority of the
observations were collected from students in schools that offered recess after lunch (73.0%) and in schools that offered salad bar (60.3%).

Table 4.3. Characteristics of students, trays, and schools participating in a study measuring fruit and vegetable consumption among 2nd and 3rd grade students from schools enrolled in the FoodCorps farm-to-school program in the United States, 2015-16

<table>
<thead>
<tr>
<th>Student-day lunch tray observations (n=2,571)</th>
<th>n, %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade</strong></td>
<td></td>
</tr>
<tr>
<td>• 2nd grade</td>
<td>1360 52.9</td>
</tr>
<tr>
<td>• 3rd grade</td>
<td>1065 41.4</td>
</tr>
<tr>
<td>• Indistinguishable</td>
<td>146 5.7</td>
</tr>
<tr>
<td><strong>Day of data collection</strong></td>
<td></td>
</tr>
<tr>
<td>• Day 1</td>
<td>1259 49.0</td>
</tr>
<tr>
<td>• Day 2</td>
<td>1312 51.0</td>
</tr>
<tr>
<td><strong>Recess structure</strong></td>
<td></td>
</tr>
<tr>
<td>• Recess before lunch</td>
<td>695 27.0</td>
</tr>
<tr>
<td>• Recess after lunch</td>
<td>1876 73.0</td>
</tr>
<tr>
<td><strong>Salad bar access</strong></td>
<td></td>
</tr>
<tr>
<td>• No salad bar</td>
<td>606 23.6</td>
</tr>
<tr>
<td>• Salad bar</td>
<td>1550 60.3</td>
</tr>
</tbody>
</table>

**Schools (n=20)**

<table>
<thead>
<tr>
<th>Gender*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Male (%)</td>
<td>51.4 43 - 57</td>
</tr>
<tr>
<td>Ethnicity*</td>
<td></td>
</tr>
<tr>
<td>• White (%)</td>
<td>29.4 0 - 98</td>
</tr>
<tr>
<td>• Black (%)</td>
<td>40.1 0 - 90</td>
</tr>
<tr>
<td>• Hispanic (%)</td>
<td>22.1 0 - 76</td>
</tr>
<tr>
<td>• Asian (%)</td>
<td>3.5 0 - 36</td>
</tr>
<tr>
<td>• Other (%)</td>
<td>4.3 0 - 16</td>
</tr>
<tr>
<td>Total enrollment*</td>
<td>384 87 - 635</td>
</tr>
<tr>
<td>Free/reduced price lunch eligible (%)†</td>
<td>76.5 32 - 100</td>
</tr>
<tr>
<td>Prior years of participating in FoodCorps</td>
<td>2.2 1 - 4</td>
</tr>
<tr>
<td>Time for lunch (min)</td>
<td>27.9 21 - 39</td>
</tr>
<tr>
<td>Fruit and vegetable items offered</td>
<td>7.4 3 - 14</td>
</tr>
<tr>
<td>Healthy School Progress Report score</td>
<td>55 24 - 97</td>
</tr>
<tr>
<td>• Hands On Learning – Knowledge</td>
<td>17 5 - 25</td>
</tr>
<tr>
<td>• Hands-on Learning – Engagement</td>
<td>12 0 - 25</td>
</tr>
<tr>
<td>• Healthy School Meals</td>
<td>13 3 - 24</td>
</tr>
<tr>
<td>• Schoolwide Culture of Health</td>
<td>13 6 - 23</td>
</tr>
</tbody>
</table>

**Urbanicity * |  |
| • City | 13 65.0 |
• Suburb 1 5.0
• Town 1 5.0
• Rural 5 25.0

State *
• New York 4 20.0
• New Jersey 2 10.0
• Connecticut 4 20.0
• Mississippi 2 10.0
• Montana 2 10.0
• Iowa 2 10.0
• D.C. 2 10.0
• Maine 2 10.0

*Data were obtained from the National Center for Education Statistics Common Core of Data 2013-14
† Free/reduced price lunch eligibility was obtained for the school year during which data were collected (2015-16) by contacting school staff

On average, across all observations, 82.5% of student trays had a fruit item and 63.5% had a vegetable item (Table 4.4). Overall, 96.0% of trays had either a fruit or a vegetable. Among those who had a fruit or vegetable item on the tray, there were on average 0.96 cup equivalents (SD=0.49) present on the tray. For fruit, there were on average 0.61 cup equivalents (SD=0.29) and for vegetables, there were on average 0.64 cup equivalents (SD=0.34) for those who had either a fruit or vegetable item on their tray, respectively. Across students who had either a fruit or vegetable item on their tray, respectively, 82.5% and 68.8% ate any of the item. The average consumption of fruit and vegetable items was 0.35 cup equivalents (SD=0.31) and 0.24 cup equivalents (SD=0.29), respectively, among students who had them on their tray. Together, among students with a fruit or vegetable item on their tray, the average consumption of fruits and vegetables was 0.45 cup equivalents (SD=0.40).

Table 4.4. Fruit and vegetable consumption outcome indicators in a study of 2nd and 3rd grade students school lunch trays (n=2,571) from 20 schools in the U.S.

<table>
<thead>
<tr>
<th></th>
<th>On tray</th>
<th>On tray, cup equivalents, among selecting</th>
<th>Eat any, among selecting</th>
<th>Eaten, cup equivalents, among selecting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Mean (SD)</td>
<td>%</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Fruit</td>
<td>82.5</td>
<td>0.61 (0.29)</td>
<td>82.5</td>
<td>0.35 (0.31)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>63.5</td>
<td>0.64 (0.34)</td>
<td>68.8</td>
<td>0.24 (0.29)</td>
</tr>
<tr>
<td>Fruit and vegetables</td>
<td>96.0</td>
<td>0.96 (0.49)</td>
<td>84.2</td>
<td>0.45 (0.40)</td>
</tr>
</tbody>
</table>
The observed intra-class correlation coefficients for fruit and vegetable outcome variables are displayed in Table 4.5. In the empty model, the observed ICCs for all fruit and vegetable consumption outcomes ranged from 0.159 (vegetables on tray, continuous) to 0.472 (vegetables on tray, binary). Within each of food item category (fruit, vegetables or fruit and vegetables combined), the highest ICC was observed for items on tray (binary).

Model 1, which controlled for the percent of students in the school eligible for free/reduced price lunch and the percent of white students, was shown to decrease the ICC for each fruit and vegetable outcome variable except fruit on tray (binary). These covariates reduced the ICC in fruit eaten (continuous) by 47%, in vegetable eaten (continuous) by 35%, and in fruit and vegetables combined by 49%. However, it was associated with slight increases in the ICC for fruit on tray (binary) [+4%]. Model 2, which accounted for the percent free/reduced price lunch eligible students, percent white students, presence of a salad bar, number of fruit and vegetable items offered, was associated with decreases in the ICC relative to the empty model in most outcomes. The model reduced ICC in fruit eaten (binary), fruit and vegetables on tray (binary), fruit and vegetables eaten (binary) and fruit and vegetables eaten (continuous). Model 3 contributed to further reductions in all combined fruit and vegetable on tray and consumption outcomes over the empty model and over Models 1 and 2, with a 53% reduction in the ICC for combined fruit and vegetable consumption (cup equivalents).

Table 4.5. Intraclass correlation coefficients for selected indicators of fruit and vegetable consumption measured using digital photography among 2nd and 3rd grade students' school lunch trays from 20 schools in the United States, 2015-16

<table>
<thead>
<tr>
<th></th>
<th>Empty Model (95% CI)</th>
<th>Model 1§</th>
<th>Model 2§</th>
<th>Model 3§</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICC</td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td>ICC</td>
</tr>
<tr>
<td><em><em>Fruit outcomes</em>,†</em>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On tray (binary)</td>
<td>0.140</td>
<td>0.055</td>
<td>0.224</td>
<td>0.145</td>
</tr>
<tr>
<td>On tray (cup equivalents)</td>
<td>0.298</td>
<td>0.151</td>
<td>0.446</td>
<td>0.245</td>
</tr>
<tr>
<td>Eaten (binary)</td>
<td>0.094</td>
<td>0.029</td>
<td>0.159</td>
<td>0.065</td>
</tr>
<tr>
<td>Eaten (cup equivalents)</td>
<td>0.171</td>
<td>0.068</td>
<td>0.275</td>
<td>0.090</td>
</tr>
<tr>
<td>*<em>Vegetable outcomes</em>,†**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On tray (binary)</td>
<td>0.246</td>
<td>0.118</td>
<td>0.374</td>
<td>0.217</td>
</tr>
<tr>
<td>On tray (cup equivalents)</td>
<td>0.181</td>
<td>0.069</td>
<td>0.293</td>
<td>0.077</td>
</tr>
<tr>
<td>Eaten (binary)</td>
<td>0.254</td>
<td>0.113</td>
<td>0.394</td>
<td>0.156</td>
</tr>
<tr>
<td>Fruit and vegetable outcomes*</td>
<td>0.293</td>
<td>0.140</td>
<td>0.446</td>
<td>0.190</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Eaten (cup equivalents)</td>
<td>0.120</td>
<td>0.045</td>
<td>0.194</td>
<td>0.112</td>
</tr>
<tr>
<td>On tray (binary)</td>
<td>0.268</td>
<td>0.132</td>
<td>0.404</td>
<td>0.018</td>
</tr>
<tr>
<td>On tray (cup equivalents)</td>
<td>0.093</td>
<td>0.031</td>
<td>0.155</td>
<td>0.051</td>
</tr>
<tr>
<td>Eaten (binary)</td>
<td>0.205</td>
<td>0.090</td>
<td>0.320</td>
<td>0.105</td>
</tr>
</tbody>
</table>

* Vegetables exclude all white potatoes; Fruit includes 100% juice
† On Tray and Eaten indicators are calculated among students who selected these items
§ Model 1 includes percent white and percent free/reduced price lunch eligible. Model 2 controls for the following school-level covariates: white (%), free/reduced price lunch eligible (%), number of fruit and vegetable items available, and for vegetables, the presence of a self-serve salad bar. Model 3 controls for the following school-level covariates: white (%), free/reduced price lunch eligible (%), number of fruit and vegetable items available, and for vegetables, the presence of a self-serve salad bar, and the Healthy Schools Progress Report Hands on Learning – Knowledge score
\( \Delta \) is the percent change in ICC from the empty model, calculated using the following formula: (ICC for Model 1 or 2 or 3 – ICC for the Empty Model) / ICC for the Empty Model

4.4 DISCUSSION

The objective of this study was to estimate the degree of school-level clustering observed in fruit and vegetable consumption outcomes among 2nd and 3rd grade students from schools participating in a multi-state farm-to-school program. The intra-class correlation estimates obtained in this study were higher than two comparable studies among elementary school-aged children in the U.S. (Adams et al, 2005; Hoffman et al, 2010). In those two studies, the observed ICC of students’ consumption of fruit and vegetable items at school ranged from 0.03 to 0.11. The baseline ICCs observed in this study for fruit and vegetable consumption outcomes were all roughly twice as high as these estimates. The cause of the high ICC observed in this study as compared to previous estimates deserves further explanation. First, one potential explanatory factor is the degree of heterogeneity in the students by race, ethnicity and income across the schools participating in this study. For example, schools in the sample ranged from having students who were, on average, 0% to 98% white and 20% to 98% eligible from free/reduced price lunch. To our knowledge, this is the first study reporting the ICCs estimates in fruit and vegetable consumption outcomes at school lunch across multiple states among students participating in national farm to school program. Thus, although these estimates are high, this is level of clustering may be expected when evaluating a similar, multi-state program.

Despite this high baseline level of clustering, several school-level covariates were identified that,
when controlled for in analyses, reduced the ICC by roughly one half, although these reduced estimates were still higher than those previously observed by Adams et al (2005) and Hoffman et al (2010). The school-level covariates examined in this study include: white (%), free/reduced price lunch eligible (%). These indicators are readily available via a publically available database (the Common Core of Data) and can be used a priori to account for clustering. This is similar to a previous study by Gray et al (2015), in which the authors found that demographic variables, including white (%) and free/reduced price lunch eligible (%) were significant in explaining between-school variation among a sample of urban youth. In this study, there were several additional school-level covariates that, when adjusted for, did not considerably reduce the level of clustering in the outcomes of interest. These include: offering potatoes, offering juice, time allocated for eating lunch, time of day for lunch, and recess order relative to eating. When considered in the model, these covariates did not contribute to reductions in ICC from baseline (and in some cases contributed to increases in ICCs). The demographic only model in this study was sufficient to explain a large proportion of variation, however, there is still a significant amount of between-school left unexplained by covariates, which may be accounted for by other policy-related variables not measured in this study.

Levels of clustering this large greatly increase the potential for errors in cluster-randomized controlled trials. For example, in a cluster-randomized controlled trial of a school-based smoking prevention program in South Africa, Resnicow et al (2010) found that the use of smaller ICCs for the a priori power calculation potentially caused a Type II error in their outcome evaluation. The authors used ICC estimates of 0.002-0.004 in their power calculation but, when baseline data were collected, they found that actual ICCs ranged from 0.087-0.217 in smoking-related outcomes, which effectively reduced their sample size by a factor of 17. Thus, failing to consider the potential for clustering leads to the potential for underpowered trials, and potentially a waste of resources.

The practical application of these ICC estimates can be demonstrated through a mock power calculation. For example, suppose a researcher was interested in designing a cluster-randomized trial with the primary outcome of vegetable consumption in a continuous cup-equivalent measurement obtained via digital photography. A power calculation can be conducted using Optimal Design Software: with the ICC estimate obtained in this study for this outcome (rho=0.293), a sample of 100 schools with
100 students per schools would be required to achieve 80% to detect an effect size of 0.3 in a cluster randomized trial. In contrast, if the ICC were reduced by about half (rho=0.150), a sample of 60 schools with 100 students per schools would achieve the sample level of power for a 0.3 effect size (See Figure 4.2). Therefore, the importance of understanding the ICC cannot be overstated; as the failure to account for potentially high levels of clustering may result in severely underpowered cluster randomized controlled trials. Controlling for the factors that are likely to drive clustering, such as those identified in this study, may be one strategy to reduce the potential effect on the standard error and therefore the likelihood of underpowered designs.

Figure 4.2. Effect size as a function of the number of clusters participating in a cluster randomized controlled trial at two levels of clustering
However, researchers should use caution in interpreting the ICCs for binary outcomes. As explained in detail by Snijders and Bosker (2012) and O’Connell & McCoach (2008), the ICC calculation for binary (dichotomous) outcome variables are closely related to the sample average for that outcome. Several approaches to overcoming these challenges have been described, for example in Schochet (2013). Given these limitations, however, the ICCs for the binary outcomes of fruit and vegetable selection and consumption reported in this paper should be interpreted in the context of the average proportions for these variables. For example, it was noted that 64%, 83%, and 96% of students in our sample had a vegetable, fruit and fruit or vegetable on their tray. Thus, because the ICCs reported for these binary outcomes are closely tied to these proportions, they should not be used to generalize in the case of schools wherein the proportions are much different. Furthermore, Schochet (2013) recommends
that cluster-randomized designs only utilize primary outcomes that are dichotomous if the expected impact of the intervention on proportions are large and the ICCs in these outcomes are relatively small.

There are several strengths to this study that should be considered. First, a digital photography method to assess fruit and vegetable consumption at school lunch. This method is widely used in the school lunch dietary assessment literature and has shown good accuracy relative to direct observations in previous validation studies (Hanks et al, 2014). Second, the large, diverse sample of students is advantageous to this study to identify cross-cutting factors that explain the variation in fruit and vegetable consumption outcomes between these schools. However, this study is not without limitations. While the schools involved in this study were diverse and from multiple states, they were all participating in the FoodCorps program. Although this program is relatively unstructured, in that service members could implement a host of activities but are not required to implement any specific ones, there is the potential that there are systematic program-related factors that are contributing to the high ICCs. In addition, one assumption of this study is that there are no systematic measurement errors in the outcome of interest that would bias the ICC estimates arising from the use of the digital photography method. Because a consistent training protocol was used in each school for all data collection staff as well as a systematic protocol for coding the digital photographs and evaluating IRR, the potential for systematic measurement error is small.

Considering the increasing frequency with which interventions designed to promote fruit and vegetable consumption at school lunch are implemented, researchers and evaluators can greatly benefit from published estimates of the potential ICCs observed between schools. The power calculations for cluster randomized controlled trial informed by these data will ensure that researchers have adequately powered their studies and may prevent the underpowered designs (for example, Gatto et al, 2015). While these estimates are useful, they are not the final answer to the question of clustering in fruit and vegetable consumption outcomes. Because there is difficulty in finding ICC estimates that are directly applicable to potential trials, there is a need for more frequent reporting of these estimates. This study provides a basis for comparison for future estimates, an impetus for continued reporting of the ICC estimates and an invitation for researchers to engage in more transparent discussion of study design considerations before, during and after the interventions are conducted.
CHAPTER 5: ENVIRONMENTAL FACTORS ASSOCIATED WITH CONSUMPTION OF FRUITS AND VEGETABLES AT SCHOOL LUNCH AMONG 2ND AND 3RD GRADE STUDENTS

5.1 INTRODUCTION

In the U.S, few children meet federal recommendations for the daily consumption of fruits and vegetables (Krebs-Smith et al, 2010). Schools are frequently the setting of interventions that encourage the consumption of these healthful meal components and previous school-based intervention studies have demonstrated moderate increases in students' consumption of fruits and vegetables (Sobol-Goldberg et al, 2013). Recent policy changes contained in the 2010 Healthy Hunger Free Kids Act (HHFKA) imposed nutrition standards on federally-reimbursable school meals served via the NSLP. These rules require that schools increase the availability of fruit, vegetables, whole grains, and fat-free or low-fat fluid milk in school lunch meals served to students. Recent studies have found that the updated nutrition standards required by the HHFKA have been implemented successfully across most U.S. schools (Fox & Condon, 2012) and have resulted in greater availability of these healthful meal components (Merlo et al, 2015). And, although there is limited evidence of how these regulations have influenced fruit and vegetable consumption, the preliminary reports among elementary school students have been positive (Cullen et al, 2016).

However, several aspects of the school cafeteria environment that are not presently regulated via the NSLP (henceforth, unregulated factors) could moderate the effect of policies and interventions on student's consumption patterns and thus overall diet quality (Prescott et al, 2015). Because they are unregulated, there is the potential that these factors vary across schools and therefore should be accounted for in the design and analysis of intervention studies or else risk confounding effects on intervention outcomes of interest. Additionally, there is growing scientific interest in understanding elements of the cafeteria environment as a de facto intervention to increase students’ consumption of school lunch meal components. The growing evidence base around these factors could be used to inform future interventions and regulations in the school lunch setting.

Recent authors have proposed ten elements of design of school environment are present evidence that can increase consumption of healthy meal components (Huang et al, 2013). In addition,
findings from empirical studies have found that modification of the school cafeteria environment results in improved nutrition among elementary school students (Kessler et al., 2015), as well as small increases in students’ attention in the classroom following the lunch period (Golly et al., 2010). However, previous studies have generally only examined one environmental factor in isolation; the relationship between cafeteria environmental exposures and students’ consumption of school lunch meal components is likely multifactorial and complex (Gorman et al., 2007). There is a need for a more holistic view of the school lunch cafeteria environment with the realization that factors may work together to constrain or enhance students’ consumption patterns.

Thus, the present study will examine the relationship between selected environmental factors and 2nd and 3rd grade students’ consumption of fruits and vegetables. In the forthcoming sections, each environmental factor that is operationalized in the current study is introduced and the prior literature to support a relationship with consumption of fruits and/or vegetables during school lunch is summarized. The environmental factors operationalized in this study include: the noise level of the cafeteria, the time allocated for eating lunch, the recess order, and the presence of a school lunch salad bar.

5.1.1. Noise

Excessive noise is one of the most prevalent environmental exposures in the U.S., which has to date received little attention in the public health literature (Hammer et al, 2014). Children are especially vulnerable to excessive noise for several reasons: children have little agency in altering the noise levels of their environment; noise can impede necessary communications in times of acute danger; and noise can uniquely influence health and impair cognitive development among children. Although no federal safe level of noise exposure exists (Fink, 2017), the National Institute for Occupational Safety and Health uses an 85-DbA criterion for exposure over which hearing loss becomes very likely and the level at which employers must implement a noise reduction program. In addition, it is the policy of the American Academy of Pediatrics that parents, children, and adolescents avoid loud noises whenever possible to reduce noise exposure (Etzel & Balk, 2012).

There are few studies describing the prevalence of noise exposure among children. Existing data, though small in scope and generally focused on adults, suggests that large proportions of the U.S.
population exceed recommended levels of noise exposure. Hammer et al (2014) estimate that in 2013 about 104 million people (one third of U.S. population) were exposed to noise at or above 70 dBA equivalent continuous exposure per day, thus exceeding the EPA recommended limit. Among a sample of children between 6 and 18 years of age, a 1982 report found that average daily equivalent continuous exposure ranged from 77 to 84 dB, although no more recent estimates exist for this age group.

Exposure to high levels of noise in early childhood is primarily associated with auditory health effects. Noise-induced hearing loss is highly prevalent among adults in the US (Lin et al, 2011), which is caused by cumulative noise exposure throughout the lifetime. According to the WHO and EPA, exposure to >80.3 dBA for more than 160 minutes per day may be expected to produce hearing loss in some exposed individuals (Nietzel et al, 2009). Exposure to loud noises may result in tinnitus and noise-induced threshold shift, a temporary decrease in hearing sensitivity (Etzel & Balk, 2012). Using 1994 NHANES data, Niskar et al (2001) estimate that 12.5% of children between 6 and 19 years of age experienced noise-induced hearing shift. Although it is a temporary, reversible condition, noise-induced hearing shift may become permanent if the exposure persists (Etzel & Balk, 2012).

Noise also has several non-auditory health effects. In the most basic sense, noise is a perceived annoyance and likely to act as a distraction to children. In school settings, previous research has shown that external noise is likely to impair children’s cognitive development and academic achievement (Klatte et al, 2013). Noise is also related to hypertension and risk of cardiovascular disease in both children and adults via a biopsychosocial stress pathway (Hammer et al, 2014). Noise at levels greater than 70 dBA has been shown to increase vasoconstriction, heart rate and blood pressure among adults (Etzel & Balk, 2012). In a modeling study, Swinburn et al (2015) suggest that a 5-dB noise reduction would reduce the prevalence of hypertension by 1.4% and coronary heart disease by 1.8% among adults in the United States and have an economic benefit of $3.9 billion. While studies specifically focused on children in schools with high levels of noise exposure due to aircraft and cars have not demonstrated effects on specific stress biomarkers, there is a wealth of evidence linking high noise exposure to decreased cognitive function and reading comprehension (Etzel & Balk, 2012).

Importantly, noise exposures may accumulate throughout the day in different settings and from different sources – what is often termed the “noise-scape”. For example, as children travel by subway
(Neitzel et al, 2009), walk along noisy streets (McAlexander et al, 2015), use personal music devices (Etzel & Balk, 2012), and/or play with sound-producing toys (Etzel & Balk, 2012), the exposures are likely additive. An effective public health response would underscore the need for regulated noise environments to combat the multiple, additive effects of noise exposure from certain lifestyle choices throughout the course of the day (Hammer et al 2014) with the recognition that exposure to noise is not always a personal choice.

The noise level of the school cafeteria is one factor that may influence students’ consumption of meal components offered via the NSLP. Theorists have argued that noise, one aspect of the ambiance of the overall eating environment, may act through a comfort pathway to influence consumption of meals (Wansink et al, 2004). Students in cafeterias may experience discomfort in a nosier environment, thereby reducing their enjoyment of the meal and thus reduce the amount of time they spend eating. In a review of studies that manipulate noise in the laboratory, Spence et al suggests that there is a demonstrated adverse effect of noise on flavor perception in adults, potentially resulting in reduced enjoyment or preference for foods consumed in a noisy environment. There is, however, no direct evidence to support this pathway in elementary school cafeterias and students’ consumption of NSLP meal components, except for one conference abstract which does not report empirical results (Byker et al, 2014). Given the unique auditory and non-auditory health effects of noise in children, and the potential for similar influences on the health of teachers, paraprofessionals, and food service staff who spend most their time in the cafeteria, additional research is needed to describe the average exposure to noise in this setting as well as to understand its relationship with fruit and vegetable consumption. An increased cafeteria noise level is hypothesized to be inversely associated with consumption of fruits and vegetables at school lunch.

5.1.2. Recess order

A 2002 USDA Economic Research Service report to congress recommends scheduling recess before lunch as a means to reduce food waste at school lunch and increase consumption (Buzby & Guthrie, 2002). However, few schools are implementing this practice. According to the 2014 School Health Policies and Practices survey, in over a third of schools (38.2%) no students are offered recess
before lunch; 11.3% of schools report offering recess before lunch to all of their students. There are several logistical and administrative challenges documented among school stakeholders to offering recess before lunch to all students, including scheduling conflicts and unanticipated challenges around hand washing and dressing in jackets and coats for weather conditions (Hunsberger et al, 2014).

Consistent with behavioral economic theory, the placement of recess relative to lunch may influence students’ school lunch consumption. There are several mechanisms suggested to contribute to greater consumption when recess is schedule before lunch: 1) recess before lunch results in hungrier students because they have developed a greater appetite via increased physical activity; 2) recess before lunch results in a later lunch time and thus students coming to lunch hungrier; 3) in the reverse order, recess scheduled after lunch, students may opt to finish lunch more quickly to “rush off” to recess.

Five peer-reviewed studies examined the order of recess relative to the lunch meal as it relates to consumption of fruit and vegetable components of school lunch meals (Bergman et al, 2016; Fenton et al, 2015; Price & Just, 2013; Hunsberger et al; 2014, Getlinger et al; 1996), and of these, four documented significant increases in consumption when recess was scheduled before lunch, although no study has utilized a randomized design. Getlinger et al (1996) documented decreases in plate waste and increases in vegetable consumption among 1st through 3rd grade students in one school in Illinois when recess was placed before lunch relative to after lunch (30.2g [46.5] vs. 19.0g [35.5]; P<0.05) using a weighed plate waste methodology, although no difference was observed in fruit consumption. Fenton et al (2015) found that recess before eating was associated with a 0.349 (0.074) cup increase in fruit and vegetable consumption among 4th and 5th grade students relative to the recess after lunch (P<0.001) after adjusting for ethnicity, sex, spoken language, and whether school lunch items were eaten. Price and Just (2013), among a sample of 1st through 6th graders, found that schools that shifted recess before lunch experienced a 0.157 serving increase in fruit and vegetable consumption (a 54% increase relative to the baseline rates at these schools). Bergman et al (2016) found that recess before lunch increased consumption of all meal components (Recess before lunch: 72.8% ± 18.2% vs. recess after lunch: 59.9% ± 21.5%; p<0.0001; the data were not disaggregated by food group subtype). However, in a pilot study by Hunsberger et al (2014) among a sample of K through 2nd graders, placing recess before lunch appeared to increase students’ consumption of milk, but not consumption fruits or vegetables. Qualitative
perceptions of the recess placement from teachers obtained in the study by Hunsberger et al (2014) confirmed the scheduling concerns of teachers, but also raised several potential positive benefits including students being calmer in the classroom when recess was scheduled before lunch.

Generally, there appears to be modest, positive benefits to scheduling recess before lunch on students’ fruit and vegetable consumption at school lunch, although study designs and populations are heterogeneous. The conflicting results among studies examining recess placement relative to lunch can be explained by differences in methodology and sample population; the study by Hunsberger et al (2014), which did not find the expected positive association included kindergarten students who may not play as vigorously at recess as older students and included data collection on 5 days throughout the entire school year. Although there appears to be modest benefits of scheduling recess before lunch, future research should examine the effect of recess placement in combination with other school cafeteria environment factors, to understand if this effect is robust in the presence of other varying environmental factors. In the current study, recess placement before lunch is hypothesized to be associated with an increased fruit and vegetable consumption.

5.1.3. Time allocated for lunch

Increasing the time allocated for students to eat school lunch is also listed in the 2002 USDA Economic Research Service report to congress to reduce food waste at school lunch and increase consumption (Buzby & Guthrie, 2002). According to the 2014 School Health Policy and Practice Survey, schools offered an average of 24.7 minutes (23.6 – 25.9 minutes) to students to eat lunch once they are seated, as reported by adult school staff. The rationale for offering more time to students to consume school lunch to increase fruit and vegetable consumption is simple: children who are given inadequate time to may have increased plate waste and decreased consumption of the foods served to them. However, regulating the time allocated to eat lunch is difficult, given that there are several logistical considerations related to scheduling regardless of the stated lunch time periods, including the travel time to and from the cafeteria, wait time for service of school lunch, eating rate, and time for socializing at lunch tables.

To date, there is limited evidence examining the effect of time allocated for school lunch on
students’ consumption of fruits and vegetables. Two studies examined the effect of the amount of time allocated to students for eating lunch on the consumption of meal components among elementary students (Cohen et al, 2016; Bergman et al, 2004). Cohen et al (2016) demonstrated among 3rd to 8th grade students from 8 schools in Massachusetts that the amount of time allocated for lunch, >25 minutes vs. 20-24 minutes vs. <20 minutes, was related to consumption of entrees (77.2% vs. 70.3% vs. 64.4%), vegetables (46.6% vs. 42.9% vs. 34.8%) and milk (72.6% vs. 70.3% vs. 62.3%) but not fruit (all P<0.05). This study measured time allocated for lunch on an individual student-level using direct observations of students entering and exiting the cafeteria. In a study of 3rd through 5th grade students from two schools, Bergman et al (2004) observed an increased consumption in all NSLP meal components when lunches lasted for 30 minutes as compared to when they lasted for 20 minutes (72.8% [18.2%] vs. 56.5% [22.1%]; p<0.0001). This study measured time allocated for lunch using the stated lunch time period via the official school schedules.

One study examined the length of the lunch period among middle school students. Goslinger et al (2013) conducted a cross-sectional study using self-reports of 7th and 9th grade students’ consumption of fruits and vegetables at school lunch from 31 schools in California. The author conducted a lunchroom observation to determine the length of the lunch period using information from the printed bell schedule and found increased odds of fruit (OR=1.40 [95% CI=1.05, 1.88]) and vegetable consumption (OR=1.54 [95% CI=1.26, 1.88]) among students in schools that offered a lunch period ≥34 minutes relative to students in schools that offered a lunch between 20 and 30 minutes.

There are important considerations for the research examining time allocated for school lunch. As with the studies examining recess placement, the time allocated for lunch was not randomly assigned to schools and thus subject to confounding with unobserved variables. Furthermore, although the study by Cohen et al (2016) utilized direct observations of students entering and exiting the cafeteria to define the independent variable, there is limited specification to students actual eating time across studies and the time at the lunch table may be spent socializing instead of eating. Future research should consider actual time eating to determine eating rate and socialization variables that may mediate the effect of time allocated for lunch. There is also the potential that these variables differ widely across grades, making targeted studies of individual grades important in future research. Increased time allocated for school
lunch is hypothesized to be associated with an increased fruit and vegetable consumption in the present study.

5.1.4. Presence of a self-serve salad bar

Within the past few years, there has been a push to increase the availability of fruit and vegetables in school lunch cafeterias across the U.S. The use of school lunch salad bars has gained significant support and attention as a strategy to improve fruit and vegetable consumption. In 2014, nearly one third of schools in the U.S. offered self-serve salad bars to students (Harris et al, 2012). The prevalence of salad bars is similar among elementary, middle and high schools (28.6% vs. 31.2% vs. 34.7%). This high level of salad bar implementation is the result of several ongoing initiatives that have centered around the goal of increasing the use of salad bars in schools. For example, Let’s Move, the public-private partnership spearheaded by the First Lady of the United States, Michelle Obama, has granted nearly 4,000 salad bars to schools in the U.S (Harris et al, 2012). The Centers for Disease control and Prevention also lists the use of salad bars in schools among its top strategies for use in preventing obesity. The U.S. Department of Agriculture has strongly supported the use of salad bars in schools, suggesting that “salad bars have the potential to improve nutrition and encourage the consumption of fruits, vegetables, and legumes.” School lunch salad bars offer to students’ an ability to exercise agency in the selection of meal components, including the ability to choose the amounts and types of fruits and vegetables that they prefer and deem appropriate or normative.

Despite the push for greater implementation of salad bars in schools, limited empirical evidence supports the efficacy of salad bars in increasing fruit and vegetable consumption at school lunch. The commentary by Adams et al (2015) identified 4 studies which examined the use of salad bars among students in U.S. schools, although the population and study designs are heterogeneous (one additional study examining the placement of salad bars was published in the time since this review and is described below). One pre-post study conducted in 1998-2000, examined the use of salad bars in 3 schools within the Los Angeles Unified School District by collecting 24-hour recalls among 337 students between 2nd and 5th grade both before and after the implementation of the salad bars (Slusser et al, 2007). The authors observed an increase in the daily frequency of fruit and vegetable consumption from a mean (SD)
of 2.97 (2.0) to 4.09 (2.7) servings (P<0.001). Importantly, this study was conducted well before the more-rigorous nutrition standards associated with the 2004 and 2010 Child Nutrition Reauthorization, and thus cannot disentangle the secular effects experienced during the time and the additional concurrent promotion activities implemented during the same time period (e.g. farmers market trips and school assemblies). Adams et al (2005) examined the effect of a salad bar on 1st through 5th grade students’ consumption of fruits and vegetables from 4 schools in California. Using weighed-plate waste to assess consumption, the authors found no significant differences in the overall fruit and vegetable consumption between schools with or without a salad bar (47 ± 60g vs. 43 ±58 g, respectively). In addition, the authors in this study observed an interesting secondary outcome, which was that fruit and vegetable consumption increased when a greater number of fruit and vegetable items were offered to students (F=2.83, P<.05), suggesting that salad bar item variety is an important mediator of efficacy.

Two cross-sectional studies examined the use of salad bars among middle and high school students and consumption of fruit and vegetables at school lunch. Goslinger et al (2013) examined the self-reports of 7th and 9th grade students from 31 schools in California, finding increased odds of vegetable consumption among students in schools that offered a salad bar (OR = 1.48 [95% CI=1.19, 1.84]). In this study, the use of salad bars was objectively assessed by research staff, finding that 35% of schools in the sample used salad bars and most offered produce that was rated good or excellent quality. The second cross-sectional study conducted by Terry-McElrath et al (2014) utilized data from Monitoring the Future, a nationally-representative study of 8th, 10th and 12th grade students, and the Youth, Education and Society study, a survey of administrators regarding school practices in which salad bar use was self-reported. Using food-frequency questionnaire type items, the authors found that middle schools with salad bars were more likely to have students who consumed green vegetables (OR=1.071 [1.008,1.137]), although this effect was not found among high schools. Notably, these studies did not use objective methods to assess fruit and vegetable consumption and, in the second study, to assess the use of salad bars.

The placement of salad bars was examined in the cross-sectional study by Adams et al (2016). This study used weighed-plate waste to assess fruit and vegetable among a sample of middle school students in 6 middle schools in Arizona. Three of these schools had the salad bar placed directly in the
school lunch line before the point of purchase, while the other three schools had the salad bar placed within the cafeteria after the point of purchase. The authors found that the prevalence of fruit and vegetable consumption was higher among students in schools with salad bars placed before the point of purchase (prevalence ratio=4.8 [95% CI=3.4, 6.8]) relative to students in schools were salad bars were placed after the point of purchase. However, there are concerns with the definition of fruit and vegetable consumption outcome variable, given that potatoes were excluded and all three schools with salad bars outside of the lunch served potatoes on the day of data collection. In this case, the unbalanced design confounds the independent variable in this study (Graziose & Ang, 2016).

Although there is conflicting evidence of efficacy for promoting fruit and vegetable consumption, salad bars are continually implemented in schools. The lack of existing evidence should not be interpreted as pointing to a lack of efficacy, but instead representative of the need for additional evidence from replication studies to confirm the relationship. Especially relevant is that only two of these studies were conducted among elementary school students. Thus, future research is needed among this age group to confirm the relationship between the implementation of salad bars and consumption of fruit and vegetable consumption. For this study, the presence of a self-serve salad bar and an increased number of fruit and vegetable items offered to students is hypothesized to be associated with increased consumption of fruits and vegetables.

5.2. METHODS

5.2.1. Study design and participants

This cross-sectional study was part of a larger evaluation of the FoodCorps program. During the 2015-16 school year, 20 schools participated in a study examining students’ consumption of school lunch meal components using digital photography. Digital photographs were collected across 2 days of school lunch from 2nd and 3rd grade students at each of the 20 schools between April 2016 and June 2016. During each day of data collection, research staff also collected observational data regarding the school cafeteria environment for the purpose of this study. Students participated if they assented to the research
and if their parents did not return an opt-out consent form prior to the day of data collection.

5.2.2. Outcome variables

Fruit and vegetable consumption at school lunch

Students’ consumption of meal components during lunch was assessed on two consecutive days among 2nd and 3rd grade students from each school using a digital photography method using a protocol informed by previous authors (Taylor et al, 2014; Swanson et al, 2008; Bontrager-Yoder et al, 2014). The dates of data collection were chosen in consultation with school staff, but no consideration was given to the lunch menu for that day prior to data collection. For consistency, one of two senior members of the research staff was present at each of the schools to oversee data collection.

Research staff set up photography stations in the cafeteria before the lunch period. Up to four digital cameras (Cyber-shot DSC-W800, Sony Corp., USA) attached to a tripod affixed at a 60-degree angle on folding tables were used to collect photographs. A station with three cameras on tripods was placed directly following the serving line to capture pre-photos. Students’ school lunch trays were placed in a marked area on the table to take the photos. The photographer conducted a visual inspection of the tray to assure all foods, as well as the label with the unique code, were fully visible before taking the photo, and used a marker and/or rubber band to denote the contents consumed from opaque food containers (such as bags of chips, milk containers, etc.). The photo station was moved near the tray disposal area once all students had exited the line to capture post-meal photos. This protocol was adapted for one school in which meals were served family-style by students at individual tables by using digital cameras at tables without the tripod. To capture fruits and vegetables selected from stand-alone salad bars in the cafeteria, research staff stood directly next to the salad bar and/or circulated the lunchroom with a camera to collect photos at the lunch table of these items.

Digital photographs of student’s lunch trays were imported to a computer and renamed using the unique code number from the sticker on the tray to facilitate side-by-side comparison of photos. Six coders (trained, undergraduate-level students in nutrition) first visually assessed the portion sizes of food items available on the lunch tray in the pre-photo, which was supplemented by portion size information
obtained on the day of data collection from food service directors and cafeteria staff, school menus and/or nutrition facts panel labeling, and uneaten reference images of meal components and packaging. The USDA Nutrient Database was used for consistency in estimations of standard portion sizes (in cup equivalents) for fruits and vegetables. Coders conducted a side-by-side comparison of pre- and post-meal photographs to determine amount consumed, assuming that amounts that had disappeared from the photos were consumed. Coders rated amount consumed in 10% increments (e.g. 0%, 10%, 20%, etc.), and items or packaging completely missing from the photographs were treated as missing data. The portion size on the tray in the pre-photo was multiplied by the percentage consumed to determine the absolute amount consumed. Outcome measures were portions of foods served and consumption of school meal components (in cup equivalents), categorized according to the NSLP meal components definitions for fruits (including juice) and vegetables (excluding white potatoes).

Inter-rater reliability (IRR) was assessed prior to and during data analysis. First, each coder participated in a 3-hour training and coded 12 photos and IRR was assessed by overlapping with the lead author (MMG), reaching a match rate of 100% for identifying items present on the tray and 92% for amount eaten in adjacent categories across all food categories. Throughout coding, photographs from each day of data collection were assigned to one coder, in a counter balanced order, and IRR was assessed by having two coders and the lead author overlap on 5 photos from each day of data collection (200 photos total). Results of the IRR are displayed in Table 4.2 (see previous chapter). The average IRR for the entire sample was 99.5% match rate for identifying items present on the tray and a 95.8% adjacent match rate for amounts eaten across all food categories. In addition to these reliability statistics, any questions on photographs were reviewed by a quorum of at least 3 other coders and the lead author, and a majority consensus was reached.

5.2.3. Environmental factors

Cafeteria noise

Cafeteria noise was assessed at the at lunch period-level. The protocol for measuring noise level of the cafeteria during school lunch meals was developed based on a consultation with a research group
who performed a similar study (Byker et al, 2014). Sound pressure levels of the cafeteria environment were assessed using a Type-II Sound Level Meter (SP-DL-2-1/3; 3M; Quest Diagnostics, Oconomowoc, WI). To ensure consistency across measures, sound-level meters were placed on tripods within 5 feet of tables where students were eating lunch. Noise measures were made throughout the duration of the entire lunch period, from when the first student entered until the last student left. Leq levels, representing the average exposure level over the duration of measurement, are the variable is expressed in DbA units. During sound measures, the lead author of this study counted the number of students present in the cafeteria, and denoted the timing and location of the sound level meter measurements using a standardized form.

**Time allocated for eating school lunch**

The time allocated for school lunch was assessed at the at the lunch period-level on the day of data collection wherein one member of the research staff recorded start and end time of the lunch period. This was defined by observing the first student entering the cafeteria and the last student leaving. The difference between these times was defined as the time allocated for lunch. This was assessed on a lunch period level and was cross-checked with printed school time schedules to ensure accuracy. This measurement method is similar to previous research (Bergman et al, 2004), in that the time was ascribed to the lunch period-level, as opposed to the study by Cohen et al (2016) which ascribed time on the individual-level using direct observations of students. In this study, the time individual students spent eating their lunch meal less waiting time and socializing time cannot be determined; this variable is assumed to represent the maximum time a student could spend eating their lunch.

**Recess order**

Recess order (e.g. recess before or after lunch) was also assessed at the at the lunch period-level by referencing stated school day schedules and through consultations with teachers and school administration on the day of data collection. Recess was defined as time outdoors to play or a physical education class. The lead author of this study noted the order of recess and lunch on a checklist for each school lunch period on the day of data collection. In two schools, students’ participated in “field day”
outdoors prior to the lunch period on the day of data collection, which was considered recess for the purpose of this study. This definition for recess before lunch is consistent with that operationalized in previous research by Just & Price (2013), but was dissimilar from the study by Fenton et al (2015) in that administrator reports were directly verified through on-site observations on the day of data collection.

**Number of fruit and vegetable items offered**

The number of fruit and vegetable items offered to students during the lunch was assessed at the lunch period-level on the day of data collection. Research staff denoted all fruit and vegetable items offered via the school lunch service line and via the salad bar on an observational sheet, which was verified by a review of all photos collected on the day of data collection. The final variable is a count of all fruit and vegetable items offered to students. (Please see **Table 4.1** in the previous chapter for a full list of items considered fruits and vegetables; for this study, potatoes were not counted as a vegetable.)

**Presence of a school lunch salad bar**

The presence of a school lunch salad bar was denoted at the school-level by research staff using a standardized observational sheet. A salad bar was operationalized as any apparatus for the service of fruit and or vegetable items that allows students to self-select both the types and portions these items. (This is as opposed to fruit and vegetable items served to students on the lunch line where portions are standardized). All salad bars were counted regardless of whether they were placed before or after the point of purchase and regardless of if the items were counted toward the federally reimbursable school meal. Salad bars were also included if they were stand-alone or if they connected to the hot lunch meal service line.

**School-level covariates**

School level covariates, including percent of students eligible for free/reduced price lunch and percent of students White, Black, Hispanic and Asian, for use in this study were obtained with the National Center for Education Statistics Common Core of Data 2013-14 which provided data on the percent of students eligible for free/reduced price lunch and students of each ethnicity.
5.2.4. Data analysis

Descriptive statistics are presented for school-level sociodemographic variables, for primary fruit and vegetable consumption outcomes, and for all cafeteria environmental variables measured in this study. To examine the association between environmental variables and consumption variables, a multilevel linear modeling technique was used to account for cluster effects at the school-level, given the high ICCs observed in fruit and vegetable consumption outcomes (detailed in Chapter 4). Multilevel models were created using HLM version 7.0 (Skokie, IL, USA) and missing data were excluded when running analysis. Models were created separately for each consumption outcome variable (fruit, vegetable, and fruit and vegetable consumption in cup equivalents). Given that the indicators of fruit and/or vegetable consumption were skewed right (there were a large portion of students that did not have fruit or vegetable on their tray or did not eat them), a square-root transformation was performed to normalize the distribution. The models included all environmental variables of interest (noise, recess placement, time for lunch, number of fruit and vegetable items, and presence of self-serve salad bar) and controlled for relevant environmental confounding variables (the day of week (Monday vs. Tuesday, Wednesday, Thursday, or Friday), day of data collection (one vs. two), lunch period time (before 12:00pm vs. 12:00pm - 12:30pm or after 12:30pm) and school-level sociodemographic variables (enrollment, male [%], white [%], Hispanic [%], Black [%], Asian [%], free/reduced price lunch eligible [%]) which were informed by previous studies of fruit and vegetable consumption at school lunch. For interpretation, adjusted mean values of the outcomes were calculated using the regression formula identified in each model for significant factors. For continuous variables, the values of the factors at their 75th and 25th percentiles were chosen for comparison to facilitate interpretation in the context of the sample.

5.3. RESULTS

The final sample for fruit and vegetable consumption outcomes in this cross-sectional study included a total of 2,571 before- and after-meal digital photographs collected of students’ lunch trays.
across 40 days of data collection within 20 schools across 58 lunch periods. Descriptive statistics for the student-day lunch tray observations are presented in Table 4.3 (see previous chapter). These observations were obtained from 2nd and 3rd graders at a roughly equivalent rate (52.9% vs. 41.4%, respectively; 5.7% of the sample was indistinguishable by grade owing to mixed classrooms). These observations were also collected equally across both days of data collection at each school (49.0% and 51.0%).

The descriptive statistics for environmental factors measured in this study are presented in Table 5.1. Most school-lunch tray observations (60.3%) were obtained from schools that had a salad bar, defined as any apparatus in which students could self-select fruit or vegetables in varying portions. In addition, slight over one fourth (27.0%) of school lunch tray observations were collected from students that had recess scheduled prior to eating lunch. All schools offered students more than 20 minutes to eat. On average, students were provided with 27.9 (SD=5.1) minutes to eat lunch, but this ranged from a high of 38.5 to a low of 20.5 minutes. The average continuous sound pressure level measured across all lunch periods was 79.7 DbA (SD=4.1), and all schools had a continuous noise exposure above 70 DbA but below 84 DbA.

Table 5.1. Environmental factors measured during the lunch periods of 2nd and 3rd grade students from 20 U.S. elementary schools, 2015-16

<table>
<thead>
<tr>
<th>School</th>
<th>Sample size</th>
<th>Noise*</th>
<th>Length*</th>
<th>Salad Bar †</th>
<th>Recess*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Measures</td>
<td>Noise Leq (dBa)</td>
<td>Lunch period length (min)</td>
<td>Has a salad bar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>C</td>
<td>48</td>
<td>71.0</td>
<td>1.4</td>
<td>31.0</td>
<td>2.8</td>
</tr>
<tr>
<td>D</td>
<td>133</td>
<td>73.7</td>
<td>1.4</td>
<td>23.8</td>
<td>5.4</td>
</tr>
<tr>
<td>E</td>
<td>157</td>
<td>71.9</td>
<td>1.3</td>
<td>36.7</td>
<td>9.3</td>
</tr>
<tr>
<td>F</td>
<td>106</td>
<td>82.7</td>
<td>1.8</td>
<td>25.4</td>
<td>0.8</td>
</tr>
<tr>
<td>G</td>
<td>191</td>
<td>78.1</td>
<td>2.8</td>
<td>30.8</td>
<td>2.9</td>
</tr>
<tr>
<td>H</td>
<td>108</td>
<td>74.5</td>
<td>0.4</td>
<td>20.5</td>
<td>2.1</td>
</tr>
<tr>
<td>I</td>
<td>125</td>
<td>75.4</td>
<td>2.1</td>
<td>28.0</td>
<td>1.4</td>
</tr>
<tr>
<td>J</td>
<td>63</td>
<td>81.4</td>
<td>2.1</td>
<td>27.3</td>
<td>1.7</td>
</tr>
<tr>
<td>K</td>
<td>200</td>
<td>79.9</td>
<td>0.6</td>
<td>30.3</td>
<td>0.5</td>
</tr>
<tr>
<td>L</td>
<td>143</td>
<td>83.1</td>
<td>5.1</td>
<td>32.0</td>
<td>2.8</td>
</tr>
<tr>
<td>M</td>
<td>71</td>
<td>78.4</td>
<td>1.0</td>
<td>27.5</td>
<td>3.5</td>
</tr>
</tbody>
</table>
The average consumption of fruit and vegetable items was 0.35 cup equivalents (SD=0.31) and 0.24 cup equivalents (SD=0.29), respectively, among students who had them on their tray. Together, among students with a fruit or vegetable item on their tray, the average consumption of fruits and vegetables was 0.45 cup equivalents (SD=0.40).

In multilevel models, there were several environmental variables significantly associated with fruit and vegetable consumption (Table 5.2). In the first model examining vegetable consumption, the only significant predictor was the number of fruit and vegetable items offered (B=0.021; SE=0.006; P<0.001). The second model, which examined fruit consumption, showed a significant negative association of noise (B=-0.012; SE=0.004; P=0.003) and a positive association of having recess scheduled before lunch (relative to recess after lunch; B=0.100; SE=0.023; P<0.001). In the third model, combined fruit and vegetable consumption was associated with noise (B=-0.017; SE=0.004; P<0.001) and recess before lunch (relative to recess after lunch; B=0.096; SE=0.023; P<0.001). There were no associations observed among any of the fruit and vegetable consumption outcomes and the presence of a salad bar or the time offered for students to eat lunch. Adjusted mean values based on these regression models are displayed in Table 5.3.
Table 5.2. Multilevel linear models examining the relationship between school cafeteria and environmental factors and 2nd and 3rd grade students' consumption of fruits and/or vegetables at school lunch within 20 schools in the U.S. participating in the FoodCorps program, 2015-16

<table>
<thead>
<tr>
<th>Category</th>
<th>Vegetable consumption (cups)</th>
<th>Fruit consumption (cups)</th>
<th>Fruit and vegetable consumption (cups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunch length (min)</td>
<td>0.003</td>
<td>0.003</td>
<td>0.404</td>
</tr>
<tr>
<td>Noise (DbA)</td>
<td>-0.004</td>
<td>0.004</td>
<td>0.333</td>
</tr>
<tr>
<td>No. of fruit and vegetable items</td>
<td>0.021</td>
<td>0.006</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Salad bar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>ref</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td>Yes</td>
<td>-0.004</td>
<td>0.103</td>
<td>0.968</td>
</tr>
<tr>
<td>Recess order</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After lunch</td>
<td>ref</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td>Before lunch</td>
<td>0.003</td>
<td>0.026</td>
<td>0.909</td>
</tr>
</tbody>
</table>

* Adjusted for day of week (M vs. Tu, W, Th, or F), day of data collection (one vs. two), lunch period time (before 12:00pm vs. 12:00pm - 12:30pm or after 12:30pm) and school-level sociodemographic variables (enrollment, male [%], white [%], Hispanic [%], Black [%], Asian [%], free/reduced price lunch eligible [%])

† Consumption outcomes are calculated among those students selecting fruit and/or vegetable items and have been square-root transformed to meet assumptions of normality. Vegetables exclude white potatoes; fruits include 100% juice.

Definitions: Lunch length is the time on the class period-level allocated to students to eat lunch, from the time the first student enters to the time the last student exits; Noise is the average sound pressure level of the cafeteria for the duration of the lunch period; Number of fruit and vegetable items is the sum of all fruit and vegetable items offered to students during each lunch period measured by direct observation of the day of data collection; Salad bar is defined as an apparatus wherein students can self-select and self-serve fruit and/or vegetable items in variable portions measured by direct observation of the day of data collection; Recess order is classified as a lunch period wherein recess was held before lunch or recess was held after lunch, measured by direct observation of the day of data collection.

Table 5.3. Estimated means for factors associated with fruit and vegetable outcomes based on hierarchical linear regression models adjusting for school and environmental covariates

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Vegetable consumption (cups)</th>
<th>Fruit consumption (cups)</th>
<th>Fruit and vegetable consumption (cups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise (DbA)</td>
<td>25th Percentile</td>
<td>74.8</td>
<td>n/a</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>75th Percentile</td>
<td>n/a</td>
<td>0.28</td>
<td>0.31</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Number of fruit and</td>
<td>75th Percentile</td>
<td>11</td>
<td>0.20</td>
<td>n/a</td>
</tr>
<tr>
<td>vegetable items</td>
<td>25th Percentile</td>
<td>4</td>
<td>0.10</td>
<td>n/a</td>
</tr>
<tr>
<td>Recess order</td>
<td>Before</td>
<td>1</td>
<td>n/a</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>After</td>
<td>0</td>
<td>n/a</td>
<td>0.28</td>
</tr>
</tbody>
</table>

5.4 DISCUSSION

This cross-sectional study examined the relationship between several environmental factors related to the school lunch meal, including recess order, time allocated for lunch, presence of self-serve salad bar, number of fruit and vegetable items offered and cafeteria noise, and elementary students’ consumption of fruits and vegetables. This study was conducted among 2nd and 3rd grade students within 20 schools in the U.S. that were participating in the NSLP and the FoodCorps farm to school program. This study demonstrated evidence of an association between the number of fruit and vegetable items offered, cafeteria noise, and recess order, but did not find associations between the time allocated for lunch and the presence of a self-serve salad bar. Importantly, for noise and recess, these associations were only significant for fruit consumption and fruit and vegetable consumption combined, and not vegetable consumption alone, making it likely that the association was driven mostly by students consuming fruit. One strength of this study, in contrast with previous ones, is in the examination of these environmental factors together in the explanatory models, which allows for conclusions about the relative strength of the associations.

Our findings related to the presence of a self-serve salad bar and number of fruit and vegetable items are consistent with those of Adams et al (2005), who conducted a cross-sectional study among 1st through 5th grade students in schools with and without a salad bar. The authors found no relationship between the presence of a salad bar and students’ fruit and vegetable consumption, but did note that a greater number of fruit and vegetable items served or offered to students was associated with greater fruit and vegetable consumption. The lack of association between a school lunch salad bar and consumption outcomes in the present study may be attributable to differences in the implementation of the school lunch salad bar across schools in this sample. For example, although this was not measured empirically
in the present study, there may have been differences in the quality and appeal of the salad bars as perceived by students and there may also be differences in the use of signage to promote the salad bar. Because salad bars are not regulated by the NSLP, there are few rules that govern their implementation in the school lunch program, and previous research has shown that there are differences in the salad bar implementation strategies used to support salad bars (Ohri-Vaschaspati et al, 2016). Furthermore, each additional fruit or vegetable item offered to students was associated with slight increases in the average consumption of vegetables. This finding may be attributable to the greater sense of choice and agency afforded to students in lunches in which more items are offered, thus making it more likely that they are offered a vegetable item that they prefer and will eat, especially given that previous research supports preference as a strong predictor of fruit and vegetable consumption among children (Rasmussen et al, 2006). Additional research among young adults (age 12-21) has shown that meals with a greater variety of foods results in greater consumption, potentially operating via a “stimulus bound eating” concept whereby the stimuli (e.g., sight, smell) from additional foods elicit consumption (Levitsky et al, 2012). Recess order has been examined in several recent studies and has shown a consistent, albeit modest, positive association with fruit and vegetable consumption. The findings from this study support the conclusion that recess before lunch is associated with greater consumption of fruits and vegetables, although the increases in consumption are only modest and driven by fruit consumption. Again, as aforementioned, there are several potential mechanisms by which having recess before lunch contributes to greater consumption of fruits and vegetables among children in school lunch. This study did not empirically examine evidence to support any of the potential mechanisms.

The finding that cafeteria noise is associated with fruit and vegetable consumption is a novel finding of the current study. Using an objective measure of cafeteria noise, there were variable noise levels across the lunch periods in this study, ranging from 70.1 to 83.1 dba (given this logarithmic scale, every 10 decibel increase is perceived by the human ear as 2x louder). This study demonstrated a negative association between noise and fruit and vegetable consumption, with each decibel increase in the sound level pressure of the cafeteria corresponding to a decrease in consumption of fruit and fruits and vegetables combined. In similar regard to the finding about recess before lunch, this study did not empirically examine a potential mechanism by which increased cafeteria noise would result in decreased
consumption. However, a likely interpretation of this finding is that a greater number of students talking (instead of eating) would both increase the level of noise and decrease the average consumption of fruits and vegetables. Thus, there is potential for reverse causation among these variables: given that school lunch is not only a time for eating but also an opportunity for students to socialize, there is the potential that students’ who chose not to eat will talk more and add to the level of noise in the cafeteria. The implications of this finding are not straightforward given the tradeoff between eating and socializing; a policy around talking during lunch would necessarily involve a trade-off between eating and socializing.

This study did not observe a consistent association with fruit and vegetable consumption and the amount of time allocated for lunch. This may be because, in part, there was little variability in the lunch times for students, ranging only from 20-30 minutes. In the previous study by Cohen et al (2015) several of the schools offered lunch for durations shorter than 15 minutes, and the authors noted positive association with increased time allocated for lunch in that study. None of the schools in the sample offered a lunch period in a duration less than 20 minutes. Thus, given that there were no significant association, the findings of this study can be interpreted supporting the conclusion that a lunch length >20 minutes does not negatively impact consumption of fruits and vegetables.

It should be noted that the practical significance of these variables is relatively small. Estimated means for fruit and vegetable consumption adjusted for covariates obtained via the hierarchical linear regression models are displayed in Table 5.3. Recess before lunch, for example, is associated with a 0.12 cup increase in fruit and vegetable consumption relative to recess after lunch. Although these estimated increased seem small, changes like these across the population of elementary school children within schools participating in the NSLP are likely to have large public health impacts. Moreover, increased in fruit and vegetable consumption in this magnitude are similar, albeit smaller, than those obtained in well-controlled, multi-component interventions. For example, Evans et al (2012), conducted a meta-analysis of studies of children aged 5 to 12 years of age between 1985 to 2009 finding an average increase in consumption of fruit and vegetable 0.25 portions daily (95% CI: 0.06, 0.43 portions) among students participating in interventions that included nutrition education, communications, food provision, and/or social marketing components.

There are several immediate implications of this work for researchers and practitioners. This
study examined multiple factors simultaneously in one model and controlled for relevant contextual variables, therefore it allows for the conclusion that, holding other contextual variables constant, cafeteria noise, having recess before lunch and increasing the number of fruit and vegetable items offered to students are associated with increased consumption of fruits and vegetables. Future research is warranted to systematically manipulate these variables to understand their impact. For practitioners in school lunch settings, these variables may be directly amenable to intervention, but future research is necessary to examine secondary outcomes beyond consumption (such as socializing or physical activity) that may also be impacted by changes to the environment. For those who are developing and designing future studies that measure fruit and vegetable consumption at school lunch, this study provides a rationale for considering these environmental factors in the design and analysis of data to prevent any moderating effects.
CHAPTER 6: DISCUSSION

There are documented shortfalls in fruit and vegetable consumption among children in the U.S. as compared to the federal recommendations. In response, there has been a growing interest among scientists, practitioners, and policymakers in developing interventions that are efficacious in increasing their consumption. Schools have emerged as a common setting for implementing these interventions, given the opportunity to reach many youth and for interventions to be institutionalized and sustained. Moreover, a consensus has emerged on the need for intervention in early and middle childhood because many diet-related behaviors are formed during this period and may track into adulthood. Recent reforms to the National School Lunch Program that govern the nutritional quality of foods offered to students as part of the lunch meal within participating schools offer the opportunity to promote healthy eating habits among children. These reforms have resulted in greater availability of fruits and vegetables at school and a greater consistency in the nutrient content of meals offered to students; they are also associated with small increases in fruit and vegetable consumption. However, those who evaluate the effects of school-based interventions to increase fruit and vegetable consumption at school meals are faced with several challenges in the design of studies, which are not limited to: the number of students and schools to recruit; the type of dietary assessment method utilized to measure fruit and vegetable consumption, and the potential confounding effects of environmental factors that are not regulated by the NSLP. These issues are not unique to studies examining fruit and vegetable consumption at school lunch, but instead may be emblematic of cluster randomized designs in general.

6.1. MAIN FINDINGS FROM THIS DISSERTATION

Using data collected as part of a larger evaluation of the FoodCorps program, the three empirical articles in this dissertation address specific questions about the design of studies measuring fruit and vegetable consumption at school lunch. The studies within this dissertation focus on a specific population – 2nd and 3rd grade students from public schools within the U.S. who participate in the NSLP – which provides a distinct context in which to generalize the findings (e.g. the population of elementary school
students participating in this program). The twenty schools participating in this evaluation, recruited from the sample of FoodCorps schools in the U.S., display average sociodemographic roughly equivalent to the population of elementary schools (Grades K to 5) in the U.S. eligible for Title I funding. This sample of FoodCorps schools, on average, has a lower proportion of white students and a higher percent of Black students and free/reduced price lunch eligible students. Thus, the findings from this dissertation may be generalized to a population of schools eligible for Title I funding with similar demographics. Together, the articles contribute to a broader understanding of the necessary considerations for conducting this type of research and are used to inform the development of conceptual evaluation framework that can be utilized by researchers and evaluators who design studies.

**Chapter 2** is a systematic mapping review of the literature to identify all previous studies measuring fruit and vegetable consumption at lunch among elementary students within schools participating in the NSLP. The objective of this systematic review was to identify elements of the design, sample, dietary assessment methods, and results of previous studies to inform the three research questions in this dissertation. In summary, this systematic mapping review identified 61 studies that examined fruit and vegetable consumption at school lunch among students in the U.S. during the period from 2004 through the present. Most these studies are cross-sectional or quasi-experimental in design and most studies utilized objective methods to measure fruit and vegetable consumption. Given the nature of their designs, few studies reported an a priori power calculation to determine an adequate sample size. These studies also examined several environmental factors related to fruit and vegetable consumption at school lunch, but few examined more than one factor in the same study.

**Chapter 3** describes a validation study to examine the accuracy of a paper-and-pencil questionnaire method for measuring fruit and vegetable consumption at school lunch. A paper-and-pencil questionnaire method was found to be accurate for measuring fruit and vegetable consumption relative to a digital photography method in a sample of 2nd and 3rd grade students from elementary schools participating in the NSLP. This study was conducted within 23 schools across 8 states which varied in their school lunch service procedure (e.g. some used self-serve salad bars and some did not), leading to the conclusion that the questionnaire is valid and applicable across diverse contexts and with diverse groups of students.
Chapter 4 reports the observed intra-class correlation coefficients in fruit and vegetable consumption outcomes, as well as identifies covariates to reduce the effect of clustering. The novelty of these estimates are two-fold. First, previous estimates of fruit and vegetable consumption at school lunch have been derived from small, primarily White, samples; this work is important for reporting ICCs from schools participating in a multi-state, farm-to-school program which include a diverse sample of elementary school students (in terms of race, ethnicity and eligibility for free/reduced price lunch). These estimates can be used to inform the sample selection for future multi-state evaluations. Second, this work provides estimates of the ICC for multiple fruit and vegetable consumption outcomes, including items on tray (e.g. selection) and items consumed, in both dichotomous and continuous variables. By reporting the ICC estimates for these diverse outcomes, researchers can choose the estimate to power their intervention study for the specific outcome of interest.

Chapter 5 examines environmental factors within the cafeteria and their relationship with fruit and vegetable consumption at school lunch. This study demonstrated a positive relationship between the number of fruit and vegetable items offered and the order of recess (e.g. before or after lunch) fruit and vegetable consumption, as well as a negative relationship between noise and fruit and vegetable consumption. Given the nature of the study design as well as the sample of schools from which data were collected, there is room for caution in the interpretation of these results. The findings from this study should be interpreted as identifying factors with the potential to influence fruit and vegetable consumption and/or moderate the effect of interventions designed to influence this outcome. Future cluster-randomized controlled trials should be conducted to confirm the direction and degree of these associations.

There are several strengths to this dissertation. First, the fruit and vegetable consumption data were collected among a relatively large sample of students, which were recruited from a diverse sample of schools from across 8 states. In addition, the sampling strategy utilized allows us to generalize the findings of this dissertation to the population of FoodCorps schools. There are also several limitations inherent to the empirical studies in this dissertation. The objective method used to measure fruit and vegetable consumption across these three studies was the digital photography method, which has shown good accuracy relative to direct observation in previous validation studies (Hanks et al, 2013). However, there is the potential that this method did not accurately capture foods consumed, such as it is influenced
via trading between students (Baxter et al, 2001) or foods packed away to be consumed later (Swanson et al, 2012), which would have been captured via a direct observation method. However, in an unpublished pilot study conducted among 3rd – 5th graders in one school in New York City, we observed that direct observation and digital photography methods were reasonably consistent, resulting in rates of agreement over 80% for fruit and vegetable items. In addition, the recruitment of schools for this dissertation relied both on a convenience sample of schools and schools already participating in the FoodCorps farm to school program. Thus, although these schools were similar in that they all participated in the National School Lunch Program, there is the potential that they are dissimilar from the population of U.S. elementary schools. This dissertation reports several observable indicators at the school-level, such as the eligibility for free/reduced price lunch and ethnicity, to facilitate comparison with existing and future research.

6.2. TOWARD A CONCEPTUAL EVALUATION FRAMEWORK

The complexity the school lunch cafeteria environment and the multitude of factors related to fruit and vegetable consumption raises several implications for decisions related to the design of, assessment methods used for, and analysis of data from intervention and evaluation studies. The objective of this dissertation was to provide, through a systematic mapping review of the literature and three empirical studies, considerations for researchers who are conducting intervention and evaluation studies designed to promote fruit and vegetable consumption at school lunch. By categorizing findings from the mapping review and the three empirical studies, a conceptual evaluation framework was developed which can be used to inform the design of future cluster-randomized controlled trials. Although conceptual frameworks exist for evaluating behavioral nutrition and public health interventions (Harden et al, 2015; Baranowski et al, 2009; Sahyoun et al, 2004; Contento, 2016), there are none that are focused exclusively on the outcome of fruit and vegetable consumption at lunch among elementary school students. This framework is predicated on the use of a cluster-randomized controlled design, given that it is often infeasible (and/or unethical) to randomly allocate individual students to an intervention in the school-setting. Cluster randomized designs are considered the gold standard for evaluating the effect of interventions that
operate at the group-level; they are a type of randomized-controlled trial in which the unit of randomization occurs at the group- or cluster-level, as opposed to the individual-level.

This evaluation framework is designed to guide researchers through several key critical control points to improve the quality and reproducibility of a cluster-randomized design. It should be noted that the design considerations highlighted in the framework are not unique to studies focused on the outcome of fruit and vegetable consumption at school lunch, instead they are applicable to all studies that utilize a cluster randomized design. There are, however, specific empirical data from this dissertation that can be used by researchers while designing a study with this outcome that are specified in the framework. Therefore, this framework is made specific to research conducted within the population of elementary students (grades K-5) in schools participating in the National School Lunch Program. The framework is informed by the Cochrane Handbook for Systematic Reviews of Interventions (Higgins & Green, 2011), the Consolidated Standards of Reporting Trials (CONSORT) extension for cluster randomized trials (Campbell et al., 2010) and several related reports in the peer-reviewed literature. Aspects of the conceptual framework are further described below and illustrated in Figure 6.1.

Figure 6.1. A conceptual evaluation framework for designing cluster-randomized controlled trials to measure fruit and vegetable consumption at lunch among elementary students participating in
the National School Lunch Program within the U.S.

**Design and Analysis Framework:** What is the relationship between school-based interventions and fruit and vegetable consumption at lunch among elementary students participating in the National School Lunch Program?

**Target Population:** Students in grades K-5 within schools in the U.S. participating in the National School Lunch Program

**Intervention/Exposure:** Any school-based intervention targeting: Individual; Fruit/Vegetable Item-Specific; Meal-Specific; Cafeteria Environment; or Classroom, School or Policy-Related Factors.

**Comparator:** Control students (e.g., unexposed)

**Outcome(s)**
- *Selection*: Fruit and/or vegetable items selected (e.g., present on school lunch tray)
- *Consumption*: Fruit and/or vegetable consumption
  * Continuous or dichotomous

**Mediators/Moderators:**
- Individual (e.g., age, gender, SES)
- Item-specific (e.g., types of fruit/veg, order of service, slicing)
- Meal-specific (e.g., order of service, tray type)
- Cafeteria environment (e.g., noise, recesses, timing)
- School-wide (e.g., policies, nutrition education)

**Key Considerations:**

1. **Study Design/Sample Section**
   - a) Which study design is appropriate (e.g., when is a cluster randomized design appropriate)?
   - b) When is power calculation crucial?
   - c) What data is needed to conduct power calculation?
   - d) What sampling methodology? When is a stratified sampling is appropriate?

2. **Intervention**
   - a) How to choose appropriate unit of randomization (e.g., school, grade, class, or individuals)?
   - b) What do you know about the intervention? What needs to be clarified or defined before conducting evaluation?
   - c) What kind implementation process data can be collected?
   - d) What are confounders that should be considered? Do you need to collect data related to these? Is secondary data available?

3. **Outcomes**
   - a) Which diet assessment method is most appropriate and practical?
   - b) Any fruits or vegetables to definitely measure (e.g., if part of intervention) or to exclude (e.g., juice, white potatoes)?
   - c) Should outcomes be calculated as intent-to-treat (when is this appropriate?) or exposed groups (when is this appropriate?)

**Study Design**

*Is the intervention best evaluated through a cluster-randomized design?*

The gold standard research design for evaluating interventions operating at the group level is a cluster randomized design. The use of a cluster randomized designs in school-based research is often indicated for both ethical considerations and concerns about contamination that may arise with the use of individually randomized designs.

*What is the unit of randomization?*

In cluster-randomized designs, groups are randomly allocated to intervention groups. However, in school-based research, there are many ways to create groupings of individual, such as classes, grades, or entire schools. The unit of randomization should be specified in the study design, and the power calculations and statistical analyses should be appropriately matched to the unit of randomization.
Can a power calculation be performed?

A power calculation is a technique used to estimate an appropriate sample size to meet the objectives of the study. The variables needed for this calculation include: the minimum detectable effect size (MDES); the intra-class correlation (ICC); and the number of schools (m), number of students within each school, estimate of uncertainty. The ICCs reported in this dissertation provide empirical estimates of clustering for several different outcomes of interest in school-based research examining fruit and vegetable consumption. The binary outcomes of fruit and vegetable selection and consumption are provided alongside their respective proportions observed in this study. These data can be used for future power calculations.

Sample selection

Can a stratified sampling strategy be utilized?

Sample selection in studies measuring fruit and vegetable consumption at school lunch is almost always a two-level approach, which first involves recruiting schools and then students therein. In reality, it is not always possible to select schools randomly from the population; oftentimes, schools are a convenience sample. Therefore, sample selection should involve a stratification technique to control for observable confounding variables that may be related to the outcome of interest. In this dissertation, the following variables were identified that could be used a priori in the sample selection process to create strata: percent white and percent free/reduced price lunch eligible.

Interventions

What is the intervention?

Clearly defining the intervention and a theoretical pathway to link to fruit and vegetable consumption is necessary, including whether the intervention operates on the individual or group level. There are several environmental factors that have been examined as they relate to fruit and vegetable consumption at school lunch and thus could be the target of an intervention. This dissertation identified 19
environmental factors that had been the subject of 51 previous studies which were grouped into 5 clusters informed by a socio-ecological framework. These clusters include: individual, item-specific, meal-specific, cafeteria environment and school-wide environmental factors. Although this list emerged from a systematic search of the literature, there are limitations in that there may be publication bias (e.g. only statistically significant results were reported in the published literature) and that they may be derived from studies of low-methodological quality (e.g. cross-sectional studies or small samples). While future research is needed on all factors in this review, several may be amenable to intervention immediately within school lunch settings with potential positive effects on consumption, such as reducing the noise level in the cafeteria, scheduling recess before lunch or allocating additional time for eating. These interventions, however, will need to be tempered against competing demands for time and logistical constraints.

*Can intervention implementation processes be assessed?*

Utilize accepted operational measures to define intervention implementation processes. For example, use conventional methods to define the exposure to noise during the lunch period or to time the duration of the lunch period. This is useful for reporting and understanding fidelity to the intervention processes as well as reach/exposure among the sample.

*Are there factors that may act as effect modifiers?*

In addition, although not directly evaluated in this dissertation or in studies identified in this review, there is potential that these factors may act as effect modifiers in intervention studies and should be accounted for in the analysis of data. These are factors that if not assessed or accounted for in the analysis may modify the effect of an intervention. While future research is necessary to understand which factors may act in this regard, it may be prudent to assess the factors identified in the framework identified in chapter 2 of this dissertation.

*Dietary assessment methods*
What dietary assessment method is being used?

In general, the choice of dietary assessment methods should be based on the unique needs of the research and the population under study. However, the method should have some empirical evidence of validity for measuring the outcome of interest. For the population of elementary school students, the following methods have been validated for use in measuring fruit and vegetable consumption: direct observations, weighed plate waste, digital photography and self-report methods. This dissertation provides rationale for the continued use and improvement of self-report questionnaire methods and provides a validated instrument.

Outcomes

What is the operation definition of fruits and vegetables?

Given that the NSLP provides only general definitions of the types of fruits and vegetables that can be offered to meet eligibility criteria for reimbursement, researchers are charged with creating a definition to operationalize their measurement. To date, an open question for researchers measuring fruit and vegetable consumption at school lunch is whether to quantify consumption of white potatoes and 100% juice as part of their measure. Although these items are counted toward the reimbursable meal, previous research has not consistently included these items in their measurement. In general, the reporting of this definition should be made clear and, ideally, consistent with previous research.

How is fruit and vegetable consumption measured?

Although the outcome of fruit and vegetable consumption at school lunch appears simple, there are many ways of operationalizing this variable. Across studies included in the systematic mapping review, there were differences in the estimate of fruit and vegetable consumption, which included a weight (e.g. grams), a volume (e.g. cup equivalents) and a percentage (e.g. as a percent consumed relative to what was served). In addition, these variables can be presented as dichotomous (e.g. a proportion of students eating a vegetable) or as a continuous variable (e.g. cups consumed). Within studies reporting dichotomous outcome variables, there is little consistent in whether these variables are reported among
all students or among only students who selected a given fruit or vegetable item. To make matters more complex, fruits and vegetables can be reported together as a sum of both. As in the definition of fruits and vegetables, there is a clear need for transparency and consistency in the reporting of these outcome variables.

6.3. IMPLICATIONS FOR FUTURE RESEARCH

This dissertation raises several considerations and implications for future research within the school setting to quantify fruit and vegetable consumption at lunch. The first and most apparent implication is that future researchers could use the conceptual framework to consider key questions when planning and evaluating interventions to promote fruit and vegetable consumption at school lunch among elementary school students. For example, the conceptual framework identifies several factors that have been explored as they relate to fruit and vegetable consumption. These factors can serve as the basis for developing interventions and as considerations for potential moderating or confounding factors to interventions. However, there is a need for empirical testing of the conceptual framework, given that this dissertation serves only as an exploratory development study. A Delphi-type study should be conducted to examine (this should be tested empirically in future research).

The specificity of this conceptual framework for fruit and vegetable outcomes is both a strength and a limitation. While promoting fruit and vegetable consumption has been a priority for federal agencies and expert groups, there are several additional outcomes that may be relevant to for researchers conducting school-based studies. These additional outcomes are not limited to: educational attainment, physical activity, prosocial behaviors, or consumption of other foods during school lunch. However, there is a limited body of research examining the interrelationships among these outcomes, which limited the ability to categorize them in a meaningful way for this conceptual framework. In terms of fruit and vegetable consumption, there are also more proximal, psychosocial outcomes, such as preferences, intentions, and self-efficacy, that may act as mediators to fruit and vegetable consumption in intervention studies, but these were similarly limited across previous studies examined in the systematic mapping review, and thus were not categorized within this framework.
The three empirical studies in this dissertation also raise discreet implications for future research. First, the Fruit and Vegetable Recall Questionnaire developed and validated in this dissertation serves as a tool for future researchers who require a self-report instrument in lieu of the objective methods most frequently used to measure fruit and vegetable consumption at school lunch. Given the larger discussion in the field of nutrition regarding the use of self-report methods, this study provides rationale for the continued use and development of such instruments to identify the factors and methods under which children can accurately self-report their school lunch consumption. This validation study supports the use of self-report instruments among lower elementary school children to recall school lunch consumption within a short time frame since eating. While this validation study was conducted among a large, diverse sample of 2nd and 3rd grade students, future research is needed to understand the sensitivity of the instrument in the context of an evaluation study (e.g., the ability to detect group-differences).

Second, the ICCs reported in this dissertation serve as a basis for conducting power calculations in future research, helping to reduce the likelihood of erroneous conclusions in school-based research based on underpowered designs. The proliferation of studies examining fruit and vegetable consumption at school lunch has occurred in the absence of a critical discussion of the considerations for sample size, power and selection of participants (both students and schools). The multi-level structure of school-based research requires special methods for design and analysis of data which has, to date, received little attention. Importantly, the ICCs reported in this dissertation were obtained in the context of an ongoing, multi-state farm to school program, and thus should serve only as estimates of the potential clustering that may be observed in similar trials. Future researchers should use these as a point of comparison for the ICCs observed in their own trials as well as for conducting power calculations for the necessary sample size while planning trials.

Third, several environmental variables were examined as they relate to fruit and vegetable consumption among a sample of elementary students from 20 schools. There is theoretical and empirical consensus in the field of behavioral nutrition that food-choice related behaviors are influenced by several environmental factors (Contento, 2016). Consumption of fruits and vegetables at school lunch occurs in a complex, multi-level environment, and is influenced by several environmental factors (Gorman et al, 2007). Consumption of fruits and vegetables among elementary school students may be influenced by
individual, food item-specific, meal-specific, cafeteria, school and national policy-related factors. The interplay among these factors raises several considerations for researchers who conduct and evaluation school-based interventions designed to increase fruit and vegetable consumption. However, most previous research has examined only one factor in isolation, and thus fails to acknowledge that the relationship between factors is likely complex. This study identified several environmental factors, including the amount of noise in the cafeteria, the number of fruit and vegetable items offered to students, and the order of recess relative to lunch, that were associated with fruit and vegetable consumption. This study serves to generate hypotheses and to invite future research using rigorous designs to identify a causal relationship between these variables and students’ consumption of fruits and vegetables. While these factors may be immediately amenable to intervention in the cafeteria setting, future research is necessary to confirm the relationships observed in this study.

6.4. CONCLUSION

The documented shortfalls in fruit and vegetable consumption among children in the U.S. has raised concerns about potential for deleterious effects on health and wellbeing. While schools are seen as a priority setting for implementing interventions to increase fruit and vegetable consumption among youth, there are several challenges inherent to designing and evaluating interventions in schools. The NSLP provides an opportunity to institutionalize best practices around promoting fruit and vegetable consumption, as well as the ability to reach many children. A string of recent research has examined factors that may contribute to increased fruit and vegetable consumption via the NSLP. However, given the rate at which these studies have been published and that many have been published only recently, there is little meta-evidence describing appropriate study designs and considerations for dietary assessment methodologies. This dissertation provides a conceptual evaluation framework that can be used by researchers who are designing interventions in the aim of increasing fruit and vegetable consumption. The end goal of the use of this framework is both to improve the rigor and reliability of such studies as well as to provide more robust evidence for dissemination of the interventions that are most likely to move the needle on fruit and vegetable consumption among school-aged children in the U.S.
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Groziose MM, Ang IY. Location of School Lunch Salad Bars in Cafeterias: Design and Analysis Issues. J


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## APPENDIX A. SEARCH STRATEGY FOR SYSTEMATIC MAPPING REVIEW (CHAPTER 1)

<table>
<thead>
<tr>
<th>DATABASE</th>
<th>Search Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROQUEST</td>
<td>&quot;school&quot; AND &quot;lunch&quot; AND (&quot;diet&quot; OR &quot;consumption&quot; OR &quot;nutrition&quot;) AND &quot;elementary&quot;</td>
</tr>
<tr>
<td></td>
<td>Additional limits - Date: After 2004; Source type: Scholarly Journals; Language: English; Full text; Peer-reviewed</td>
</tr>
<tr>
<td>PUBMED</td>
<td>&quot;school&quot; AND &quot;lunch&quot; AND (&quot;diet&quot; OR &quot;consumption&quot; OR &quot;nutrition&quot; OR &quot;intake&quot;) AND &quot;elementary&quot;</td>
</tr>
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<td>PSYCHINFO</td>
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</tr>
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<td>2004 – present</td>
</tr>
<tr>
<td>ERIC</td>
<td>&quot;school&quot; AND &quot;lunch&quot; AND (&quot;diet&quot; OR &quot;consumption&quot; OR &quot;nutrition&quot; OR &quot;intake&quot;) AND &quot;elementary&quot;</td>
</tr>
</tbody>
</table>
PHASE 1:

Apple
Did you have the apple on your tray?
Yes ☐ No ☐

How much of the apple did you eat?
I didn't eat any ☐ I tasted it ☐ I ate a little bit ☐ I ate half ☐ I ate most ☐ I ate all ☐

How much did you like the apple?
I didn't eat any ☐ I loved it ☐ I liked it ☐ I didn't like it ☐

Would you eat the apple next time it is served at school lunch?
Yes ☐ No ☐ Maybe ☐

Broccoli trees
Did you have the broccoli trees on your tray?
Yes ☐ No ☐

How much of the broccoli trees did you eat?
I didn't eat any ☐ I tasted it ☐ I ate a little bit ☐ I ate half ☐ I ate most ☐ I ate all ☐

How much did you like the broccoli trees?
I didn't eat any ☐ I loved it ☐ I liked it ☐ I didn't like it ☐

Would you eat the broccoli trees next time it is served at school lunch?
Yes ☐ No ☐ Maybe ☐
Fruits and Vegetables at School Lunch

ID Number____________________________________ Date ____/____/____ Class___________ School____________________

Think about all the fruits and vegetables you had at school lunch today. For each question, choose only one answer.

School food: ______________________

Did you have it on your tray?
○ No
○ Yes

How much of it did you eat?
○ None
○ A little
○ Half
○ Most
○ All

How much did you like it?
○ I didn’t eat any
○ I didn’t like it
○ I liked it
○ I loved it

Would you eat it next time it is served at school lunch?
○ No
○ Maybe
○ Yes

School food: ______________________

Did you have it on your tray?
○ No
○ Yes

How much of it did you eat?
○ None
○ A little
○ Half
○ Most
○ All

How much did you like it?
○ I didn’t eat any
○ I didn’t like it
○ I liked it
○ I loved it

Would you eat it next time it is served at school lunch?
○ No
○ Maybe
○ Yes
Fruits and Vegetables at School Lunch

<table>
<thead>
<tr>
<th>School food: ____________________________</th>
<th>School food: ____________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you have it on your tray?</td>
<td>Did you have it on your tray?</td>
</tr>
<tr>
<td>☐ No</td>
<td>☐ No</td>
</tr>
<tr>
<td>☐ Yes</td>
<td>☐ Yes</td>
</tr>
<tr>
<td>How much of it did you eat?</td>
<td>How much of it did you eat?</td>
</tr>
<tr>
<td>☐ None</td>
<td>☐ None</td>
</tr>
<tr>
<td>☐ A little</td>
<td>☐ A little</td>
</tr>
<tr>
<td>☐ Most</td>
<td>☐ Most</td>
</tr>
<tr>
<td>☐ All</td>
<td>☐ All</td>
</tr>
<tr>
<td>How much did you like it?</td>
<td>How much did you like it?</td>
</tr>
<tr>
<td>☐ I didn't eat any</td>
<td>☐ I didn't eat any</td>
</tr>
<tr>
<td>☐ I didn't like it</td>
<td>☐ I didn't like it</td>
</tr>
<tr>
<td>☐ I liked it</td>
<td>☐ I liked it</td>
</tr>
<tr>
<td>☐ I loved it</td>
<td>☐ I loved it</td>
</tr>
<tr>
<td>Would you eat it next time it is served at school lunch?</td>
<td>Would you eat it next time it is served at school lunch?</td>
</tr>
<tr>
<td>☐ No</td>
<td>☐ No</td>
</tr>
<tr>
<td>☐ Maybe</td>
<td>☐ Maybe</td>
</tr>
<tr>
<td>☐ Yes</td>
<td>☐ Yes</td>
</tr>
</tbody>
</table>

Think about all the fruits and vegetables you had at school lunch today. For each question, choose only one answer.
Let's try an example...

Fruit 1: Apple
Did you have it on your tray?

Fruit 2: Banana
Did you have it on your tray?

Veggie 1: Broccoli
Did you have it on your tray?

Salad bar
Did you have anything from the salad bar on your tray?
Questionnaire:

**Fruits and Vegetables at School Lunch**

Wristband Number ______________________

### Fruit 1:

- Did you have it on your tray?
  - No
  - Yes

- How much of it did you eat?
  - None
  - A little
  - Half or most
  - All

- How much did you like it?
  - I didn't eat any
  - I didn't like it 😞
  - It was okay 😊
  - I liked it 😊

- Would you eat it next time at school lunch?
  - No
  - Maybe
  - Yes

### Fruit 2:

- Did you have it on your tray?
  - No
  - Yes

- How much of it did you eat?
  - None
  - A little
  - Half or most
  - All

- How much did you like it?
  - I didn't eat any
  - I didn't like it 😞
  - It was okay 😊
  - I liked it 😊

- Would you eat it next time at school lunch?
  - No
  - Maybe
  - Yes
### APPENDIX C. OBSERVATIONAL CHECKLIST FORM (CHAPTER 4)

Data Collector: _____ School Name: ___________________ School Code: _____ Date: ______

#### 2nd Grade

<table>
<thead>
<tr>
<th>Class codes: ______</th>
<th>No. students: _____</th>
<th>No. adults: ____</th>
<th>No. data collectors: _____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recess Before Lunch:</td>
<td>□ Yes □ No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch Period Length:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A: First student enters</td>
<td>Time B: First student served</td>
<td>Time C: Last student served</td>
<td>Time D: Last student discards tray</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Noise Measures:

<table>
<thead>
<tr>
<th>Time A: Measure starts (empty)</th>
<th>Time B: Measure stops (empty)</th>
<th>Time C: Measure starts (full)</th>
<th>Time D: Measure stops (full)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DbA</td>
<td>Leq</td>
<td>DbA</td>
<td>Leq</td>
</tr>
</tbody>
</table>

#### 3rd Grade

<table>
<thead>
<tr>
<th>Class codes: ______</th>
<th>No. students: _____</th>
<th>No. adults: ____</th>
<th>No. data collectors: _____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recess Before Lunch:</td>
<td>□ Yes □ No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch Period Length:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time A: First student enters</td>
<td>Time B: First student served</td>
<td>Time C: Last student served</td>
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<th>Time A: Measure starts (empty)</th>
<th>Time B: Measure stops (empty)</th>
<th>Time C: Measure starts (full)</th>
<th>Time D: Measure stops (full)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DbA</td>
<td>Leq</td>
<td>DbA</td>
<td>Leq</td>
</tr>
</tbody>
</table>
APPENDIX D. IRB APPROVAL

Teachers College IRB Expedited Approval Notification

To: Matthew Graziuse
From: Eva Hachikian
Subject: IRB Approval: 16-071 Protocol
Date: 02/05/2016

Please be informed that as of the date of this letter, the Institutional Review Board for the Protection of Human Subjects at Teachers College, Columbia University has given full approval to your study, entitled "What 2nd and 3rd Graders Eat at School Lunch," under Expedited Review (Category (4) Collection of data through noninvasive procedures; (6) Collection of data from voice, video, digital, or image recordings made for research purposes.).

The approval is effective until 11/03/2016.

The IRB Committee must be contacted if there are any changes to the protocol during this period. Please note: If you are planning to continue your study, a Continuing Review report must be submitted to either close the protocol or request permission to continue for another year. Please submit your report by 10/06/2016 so that the IRB has time to review and approve your report if you wish to continue your study. The IRB number assigned to your protocol is 16-071. Feel free to contact the IRB Office (212-678-4105 or irb@tc.columbia.edu) if you have any questions.

Please note that your Consent form bears an official IRB authorization stamp and is attached to this email. Copies of this form with the IRB stamp must be used for your research work. Further, all research recruitment materials must include the study’s IRB-approved protocol number. You can retrieve a PDF copy of this approval letter as well as the stamped consent(s) and recruitment materials from the IRB Mentor site.

When your study ends, please visit the IRB Mentor site. Go to the Continuing Review tab and select "terminate" from the drop-down menu.

Best wishes for your research work.

Sincerely,

Eva Hachikian
IRB Assistant, TC IRB
(212) 678-4105
irb@tc.columbia.edu